Chapter 4
Risk Assessment

Introduction

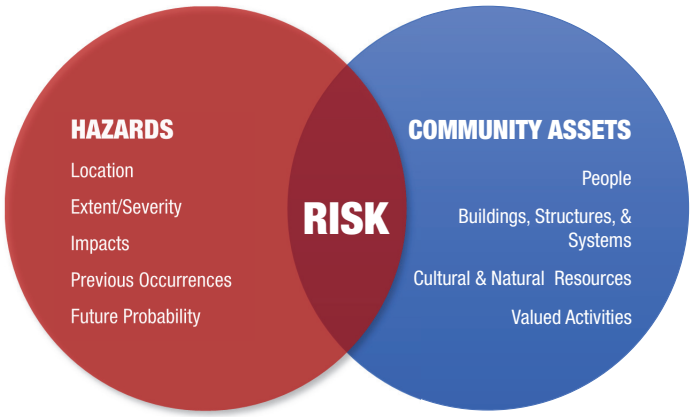
The risk assessment evaluates the threats posed by nine natural hazards that have occurred or are likely to occur in Thurston County in the future. Understanding and documenting how these hazards harm people, property, and the environment is the first step to developing a mitigation strategy. This chapter introduces how risk is measured and orients the reader to the content presented in each of the sections that follow. Chapters 4.1 through 4.9 profile the hazards that are assessed in this plan. Appendix C includes additional data that supports the hazard risk ratings for the overall planning area and each jurisdiction.

Chapter 4 Risk Assessment Contents

Assets, Vulnerabilities, Impacts, and Risks

Performing and documenting the risk assessment is the most technical process of hazard mitigation planning. A risk assessment describes the hazards that impact a community and summarizes which assets are vulnerable (Figure 4.1 – courtesy of FEMA). It is an important tool to inform a range of projects, programs, and services that communities can invest in to protect assets and make communities safer and more disaster resilient.

Figure 4.1 General Risk Concept, Hazards, and Community Assets



Risk Assessment Process, Format, and Content

This plan's risk assessment follows the guidance outlined in the Federal Emergency Management Agency (FEMA) Local Mitigation Planning Handbook.[1] Each hazard's risk assessment is documented through narratives, data, figures, images, and maps. Each subchapter of the risk assessment is referred to as a hazard profile. There are several key terms used in the hazard mitigation planning process that are used to describe the risk assessment process (Figure 4.2). These terms are used throughout Chapter 4 and its hazard profiles.

Figure 4.2 Key Hazard Mitigation Risk Assessment Terms

Natural Hazard: a harmful phenomenon produced by a meteorological, environmental, or geological event such as floods, earthquakes, storms, volcanic eruptions, and landslides.

Community Assets: people, homes, property, buildings, utilities, lifeline services, historic or cultural resources, natural resources, and activities that are valued by a community.

Vulnerability: a description of assets within locations identified to be hazard prone, that are at risk from the effects of a hazard.

Impacts: the consequences of the effects of each hazard on assets. Impacts can be anecdotal accounts as documented from previous disasters. Impacts can be an estimate of assets that are exposed to hazards or located in areas prone to hazards. The most detailed impacts can be derived from loss estimates produced by scenario-based data driven computer models.

Risk: the potential for damage or loss when natural hazards interact with people or assets.

Hazard Profile: The documentation of each hazard's risk assessment. It describes each identified hazard's location, extent, previous occurrences, and probability of future events.

Source: FEMA Local Mitigation Planning Handbook

Five Step Risk Assessment Process

FEMA describes the risk assessment process in five steps. This plan's risk assessment mirrors these steps. The hazard profiles in Chapters 4.1 through 4.9 document the risk assessment in accordance with FEMA's planning requirements. Each hazard profile is organized using the same format and description of contents that is described in the five steps that follow.

1. Hazard Identification

There are nine hazard profiles in the risk assessment. The Hazard Mitigation Planning Workgroup deliberated with TRPC and the consultant team, who was contracted to assist with the risk assessment process, to identify the hazards and a subset of hazard scenarios that are identified in this plan. Table 4.1 lists the changes in the hazard identification and profiling since the last plan update.

Hazard Profile Selection Criteria

Hazards were selected for risk assessment analysis based on the following criteria:

- **Common Threat** – a known hazard that was profiled in the previous Hazard Mitigation Plan and remains a threat to the region.
- **Emerging Threat** – a hazard that is included in Thurston County's Hazard Identification and Vulnerability Analysis (HIVA)[2] and was identified in the previous plan but was not profiled. The hazard has occurred in the community or is perceived as a more serious threat since the last plan update. The hazard is now profiled or described within an existing hazard profile.
- **New Evidence** – a hazard that was identified in the previous plan, but not profiled due to insufficient data or analysis to conduct a risk assessment. New evidence reveals there are areas in the Thurston Region that are vulnerable and the hazard warrants inclusion as a profiled hazard in the plan update.
- **FEMA Policy Change** – a new federal hazard mitigation planning requirements makes it advantageous to profile the hazard in the plan update.

