SECTION 2: RISK ASSESSMENT

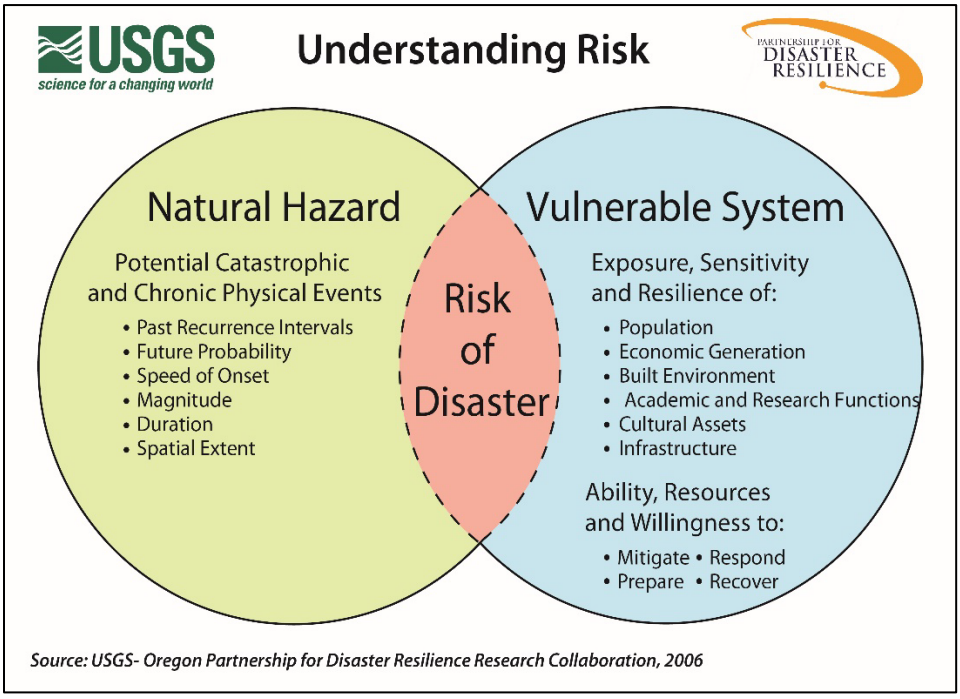
This chapter serves as the factual basis for Baker County to address Oregon Statewide Planning Goal 7 – Areas Subject to Natural Hazards. In addition, this section of the Natural Hazards Mitigation Plan (NHMP) addresses requirements in the Code of Federal Regulations found in 44 CFR 201.6(b)(2) - Risk Assessment.

Assessing natural hazard risk has three phases:

- **Phase 1 - Hazard Identification:** Identify hazards that can impact the jurisdiction. This includes an evaluation of potential hazard impacts – type, location, extent, etc.
- **Phase 2 – Vulnerability Assessment:** Identify important community assets and system vulnerabilities. Example vulnerabilities include people, businesses, homes, roads, historic places, and drinking water sources.
- **Phase 3- Risk Analysis:** Evaluate the extent to which the identified hazards overlap with, or have an impact on, the important assets identified by each community.

The information presented below, along with hazard specific information presented in the Hazard Annexes and community characteristics presented in the Community Profile Appendix, will be used as the local level rationale for the risk reduction actions identified in Section 3 – Mitigation Strategy. The risk assessment process is graphically depicted in Figure 2 below. Ultimately, the goal of hazard mitigation is to reduce the area where hazards and vulnerable systems overlap.

Figure 2. Understanding Risk



Source: Oregon Partnership for Disaster Resilience

What is a Risk Assessment?

A risk assessment consists of three phases: hazard identification, vulnerability assessment, and risk analysis, as illustrated in the graphic in Figure 2.

The first phase, **hazard identification**, involves the identification of the geographic extent of a hazard, its intensity, and its probability of occurrence. This level of assessment typically involves producing a map. The outputs from this phase can also be used for land use planning, management, and regulation; public awareness; defining areas for further study; and identifying properties or structures appropriate for acquisition or relocation.[16]

The second phase, **vulnerability assessment**, combines the information from the hazard identification with an inventory of the existing (or planned) property and population exposed to a hazard, and attempts to predict how different types of property and population groups will be affected by the hazard. This step can also assist in justifying changes to building codes or development regulations, property acquisition programs, policies concerning critical and public facilities, taxation strategies for mitigating risk, and informational programs for members of the public who are at risk.[17]

The third phase, **risk analysis**, involves estimating the damage, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (1) the magnitude of the harm that may result, defined through the vulnerability assessment, and (2) the likelihood or probability of the harm occurring.

The following risk assessment draws upon four sources: 1) the *2014 Northeast Oregon Natural Hazard Mitigation Plan (2014 NHMP)*, 2) a risk analysis exercise conducted with Baker County NHMP Steering Committee, 3) a geospatial analysis performed by the Department of Geology and Mining Industries (DOGAMI) using a risk assessment software program for analyzing potential losses from floods, hurricane winds and earthquakes called HAZUS®-MH. Hazards U.S. – Multi-Hazard (HAZUS®-MH) is a software program that joins current scientific and engineering knowledge with the latest geographic information systems (GIS) technology to produce estimates of hazard-related damage before, or after a disaster occurs. The assessment is contained in a report entitled *Natural Hazard Risk Report for Baker County, Oregon*. And 4) the results of FEMA's Discovery process summarized in a report entitled *Region X Discovery Report Baker County, Oregon.*

Hazard Identification

The hazards facing Baker County are summarized here to provide context to the following sections on vulnerability assessment and risk analysis, however additional detail regarding characteristics, location and extent of each hazard in Volume II, Hazard Annexes.

[16]Burby, R.1998.Cooperating with Nature. Washington, DC: Joseph Henry Press.

[17]Ibid.

Drought

Characteristics

Droughts are not uncommon in Oregon, particularly in eastern Oregon. Droughts tend to be an economic hazard, particularly damaging to the agricultural sector and may lead to increased wildfire risk. Agriculture makes up a particularly large portion of Baker County businesses and drought therefore affects the economic stability of the region. The environmental consequences also are far-reaching. They include insect infestations in forests and the lack of water to support endangered fish species. In recent years, the state has addressed drought emergencies through the Oregon Drought Readiness Council. This interagency council meets to discuss forecasts and to advise the Governor as the need arises.

The Oregon State University Extension Service published a report in June 1979 following the 1977 drought (EM-3039). Highlights of the survey findings indicate that the 1977 drought affected 80% of ranches in eastern Oregon, decreased forage, increased purchase of feed, reduced rate of gain of cattle, delayed breeding, herd health problems and increased water hauling and equipment investments.[18]

Connections between drought conditions and the susceptibility of landscapes to wildfires have been the subject of research across the United States and across the globe. The unusually hot and dry summer in parts of the northern hemisphere has turned fields and forests into fuel for fires which are raging from the Arctic to the Mediterranean and West Coast of North America[19].

Location/Extent

The extent of drought events depends upon the degree of moisture deficiency, the duration of the drought and size of the affected area. Typically, droughts occur as regional events and often affect more than one city and county.

The incidence of drought in Oregon is between eight and twelve years.[20] Baker County is susceptible to droughts because of its location east of the Cascades and within the high desert. The region experiences dry conditions annually during the summer months from June to September.

Drought Events 2014-2019

US Drought Monitor records data that contribute to drought. For the period between January 2014 and December 2019, US Drought Monitor data represented in Figure 3 shows that 40% of Baker County was

[18] Oregon State University Extension Services. "Effects of the 1977 Drought on Eastern Oregon Ranches. "June 1979. http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/4743/SR%20no.%20555_ocr.pdf?sequence=1 . Northeast Oregon's cow herd production alone decreased more than 37%.

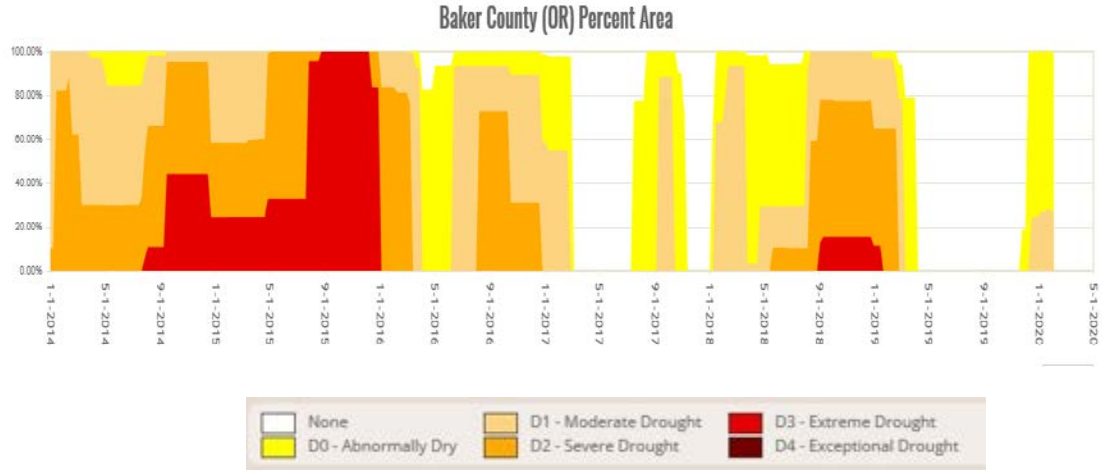
[19] World Meteorological Organization. "Drought and heat exacerbate wildfires", July 2018, https://public.wmo.int/en/media/news/drought-and-heat-exacerbate-wildfires

[20] Oregon Natural Hazards Mitigation Plan (2012) Region 7: Regional Profile

experiencing severe drought in late summer of 2014 and that all of Baker County experienced extreme drought from July 14, 2015 through December 29, 2015[21]. The Oregon Governor issued three Executive Orders at the request of the county and based on recommendations by the Drought Readiness Council and the Water Supply Availability Committee in 2014, 2015 and 2018 (EO 14-12 issued September 3, 2014; EO 15-04 issued April 20, 2015 and EO 18-09 issued June 14, 2018). These Executive Orders declared that dry conditions presented hardships for Baker County, that crops and agricultural investments were at risk, that animals and plants that rely on Oregon's surface water supplies were threatened and that the risk of wildfires is greatly increased.

Later in the summer of 2015 wildfires caused extensive damage and risk to people and property in Baker County. Three additional Executive Orders related to these wildfires were issued by the Governor during 2015.

Figure 3. Periods of drought in Baker County from January 2014 through December 2019



– Source: Drought Atlas https://droughtatlas.unl.edu/Data/Climate.aspx consulted February 2020

Full details of the hazard posed by drought can be found in Volume II, Drought Annex.

Winter Storm

Characteristics

Severe winter storms can consist of rain, freezing rain, ice, snow, cold temperatures, and wind. They originate from troughs of low pressure offshore that ride along the jet stream during fall, winter, and

[21] US Drought Monitor https://droughtatlas.unl.edu/Data/Climate.aspx The United States Drought Monitor (USDM) map is a composite index that has been released on a weekly basis since 1999.

early spring months. Severe winter storms affecting Baker County typically originate in the Gulf of Alaska or in the central Pacific Ocean. These storms are most common from October through March.[22]

Winter storm events are relatively common in eastern Oregon, where the air is generally cold enough for snow and ice, when a Pacific storm is associated with an air mass from the Gulf of Alaska, a major snowstorm may ensue.

Like snow, ice storms are comprised of cold temperatures and moisture, but subtle changes can result in varying types of ice formation, including freezing rain, sleet, and hail. Freezing rain can be the most damaging of ice formations. While sleet and hail can create hazards for motorists when it accumulates, freezing rain can cause the most dangerous conditions within a community. Ice buildup can bring down trees, communication towers, and wires creating hazards for property owners, motorists, and pedestrians alike.

Location/Extent

All of Baker County is vulnerable to winter storms and impacts typically extend region-wide. The magnitude or severity of severe winter storms is determined by a number of meteorological factors including the amount and extent of snow or ice, air temperature, wind speed, and event duration.

Winter Storm Events 2014-2019

Fifteen days with Heavy Snow or Ice Storm events in Baker County were logged by the National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information storm event database for the period between January 1, 2014 and December 31, 2019[23]. One of these storm events resulted in the Oregon Governor declaring a State of Emergency.

The latter half of December 2016 (December 8-27) was characterized by a series of storms and low pressure troughs moving through the eastern mountains dumping up to 12 inches of snow at a time on Baker County. Damage caused included collapsed roofs on over 100 structures in Baker City-most notable a portion of the historic Geiser Grand Hotel downtown.[24] Among the damage caused by the snow load was damage to the roof of Baker County Library in Baker City. [25]

Executive Order 19-04 declared the winter storms that began March 24, 2019 resulted in "critical transportation failures, loss of power and communications capabilities, and sheltering needs. This storm system damaged state highways with scour, washouts, sinkholes, serious debris flows and mudslides."[26]

NOAA's storm event database reports that a winter storm moved into the Intermountain West on January 29, 2014 spreading freezing rain, with up to a 0.5" of ice accumulation and high mountain snow across parts of Eastern Oregon. The Baker County Sheriff's office reported a quarter to a half an inch of

[22]Interagency Hazard Mitigation Team.2012- Oregon Natural Hazards Mitigation Plan. Salem, OR: Oregon Military Department – Office of Emergency Management

[23] NOAA Storm Event Database, consulted January 2020.

[24] Personal communication, Michelle Owen, June 2020

[25] Personal communication, Ed Adamson, May 2020

[26] Executive Order No. 17-06, Office of the Governor, State of Oregon, April 13, 2017

ice was covering most of the county. Numerous accidents were reported and Interstate 84 was closed between Baker and Huntington.[27]

Full details of the hazard posed by winter storms can be found in Volume II, Severe Weather Annex.

Wildfire

Characteristics

Wildfires are a natural part of the ecosystem in Oregon; however, wildfires can present a substantial hazard to life and property when communities grow, because development often occurs in the wildland-urban interface (WUI). The most common wildfire hazard factors include: hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, its behavior is influenced by numerous conditions, including fuel, topography, weather, drought, and development[28]. The negative impact of smoke on air quality is a secondary impact of wildfire. Post-wildfire geologic hazards can also present risk. These usually include flood, debris flows, and landslides.

Location/Extent

According to both the DOGAMI *Risk Report* and the local vulnerability assessment, there is potential for loss due to WUI fires in Baker County. Fire prone areas cover a large portion of the county and are present in developed areas in the county. There are also primary areas of exposure to this hazard located in the forested unincorporated areas of the county that have not already experienced recent burns. Both of these areas are represented in Figure 4 contained in the DOGAMI *Natural Hazard Risk Report for Baker County, Oregon (*DOGAMI *Risk Report)* [29] .

