Identification and Profiling of Hazards

Risk Assessment FEMA Requirements
Requirement §201.6(c)(2): Plan content. The plan shall include the following:
(2) A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

This plan is an update of the 2004 City of Redmond Hazard Mitigation Plan (HMP). Although it is an update, this document has been redesigned so that it looks, feels, and reads differently than the original. This is due to several factors: new hazard information has become available that drives new definitions of risk, the City has matured and new capabilities are now available, and the new format will allow readers to more easily understand the content. In addition, the 2004 HMP included several action items that have been completed, creating an opportunity for developing new mitigation strategies.

It is critical that risk assessment, mitigation and preparedness efforts are founded on accurate information. This section of the plan assess the potential threats to the City of Redmond – earthquakes, severe storms, flooding, wildfires, landslides, pandemics, heat waves, droughts and hazardous materials spills – and the corresponding vulnerabilities. The risks have been identified based on historical events and available information about changing conditions. Changes in land use and climate change were researched in order to provide a valuable assessment of how these risks may vary from the historical patterns.

The City of Redmond and King County GIS databases were used to determine the potential impact of each hazard on the critical infrastructure and city services. Historical data and climate change predictions were used to identify the likelihood that the identified hazards would affect Redmond in the future.

The first round of screening looked at a wide variety of hazards that are probable in the United States. Through this screening, the project team identified the significant risks for Redmond. The Risk Assessment Model (described below) was used to determine the relative risk of each hazard based on the location, frequency and vulnerabilities. Three likely scenarios were written in order to illustrate the probable sequence of events. In order to understand the likely risks, each hazard was profiled considering the location, timing/duration, severity, frequency, vulnerabilities and future planned development.

Hazards Screening for the City of Redmond		
HAZARD	**RISK**	**WHY / WHY NOT**
Avalanche	None	Does not affect City
Coastal Erosion	None	Does not affect City
Coastal Storm	None	Does not affect City
Drought	Low Risk	Risk may increase in future with climate change
Earthquake – Crustal	High Risk	Low frequency, highly destructive
Earthquake – Benioff	High Risk	Moderate frequency, moderately destructive
Earthquake – Subduction	High Risk	Low frequency, highly destructive
Extreme Heat	Low Risk	Risk may increase in future with climate change
Flood	High Risk	Risk may increase in future with climate change.
Hazardous Material Spill	Low Risk	Hazardous Materials are highly regulated
Hurricane	None	Does not affect City
Landslide	Low Risk	Risk may increase in future with climate change and increased development
Pandemic	Low Risk	Risk may change or increase in future with climate change and globalization
Seiche	Low Risk	May be a secondary hazard (addressed as part of landslides)
Tornado	None	Does not affect City
Tsunami	None	Does not affect City
Volcano	None	Does not affect City
Wildfire	Low Risk	Risk will increase in future with climate change
Winter Storm	High Risk	Risk will increase in future with climate change

Table 9: Hazards Screening for the City of Redmond

Significant Risks

- Benioff Earthquake and Liquefaction
- Severe Storms
- Floods
- Crustal / Subduction Earthquakes and Liquefaction

Less Significant Risks

- Landslide
- Drought

Risks Monitored by an Outside Agency

- Pandemic (WHO and CDC)
- Hazardous Materials Spill (EPA)

Emerging Risks Due to Climate Change

- Wildfires
- Heat Wave

The City of Redmond is exposed to a number of natural hazards that vary in potential intensity and impact on the City. This plan addresses four hazards that pose a significant threat and six that pose limited threats. Of the six that pose limited threats, two are primarily monitored by an outside agency and two are emerging risks that are likely to pose a greater threat to Redmond in the future.

Risk Assessment FEMA Requirements
Requirement §201.6(c)(2): Plan content. The plan shall include the following:
(2)(i) A description of the type, location, and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Hazards were included in the plan based on the likelihood of occurrence and the potential impact on the City. Vulnerabilities considered include people, buildings, systems, the local economy, and the natural environment. Although heat related hazards do not currently present a significant hazard in Redmond's mild climate, climate change predictions indicate that these hazards may be more significant in the future. In addition to considering the hazards independently, the plan addresses the likelihood that one event may trigger secondary hazards or exacerbate existing conditions.

The hazards included in this plan were identified through academic research and community input. The MIC (Mitigation Implementation Committee) provided local expertise and historical knowledge to the Project Team, which subsequently conducted extensive research. The list of hazards includes all those that pose a potential risk to the City of Redmond.