Table 4.1 Changes in Hazard Identification and Profiling

Hazards	2017 Plan*	Plan Update	Reason for Change
Dam Failure	Identified	Profiled	FEMA Policy Change
Earthquake	Profiled	Profiled	Common Threat
Flood	Profiled	Profiled	Common Threat
Landslide	Profiled	Profiled	Common Threat
Sea Level Rise	Identified in Flood Profile	Profiled Independently	Emerging Threat
Severe Weather	Hazardous temperatures not included in profile	Hazardous temperatures added to Profile	Emerging Threat
Tsunami	Identified in Earthquake Profile	Profiled Independently	New Evidence
Volcanic Activity	Profiled	Profiled	Common Threat
Wildfire	Profiled	Profiled	Common Threat

*The last Natural Hazards Mitigation Plan for the Thurston Region was approved by FEMA in August 2017.

Hazards Not Profiled

Communities in Thurston County are subject to a wide variety of natural, technological, and human- caused hazards and threats that are documented in the Thurston County HIVA. The following threats and hazards have a likelihood of occurring in Thurston County communities but are not profiled in this plan. The plan participants may or may not include these hazards or other hazards in their annex to this plan.

1. **Critical Shortage** – Critical shortage is the lack of or a reduction in the supply of essential goods or services to a regional economy due to a disruption caused by events that occur elsewhere. These events may include embargoes, strikes, natural disasters, epidemics, crop failures, overexploitation of a natural resource, terrorist activities, or political unrest. Critical shortage is described as a potential impact to communities in several hazard profiles. It is not profiled as it is not a natural hazard.
2. **Cyberattack** – A cyberattack is an offensive maneuver against individuals, businesses, governments, or other organizations that targets computer information systems, infrastructure, networks, or personal devices. These attacks attempt to disable operations, steal information, or hold systems ransom. They may be launched by nation states, criminal organizations, or hackers acting with malicious intent. Local government infrastructure such as signal controllers, water systems, and other utilities that are controlled remotely by computers may be at risk to disruptions. A risk assessment was not performed for cyberattack. While attacks are common, it is one of the most mitigated threats in the technology industry. Local governments take great measures to train personnel about cybersecurity and invest in technologies and services to mitigate malicious attacks on their communications infrastructure.

3. **Drought** – Drought is a condition of climatic dryness severe enough to reduce soil moisture levels and water levels below the minimum necessary for sustaining plant, animal, and human life systems. Climate change projections for the Puget Sound Region indicate that longer, warmer, and drier summers will become the norm by mid-century. Drought can destroy or lower crop yields, impact fish habitat, and increase risk for wildland fires. A risk assessment was not performed for drought. However, the impacts of extreme heat are documented in the severe weather hazard profile. Drought may be profiled in a future plan update if the Hazard Mitigation Planning Workgroup decides it is an emerging threat or if new evidence warrants its inclusion. For this plan update, jurisdictions may include drought in their annex.
4. **Epidemic** – Epidemics are outbreaks of disease that affect or threaten to affect a significant portion of a population in a relatively short period of time. Although usually referring to a human contagious disease, epidemics can also affect domestic and wild animals and crops. Epidemic diseases such as COVID-19, Influenza, West Nile Virus, and the Zika Virus are usually introduced into an area from remote regions and inflict devastation because of a lack of natural or induced immunity. Epidemic mitigation measures are principally within the jurisdiction of the state and county public health departments. As such, a risk assessment for epidemic was not performed.
5. **Hazardous Material Incident** – Hazardous materials include chemicals used in manufacturing, household chemicals, crude oil and petroleum products, pesticides, herbicides, fertilizers, paints, medical wastes, radioactive materials, and a host of other substances. Their manufacture, transport, storage, use, and disposal place public property and the environment at risk from their inadvertent or intentional release. Local communities have little to no knowledge of when and what types of hazardous materials are being transported by highways or railroads through Thurston County. A risk assessment for hazardous materials release was not performed as it is not a natural hazard. Hazardous materials release planning and oversight is coordinated by Thurston County Emergency Management through the Local Emergency Planning Committee.
6. **Space Weather/Solar Wind/ Geomagnetic Storm** – The energy output of the sun varies according to its 11-year cycle. A coronal mass ejection or other solar phenomena can release magnetic storms that can severely disrupt and damage electrical distribution systems and electric devices on Earth. In March 1989, a current surge induced by the changing magnetic fields at ground level affected transformers at power stations in Canada. The surge led to power blackouts throughout Quebec that lasted for several hours, and the

power company lost more than 21,500 megawatts of its production capacity. Space weather is not considered an emerging threat and there is little new evidence to conduct a risk assessment for the impacts of a geomagnetic storm for the planning area.

7. **Terrorist Attack** – Terrorism is the use of force or violence against persons or property violating the laws of the United States for purposes of intimidation, coercion, or ransom. Terrorists often use threats to create fear among the public; try to convince citizens that their government is powerless to prevent terrorism; and sometimes try to garner publicity for their causes. Bombings and mass shootings are the most frequently used terrorist method in the United States. Other possibilities include attacks upon transportation facilities, utilities, or other public services, or an incident involving chemical or biological agents. Terrorism is not a natural hazard. A terrorism risk assessment was not performed. Measures to mitigate or prevent terrorism is best addressed through interagency coordination of national security with federal, state, and local law enforcement agencies.