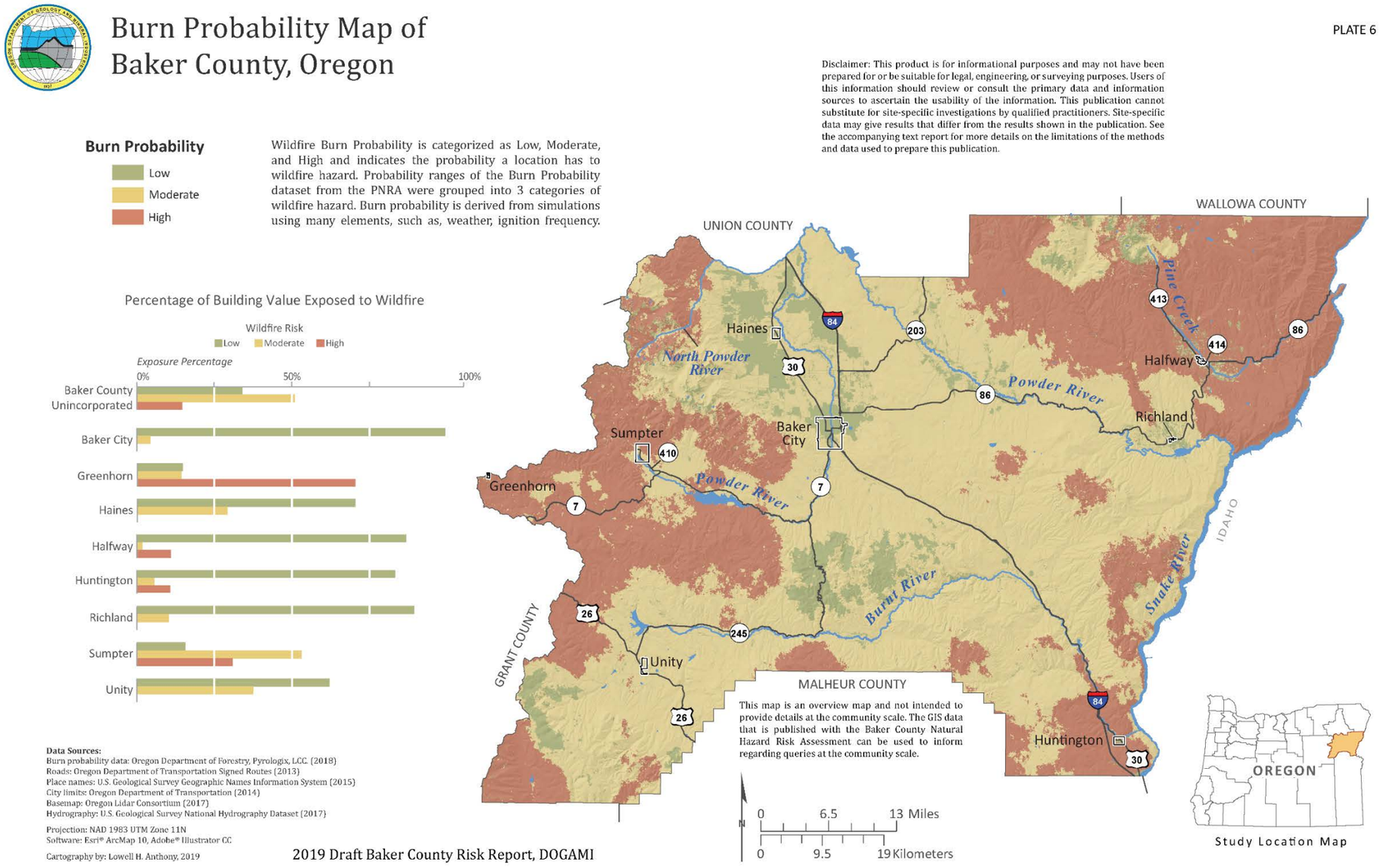
DOGAMI's analysis utilized the Burn Probability dataset contained in the US Forest Service's Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results developed for the States of Oregon and Washington to analyze the extent of wildfire hazard risk in Baker County. The Burn Probability dataset was categorized into low, moderate and high hazard zones for the county.

[27] NOAA Storm Event Database, consulted January 2020.

[28] Pyrologix LLC, 2018, Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results, final report, report to Oregon Department of Forestry and others, 86 p. http://oe.oregonexplorer.info/externalcontent/wildfire/reports/20170428_PNW_Quantitative_Wildfire_Risk_Assessment_Report.pdf

[29] Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report for Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries

Figure 4. Burn Probability Map of Baker County, Oregon



Source: Williams, M.C., Anthony, L.H. & O'Brien, F. (2019). *Natural Hazard Risk Report for Baker County, Oregon* (unpublished report to Oregon Department of Land Conservation and Development). Oregon Department of Geology and Mineral Industries.

Wildfire Events 2014-2019

The Oregon Department of Forestry's Fire List catalogues 71 fires that occurred in Baker County between 2014 and 2019. Of these, 58 fires were contained and burned one acre or less. Five large fires each burning over 12,000 acres occurred in 2015 alone comprising 78% (157,068 acres) of the 200,352 acres burned in this period.

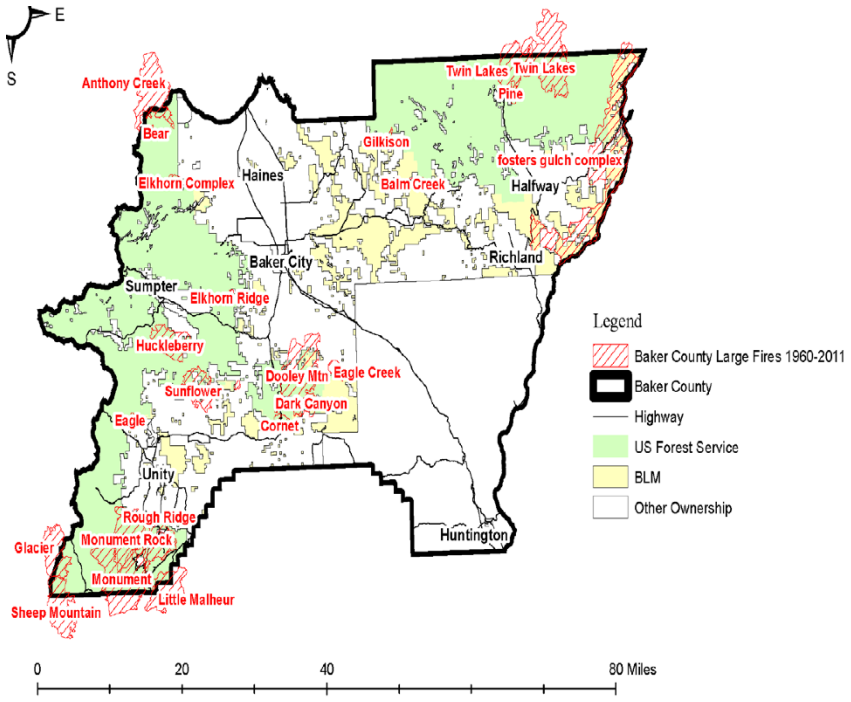
The 2015 fires in Baker County included the Cornet and Windy Ridge fires, a pair of lightning-sparked blazes that burned together and spread over 104,000 acres on public forest and private land beginning August 10th (Cornet fire) and 11th (Windy Ridge fire). This fire was the largest in the county's recorded history and resulted in evacuations, destruction of multiple structures and the closure of I-84 between Pendleton and Ontario for a period of time. Three other major wildfires burned in Baker County that year as well making it the worst fire year in history for Baker County. The Eagle Complex fire was a complex of three fires ignited by lighting on August 11, 2015 that burned 12,757 acres east of Medical Springs. The El Dorado fire was ignited by lightning on August 14, 2015 and burned 20,621 acres, 5,448 acres of which were on Oregon Department of Forestry land. Later in the summer, the Dry Gulch fire was ignited by a motor vehicle accident on September 12, 2015 and burned 17,823 acres northwest of Richland[30]. Governor Brown declared Emergency Orders (EO) invoking the Emergency Conflagration Act through EO 15-13 for the Cornet and Windy Ridge Fire, EO-20 declaring a state of emergency in Baker and Grant Counties and EO-21 invoking the Conflagration Act for the Dry Gulch Fire.

In 2016 the Rail Fire, the source of which is under investigation according to the ODF Fire List, burned 41,706 acres near Unity. The fire started July 31, 2016 and was pushed north and east by winds up to 35 mph. By August 4th, the fire was being fought by almost 500 firefighters with 11 bulldozers, 31 engines, 10 water tenders and four helicopters. By September 1, 2016 the fire had burned about 27,100 acres on the Wallowa-Whitman National Forest, and 13,700 acres on the Malheur National Forest.

In 2017 the Bear Butte fire burned 500 acres on US Forest Service land. This fire was started by a lightning strike and resulted in the evacuation of people staying at the Anthony Lake Mountain Resort and the Anthony Lake campground. The fire was extinguished before there was any loss of life or property.

[30] Oregon Department of Forestry, Fires List https://apps.odf.oregon.gov/DIVISIONS/protection/fire_protection/fires/FIRESlist.asp consulted February 2020

Figure 5. Baker County Large Fires 300 acres or larger 1960-2011



Source: Baker County Community Wildfire Protection Plan (2015)

Full details of the hazard posed by wildfire can be found in Volume II, Wildfire Annex.

Windstorm

Characteristics

Extreme winds occur throughout Oregon, and most communities have some level of vulnerability to windstorms. Windstorms can trigger flying debris, which can also damage utility lines; overhead power lines can be damaged even in relatively minor windstorm events. Industry and commerce can suffer losses from interruptions in electric service and from extended road closures. Windstorms can result in collapsed or damaged buildings, damaged or blocked roads and bridges, damaged traffic signals, streetlights, and parks, among other impacts. Roads blocked by fallen trees during a windstorm may have severe consequences to people who need access to emergency services. Emergency response operations can be complicated when roads are blocked or when power supplies are interrupted.

Although rare, tornados can and do occur in Oregon, with recorded events happening in all four counties. A tornado touched down in Baker County on June 23, 2004.[31] Tornadoes are the most concentrated and violent storms produced by the earth's atmosphere. They are created by a vortex of rotating winds and strong vertical motion, which possess remarkable strength and cause

[31]NOAA Storm Event Database, https://www.ncdc.noaa.gov/stormevents/ accessed June 2020

widespread damage. Smaller wind events, often known as, “dust devils”, are fairly common in Northeast Oregon and pose some risk to the local community.

Windstorms or gusting wind can exacerbate the risk of wildfire spread. This was a factor in the conflagration of the Cornet/Windy Ridge fire in August, 2015.

Location/Extent

The damaging effects of windstorms may extend for distances of 100 to 300 miles from the center of storm activity. Windstorms in Baker County usually occur from October to March. The extent of windstorms is determined by their track, intensity (the air pressure gradient they generate), and local terrain. More intense windstorms generally occur within the valley corridors.[32]

Oregon and other western states experience tornadoes on occasion, many of which have produced significant damage and occasionally injury or death. Most of the tornadoes that develop in Oregon are caused by intense local thunderstorms. These storms also produce lightning, hail, and heavy rain, and are more common during the warm season from April to October.[33]

Windstorm Events 2014-2019

The NOAA Storm Event Database recorded a high wind event in Baker County during the planning period. On April 7, 2018 a trough of low pressure moved through the Inter-mountain West kicking off strong to severe thunderstorms and causing damage around Baker County. Severe thunderstorms raced through the Baker City area downing large trees and power lines. Winds gusted to 65.6 mph (57 knots) at Baker Municipal Airport.

Full details of the hazard posed by windstorms can be found in Volume II, Severe Weather Annex.

Flood

Characteristics

Typically the principal types of flood that occur in Baker County include snow melt (spring) floods resulting from rapid snowmelt, occasionally augmented by rainfall, riverine, and local flash floods. In the period since the *2014 NHMP*, heavy rainfall on areas that have recently experience wildfire have produced debris flows and flood after fire type events. Further details on the characteristics of these types of flooding can be found in Volume II, Flood Annex.

Location/Extent

The location and extent of flooding hazard are represented by the Flood Insurance Rate Maps issued by FEMA, in conjunction with their Flood Insurance Studies (FIS). Flood records are often not well documented, particularly in unincorporated areas because their floodplains are sparsely

[32]Natural Hazards Mitigation Plan Risk Assessment Meetings

[33] Taylor, George H., Holly Bohman, and Luke Foster. August 1996. A History of Tornadoes in Oregon. Oregon Climate Service. Corvallis, OR: Oregon State University.

developed[34]. Only a portion of the watercourses in Baker County are covered by regulatory floodplains as shown by the FIRMs. Selection of areas to map for flood risk and flood insurance requirements are made based on the number of structures and people at risk, therefore, the areas shown on the FIRMs (and in Figure 6 below) represent areas currently mapped by FEMA of flood risk where people or property may be at risk for damage.

Baker County's FIRMs date from 1988. Since then additional development has occurred. Baker County is considering working with FEMA to update these maps to provide greater accuracy in determining the location and extent of flooding.