Risk Assessment Model

In order to comprehensively assess the relative risk posed by hazards, the Project Team developed a model that considers both the frequency and vulnerability to the hazards. The objective of the rating system is to identify which hazards pose the greatest risk to the City of Redmond. In order to comprehensively assess the relative risk, the model considers the frequency and the vulnerability of each hazard. The model deals with hazards and risk in a relative manner and the risk rankings are to be considered within this context. Frequency and vulnerability were given equal weighting. Specifically, the model uses the following simplified equation:

Risk = Frequency x Vulnerability Factor

Frequency
The hazard frequency was determined for each hazard using a 0-3 scale:

0	Hazard is unlikely to ever occur in Redmond
1	Hazard may occur once in a generation
2	Hazard may occur every ten to fifty years
3	Hazard will occur with some regularity

Vulnerability Factor

A vulnerability factor was used to address the various vulnerabilities and the severity of a hazard. The built environment, systems (transportation, utilities, economy, etc.), natural systems, the human population and severity were each assigned a zero to three value. In order to equally weight frequency and vulnerability, the average of the vulnerabilities provided a "vulnerability factor." The vulnerability ratings used the following equation:

Vulnerability Factor = (Human + Built + Natural + Systems + Severity)/5

The vulnerability factor was then classified on a 0-3 scale:

0	The vulnerable population or system will not be affected
1	Event causes some mild disturbances to some systems, buildings, natural environment or populations
2	Event causes some mild disturbances to all systems, buildings, natural environment or populations OR event causes severe disturbance to some systems, buildings, natural environment or populations
3	The entire City is significantly affected by the event

Based on the information provided about each of the hazards, the assessment used the following equation to complete the Hazard Rating Chart:

Risk = Frequency x ((Human + Built + Natural + Systems + Severity)/5)

Due to the variability inherent in each of the hazards and the rating system, the risks were divided into categories of low, moderate and high-risk hazards. The relative ranking established by this model provided a framework for the risks and strategies addressed in the Hazards Mitigation Plan.

The hazards ranked in 2004 have changed only slightly in 2009. Severe storms and earthquake remain the primary hazards Redmond must be concerned with. Climate change has been incorporated into the risk assessment in 2009 and that has resulted in a little shifting of the order of hazards. The biggest change has come with the rise of epidemic/pandemic on the list. In 2004, pandemic ranked eighth out of ten items. In 2006, pandemic was listed second on the hazards list. In 2009, it ranks at the top of the lower half of the list.

Table 10, Redmond Risk Assessment Model, shows the Risk Assessment as applied to the hazards applicable to Redmond.

Event	Frequency	Vulnerability					Vulnerability Factor	Risk Rating	Risk Level
		Built	Natural	Systems	Population	Severity			
Possible Rankings	0 - 3	0 - 3	0 - 3	0 - 3	0 - 3	0 - 3	0 - 3	0 - 9	Low-High
Severe Storms	3	1	1	3	2	2	1.8	5.4	High
Benioff Earthquake	2	2	1	2	2	2	1.8	3.6	High
Floods	2	2	2	1	1	2	1.6	3.2	High
Crustal / Subduction Earthquake	1	3	1	3	3	3	2.6	2.6	High
Wildfire	1	2	2	1	1	2	1.6	1.6	Low
Landslide	1	2	0	2	1	2	1.4	1.4	Low
Pandemic Mild	2	0	0	0	2	1	**0.6**	**1.2**	Low
Pandemic Catastrophic	1	0	0	0	3	3	**1.2**	**1.2**	Low
Heat Wave	1	0	2	0	2	2	1.2	1.2	Low
Drought	1	0	2	1	2	1	1.2	1.2	Low
Hazardous Materials	1	0	1	1	0	2	**0.8**	**0.8**	Low

Table 10: Risk Assessment Model

Scenarios

Scenarios provide a narration of events that are likely to occur in Redmond. Each scenario considers the threat of the hazard and the probable subsequent events that will occur based on the current conditions. Three scenarios were developed to look at regional, municipality-wide and localized events. These scenarios were developed to help illustrate identified vulnerabilities and facilitate public participation. The HAZUS software package produced by FEMA was used to predict the impacts of Scenario 1: Crustal Earthquake.

Scenario 1: Crustal Earthquake[16]

At 1:38pm on March 18th a 6.7 magnitude earthquake occurs along the Seattle fault. The epicenter is located within two miles directly south of Redmond. Peak Ground Acceleration (PGA) ranged from 0.35 in the Northern end of the City to as high as 0.51 in the Southern edge of the City. The massive shaking caused over $980 million of damage and 57 casualties.

The magnitude of the earthquake was similar to the 2001 Nisqually earthquake, but the violent ground shaking caused much more damage. The earthquake caused damage to 5,547 of the City's 17,000 buildings. 271 of those buildings are damaged beyond repair. 47 of the 52 unreinforced masonry buildings were at least moderately

16 Scenario and damage is based on HAZUS run of 6.7 magnitude earthquake on the Seattle Fault. The region was defined as the main census tracts within the City of Redmond. Consequently, the numbers of buildings, population, etc. are not completely consistent with City specific data.

damaged. The total cost of damages to the buildings exceeded $806 million. Transportation systems within the City of Redmond also sustained damage. Two bridges were damaged, but one regained functionality after the day of the event. The total cost of damage to the transportation system was over $30.2 million. Regional transportation failures, such as the collapse of the SR 520 bridge, limited Redmond's access to regional facilities that were already overwhelmed.

Lifeline utilities were also damaged. On the day of the earthquake, 231 leaks and 58 breaks in the water lines left over 8000 households without access to potable water. Service was promptly restored within 72 hours. Additional leaks and breaks in the wastewater sewer lines caused additional complications.