2. Hazard Description

Each hazard profile follows the same format. This section describes the contents that comprise the hazard profiles and how the hazard occurs within the planning area.

Definition

The profile introduces the hazard by defining its source of energy, origin, and the types of damaging effects the hazard produces. Profiles with multiple effects, like severe weather, have several unique effects or elements that are defined separately. For example, heavy snow, freezing rain, and hail are all forms of hazardous precipitation, but each is produced by different conditions and presents unique risks.

Area of Impact

The hazard profile describes the areas that are most affected by a hazard. In this plan, Thurston County is the overall planning area. Each participating jurisdiction, whether a local government, special purpose district government, or a public college is located in part or all of the planning area.

Affected areas are described using both narrative descriptions and maps. Some communities are more vulnerable to hazards due to their geography or other conditions. In such instances, the communities that are most vulnerable to a hazard are described. For example, sea level rise and tsunami directly affect communities and neighborhoods that are on the Puget Sound. On the other hand, severe weather impacts the entire planning area and so it is more challenging to characterize and rate risks that are unique to individual communities. The hazard delineation maps in Chapter 4 refer to the entire area. Hazard maps are located at the end of each profile. Agency-specific hazard area impact descriptions and maps are also shown in the participating jurisdictions' annexes.

Extent

For some of the profiled hazards, there are means to measure the strength or intensity of its effects. For example, temperature, windspeed, snow depth, flood water depth, number of acres burned, and Mercalli intensity index describe the degree to which a hazard could damage or disrupt community assets. Where measures are lacking, a general description of the types of factors that contribute to a hazard's level of severity are presented.

Effects of Climate Change

Climate change affects atmospheric and environmental conditions to the extent that it is changing the timing, frequency, intensity, and reach of natural hazards such as extreme heat, precipitation, and wildfire conditions.

Documenting data-supported projections for climate impacts informs the risk assessment and considerations for mitigation actions. The effects of climate change are documented for flood, landslide, severe weather, and wildfire hazards.

Previous Incidents

Previous incidents offer communities insights about potential future impacts. Where available, historic disaster events, dates, disaster declaration numbers, and brief descriptions of the impacts to people, property, infrastructure, and the environment are presented.

Probability of Occurrence

The probability of occurrence is a description or measurement of how likely a hazard event will occur or reoccur in the future. Statistical probability values are shown, if available. In general, probability is described for each hazard using a qualitative description. The probability of a hazard is one of the main factors used to calculate each hazard's risk rating. Probability is described within a 25 to 100-year period as follows:

- **High** – Hazard event is likely to occur within 25 years
- **Medium** – Hazard event is likely to occur within 100 years
- **Low** – Hazard event is not likely to occur within 100 years
- **None** – If there is no exposure to a hazard, there is no probability of occurrence

3. Inventory of Community Assets

Tetra Tech Consulting was contracted by TRPC to assist the region with the risk assessment. For the regional risk assessment, a variety of data sources were used to assess assets exposure and vulnerability to the hazards. This section describes the assets and data sources that were used as inputs and to inform the plan's exposure analysis, hazard modeling, and risk assessment.

People

The people who live and work in Thurston County are the region's most valuable asset. Knowing where and how many people are potentially exposed to hazards is vital to identifying strategies to protect them. Thurston County Population data was obtained from the Washington State Office of Financial Management. Estimates of hazard population exposure were derived from residential units within affected hazard areas. For each hazard, the portion of a community's population exposed to the hazard was calculated. Population exposure is the highest weighted factor for calculating a community's hazard risk rating. A table summarizing the number of individuals, by jurisdiction that are located in areas that are prone or exposed to each hazard is documented in the Impacts and Vulnerability section.

Measuring the impact of hazards on socially vulnerable populations is difficult as there is little community-specific data available to evaluate risk for subareas within a community. This plan presents information from the FEMA National Risk Index and Center for Disease Control Social Vulnerability Index ratings. Social Vulnerability Index ratings are mapped by Census Tract for each hazard in the Risk Ratings section. More information about these indices can be found in section 5. Summarizing Vulnerability and in Chapter X. Community Profile.

Structures and Systems

Residential units, commercial buildings, public buildings, and other building types are exposed to some level of risk depending on their age, construction type, location, and how they are used. Buildings are also referred to as the region's general building stock. An inventory of general building stock and parcel data was obtained from the Thurston County Assessor's Office through Thurston GeoData.

Nearly 105,000 structure point locations were mapped in GIS to assess the structural assets' exposure to each hazard and to estimate potential replacement value losses. Replacement value is the cost to replace the entire structure with one of equal quality and utility. Replacement value is based on industry-standard cost-estimation models published in RS Means Square Foot Costs[1]. It is calculated using the RS Means square foot cost for a structure, which is based on the Hazus occupancy class (i.e., multi-family residential or commercial retail trade), multiplied by the square footage of the structure from the tax assessor data. The construction class and number of stories for single-family residential structures also factor into determining the square-foot costs.