Flooding Events 2014-2019

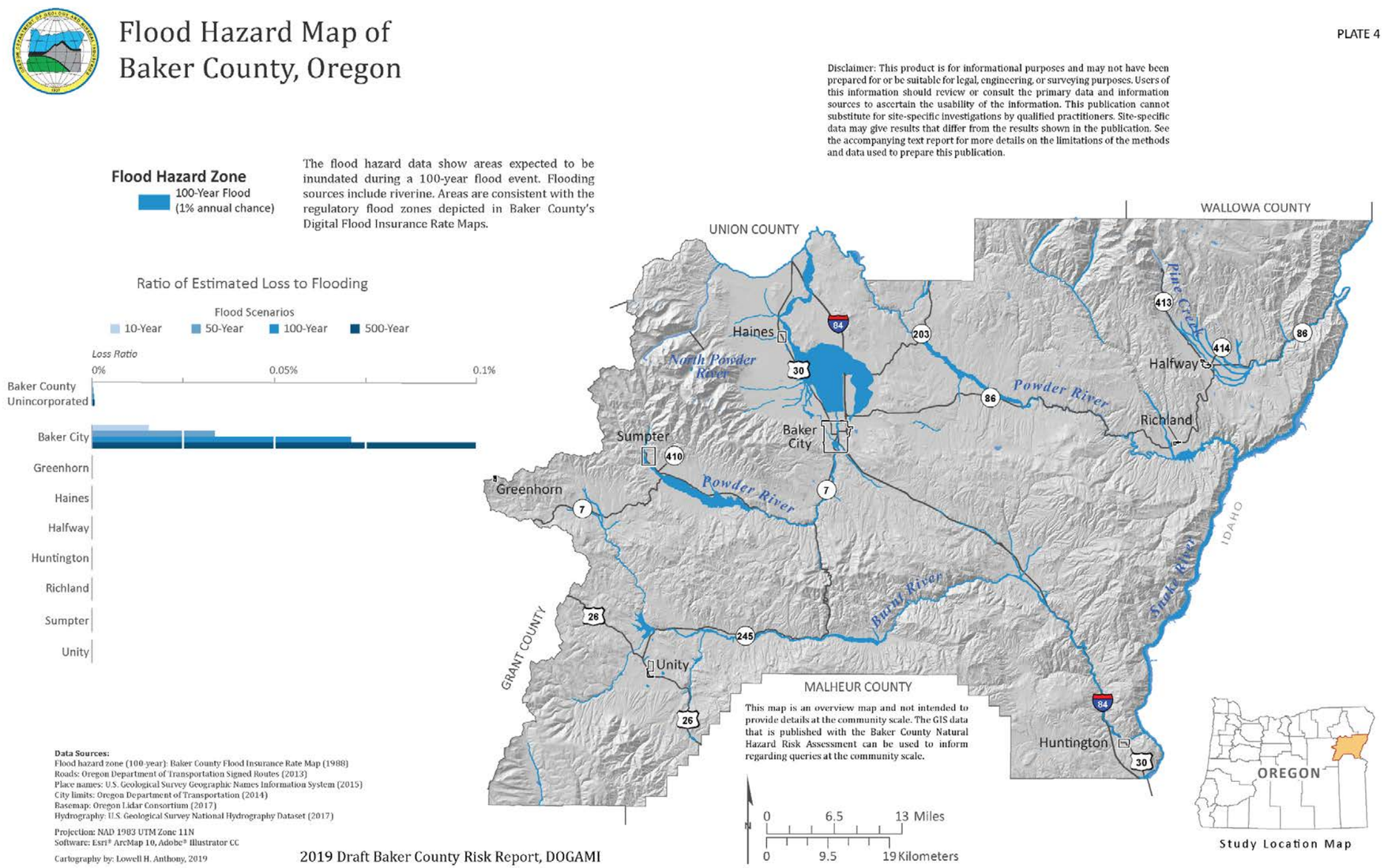
In the six years since the completion of the *2014 NHMP* that included Baker County, the county has experienced flooding in three of those years. Flood after fire events dominated the recent events catalogued by the NOAA Storm Event database. In May 2016 a strong thunderstorm dumped up to a quarter of an inch of rain over a 15 minute period over terrain scorched by wildfire in August of 2015 causing flash flooding and debris flows. In September 2017 thunderstorms producing heavy rain over the 2016 Rail Fire burned area on the Wallowa-Whitman National Forest resulted in flash flooding and debris flows. In June 2018 thunderstorms with heavy rainfall developed over Southwest Baker County, Oregon on June 20th, leading to flash flooding and debris flow on the Rail and Cornet-Windy Ridge fires burn scar areas.[35]

Full details of the hazard posed by flooding can be found in Volume II, Flood Annex.

[34] Baker County Flood Insurance Rate Study, NFIP, 5/18/1982

[35] National Climate Data Center Storm Events Database http://www.ncdc.noaa.gov/stormevents

Figure 6. Flood Hazard Map of Baker County, Oregon



Source: Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report for Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries

Earthquake

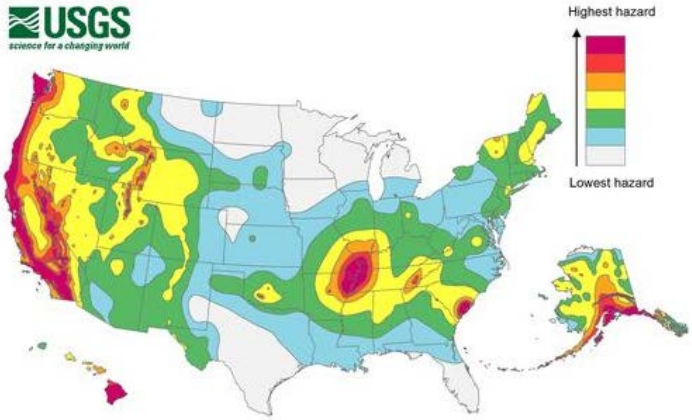
Characteristics

An earthquake is a sudden movement of material on each side of a fault in the earth's crust that abruptly releases strain accumulated over a long period of time. The movement along the fault produces waves of strong shaking that spread in all directions. Oregon is underlain by a large and complex system of faults that can produce damaging earthquakes. Although smaller faults produce smaller earthquakes, they are often close to populated areas, and damage can be extensive to nearby buildings[36].

Two potential earthquake-induced hazards are liquefaction and landslides. Liquefaction occurs when loose, saturated soils substantially lose bearing capacity due to ground shaking, causing the soil to behave like a liquid; this action can be a source of tremendous damage. If an earthquake causes strong shaking in populated areas, it may result in causalities, economic disruption, and extensive property damage.

DOGAMI used a national map of seismic hazard created by the USGS within the HAZUS®-MH earthquake model[37]. The relative hazard for earthquake in northeastern Oregon is low as is shown by the USGS map of seismic hazard in Figure 7. The active faults in Baker County and vicinity are shown in Figure 8.

Figure 7. USGS National Seismic Hazard Map

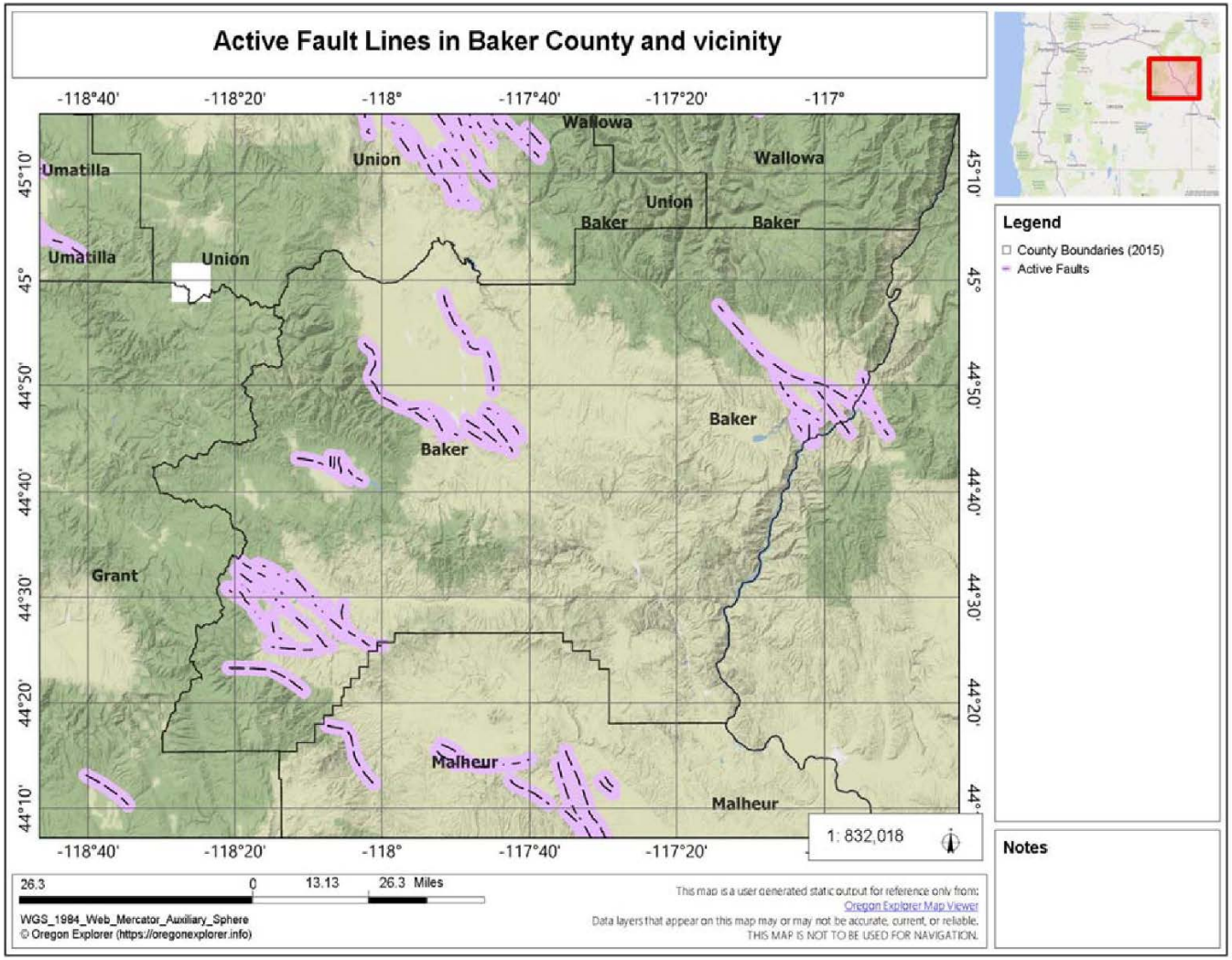


Source: USGS https://www.usgs.gov/media/images/2018-long-term-national-seismic-hazard-map

[36] Madin, I. P., and Burns, W. J., 2013, Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia subduction zone earthquakes: Oregon Department of Geology and Mineral Industries Open-File Report O-13-06, 36 p. 38 pl., GIS data. https://www.oregongeology.org/pubs/ofr/p-O-13-06.htm

[37] Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p., https://dx.doi.org/10.3133/ofr20141091

Figure 8. Active Faults in Baker County



Source: Oregon Explorer Planner's Map View application

Location/Extent

DOGAMI reports that because an earthquake can affect a wide area, it is unlike other hazards in this report — every building in Baker County, to some degree, would be affected by it[38]. The report estimates impacts from an earthquake using a scenario with a 2% probability of occurrence in a 50 year period and a magnitude set at 6.7 to develop the loss estimate. The scenario run in HAZUS®-MH was based on formulas that estimate damage in five damage states (none, low, moderate, extensive, and complete). These damage states are correlated to loss ratio that are then multiplied by the building dollar value to obtain a loss estimate.

The results indicate that Baker County would incur a moderate amount of damage (6.6%) from an earthquake similar to the one simulated in this report. These results were moderately influenced by earthquake-induced liquefaction; however, the overall age of the building stock was the primary factor. This shows us that the age of the building stock is one metric of earthquake vulnerability for a community. This analysis is represented in Figure 9 showing where earthquake shaking from a magnitude 6.7 event might occur in Baker County.

The *Natural Hazard Risk Report for Baker County, Oregon* prepared by DOGAMI identified locations within Baker County that are comparatively more vulnerable or at greater risk to the 2500-year probabilistic M6.7 earthquake hazard:

- Very high liquefaction soils are found throughout most of the populated portions of Baker County, which include the communities of Baker City, Haines, Halfway, and Huntington.
- Building inventory for the many communities in the county are comprised of older buildings, which implies lower seismic building design codes. Buildings built with older building code standards are more vulnerable to damage from earthquakes.
- Many (42%) of the critical facilities in the incorporated communities of Baker County could be non-functioning due to an earthquake similar to the scenario used in this report.

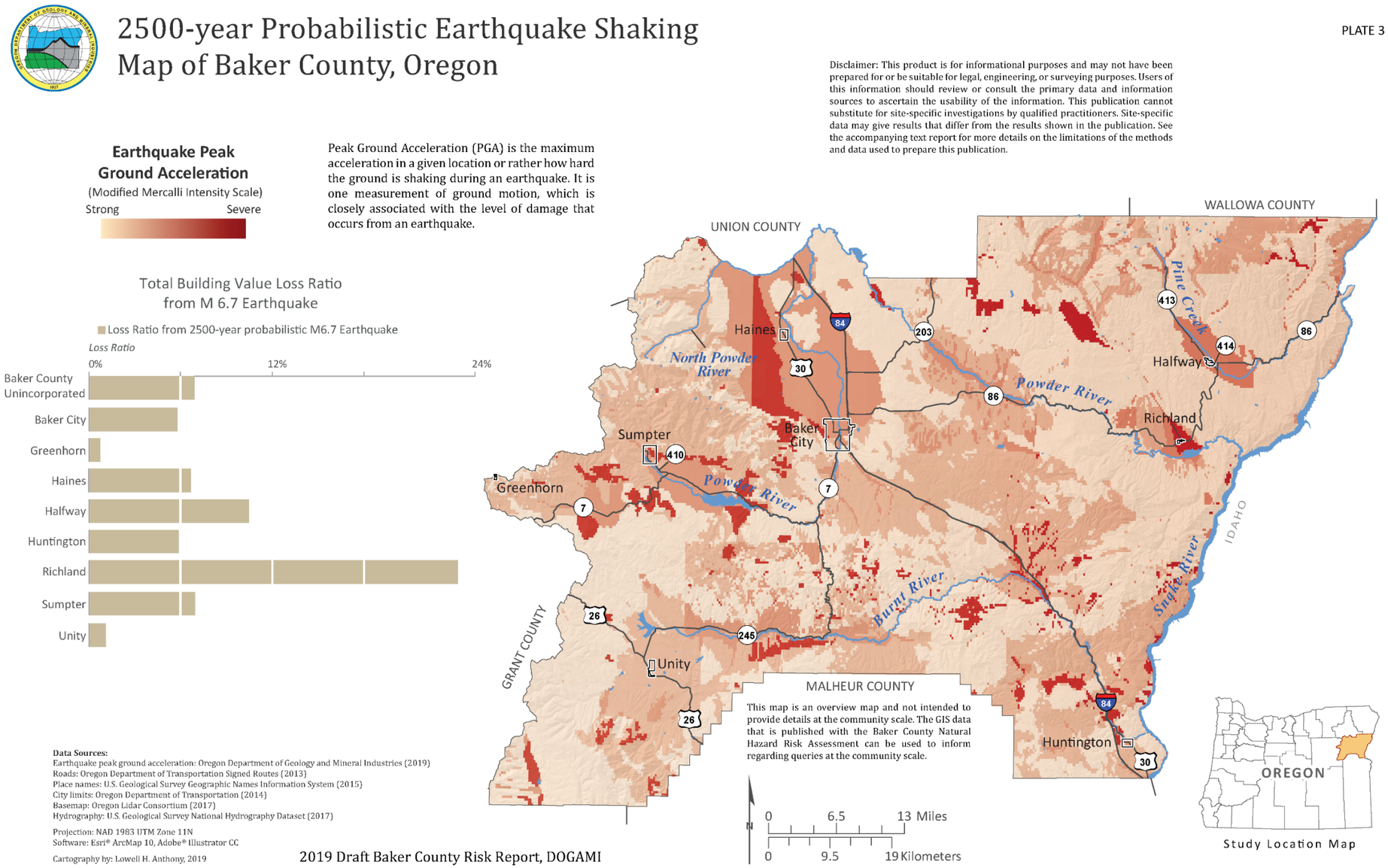
Seismic Events 2014-2019

Baker County has not experienced damaging earthquakes in the past 40 years.

Full details of the hazard posed by earthquakes can be found in Volume II, Earthquake Annex.