11,501 households lost electricity. Within a week, only 2,367 households remained without power. By April 18th only 406 households were still without electricity.

In addition to the immediate damage of the earthquake, fires broke out across the City and caused an additional $13 million of damages. The five small fires burned less that a tenth of a square mile and displaced 148 people.

The biggest problem has been the lack of a local medical facility and the fact that the regional hospitals were overwhelmed. There were 620 people who suffered minor injuries that did not require hospitalization. Another 177 suffered non-threatening injuries that did require hospitalization. There were 29 people who had serious injuries that required immediate care. The earthquake caused 57 fatalities.

Scenario 2: Winter Storm

Snow began falling heavily at 1 a.m. on January 7th and continued in periodic showers for 8 days, depositing a total of 2 feet of precipitation. When the snow stopped on January 15th, the accumulation on uncleared roads averaged 10 inches, with drifts up to 3 feet. The snow and sleet covered the streets with icy snow patches. Sidewalks were invisible under the snow and there were several instances of pedestrian and vehicular paths crossing, resulting in 36 minor accidents and 5 major accidents with 3 traffic-related fatalities. The City's power grid had several temporary shutdowns and repairs, but was consistently off from midnight on January 13th to 3 p.m. on January 15th. Emergency call volumes during this period were very high, with the majority of calls requiring the evacuation of elderly homeowners to hospitals in Bellevue.

High volumes of snowfall caused ceiling leakage and some buckling on 36 commercial and office buildings with flat roofs, causing approximately $1 million in damaged equipment and repair costs. Storm drains overflowed in several areas from debris, snowpack, and frozen water, and an ice jam on the Sammamish River flooded parts of West Lake Sammamish Parkway NE at the 520 off ramps, causing major traffic delays for 8 hours on the 14th. Many citizens were unable to drive and large numbers of businesses were closed for several days. Roads that were cleared were congested with triple the usual numbers of traffic due to impassible roads elsewhere. A family

of four died of carbon monoxide poisoning after bringing a generator into their home, and 10 house fires from candles and woodstoves caused above the usual amount of damage, due to delayed response times caused by poor road conditions. Businesses in the food industry, particularly grocery stores, discarded over 6 tons of rotting perishables. The loss of electricity compromised the most common of communication systems, making standard lines of communication unavailable, including RCTV and the internet. Several businesses sought additional loans to cover company-wide vacation time and loss of revenue and inventory; three small businesses declared bankruptcy.

Scenario 3: Landslide

At 10 p.m. on November 5th, after several weeks of rain, a section of hillside in the Education Hill area gave way. Three homes slid fifty feet down the hillside, depositing debris in the backyards of several other homes, which were not damaged directly but lost landscaping and auxiliary structures (e.g. storage sheds). The residents and the City are cleaning up the large amounts of debris. Five people were injured, but there were no life-threatening injuries. Although neighboring homes are currently stable, monitoring will continue as the section that gave way continues to occasionally crumble. The road above the hill has been closed due to instability. The debris blocked a culvert at the bottom of the hill and caused two feet of flooding on sections of SR-202, Redmond-Woodinville Road. The road was closed for thirty-six hours before crews were able to restore normal traffic flow.

Climate Change

Governor Gregoire and the State of Washington, in recognition that our climate is changing and the impacts of the expected changes could be profound, have instructed us to significantly reduce the State's contributions to climate change. - *Washington Climate Change Challenge* (*Executive Order 07- 02*).[17]

In the report "The Preparation and Adaptation Working Groups" (PAWG) our Governor is asking us to incorporate climate change and its impacts into planning and decision-making processes. Accordingly, this Plan will address the impacts of climate change.

As a result of extensive research done by the International Panel on Climate Change and University of Washington Climate Impact Group[18], we know that Washington's climate is changing, and the impacts of these projected changes will be far reaching. Although our state is working to significantly reduce its contributions to climate change, some changes cannot (or will not) be prevented. For Redmond, expected changes include:

- Hotter, drier summers
- Wetter winters with increasing rainfall and rain intensity
- Increases in weather extremes
- Secondary hazards include increased chance of wildland/urban interface fires, heat waves, insect infestation, drought, potable water shortages, flooding, erosion and landslides.

Scientists expect the Pacific Northwest climate to warm approximately 0.5˚F every ten years over the next several decades. This rate is more than three times faster than the warming experienced during the twentieth century. In Washington, scientists project that average annual temperatures will be 1.9˚F higher by the 2020s when compared with the 1970-1999 average, and 2.9˚F higher by the 2040s. Changes in total precipitation are not projected to be significant over that time period; however, patterns of precipitation will change. Winters will bring more rain and less snow in the mountains.[19]

These projections are based on calculations that take into account human contributions to the accumulation of greenhouse gasses. Being human-caused, these projections could be tempered, should efforts be made at reducing greenhouse contributions.[20] While such efforts could slow warming, the impacts would continue for some time.

17 http://www.governor.wa.gov/execorders/eo_07-02.pdf
18 Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.
19 Ibid.
20 http://www.governor.wa.gov/execorders/eo_07-02.pdf