A table summarizing the number and type of structures in the hazard area (residential, commercial, industrial, agricultural, religion, government, and education) is shown in each hazard profile's Impacts and Vulnerability section.

[1]As referenced by Tetra Tech Consulting. RSMeans.com, 2022.

The total valuation of structures and their contents as a share of the total valuation is also shown. The structural and contents value is categorized as property in the risk rating model. The share of exposed property that suffers damage is measured as an economic impact. Property exposure is the second highest weighted factor to calculate a hazard's risk rating. Economic impacts are the third rated factor for calculating risk.

Critical Facilities and Community Lifelines

Critical facilities and lifelines for police and fire, health care, energy, communication, transportation, water systems, and hazardous materials are fundamental to the safety, security, and health of a community. When these assets are disrupted, other sectors of the community can suffer impacts to services that are critical to a community's function and protection of public safety. FEMA emphasizes local governments pursue mitigation activities to protect such vital services and facilities through hazard mitigation planning.

TRPC coordinated with the plan participants to collect critical infrastructure data. This data was digitized in GIS and augmented with a variety of other data such as health care clinics, long-term care facilities, bridges, communications stations and infrastructure, FDIC insured banks, and electric substations (see Appendix C for a catalog of the data sources used in the risk assessment). In total, the critical facilities data consists of nearly 1,300 records. A table summarizing the number and type of critical facilities and lifelines is shown in the Impacts and Vulnerability section. Records of critical facilities need to be protected and are not published in this plan. General information about the types of critical facilities is described.

Natural, Historic, and Cultural Resources

Hazard mitigation should be all encompassing to protect the assets that the public values. This includes a range of natural, historic, and cultural resources. Natural resources such as wellhead protection areas, farmland, estuaries, wetlands, rivers, prairies, and forests are vital to the health and welfare of people, wildlife, and ecosystems. Historic buildings, homes, monuments, and other structures are valued for showcasing our communities' stories and educating residents and visitors about our region's past. Other cultural assets such as parks, performance halls, art, and museums contribute to a community's sense of place, quality of life, and economic development. A comprehensive analysis of natural, historic, and cultural resources was not performed during this plan update, however a general description of the types of assets that are potentially vulnerable is described in each profile's Impacts and Vulnerability section.

Activities

COVID-19 public health safety precautions profoundly disrupted a wide range of activities that people and communities across all sectors could access or experience. Physical disruptions and critical shortages from natural hazards will disrupt community lifeline services resulting in reduced levels of public and private sector services. Traditional and seasonal activities such as festivals, sporting events, and outdoor

concerts and other performances could also be disrupted. These events add to a community's quality of life and support commerce and economic development. A general discussion of the types of activities that could potentially be affected by natural hazards is described in each hazard profile's Impacts and Vulnerability section.

Changes in Development

The county, cities, and special purpose district plan participants have authorities and responsibilities for planning and implementing capital projects for transportation, water and wastewater systems, residential subdivisions, apartment buildings, new school buildings, and commercial activities within their jurisdictions. Any changes in development since the plan was last updated are described and assessed to determine whether a community's vulnerability or risk for each hazard has increased, decreased, or not changed. Descriptions about the jurisdictions' changes in development are included in the annexes.

4. Analyzing Impacts

Two methods were used to analyze the hazards' impacts on communities. The risk assessment for this plan determined exposure and vulnerability for the nine profiled hazards for the overall planning area. The methods are described below.

Exposure Analysis

An exposure analysis examines what quantity or portion of a community's assets are located in areas prone to hazards. This type of exposure is useful when a hazard area is well defined, mapped, and available as a GIS database. Using GIS, an exposure analysis can readily summarize the number of people, homes, structures, and other assets that are exposed to a hazard. A map of the hazard areas used for analyzing impacts is shown in each hazard profile. Figure 4.3 shows the hazard map data sources that were used for the exposure analysis.

Modeled Scenario Analysis

FEMA has developed a GIS modeling tool to analyze hazards and forecast outputs at varying levels of detail based on the type and availability of data used to run the model. The tool can evaluate specific hazard scenarios to estimate losses to assist communities with evaluating potential losses and evaluate their risks. The Hazus model supports a limited number of hazard types, therefore only a subset of the hazards in this plan could have modeled scenario analyses performed.

TRPC contracted with Tetra Tech to run "what if" scenarios for varying levels of severity for earthquake and flood hazards. The impact analysis for these hazards used Hazus models to estimate losses and evaluate vulnerabilities in the planning area. A Level 2 analysis was performed for all the scenarios that were developed.

Figure 4.3 Hazard Impacts Analyzed by Exposure Analysis

Hazard	Digital GIS Hazard Data Source
High Groundwater Flooding	Thurston County GeoData High Groundwater Special Flood Hazard Areas
Landslide	Washington Department of Natural Resources (WADNR) Landslide Compilation Data and Slopes >40% (delineated by a 3-foot LiDAR Digital Elevation Model)
Tsunami	WADNR Cascadia Subduction Zone M9.3 Earthquake Tsunami Scenario Inundation Map
Volcanic Activity	United States Geological Survey Case I Lahar Inundation Map
Wildfire	WADNR Wildland-Urban Interface and Intermix Map

Level 2 analysis is supported by a combination of local data inputs and baseline national datasets, whereas a Level 1 analysis only provides a baseline assessment using national data (see Figure 4.4). The approach used for each hazard is described below.