[38] Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report For Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries

Figure 9. Locations of impact by M 6.7 Earthquake



Source: Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report For Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries

Landslide

Characteristics

Landslides are downhill movements of rock, debris, or soil. There are many different types of landslides in Oregon. In Baker County, the most common are debris flow, shallow-, and deep-seated landslides. Landslides can occur in many sizes, at different depths, and with varying rates of movement. Generally, they are two types of landslides;large, deep, and slow moving or small, shallow, and rapid. Some factors that influence landslide type are hillside slope, water content, and geology. Many triggers can cause a landslide: intense rainfall, earthquakes, or human-induced factors like excavation along a landslide toe or loading at the top. Landslides can cause severe damage to buildings and infrastructure. Fast-moving landslides may pose life safety risks and can occur throughout Oregon[39].

Location/Extent

Staff from Oregon's Department of Geology and Mineral Industries (DOGAMI) have developed a database of landslide information for use in understanding the risk of landslides across the state of Oregon. The Statewide Landslide Information Layer for Oregon [SLIDO], release 4.0[40] is an inventory of mapped landslides in the state of Oregon. SLIDO is a compilation of past studies; some studies were completed very recently using new technologies, like lidar[41]-derived topography, and some studies were performed more than 50 years ago. Consequently, SLIDO data vary greatly in scale, scope, and focus and thus in accuracy and resolution across the state. Landslide inventory mapping for Baker County was done before lidar was available for high-accuracy mapping. Lidar data are now available and expanded lidar coverage for the county is part of FEMAs Risk MAP scoping process soon that is scheduled to being in Baker County in 2020.

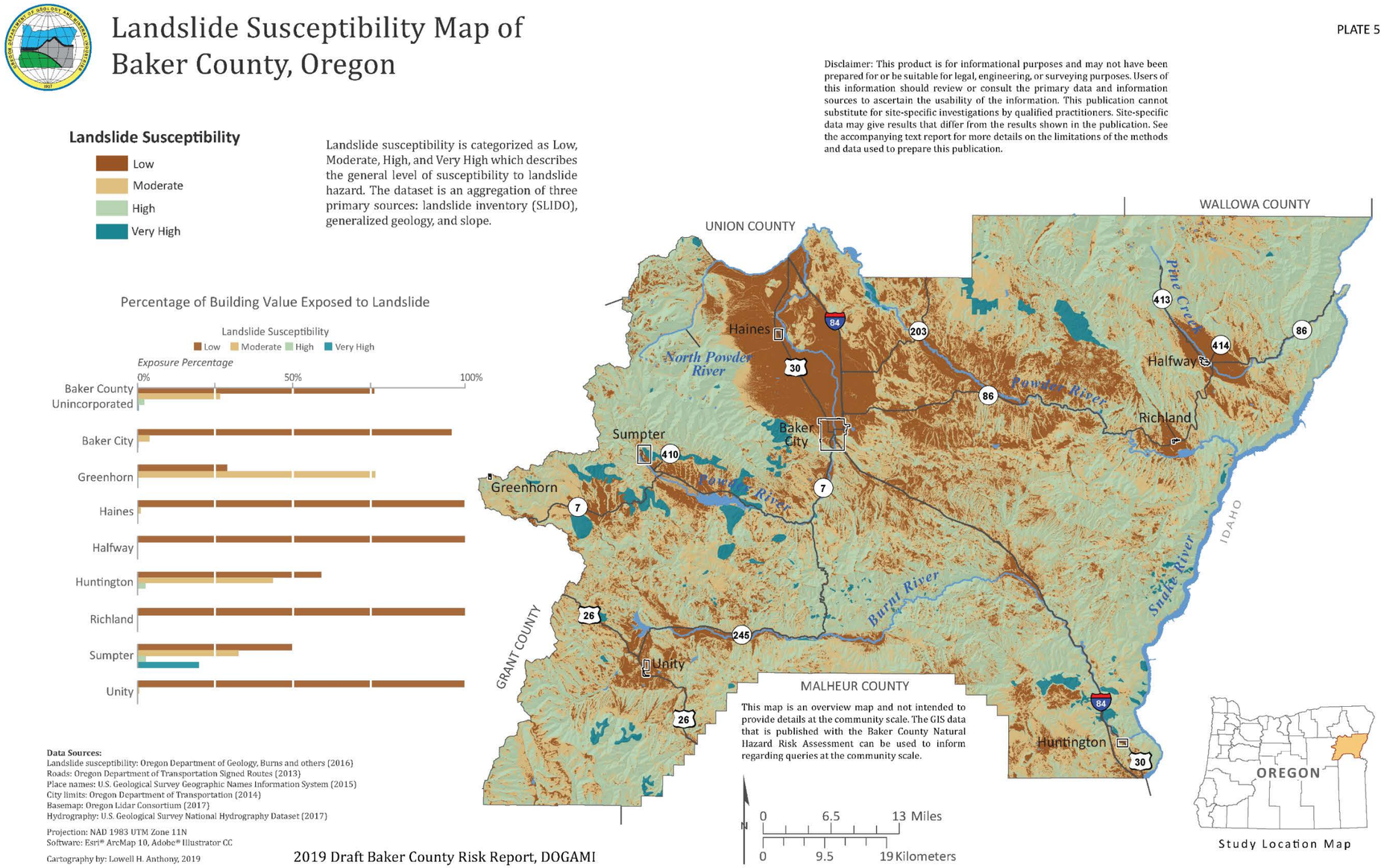
Baker County's communities have very little exposure to landslide risk as illustrated in Figure 10 below. High and very high landslide susceptibility is most prominent in the forested areas in the Blue Mountains and in the northeastern portion of the county. While these areas are highly prone to landslides, a large percentage of the populated areas are not within these zones as they are currently mapped. The percentage of building value exposed to very high and high landslide susceptibility is approximately 2% for the entire study area, but the threat is elevated for buildings in these hazard zones.

[39] Burns, W. J., Mickelson, K. A., and Madin, I. P., 2016, Landslide susceptibility overview map of Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-16-02, 48 p. https://www.oregongeology.org/pubs/ofr/p-O-16-02.htm

[40] Burns, W. J., and Watzig, R. J., 2014, Statewide landslide information layer for Oregon, release 3 [SLIDO-3.0]: Oregon Department of Geology and Mineral Industries, 35 p., 1:750,000, geodatabase.

[41] Lidar, which stands for Light Detection and Ranging, is a remote sensing technology that functions by illuminating a target with a pulsed laser and measuring the round-trip time (Time of Flight) of reflected pulses with a sensor to determine its distance.

Figure 10. Landslide Susceptibility Map

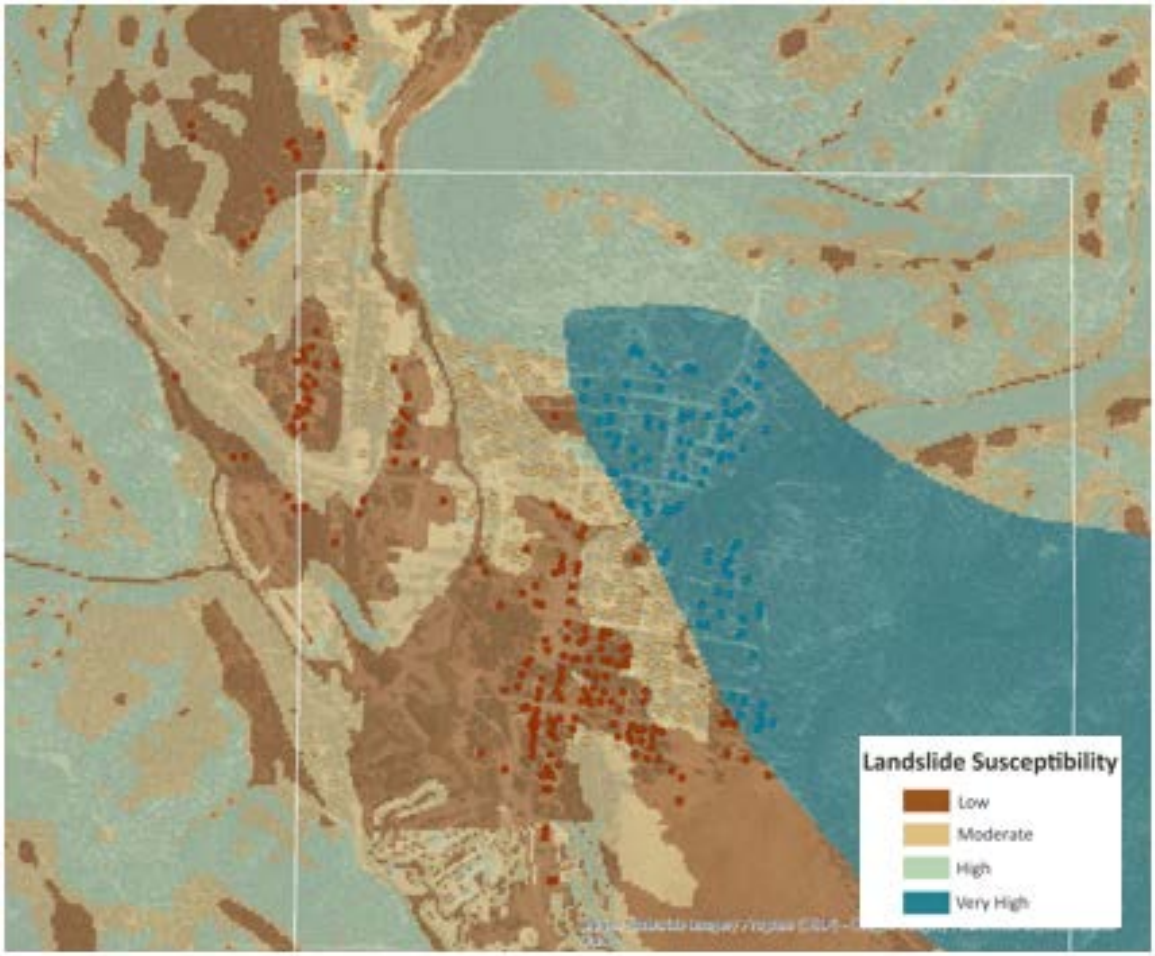


Source: Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report For Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries

The Baker County Natural Hazard Risk Report prepared by DOGAMI identified locations within Baker County that are comparatively more vulnerable or at greater risk to landslide hazard. For example, the landslide data suggests that a cluster of residential buildings in the northeastern portion of Sumpter are exposed to very high landslide hazard. (Figure 11). The City of Sumpter was the only community with significant exposure to the currently mapped landslide hazard at 20%, but this exposure could be indicative of inaccurate mapping. Some communities in Baker County may be at higher or lower risk than what the data show.

Awareness of nearby areas of landslide hazard is beneficial to reducing risk for every community and rural area of Baker County. Lidar based landslide mapping would provide a more accurate picture of the landslide hazard within Baker County.[42] Analysis of the risk of landslide along roadways such as the eastern portion of State Highway 7 and the southern portion of Interstate 84 where mapping currently shows these areas as high risk.

Figure 11. Landslide susceptibility areas and building exposure example in the City of Sumpter



[42] Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report For Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries, p. 28

Landslide Events 2014-2019

Recent heavy rain events have caused debris flows from the Wallowa-Whitman National Forest, the Rail and Cornet-Windy Ridge fire burn scar areas.

A landslide is a mass movement occurring on steep slopes under the action of gravity. Debris flow is a distinct type of mass movement commonly triggered by intense rainfall and/or melting snow on steep hill slopes. It differs from landslide in its "flowing" feature. Flow means relative movement in numerous layers of the medium, whereas a slide occurs only along one or several interfaces or beds.[43]

Full details of the hazard posed by landslides can be found in Volume II, Landslide Annex.

Volcanic Event

Characteristics

Northeast Oregon (and the greater Pacific Northwest) lays within the "ring of fire", an area of very active volcanic activity surrounding the Pacific Basin. Volcanic eruptions occur regularly along the ring of fire, in part because of the movement of the Earth's tectonic plates. Volcanic eruptions have the potential to coincide with numerous other hazards including ash fall, earthquakes, lava flows, pyroclastic flows, lahars and debris flows, and landslides. Ash fall is likely the only hazard that could have the potential to impact Baker County directly.

Location/Extent

Direct risk from local volcano-associated hazards is not a consideration for Baker County because the volcanic Cascade Mountain Range is not close enough to the county to cause damage. Mt. St. Helens, Mt. Jefferson and the volcanoes of the Cascade Range near Bend are each more than 200 miles from Baker City, consequently placing that community at low risk. These volcanic mountains are a possible, but unlikely source of ash fall or airborne tephra (rock fragments and particles ejected by a volcanic eruption). The effects of airborne tephra or ash fall may including disruption of engines of motor vehicles and health impacts to vulnerable populations, such as people with asthma.

Volcanic Events 2014-2019

None.

Full details of the hazard posed by volcanic events can be found in Volume II, Volcanic Events Annex.

[43] Wang ZY., Lee J.H.W., Melching C.S. (2015) Debris Flows and Landslides. In: River Dynamics and Integrated River Management. Springer, Berlin, Heidelberg

Vulnerability Assessment

Vulnerability assessment is the second phase of this Risk Assessment. Vulnerability assessment endeavors to identify important community assets and system vulnerabilities. Vulnerabilities include both physical assets such as businesses, homes, roads and critical infrastructure like drinking water sources, and public service and health service establishments as well as community assets including people, historic places, and environmental assets.

The Steering Committee engaged in an exercise to identify the relative vulnerability of Baker County to the hazards identified in phase one of the Risk Assessment and to describe the aspects of the community that are most at risk. A description of this exercise and its results are contained in the Risk Analysis, Local Risk Assessment section. In addition, DOGAMI's *Risk Report* analyzed the exposure of people and property to four of the eight identified hazards by overlaying high hazard areas with existing structures. This data is included in the Risk Analysis section entitled DOGAMI Risk Report.

Hazard Vulnerability Assessment

The Baker County Steering Committee identified eight natural hazards that could have an impact on the people and property in the county. These hazards include wildfire, winter storms, floods, droughts, volcanic events, wind storms, landslide, and earthquakes. Each is discussed briefly above and in detail within the Hazard Annexes (Volume II).

Local assessment of relative hazard vulnerability was accomplished using a methodology developed by the Federal Emergency Management Agency (FEMA) in 1983. It was subsequently refined by the Oregon Office of Emergency Management (OEM) and shared with local jurisdictions across Oregon. It is called the "Local Risk Assessment Methodology" or "OEM Methodology" in this Plan. Although nearly every jurisdiction in Oregon uses this process, the range of values is relatively subjective and it is not meant to compare one jurisdiction to another.

In this local risk assessment methodology, four aspects characterizing risk – history, vulnerability, maximum threat, and probability – are assessed by a group or an individual by assigning a ranking as to severity.

History is the record of previous occurrences where a rankings represent the following:

Low:	0-1 event in the past 10 years
Medium:	2-3 events in the past 10 years
High:	4+ events in the past 10 years

Vulnerability is an assessment of the percentage of the population and property likely to be affected during an occurrence of an incident where a ranking represents the following:

Low:	<1% affected
Medium:	1 – 10% affected
High:	>10% affected

Maximum Threat is an assessment of the highest percentage of the population or property which could be impacted under a worst-case scenario.