- **Flood** — A Level 2 user-defined analysis was performed for general building stock in flood zones and for critical facilities. Current flood mapping for the planning area was used to delineate flood hazard areas and estimate potential losses from the two-percent-annual-chance (50-year), one-percent-annual-chance (100-year), and 0.2-percent-annual-chance flood events (500-year). To estimate damage that would result from a flood, Hazus uses pre-defined relationships between flood depth at a structure and resulting damage, with damage given as a percent of total replacement value. Curves defining these relationships have been developed for damage to structures and for damage to typical contents within a structure. By inputting flood depth data and known property replacement cost values, dollar-value estimates of damage were generated.
- **Dam Failure** — A Level 2 user-defined analysis was performed for general building stock and critical facilities located in the dam failure hazard areas for Probable Maximum Flood (PMF) for the Nisqually Hydroelectric Project (Tacoma Power Alder and LaGrande dams) and the TransAlta Skookumchuck Dam. Depth grids were generated using the dam failure inundation areas and uploaded into the Hazus riverine flood model. By inputting depth data and known property replacement cost values, dollar-value estimates of damage were generated.

Figure 4.4 Levels of Hazus Modeling Analysis

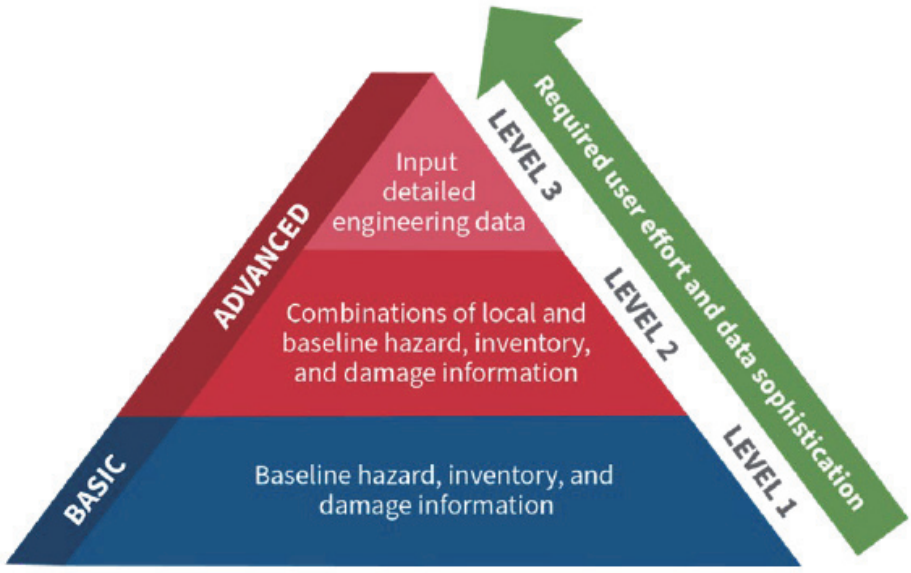


Image courtesy of FEMA

- **Earthquake** — A Level 2 analysis was performed to assess earthquake exposure and vulnerability for three scenario events:
  - A Magnitude 9.34 event on the Cascadia Fault Zone
  - A Magnitude 7.2 event on the Nisqually Fault
  - A Magnitude 7.2 event on the southern Seattle Fault Zone
- **Sea Level Rise** — A Level 2 user-defined analysis was performed for general building stock and critical facilities located in the sea level rise hazard area for a 6 inches of rise scenario. Depth grids were generated using the sea level rise hazard area and uploaded into the Hazus coastal flood model. By inputting depth data and known property replacement cost values, dollar-value estimates of damage were generated.

5. Summarizing Vulnerability

This plan provides risk ratings for both the overall area and each plan participant. As this plan is a multijurisdictional plan, each participant has differing degrees of risk exposure and vulnerability and provides additional information about existing or non-existing vulnerabilities that each hazard presents to its jurisdiction. Any differences between what is documented in Chapter 4 for impacts, vulnerabilities, and risk and an individual jurisdiction's vulnerabilities are documented in its annex.

Each hazard profile summarizes vulnerability in the Risk Rating section. The Risk Rating section presents:

- The FEMA National Risk Index; and
- The Community Hazard Risk Rating that follows the methodology prepared by Tetra Tech for this plan.

National Risk Index

The FEMA National Risk Index (NRI) provides three different types of results for risk for 18 hazard types. The plan only references the nine hazards or similar hazards that are included in the hazard profiles. The following descriptions of the NRI are borrowed from the FEMA NRI Technical Documentation.[3]

National Risk Index Composite Rating

In the National Risk Index (NRI), risk is defined as the potential for negative impacts as a result of a natural hazard. The risk equation behind the National Risk Index includes three components: a natural hazards risk component, a consequence enhancing component, and a consequence reduction component. EAL [Expected Annual Loss] is the natural hazards risk component, measuring the expected loss of building value, population, and/or agriculture value each year due to natural hazards. Social Vulnerability is the consequence enhancing component and analyzes demographic characteristics to measure the susceptibility of social groups to the adverse impacts of natural hazards. Community Resilience is the consequence reduction component and uses demographic characteristics to measure

a community's ability to prepare for, adapt to, withstand, and recover from the effects of natural hazards. The Social Vulnerability and Community Resilience components are combined into one Community Risk Factor (CRF) which is multiplied by the EAL component to calculate a composite risk value.

Risk Index scores are calculated using an equation that combines scores for Expected Annual Loss due to natural hazards, Social Vulnerability and Community Resilience:

Expected Annual Loss
× Social Vulnerability
÷ Community Resilience
= Risk Index

Expected Annual Loss

Expected Annual Loss (EAL) represents the average economic loss in dollars resulting from natural hazards each year. It is calculated for each hazard type and quantifies loss for relevant consequence types: buildings, people, and agriculture. As the natural hazards component of the National Risk Index, an Expected Annual Loss score and rating represent a community's relative level of expected losses each year when compared to all other communities at the same level. An Expected Annual Loss score is positively associated to a community's risk; thus, a higher Expected Annual Loss score results in a higher Risk Index score.

Social Vulnerability

Social vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. As a consequence enhancing risk component of the NRI, a Social Vulnerability score and rating represent the relative level of a community's social vulnerability compared to all other communities at the same level. A community's Social Vulnerability score measures its national rank or percentile. A higher Social Vulnerability score results in a higher Risk Index score.

Community Resilience

Community resilience is the ability of a community to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. As a consequence reduction risk component of the NRI, a Community Resilience score and rating represent the relative level of a community's resilience compared to all other communities at the same level. A community's Community Resilience score measures its national rank and is inversely proportional to a community's risk. A higher Community Resilience score results in a lower Risk Index score.

NRI Ratings

The Risk Rating section in each hazard profile documents the county's relative hazard composite Risk Index, EAL, and Social Vulnerability scores and ratings at the countywide level. Table 4.2 shows Thurston County's EAL, Social Vulnerability, and Community Resilience scores for the profiled hazards.

- Values – EAL values are in units of dollars, representing the community's average economic loss from natural hazards each year. For Social Vulnerability and Community Resilience, values are the index values for the community provided by the source data sets.
- Scores - Scores represent the national percentile ranking of the community's component value compared to all other communities at the same level (county or Census tract).
- Ratings - Ratings are provided in one of five qualitative categories describing the community's component value in comparison to all other communities at the same level. Rating categories range from "Very Low" to "Very High."

Table 4.2 Thurston County National Risk Index Scores and Ratings (National Percentile)

Hazard	Expected Annual Loss	National Risk Index
Dam Failure	Not available	Not available
Earthquake	$96M	98.9, Relatively High
Flood	$53K	17.3, Very Low
Landslide	$0.22M	94.4, Relatively Moderate
Sea Level Rise	Not available	Not available
Winter Weather	$30K	35.3, Relatively Low
Tsunami	No Rating	No Rating
Volcanic Activity	$14M	95.5, Relatively High
Wildfire	$39K	50.3, Very Low
Composite	**$113K**	**96.2, Relatively High**
Countywide Social Vulnerability (applies to all hazards)		**37.2, Relatively Low**
Countywide Community Resiliency (applies to all hazards)		**71.9, Relatively High**

Community Risk Rating Methodology

For the plan update, a Community Hazard Risk Rating Model was developed to calculate an overall risk rating for each profiled hazard for the overall planning area and for each plan participant. The results from the exposure analysis and the modeled scenario analysis were used to calculate the risk scores. The hazard score provides the jurisdictions a data-based method for producing a generalized planning level risk rating. For each hazard the risk rating methodology its probability of occurrence multiplied by the sum of its potential impacts on community assets (people, property, and the economy, see Figure 4.5). The higher the probability and impacts, the higher the risk rating. Each variable is described below.

Probability Factors

A probability factor is assigned based on how often a hazard is likely to occur. The probability of occurrence of a hazard event is generally based on past hazard events in an area. For example, if a jurisdiction has experienced two damaging floods in the last 25 years, the probability of occurrence is high for flooding and is assigned a probability factor of 3. If a jurisdiction has experienced no damage from landslides in the last 100 years, the probability of occurrence for landslide is low, a probability factor of 1. For each hazard, a jurisdiction is assigned a probability factor as follows:

Occurrence Description	Probability	Factor
No exposure to a hazard = no probability of occurrence	None	0
Hazard event is not likely to occur within 100 years	Low	1
Hazard event is likely to occur within 100 years	Medium	2
Hazard event is likely to occur within 25 years	High	3

Figure 4.5 Thurston Region Hazard Mitigation Plan Community Hazard Risk Rating Calculation