Low:	<5% affected
Medium:	5 – 25% affected
High:	>25% affected

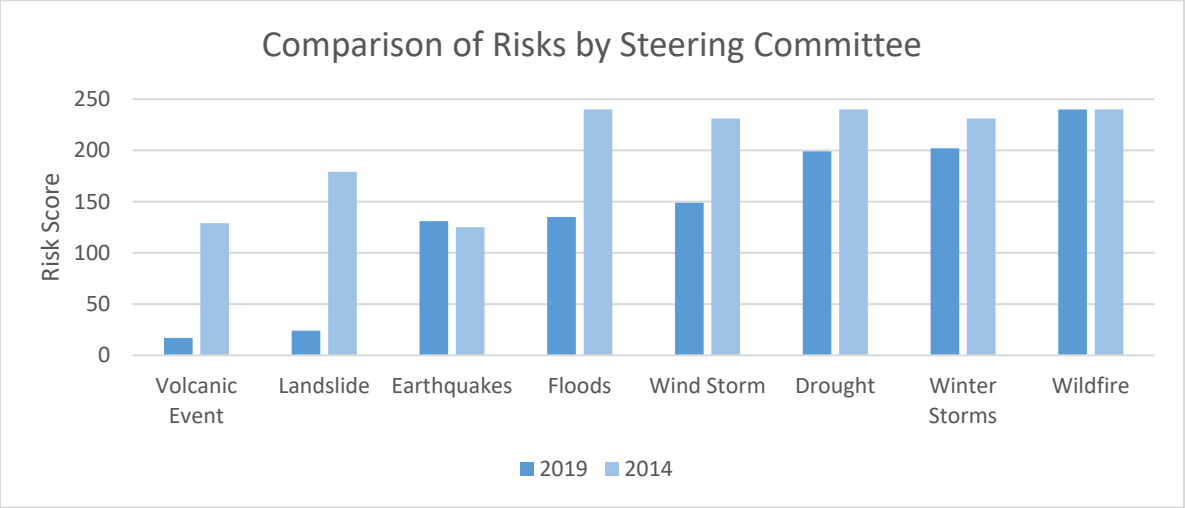
Probability is a measure of the likelihood of a future event occurring within a specified period of time.

Low:	more than 10 years between events
Medium:	from 5 to 10 years between events
High:	likely within the next 5 years

Each of these aspects are assigned a weight. History is weighted by a factor of 2; vulnerability is weighted by a factor of 5; maximum threat is weighted by a factor of 10 and probability is weighted by a factor of 7. The rankings are multiplied by their assigned weighting factors and then combined resulting in a Risk Score for each hazard. This methodology produces Risk Scores that range from a low score of 24 to a maximum score of 240. Conducting this analysis is a useful early step in planning for hazard mitigation, response, and recovery. The OEM Methodology does not predict the occurrence of a particular hazard, but it does "quantify" the relative risk of one hazard compared with another.

A group exercise was conducted at the July 16, 2019 Steering Committee meeting to rank these hazards using the OEM methodology. Figure 12 displays the ranking of each of these hazards according to the group present at that meeting as compared with the ranking reported in the *2014 NHMP*. This group was quite small and many participants focused on natural hazards in their particular jurisdiction or part of the county. Drought, winter storms, wind storms and floods previously ranked significantly higher than as ranked in 2019.

Figure 12. Comparison of OEM methodology risk assessment scores 2014 and 2019



Source: *2014 Northeast Regional Multi-Jurisdictional NHMP* and 2019 Baker County Steering Committee

Most of the Steering Committee members participated in a discussion about the assets of the community that are valued the most and those that are most vulnerable to the impacts of natural hazards during Steering Committee meeting held on September 10, 2019 and during the course of the Risk MAP Discovery meetings conducted by FEMA Region X on Thursday, September 12, 2019. Discussion about vulnerabilities in Baker County highlighted vulnerabilities of groups of people, economic drivers of Baker County vulnerable to natural hazards, features of the built environment and the natural environment that are vulnerable to the impacts of natural hazards.

The Steering Committee (SC) recognized that the elderly are particularly vulnerable to natural hazards because they often rely on others for care and protection. One Steering Committee member stated that "the most vulnerable in our community are the elderly because they are not in tune with much of the communication (computer, online, texting etc) related to natural hazards. Relying on local evening news doesn't work here." The elderly are a growing demographic in Baker County and residents expressed a concern for the "lesser ability [of the elderly] to recover from disasters." Vulnerability may also vary with the type of natural hazard. People who suffer from asthma or other lung condition may not be particularly affected by flooding, however, smoke from wildfire could put these people in a vulnerable position. Others noted that the poor are people who are particularly vulnerable to the impacts of natural hazards. Participants noted that families of lower socioeconomic means are less resilient and less able to recover from disasters. Specific areas of Baker County (south Baker City, the city of Halfway and the City of Huntington) were noted as areas where the residence are particularly vulnerable.[44]

Participants in the Discovery process conducted by FEMA Region X note that many residents of Baker County may be vulnerable to some extent due to the remote location of some cities and

[44] FEMA Region X Discovery Report Baker County, Oregon

limited access to them. Concern about accessibility of the more remote communities included impact to roadways from winter storms, from landslides and from flooding.[45]

SC members highlighted the importance of the land to the economy of Baker County. One Steering Committee member noted that "farm ground, timber ground, grazing ground, all are vulnerable to naturally occurring events. These are also the main drivers of our local economy." The impact on natural resources due to a natural hazard event will also affect the tourism industry in Baker County. The SC noted that fuel for vehicles and businesses that sell fuel are important during a natural hazard event for moving people and materials to safety[46].

Features of the built environment that are the most valued in the community include infrastructure such as dams and electricity transmission lines. In particular the Thief Valley Dam and the Unity Dam are valuable infrastructure. One SC member listed the Mason Dam, Hells Canyon Dam and other reservoirs, the (Baker) City water system, and irrigation infrastructure as features of the built environment that are particularly susceptible to natural hazards. Another SC member, the Public Works Director for Baker City, noted that the wastewater treatment plant just outside of Baker City and the Baker City airport are susceptible to wildland fire damage because water sources to combat wildfire are not readily available at the airport or wastewater treatment plant. The water transmission line borders the Inventoried Roadless Area of the USFS and is difficult, at best, to access with fire suppression equipment.

Community Vulnerability Assessment

Community vulnerabilities are an important aspect of the NHMP risk assessment. For more in-depth information regarding specific community vulnerabilities, reference Appendix A: Community Profile.

Populations

The demographic qualities of a community's population such as age, income, and household composition are factors that can influence a community's ability to cope, adapt to and recover from natural disasters. People with special needs, particularly children, the elderly, disabled people, and low-income families bear a disproportionate burden when a natural hazard occurs. Communities can develop strategies to improve the safety of these population groups in the face of natural hazards.

Vulnerabilities

- Members of the Steering Committee identified the elderly as one of the most vulnerable populations in Baker County. Based on the 2017 results of the US Census' American Fact Finder, the most recent available, 15,980 people lived in

[45] Ibid
[46] Ibid.

Baker County. Of this population 5.1% or 808 people are children under five years old and 2.6% or 413 people are adults 85 years or older. The old-age dependence ratio, a comparison of the oldest (65 and over) members of the county as compared to the population younger than 65, shows that the population of Baker County is older than Oregon as a whole[47]. (See Table 1)

- The American Fact Finder data for 2017 indicates that there were a total of 7,033 households in Baker County. Of these, 2,313 were 1-person households. Of these 1-person households, 50.8% or 1,175 households are people over 65 years old living alone[48].

- Participants in the Risk MAP Discovery process identified people living in poverty as a vulnerable population. Of all families in Baker County, 11.0% are families whose income in the preceding 12 months was below the poverty level. For a subset of those, families headed by a female householder with children under 5 years old, 49.5% of those families were living in poverty. These statistics are somewhat higher than families living in poverty in Oregon as a whole. Extensive research over the past 30 years has revealed that it is generally the poor who tend to suffer worst from disasters and impoverished people are more likely to live in hazard-exposed areas and less likely to invest in risk-reducing measures[49].

- The median household income in Baker County is $54,748; this is just over 2% lower than the State of Oregon median income of $56,119[50].

- Between 2010 and 2017, Baker County's population decreased by 154 people, representing a decrease of 0.9%.

In summary, Baker County has a number of vulnerable population groups to consider in developing mitigation strategies for natural hazards. The proportion of the population over 85 years old is greater in Baker County than in Oregon as a whole. Although the proportion of children in Baker County is lower than in Oregon as a whole, children, like the elderly, are often among the most vulnerable to the impacts of natural hazards. Baker County has a higher percentage of one-person households, and one-person households with people over the age of 65 than that found in Oregon as a whole. The county has a greater proportion of families living in poverty than in Oregon as a whole. These people are disproportionately affected by natural hazards because of their lack of access to financial resources. The median income in Baker County is less than that in Oregon as a whole reflecting the resource scarcity of county residents.

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[47] American Fact Finder, US Census Bureau, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml, consulted February 2020

[48] Ibid.

[49] Risk Driver: Poverty and inequality; Prevention Web; https://www.preventionweb.net/risk/poverty-inequality consulted January 2020

[50] American Fact Finder, US Census Bureau, 2017

Table 1. Selected demographics of Baker County compared to Oregon totals

	Baker County	Oregon
Age		
Population under 5 yrs. old	5.1% (808 children)	5.8%
Population over 85 yrs. old	2.6% (413 elderly)	2.1%
Old-age dependency ratio: Ratio of those over 65 to the rest of the population	44.8	26.1
Households		
One-person households	32.9% (2,313 households)	27.7%
One-person households over 65 yrs old	16.7% (1,175 households)	11.2%
Income		
Families living in poverty	11.0%	9.8%
Single parent families headed by women with children under 5	49.5%	48.8%
Median household income	$54,748	$56,119

Source: American Fact Finder, US Census Bureau, 2017 American Community Survey

Economy

Economic diversification, employment and industry are measures of economic capacity. However, economic resilience to natural disasters is far more complex than merely restoring employment or income in the local community. Building a resilient economy requires an understanding of how the component parts of employment sectors, workforce, resources and infrastructure are interconnected in the existing economic picture. The current and anticipated financial conditions of a community are strong determinants of community resilience, as a strong and diverse economic base increases the ability of individuals, families and the community to absorb disaster impacts for a quick recovery. The Economic Opportunities Analysis, June 2019, prepared by Johnson Economics for the Cities of Haines, Halfway, Richland, Sumpter and Unity in Baker County, Oregon provides information on current and anticipated future economic diversification with implications for employment and changes in industry profiles.

A significant proportion of Baker County's economy is based on natural resources. The employment base in Baker County has a higher share of self-employment, including farms and other self-proprietorships. Local employment is highly seasonal reflecting the county's relatively high proportion of agricultural employment. Employment tends to peak in August and September during peak harvest periods and falling to lowest levels by mid-winter. The forestry industry has been a significant economic driver in Baker County, however, the industry has seen a sharp decline in production largely attributable to declines in production from public lands since 1993. In recent years, private timber production has also decreased. These declines aside, the Eastern and Central Oregon region has been actively pursuing new and ongoing opportunities in the industry, including small diameter timber, biomass, and engineered wood products[51].

Agricultural production represents a significant component of the local economy, but agricultural crop production is less important in Baker County than in the broader region. The areas does have a significant concentration in animal stock, with 72,000 head of cattle and calves in the county, Alfalfa

[51] Johnson, J. and Buckley, B., Economic Opportunities Analysis, June 2019, p. 8-12

and other hay production was 187,700 tons in 2016, while wheat production was 922,000 bushels in 2015. [52] The significance of the agricultural economy to Baker County is a reason why drought is the top natural hazard faced by the people within it.

Another sector of the Baker County economy that is based on the county's natural resources is tourism comprised of amenity retail, recreation, and hospitality sectors. The area is centrally located with access to recreational opportunities such as Anthony Lakes, Wallowa Mountains, and Hells Canyon. The local recreational amenities are supplemented by a rich history that is shared by the many towns in Baker County[53]. The natural resource base of these industries are vulnerable to the impacts of natural hazards.

Vulnerabilities

- The establishments based on and employment in forestry and logging are 15 times more prevalent in Baker County than in the US as a whole. Animal production is more than eight times as prevalent in Baker County as they are on a national scale.[54] Natural hazards may impact the resources of these sectors to a greater extent than most other sectors.

- More than 40 percent of rural Oregon employment is concentrated in natural resources, leisure and hospitality (tourism), and government. Together those three sectors make up around 27 percent of the employment in urban Oregon[55].

- Rural areas of Oregon have higher unemployment rates and less diverse economies than metro areas. This leaves them more vulnerable to economic shocks and recessions[56].

- Baker County has a high share of land owned by the federal government. The Oregon Employment Division reports in 2017 that 51% of Baker County was owned by the federal government and the remainder was privately owned[57].

Environment

The capacity of the natural environment is essential in sustaining all forms of life including human life, yet it often plays an underrepresented role in community resiliency to natural hazards. The natural environment includes land, air, water and other natural resources that support and provide space to live, work and recreate.[58] Natural capital such as wetlands and forested hill slopes play significant roles in protecting communities and the environment from weather-related hazards, such as flooding and landslides. When natural systems are impacted or depleted by human activities those activities can adversely affect community resilience to natural hazard events. These same

[52] Ibid p. 12

[53] Ibid. P. 30

[54] Ibid., p. 22-23

[55] Oregon Employment Division, The Employment Landscape of Rural Oregon. May 2017, https://www.qualityinfo.org/documents/10182/13336/The+Employment+Landscape+of+Rural+Oregon?version=1.2

[56] Ibid.

[57] Ibid.

[58]Mayunga, J. 2007. Understanding and Applying the Concept of Community Disaster Resilience: A capital-based approach. Summer Academy for Social Vulnerability and Resilience Building.

natural systems are viewed by private landowners as economic resources, particularly in a natural resource dependent industry such as ranching or logging.

Vulnerabilities

- Baker City's public water system is vulnerable to effects of wildfire on the drinking water protection area. The Baker City public water system draws water from seven surface water intakes in the Elkhorn Mountains (Goodrich Creek, Elk Creek, Salmon Creek, Little Salmon Creek, Mill Creek, Little Mill Creek, and Little Marble Creek); a groundwater well; and a groundwater spring. This public water system serves approximately 9880 citizens. The source of this surface water is within the Powder Subbasin of the Middle Snake-Powder Basin. The geographic area providing water to Baker City's intakes (the drinking water protection area) includes a cumulative total of approximately 11.9 stream miles and encompasses a total area of 10.4 square miles.[59]

- Extended periods of drought affect vulnerability to wildfire, snowpack and agricultural irrigation.