Impact Weight Values

Weighting the value of the impacts on community assets allows a community to place emphasis on what they value most. The Community Hazard Risk Rating calculation includes three weight values that are assigned to assets that are impacted: 1) Impacts on people; 2) Impacts on property; and 3) Impacts on the economy. These weight values are multiplied by their respective impact factors:

Asset Value	Weight
People and their safety are a community's highest priority	3
Protection of property is the second priority	2
The economy is the third priority	1

People Impact Factors

The impact factors are assigned based on the percentage of the total population exposed to the hazard event. The degree of impact on individuals varies, however it is not measurable. The calculation assumes that the population exposed is equally impacted when a hazard event occurs. Impact factors are determined as follows:

% Population Exposed to Hazard	Impact	Factor
Population is not exposed to a hazard = no exposure	None	0
≤9 percent is exposed	Low	1
10 to 24 percent is exposed	Medium	2
≥25 percent is exposed	High	3

Property Impact Factors

The percent estimated exposure of property or replacement value (combined structure and contents value) is estimated from the impact analysis. Property impact factors are assigned based on the percentage of the total property value exposed to the hazard:

% Property Exposed to Hazard	Impact	Factor
Property is not exposed to a hazard = no exposure	None	0
≤9 percent is exposed	Low	1
10 to 24 percent is exposed	Medium	2
≥25 percent is exposed	High	3

Economy Impact Factors

Economic losses are estimates of the portion of exposed property (structures and their contents) that are damaged or destroyed by hazards. The economic loss impact factors are assigned the same for all hazards, however the process to estimate the economic loss values differs depending on the type of impact analysis performed for the hazard.

% Replacement Value Loss to Hazard	Impact	Factor
No losses are estimated	None	0
≤4 percent of total replacement value is lost	Low	1
5 o 9 percent loss of total replacement value is lost	Medium	2
≥10 percent of total replacement value is lost	High	3

Economic Loss Estimates based on Exposure Analysis

There are no model forecast loss estimation tools for assets that were evaluated using the exposure analysis process. For the high ground water flooding, landslide, tsunami, volcanic lahar, and wildfire hazards, economic loss estimates are calculated from the portion of the percent of total value exposed property estimates that are determined by the exposure analysis. For example, a large percentage of the building stock may be exposed to landslide or wildfire risk, but it is not expected that a single event would result in a total loss to all exposed structures. For these hazards, a loss factor is multiplied to the percent total value exposed to produce a planning level loss estimate or the total replacement value damage. A loss factor of 25 percent is applied to all the non-modeled hazards to determine which economic impact factor is assigned. The severe weather hazards do not have a defined extent and location; therefore the entire building stock is considered to be exposed, but impacts are generally considered to be "low."

Economic Loss Estimates based on Modeled Scenario Analysis

Hazus model loss data is used to calculate the loss estimates for the flood (excluding high groundwater), dam failure, earthquake, and sea level rise hazard scenarios. The percent estimated impacts on the economy are the percentage of the total property value (structure and contents) that the model estimates to be vulnerable to the hazard events. Values represent estimates of the loss from a major event of each hazard in comparison to the total replacement value of the property exposed to the hazard.

Variations in the Community Risk Rating Model for Special Purpose District Participants

Property Impacts

For special purpose district participants, property impact values are based on the percentage of a district's critical facilities exposed to the hazard area. This detail is shown for all the hazards except the earthquake scenarios (see Notes for special purpose districts on economic impacts). The property impact factor values are the same as shown above.

Flood Economic Losses

Special purpose districts' critical facilities loss estimates for the 50-, 100-, 500-year floods, dam failure, and the sea level rise scenarios calculate the flood losses based on Hazus model results. The model results forecast the percent flood damage to a structure. For a single facility in a district, this value would be multiplied by the value of the affected structure to yield the estimated percent economic loss. For a district with multiple affected structures, the mean percent damage to the structures would be used to calculate the percent economic loss. The economic ratings values are also the same as shown above.

Earthquake Functional Downtime as a Substitute for Economic Impact Factors

The Hazus earthquake model scenarios include estimates of functional downtime for the critical facilities – a facility's percent functionality after an event at days 1, 3, 7, 14, 30, and 90. For special purpose districts, functional down time is assessed for the number of days necessary for functionality to be restored to 50 percent. Functional downtime is assigned an impact factor as follows:

Days of Functional Downtime before 50% restoration	Impact	Impact Factor
0	None	0
≤14	Low	1
15-44	Medium	2
≥45	High	3

Community Risk Scores and Hazard Risk Ratings

A community's risk score and rating direct a community's hazard mitigation planning team to focus on mitigation actions for hazards and areas that are prone to hazard impacts. The higher the risk, the greater attention a community should give to evaluating actions to reduce asset vulnerabilities and impacts. Actions that mitigate higher risk hazards should be prioritized over low risk hazards as part of a jurisdiction's benefit cost review process. The Risk Scores translate to risk ratings as follows:

Risk Score	Risk Rating
0-15	Low
16-32	Medium
33-54	High

Example Community Hazard Risk Rating Calculation

Let's examine Hazard City, a foothills community that is nestled only 20 miles from the edifice of Mount Restlessness, a 14,000 foot volcano. We'll use the Community Hazard Risk Rating formula to calculate its risk. Refer to the information below to assign the probability impact factors and calculate the hazard risk rating for the city. The results are shown in Figure 4.6.