- Temperatures in the Baker County vary widely from summer to winter. The county usually experiences freezing winters with an average high of 32°F and an average low of 18°F in Baker City and summers can be blistering with average daytime high temperatures of 87°F and an average low of 50°F in Baker City.

- Management objectives vary between forest land owners. The Governor's Council on Wildfire Response report discusses the differing objectives of higher elevation forests federally owned forest land managed around restoration and conservation objectives and utilized for ecological, scenic and social/recreational values as compared to lower elevation lands owned by a wide range of private land owners whose objectives are frequently different than the federal land management agencies. Harmonizing common fire policy across these distinct ownerships—whether about use of fire as a tool or about smoke, suppression or salvage—has presented historic challenges. These challenges reflect on the vulnerability of the forested landscapes[60].

National Flood Insurance Program (NFIP)

The Baker County Flood Insurance Rate Maps (FIRMs), like much of eastern Oregon, are not available in a digital format. Below is a recap of current information related to the NFIP in Baker County and the incorporated cities provided by staff at the Department of Land Conservation and Development from the FEMA Community Information System database. For more details see the Flood Annex section of the Hazard Annexes.

[59] Oregon Department of Environmental Quality, https://www.deq.state.or.us/wq/dwp/docs/swasummary/pws00073.pdf

[60] Governor's Council on Wildfire Response; November 2019: Report and Recommendations; https://www.oregon.gov/gov/policy/Documents/FullWFCReport_2019.pdf

Baker County and incorporated cities:

- Have 104 National Flood Insurance Program (NFIP) policies in force with a total of $17,166,700 of value;
- Have 3 paid claims totaling $29,769;
- Are not members of the Community Rating System (CRS);
- There are no repetitive loss buildings and no severe repetitive loss building claims in Baker County; and
- The last Community Assistance Visit (CAV) in Baker County was on October 12, 2001 with both Baker County and Baker City; Community Assistance Contacts (CACs) were held in Baker County in August 2019

Critical Facilities and Infrastructure

Critical facilities (i.e. police, fire, and government facilities), housing supply and physical infrastructure are critical during a disaster and are essential for proper functioning and response. The lack or poor condition of infrastructure can negatively affect a community's ability to cope, respond and recover from a natural disaster. Following a disaster, communities may experience isolation from surrounding cities and counties due to infrastructure failure. These conditions force communities to rely on local and immediately available resources.

Vulnerabilities

- Twelve structures susceptible to earthquake damage are noted by DOGAMI include the following locations in the unincorporated county, Baker City, Halfway and Richland: Baker City Municipal Airport, Baker Rural Fire Protection District (RFPD), Greater Bowen Valley RFPD, Keating RFPD, Baker City Fire Department, Baker City Warehouse and Shop, Baker County Road Department, , South Baker Elementary School, St. Alphonse Hospital (formerly St. Elizabeth Hospital), Pine Eagle High School, Pine Valley Volunteer Fire Department and the Eagle Valley Fire Department [61].

- Based on DOGAMI's *Risk Report*, one of Baker County's critical facilities is at risk to landslides. This structure is the Greater Bowen Valley Rural Fire Protection District.

- DOGAMI has found that no critical facilities are exposed to high wildfire hazard.[62] The Baker City watershed, which serves the City of Baker City with surface water, however, is very vulnerable to wildfire.

- The DOGAMI *Risk Report* found that none of Baker County's critical facilities are at risk to flood hazard.[63].

[61] Ibid.

[62] Ibid.

[63]Williams, M. C., Anthony, L. H. and O'Brien, F., 2019 unpublished, Natural Hazard Risk Report For Baker County, Oregon: Final Report to the Oregon Department of Land Conservation and Development, Oregon Department of Geology and Mineral Industries

- It is critical to maintain the quality of built capacity (transportation networks, critical facilities, utility transmission, etc.) throughout the area. Interstate 84 is a major transportation corridor that connects Portland with eastern Oregon.
- Based on U.S. Census data, more approximately 74% of the residential housing in the county was built prior to current seismic building standards of 1990 and nearly 50% were constructed prior to the local implementation of the flood elevation requirements of the 1970's (county FIRMs were not completed until the 1980s)[64].

Risk Analysis

Risk analysis involves estimating the damage, injuries, and costs likely to be incurred in a geographic area over a period of time. The following risk analysis for Baker County draws from two sources, the DOGAMI Natural Hazard Risk Report, prepared as part of FEMA's Risk MAP project, and the vulnerability and probability components of the Hazard Vulnerability Assessment completed with the Steering Committee using the OEM Methodology detailed in Section C. Vulnerability Assessment.

Local Risk Assessment

The local Hazard Vulnerability Assessment does not provide damage, injury and cost estimates likely to be incurred, however, it does reflect the perceptions of the Steering Committee members about the vulnerability of the community to each of the hazards, the probability of their occurrence and a method of ranking the relative importance of the hazards to the Baker County NHMP Steering Committee members.

The data shown in Table 2 represents the final scores of the OEM Methodology exercise for 2019. The components of risk analyzed by the Steering Committee to yield these Risk Scores are composed of four factors: history, vulnerability, maximum threat, and probability. Each of these factors is multiplied by a weight factor (WF). The ranking agreed upon by the Steering Committee for Vulnerability reflects their answers to the question "What percentage of the population and property is likely to be affected during an occurrence of an incident?" Table 2 below shows that the Baker County NHMP Steering Committee (SC) believes that wildfire, winter storms, and volcanic events would result in the most damage to people and property receiving rankings of 10 followed closely by floods and droughts which received rankings of 9. Landslides were ranked at 2 out of 10 indicating that the SC believes these incidents to pose less of a threat to people and property.

[64] American Fact Finder, consulted February 2020

Table 2. Hazard Vulnerability Analysis completed May 23, 2019 by the Steering Committee

HAZARDS	HISTORY WF = 2	VULNERABILITY WF = 5	MAX THREAT WF = 10	PROBABILITY WF = 7	RISK SCORE
Wildfire	2 x 10	5 x 10	10x 10	7 x 10	**240**
Winter Storms	2 x 8	5 x 8	10 x 9	7 x 8	**202**
Droughts	2 x 8	5 x 8	10x 8	7 x 9	**199**
Wind Storms	2 x 5	5 x 6	10 x 6	7 x 7	**149**
Floods	2 x 5	5 x 6	10 x 6	7 x 5	**135**
Earthquakes	2 x 2	5 x 8	10 x 8	7 x 1	**131**
Landslides	2 x 1	5 x 1	10 x 1	7 x 1	**24**
Volcanic Events	2 x 1	5 x 1	10 x 1	7 x 1	**24**

Source: Results of OEM Methodology exercise with 2019 Baker County NHMP Steering Committee

The probability factor represents the SC's assessment of the likelihood of an incident occurring. Wildfire, winter storms and drought are scored highly for probability indicating that the SC believed it to be likely within the next 5 years, whereas, Volcanic Events are scored very low for probability indicating that the SC believes that more than 10 years will pass between events. The most probable hazards according to the results of this exercise are Wildfire ranked at 10, followed closely by Winter Storms, and Droughts ranked at 8 and 9 respectively.

These results were evaluated by some of the steering committee members who noted that although wildfire poses a threat to the area within which it occurs, the more widespread effect of drought across the whole county poses a greater threat to the entire community. For this reason throughout the remainder of this plan, drought is considered a greater overall natural hazard than wildfire.

The DOGAMI *Risk Report* is able to estimate damage, injuries, and costs likely to be incurred by an occurrence. These results may confirm or contradict the assessment of the Steering Committee.

DOGAMI Risk Report

Oregon Department of Geology and Mineral Industries (DOGAMI) conducted a natural hazard risk assessment in 2019 as part of the FEMA Risk MAP process that was reported in the *Natural Hazard Risk Report for Baker County, Oregon* in 2019. The risk assessments contained in DOGAMI's report

quantify the impacts of four of the eight natural hazards analyzed by the 2019 NHMP Steering Committee. The hazards assessed included wildfire, flood, landslide and earthquake.

The risk assessment was performed by completing three main tasks: compiling an asset database, identifying and using best available hazard data, and performing natural hazard risk assessment.

In the first task, DOGAMI created a comprehensive asset database for Baker County by synthesizing assessor data, U.S. Census information, Hazus®-MH general building stock information, and building footprint data. This work resulted in a single dataset of building points and their associated building characteristics. With these data DOGAMI was able to conduct highly accurate hazard analysis on a building-by-building basis.

The second task was to identify and use the most current and appropriate hazard datasets for Baker County. Most of the hazard datasets used in this report were created by DOGAMI and some were produced by using high-resolution lidar topographic data. Each hazard dataset for Baker County were the best available at the time of writing.

In the third task, DOGAMI performed risk assessments using Esri® ArcGIS Desktop® software. They used two risk assessment approaches: (1) estimated loss (in dollars) to buildings from flood and earthquake scenarios using FEMA Hazus®-MH methodology, and (2) calculated number of buildings, their value, and associated populations that are exposed to earthquake and flood inundation scenarios, or susceptible to varying levels of hazard from landslides and wildfire.

The datasets were provided to the county for use in hazard planning.

Wildfire

The data source used by DOGAMI to quantify risk from wildfire is the Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results (PNRA)[65]. It is a comprehensive report that includes a database developed by the United States Forest Service (USFS) for the states of Oregon and Washington. The steward of this database in Oregon is the Oregon Department of Forestry (ODF). The database was created to assess the level of risk residents and structures have to wildfire. For this project, the Burn Probability dataset, a dataset included in the PNRA database, was used to measure the risk to communities in Baker County.

[65] Pyrologix LCC, 2018

Figure 13. Burn Probability Map

Burn Probability Map of Baker County, Oregon

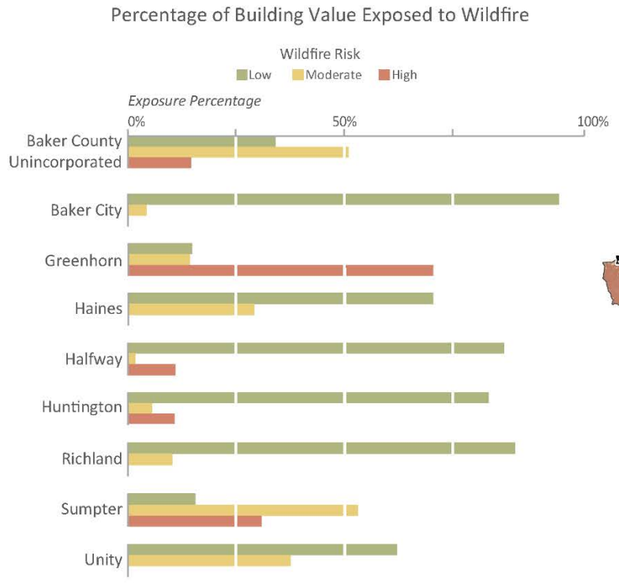
PLATE 6

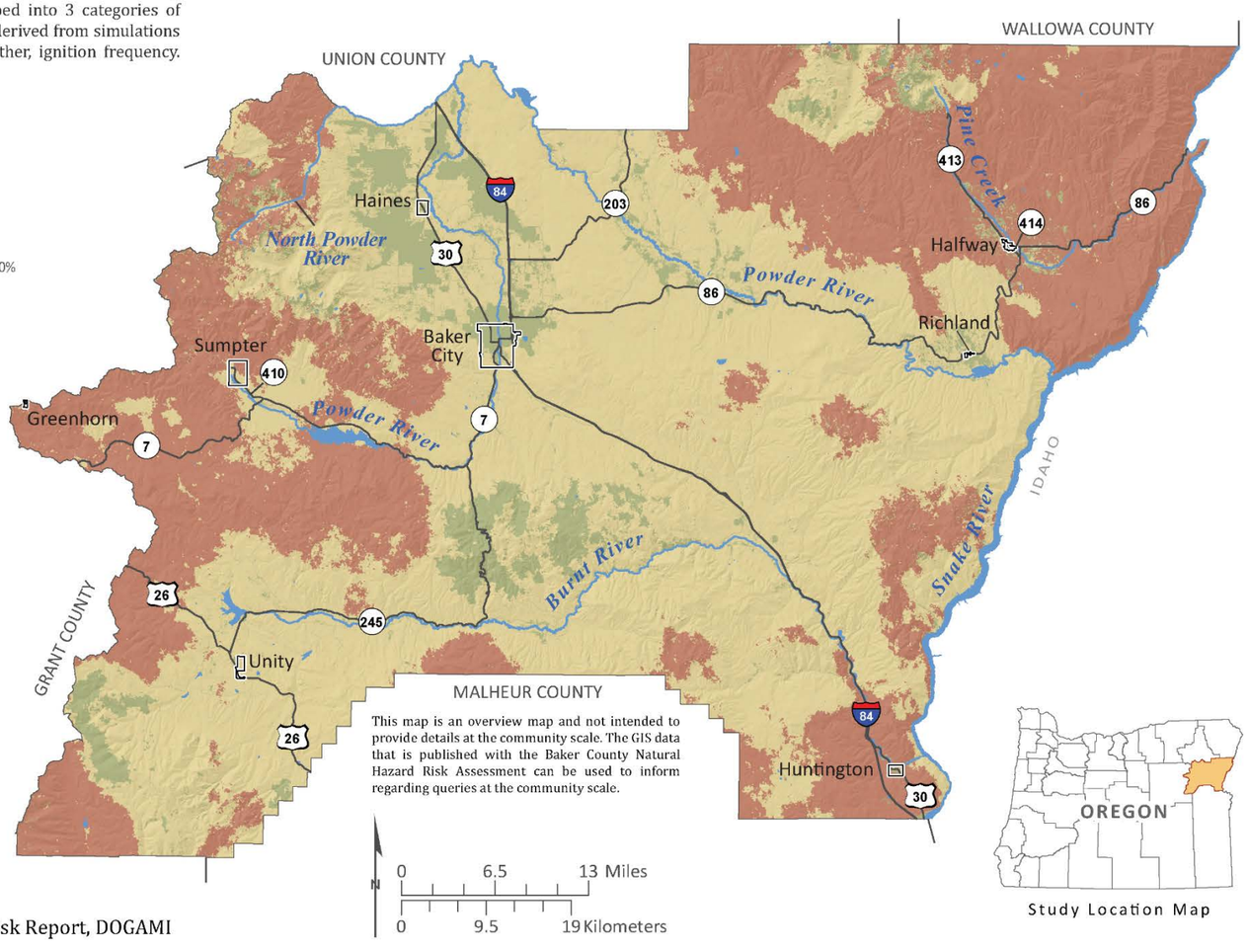
Burn Probability

- Low
- Moderate
- High

Wildfire Burn Probability is categorized as Low, Moderate, and High and indicates the probability a location has to wildfire hazard. Probability ranges of the Burn Probability dataset from the PNRA were grouped into 3 categories of wildfire hazard. Burn probability is derived from simulations using many elements, such as, weather, ignition frequency.

Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication cannot substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from the results shown in the publication. See the accompanying text report for more details on the limitations of the methods and data used to prepare this publication.





This map is an overview map and not intended to provide details at the community scale. The GIS data that is published with the Baker County Natural Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Study Location Map

Data Sources:
Burn probability data: Oregon Department of Forestry, Pyrologix, LCC. (2018)
Roads: Oregon Department of Transportation Signed Routes (2013)
Place names: U.S. Geological Survey Geographic Names Information System (2015)
City limits: Oregon Department of Transportation (2014)
Basemap: Oregon Lidar Consortium (2017)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 UTM Zone 11N
Software: Esri® ArcMap 10, Adobe® Illustrator CC

Cartography by: Lowell H. Anthony, 2019

2019 Draft Baker County Risk Report, DOGAMI

Source: *Natural Hazard Risk Report for Baker County, Oregon* (2019), DOGAMI

Using guidance from ODF, DOGAMI categorized the Burn Probability dataset into low, moderate, and high-hazard zones for the wildfire exposure analysis. Probability ranges of the Burn Probability dataset from the PNRA were grouped into 3 categories of wildfire hazard. Burn probability is derived from simulations using many elements, such as, weather, ignition frequency, ignition density, and fire modeling landscape[66].

Burn probabilities were grouped into 3 hazard categories:

- Low wildfire hazard (0.0001 – 0.0002 or 1/10,000 – 1/5,000)
- Moderate wildfire hazard (0.0002 – 0.002 or 1/5,000 – 1/500)
- High wildfire hazard (0.002 – 0.04 or 1/500 – 1/25)

The geographic extent of this analysis of wildfire hazard is illustrated above in Figure 13.

DOGAMI chose the high hazard category as the primary scenario for this report because it represents the areas that have the highest potential for losses. However, a large amount of loss would occur if the moderate hazard areas were to burn, as some communities have ~50% exposure to moderate wildfire hazard. Other communities have even higher exposure to wildfire hazard. Still, the focus of this section is on high hazard areas within Baker County to emphasize the areas where lives and property are most threatened.

Baker Countywide wildfire exposure (High risk):

- Number of buildings: 1,798
- Exposure Value: $240,321,000
- Ratio of Exposure Value: 7.6%
- Critical facilities exposed: 0
- Potentially Displaced Population: 830

For this risk assessment, the building locations were compared to the geographic extent of the wildfire hazard categories. Several communities in Baker County have a high percentage of buildings and residents exposed to high wildfire hazard. The primary areas of exposure to this hazard are in the forested unincorporated areas of the county that have not already experienced recent burns. This analysis shows that the communities of Greenhorn, Sumpter and the unincorporated county have the highest percentage of high and moderate exposure to wildfire hazard within Baker County. Wildfire hazard is based on conditions that can change on an annual basis, so local knowledge and understanding of wildfire risk may need to be considered when determining mitigation actions.

To calculate the monetary value of exposed buildings DOGAMI overlaid the buildings layer and critical facilities on each of the wildfire hazard zones to determine exposure. The total dollar value of exposed buildings in Baker County is reported below in Table 3. DOGAMI also estimated the number of people threatened by wildfire as summarized in the bulleted list above. Land value losses due to wildfire were not examined for this project.

[66] Ibid.

Table 3. Wildfire Exposure

			(all dollar amounts in thousands)					
			High Hazard			**Moderate Hazard**		
Community	**Total Number of Buildings**	**Total Estimated Building Value ($)**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**	**Number of Buildings**	**Building Value ($)**	**Percent of Building Value Exposed**
Unincorp. Baker County	8,107	1,408,882	1,502	206,898	15%	4,329	720,354	51%
Baker City	6,041	1,437,408	0	0	0%	301	60,540	4.2%
Greenhorn	24	1,876	19	1,327	71%	2	270	14%
Haines	386	55,066	0	0	0%	118	16,145	29%
Halfway	374	78,700	58	8,681	11%	13	1,382	1.8%
Huntington	420	57,259	53	6,174	11%	31	3,246	5.7%
Richland	176	34,987	0	0	0%	28	3,606	10%
Sumpter	473	55,531	166	17,243	31%	256	29,596	53%
Unity	107	16,938	0	0	0%	46	6,387	38%
Total Baker County	16,108	3,146,647	1,798	240,321	7.6%	5,124	841,526	27%

Source: *Natural Hazard Risk Report for Baker County, Oregon*, (2019) Williams, M. C., Anthony, L. H. and O'Brien, F., DOGAMI

The DOGAMI *Risk Report* identified locations within Baker County that are comparatively more vulnerable or at greater risk to wildfire hazard. The bar graph in Figure 13 represents graphically the conclusions drawn. They are as follows:

- Wildfire risk is high for many of homes in the forested area in the county north of Halfway city limits.
- The community of Sumpter, and to a lesser extent the communities of Halfway, Huntington, and the unincorporated county are most at risk to high wildfire hazard compared to other Baker County communities.
- The buildings in and around Greenhorn are exposed to high wildfire. Evacuation may be difficult due to the remoteness of this community.

Flood

The Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for Baker County were made effective in the 1980's, with some areas updated through a Letter of Map Revision in Baker City[67] [68] [69] [70] [71]; these were the primary data sources for the flood risk assessment. Further information regarding NFIP related statistics can be found at FEMA's website: https://www.fema.gov/policy-claim-statistics-flood-insurance. This was the only flood data source that DOGAMI used in the analysis, but flooding does occur in areas outside of the detail mapped areas. Flood issues like flash flooding, ice jams, post-wildfire floods, and dam safety were not looked at in this report.

Depth grids, developed by DOGAMI in 2019 and based on the effective and pending map data, were used in this risk assessment to determine the level to which buildings are impacted by flooding. Depth grids are GIS datasets where each digital pixel value represents the depth of flooding at that location within the flood zone (Figure 14). Though considered draft at the time of this analysis, the depth grid data are the best available flood hazard data. Depth grids for four flooding scenarios (10-, 50-, 100-, and 500-year) were used for loss estimations and, for comparative purposes, exposure analysis.

Building loss estimates are determined by Hazus®-MH by overlaying building data over a depth grid. Hazus®-MH uses individual building information, specifically the first floor height above ground and the presence of a basement, to calculate the loss ratio from a particular depth of flood.

For Baker County, occupancy type attributes were derived from the tax lot database for most buildings. Where individual building information was not available from assessor data, DOGAMI used oblique imagery and street level imagery to estimate these important building attributes. Only buildings in a flood zone or within 500 feet (152 meters) of a flood zone were examined closely to attribute buildings with more accurate information for first-floor height and basement presence. Because the analysis accounted for building first-floor height, buildings that have been properly elevated above the flood level were not given a loss estimate—but the analysis counted residents in

[67] Federal Emergency Management Agency, 1987, Flood insurance study: City of Mount Vernon, Baker County, Oregon: Washington D.C., Flood Insurance Study Number 410080V000, v.1, 24 p https://map1.msc.fema.gov/data/41/S/PDF/410080V000.pdf?LOC=abbb351c56a37a66da8f9e07ec83dbb5

[68] Federal Emergency Management Agency, 1988, Flood insurance study: City of Prairie City, Baker County, Oregon: Washington D.C., Flood Insurance Study Number 410082V000, v.1, 26 p. https://map1.msc.fema.gov/data/41/S/PDF/410082V000.pdf?LOC=e4a8b1a29543ab7de4a93bd106e211d2

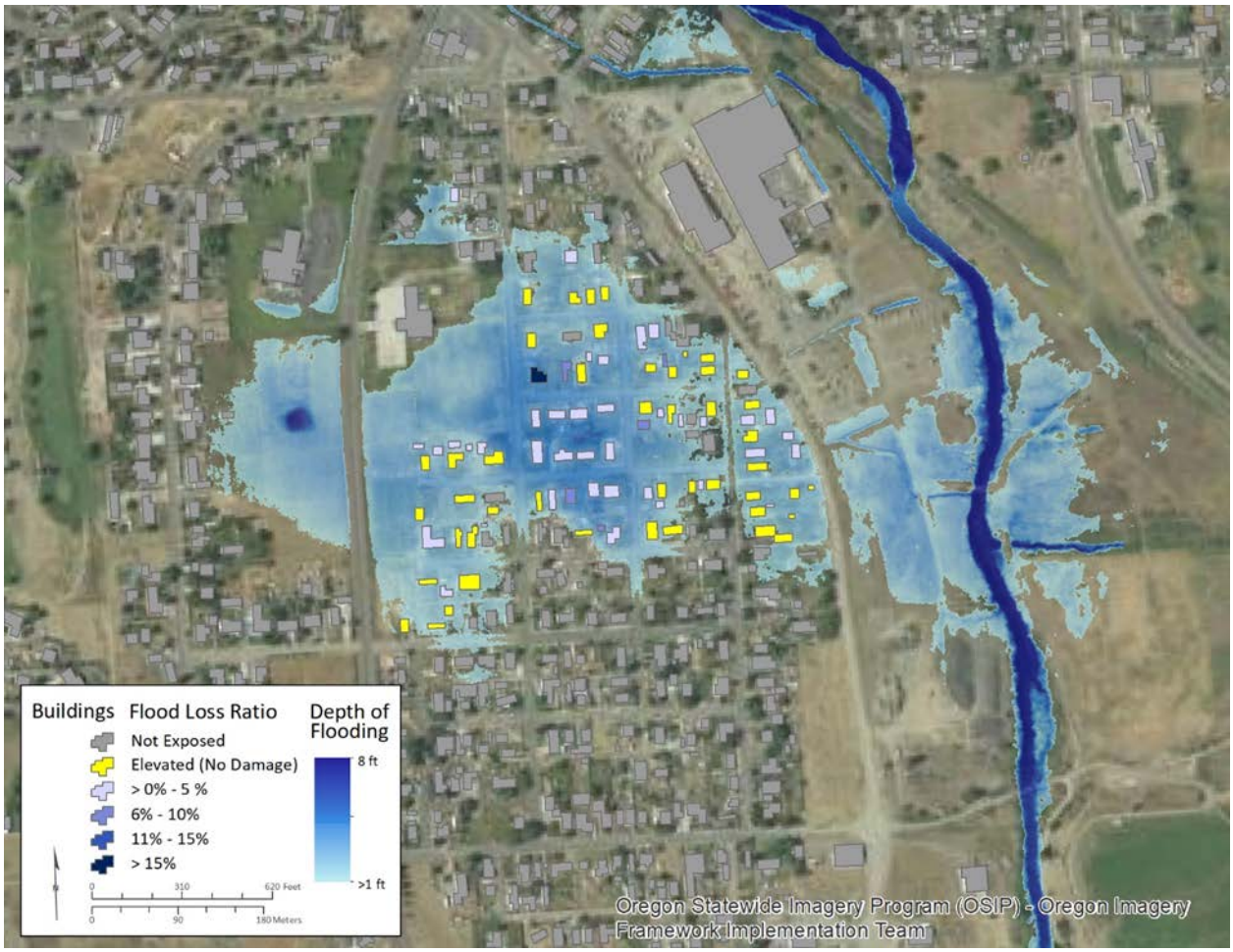
[69] Federal Emergency Management Agency, 2019a, Pending flood insurance study: Unincorporated Areas, Baker County, Oregon: Washington D.C., Flood Insurance Study Number 410074, Letter of Map Revision 19-10-0438P https://map1.msc.fema.gov/data/41/L/19-10-0438P-410074.pdf?LOC=ae449b7b4a6460d7351ae40b3b2f75f2

[70] Federal Emergency Management Agency, 2019b, Pending flood insurance study: City of Canyon City, Baker County, Oregon: Washington D.C., Flood Insurance Study Number 410075, Letter of Map Revision 19-10-0438P https://map1.msc.fema.gov/data/41/L/19-10-0438P-410075.pdf?LOC=02a01f964f244e2c75b61405f89808b9

[71] Federal Emergency Management Agency, 2019c, Pending flood insurance study: City of John Day, Baker County, Oregon: Washington D.C., Flood Insurance Study Number 410077, Letter of Map Revision 19-10-0438P https://map1.msc.fema.gov/data/41/L/19-10-0438P-410077.pdf?LOC=74fe6d41cab60737632d0484be58442e

those structures as displaced. The analysis did not look at the duration that residents would be displaced from their homes due to flooding.

Figure 14. 100-year flood zone and building loss estimates in Baker City



Source: Williams, Anthony, and O'Brien (2019)

Since there are not vast floodplains within Baker County, there are only a few areas where buildings are vulnerable to flooding. However, in areas where flooding does occur it is a reoccurring issue. For this risk assessment, we imported Baker County structure information data and depth grids into Hazus®-MH and ran a flood analysis for the four flood scenarios (10-, 50-, 100-, and 500-year). The analysis used the 100-year flood as the primary scenario for reporting the flood results (also see Figure 6). The 100-year flood has traditionally been used as a reference level for flooding and is the standard probability that FEMA uses for regulatory purposes[72].

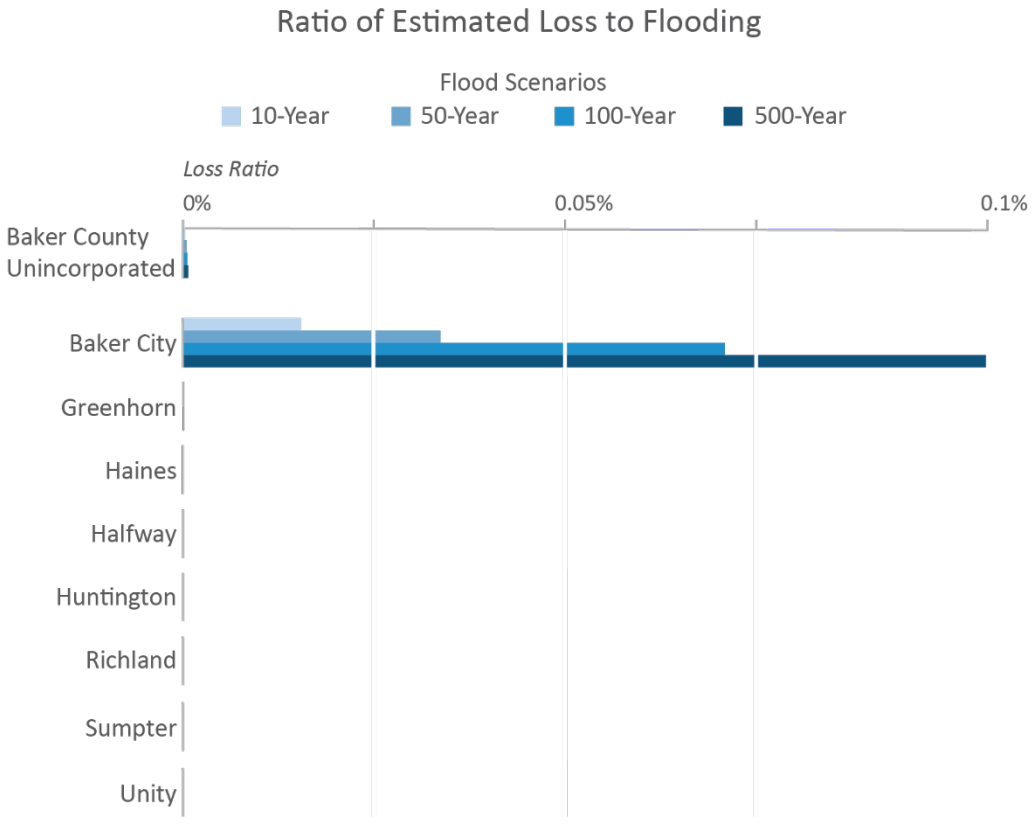
[72] Federal Emergency Management Agency, 2013, NFIP flood studies and maps, unit 3 in Managing floodplain development through the National Flood Insurance Program (Home Study Course): Washington, D.C., 59 p. https://www.fema.gov/media-library-data/20130726-1535-20490-4172/unit3.pdf

Baker Countywide 100-year flood loss:

- Number of buildings damaged: 125
- Loss Estimate: $986,000
- Loss Ratio: 0.03%
- Damaged critical facilities: 0
- Potentially Displaced Population: 359

The Hazus®-MH loss estimate of the 100-year flood scenario for Baker County is approximately $1 million. While the overall loss ratio for flood damage in Baker County is only 0.03%, 100-year flooding has a significant impact to Baker City where development exists near streams that are prone to flooding. (Figure 15). In situations with communities where most residents are not within flood designated zones, the loss ratio may not be as helpful as the actual replacement cost and number of residents displaced to assess the level of risk from flooding. The Hazus®-MH analysis also provides useful flood data on individual communities so that planners can identify problems and consider which mitigating activities will provide the greatest resilience to flooding.