A portion of Hazard City is located in the lahar inundation zone. Mount Restlessness has been dormant for nearly 300 years, but there is geologic evidence that a lahar spread through the northeast edge of the city. The following information is known about the hazard:

a. Geologists believe there is an 80% probability that Mount Restlessness will erupt in the next 100 years. A Lahar would likely occur. This is considered a medium probability, as such a probability factor of 2 is assigned for Lahar for Hazard City.

b. Fourteen percent of the city's population is within a mapped historic lahar inundation zone – a medium population impact factor of 2 is assigned. The weighting value for impacts to people is 3, so the impact results for people are equal to 2x3 = 6.

c. $207.7 million or 10 percent of the city's $2 billion property valuation is exposed to the lahar zone. This is a medium property impact factor of 2. The weighting value for property is 2. The impact results to property are equal to 2x2=4.

d. Applying the 25% loss factor to the $207.7 million exposed value is $51.9 million or 2.5 percent of the total economic valuation of properties for Hazard City. This results in an estimated economic loss of 2.5 percent – an impact factor of 1 is assigned. The weighting value for the economy is 1, so the economic impact results are equal to 1x1=1.

e. The sum of impacts for people (6), property (4), and economy (1) is 11.

f. Multiplying the probability factor 2 to the sum of impacts (11) equals 22.

Hazard City has a lahar risk ranking score of 22 which is a "Medium" risk rating. Hazard City mitigation planners have identified the following lahar mitigation actions in their plan: 1) Develop a lahar hazard public awareness outreach, education, and preparedness campaign; 2) Create a volcano emergency alert system; and 3) Designate lahar evacuation routes with signs.

Figure 4.6 Hazard City Lahar Risk Rating

Probability Factor	Impact on People	Impact on Property	Impact on Economy	Risk Ranking Score	Risk Rating
2 x	(6 +	4 +	1)=	22	Medium

Community Hazard Risk Ratings for the Thurston Region

The hazard profiles present the Community Hazard Risk Ratings for each hazard and jurisdiction. Table 4.3 summarizes the overall planning area's risk rating for the major hazards assessed in the profiles. Specific information about the data used to inform the risk scores can be found in the hazard profiles and in Appendix C.

Addressing a Hazard's Risks in the Regional Mitigation Strategy

To provide a nexus between the plan's mitigation actions and the region's vulnerabilities, each hazard profile provides a brief description of the actions included in the Region's Mitigation Strategy that will reduce the hazard's impacts on the region. More information about the regional mitigation strategy can be found in Chapter 2, Recommendations. Information about jurisdictions' specific mitigation actions can be found in the annexes.

Table 4.3 Thurston Region Hazard Risk Ratings

		Dam Failure	Earthquake (CSZ 9.3)	Flood (100-year)	Landslide	Sea Level Rise (6 inches)	Severe Weather	Tsunami	Volcanic Lahar	Wildfire
Probability	Level	Low	Medium	High	High	High	High	Medium	Low	Medium
	Factor	1	2	3	3	3	3	2	1	2
People	%Exposed	1.47%	100.00%	0.97%	1.91%	0.16%	na	0.05%	0.76%	32.24%
	Impact	Low	High	Low	Low	Low	Low	Low	Low	High
	Factor	1	3	1	1	1	1	1	1	3
	Weighted Results	3	9	3	3	3	3	3	3	9
Property	%Exposed	0.71%	100.00%	0.93%	1.71%	0.85%	na	0.13%	0.35%	35.10%
	Impact	Low	High	Low	Low	Low	Low	Low	Low	High
	Factor	1	3	1	1	1	1	1	1	3
	Weighted Results	2	6	2	2	2	2	2	2	6
Economy	% Total Value Damaged	0.37%	6.74%	0.05%	0.43%	0.06%	na	0.03%	0.09%	8.78%
	Impact	Low	Medium	Low	Low	Low	Low	Low	Low	Medium
	Factor	1	2	1	1	1	1	1	1	2
	Weighted Results	1	2	1	1	1	1	1	1	2
Risk	**Risk Score**	**6**	**34**	**18**	**18**	**18**	**18**	**12**	**6**	**34**
	Risk Rating	**Low**	**High**	**Medium**	**Medium**	**Medium**	**Medium**	**Low**	**Low**	**High**

Endnotes

[1]Federal Emergency Management Agency. 2023. Local Mitigation Planning Handbook. https://www.fema.gov/sites/default/files/documents/fema_local-mitigation-planning-handbook_052023.pdf

[2]Thurston County Emergency Management. 2004. Hazard Inventory and Vulnerability Analysis. https://www.thurstoncountywa.gov/departments/emergency-management/threats-hazards

[3]Federal Emergency Management Agency. 2023. National Risk Index Technical Documentation. https://www.fema.gov/sites/default/files/documents/fema_national-risk-index_technical-documentation.pdf