Figure 15. Flood loss estimates by community



Source: : *Natural Hazard Risk Report for Baker County, Oregon* (2019) Williams, M. C., Anthony, L. H. and O'Brien, F., DOGAMI

Separate from the Hazus®-MH flood analysis, DOGAMI did an exposure analysis by overlaying building locations on the 100-year flood extent. A large number of buildings in Baker County (223 buildings) were found to be within designated flood zones. By comparing the number of non-damaged buildings from Hazus®-MH with exposed buildings in the flood zone, DOGAMI estimated the number of buildings that could be elevated above the level of flooding. Of the 223 buildings that are exposed to flooding, they estimated that 98 are above the height of the 100-year flood. This evaluation can also shed some light on the number of residents that might have mobility or access issues due to surrounding water.

DOGAMI identified locations predominantly within Baker City that are comparatively more vulnerable or at greater risk to flood hazard:

- Flood maps indicate backwater flooding from the Powder River in Baker City, south of State Highway 7 and railroad crossing.
- A wide but shallow flooding area forms in an area north of Baker City during large flooding events.

In general, DOGAMI also concluded that the stream studies and mapping currently in use in Baker County are older and would be more accurate if an updated study occurred.

Earthquake

Hazus®-MH offers two scenario methods for estimating loss from earthquake, probabilistic and deterministic.[73] A probabilistic scenario uses U.S. Geological Survey (USGS) National Seismic Hazard Maps which are derived from seismic hazard curves calculated on a grid of sites across the United States that describe the annual frequency of exceeding a set of ground motions as a result of all possible earthquake sources (USGS, 2017). A deterministic scenario is based on a specific seismic event from a clearly defined source, such as a Cascadia Subduction Zone magnitude 9.0 event.

DOGAMI selected the probabilistic scenario method because there is no clearly defined dominant seismic source for the area and it best suited estimating the level of seismic risk. This method was used along with the database of structures and critical facilities so that loss estimates could be calculated on a building-by-building basis. The USGS 2500-year probabilistic map[74] provides the Hazus®-MH earthquake model with ground shaking parameters, peak ground velocity, spectral acceleration at 1.0 second period and 0.3 second period that have been integrated together. DOGAMI set the magnitude to 6.7 within Hazus®-MH for the scenario used in this report. Additional

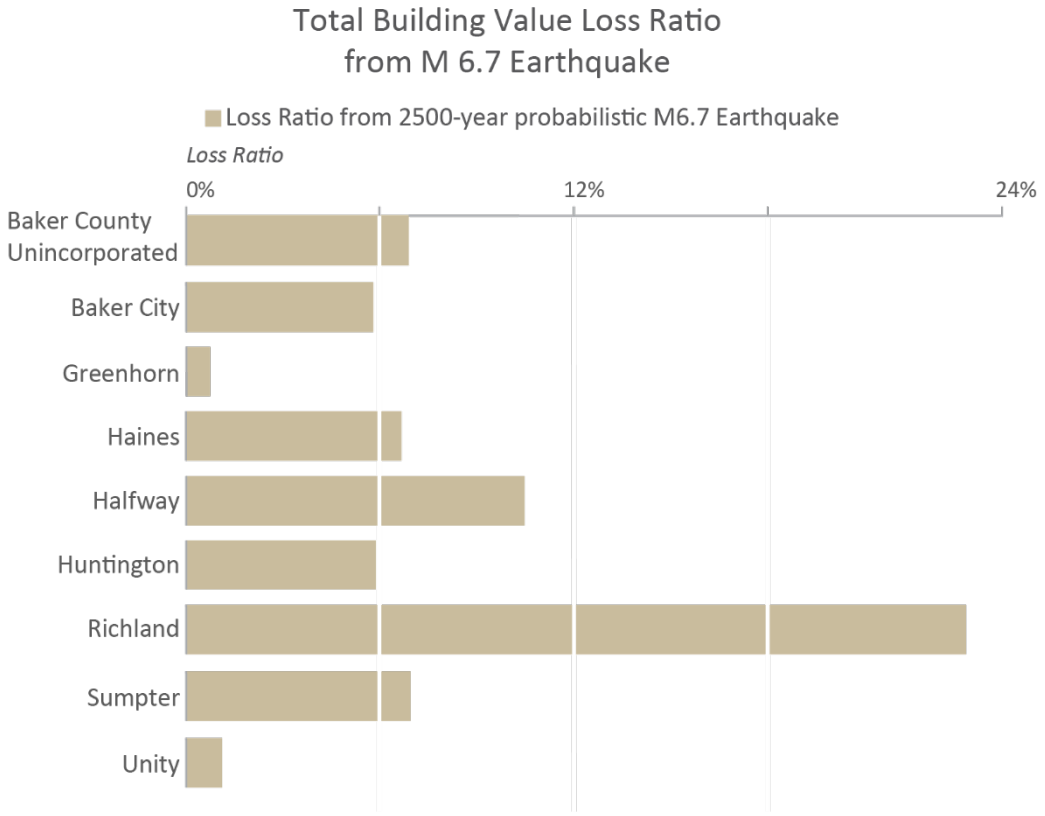
[73] Federal Emergency Management Agency, 2012b, Hazus®-MH 2.1 Technical manual, Earthquake model: Washington, D.C., 718 p. https://www.fema.gov/media-library-data/20130726-1820-25045-6286/hzmh2_1_eq_tm.pdf

[74] Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, Documentation for the 2014 update of the United States national seismic hazard maps: U.S. Geological Survey Open-File Report 2014–1091, 243 p., https://dx.doi.org/10.3133/ofr20141091

seismic inputs utilized in the earthquake scenario were liquefaction susceptibility and NEHRP site classification derived from the Oregon Resilience Plan (ORP)[75] and landslide susceptibility. [76]

Because an earthquake can affect a wide area, it is unlike other hazards in this report — every building in Baker County, to some degree, would be affected by it. Hazus®-MH loss estimates for each building are based on a formula where coefficients are multiplied by each of the five damage state percentages (none, low, moderate, extensive, and complete). These damage states are correlated to loss ratios that are then multiplied by the building dollar value to obtain a loss estimate[77] Figure 16 shows the loss estimates by community for Baker County from a 2500-year probabilistic magnitude 6.7 event.

Figure 16. Loss Estimates by Community from a 2500-year M 6.7 Earthquake



Source: Williams, Anthony and O'Brien (2019)

[75] Madin, I. P., and Burns, W. J., 2013, Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia subduction zone earthquakes: Oregon Department of Geology and Mineral Industries Open-File Report O-13-06, 36 p. 38 pl., GIS data. https://www.oregongeology.org/pubs/ofr/p-O-13-06.htm

[76] Burns, W. J., Mickelson, K. A., and Madin, I. P., 2016

[77] FEMA, 2012

In keeping with earthquake damage reporting conventions, DOGAMI used the ATC-20 post-earthquake building safety evaluation color-tagging system to represent damage states.[78] Red-tagged buildings correspond to a Hazus®-MH damage state of "complete," which means the building is uninhabitable. Yellow-tagged buildings are in the "extensive" damage state, indicating limited habitability. The number of buildings in each damage state is based on an aggregation of probabilities per community and does not represent individual buildings.[79]

Critical facilities were considered non-functioning if the Hazus®-MH earthquake analysis showed that a building or complex of buildings had a greater than 50-percent chance of being at least moderately damaged[80].

The number of potentially displaced residents from the scenario earthquake is based on the number of red-tagged and a percentage of yellow-tagged residences that were determined in the Hazus®-MH earthquake analysis results.

Baker County 2500-year probabilistic M6.7 earthquake results:

- Number of red-tagged buildings: 254
- Number of yellow-tagged buildings: 1,356
- Loss estimate: $209,210,000
- Loss ratio: 6.6%
- Non-functioning critical facilities: 12
- Potentially displaced population: 257

The results indicate that Baker County would incur a moderate amount of damage (6.6%) from an earthquake similar to the one simulated in this report. The critical facilities that would be rendered non-functional are listed in the DOGAMI Risk Report in Appendix A.

These results were moderately influenced by earthquake-induced liquefaction; however, the overall age of the building stock was the primary factor. This shows us that the age of the building stock is one metric of earthquake vulnerability for a community. Seismic building codes were implemented in Oregon in the 1970s, as such, 75% of buildings were built before "moderate" code enforcement. Communities within Baker County that are composed of an older building stock are expected to experience more damage from earthquake than newer ones.

Moderate to high liquefaction zones exist throughout the county and in the densest populated areas, which increases the risk from earthquake. Another consideration of these areas is that liquefaction could present difficulties for first responders and people in need of medical attention after an earthquake event. This factor, as well as the overall age of the building stock results in moderate levels of damage.

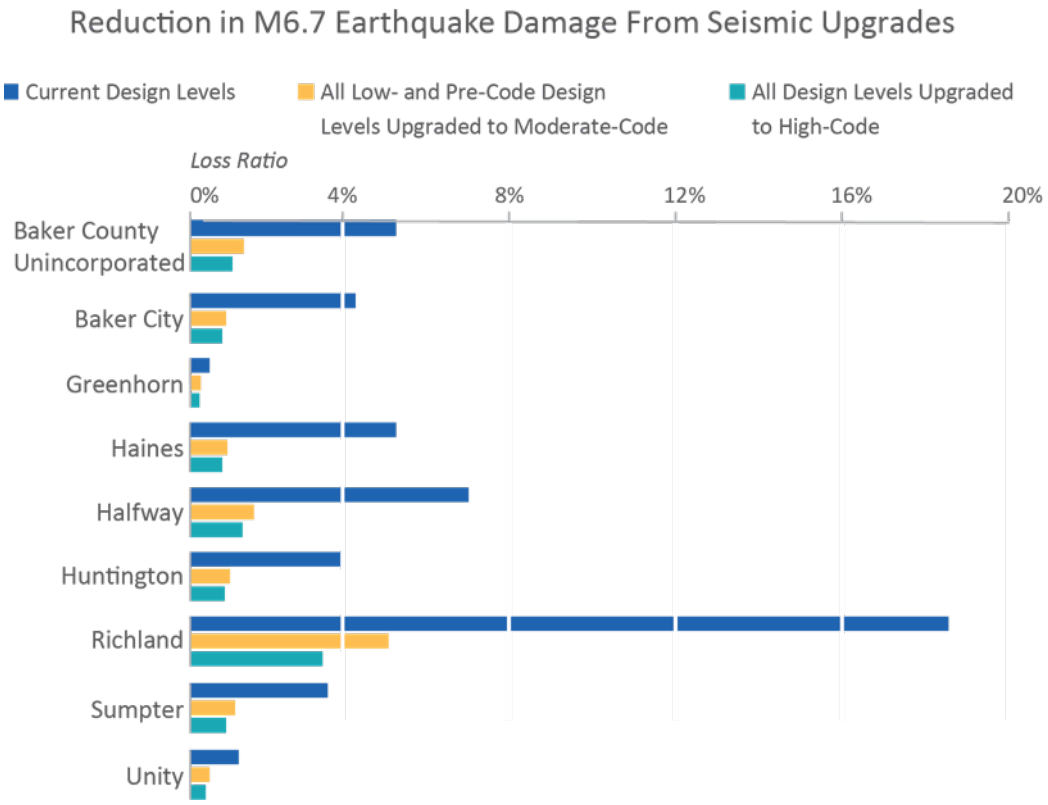
[78] Applied Technology Council, 2015, Rapid visual screening of buildings for potential seismic hazards: A handbook (3rd ed.): Redwood City, Calif., FEMA Publication 154. https://www.fema.gov/media-library-data/1426210695633-d9a280e72b32872161efab26a602283b/FEMAP-154_508.pdf

[79] FEMA 2012

[80] Ibid.

If buildings could be seismically retrofitted to moderate or high code standards, the impact of this event would be greatly reduced. In a simulation by DOGAMI using a dataset that has removed landslide and liquefaction factors (PGD), Hazus®-MH earthquake analysis shows that loss estimates drop from 4.8% to 1.2%, when all buildings are upgraded to at least moderate code level. Figure 17 illustrates the reduction in loss estimates from a CSZ magnitude 9.0 earthquake through two simulations where all buildings are upgraded to at least moderate code standards and then all buildings to high code standards.

Figure 17. 2500-year probabilistic M6.7 (PGD removed) loss ratio in Baker County, with simulated seismic building code upgrades



Source: Williams, Anthony, and O'Brien (2019)

DOGAMI identified locations within Baker County that are comparatively more vulnerable or at greater risk to the 2500-year probabilistic M6.7 earthquake hazard:

- Very high liquefaction soils are found throughout most of the populated portions of Baker County, which include the communities of Baker City, Haines, Halfway, and Huntington.
- Building inventory for the many communities in the county are comprised of older buildings, which implies lower seismic building design codes. Buildings built with older building code standards are more vulnerable to damage from earthquakes.
- Many (42%) of the critical facilities in the incorporated communities of Baker County could be non-functioning due to an earthquake similar to the scenario used in this report.

Landslide

The Statewide Landslide Information Layer for Oregon [SLIDO], release 3.2 [81] is an inventory of mapped landslides in the state of Oregon. SLIDO is a compilation of past studies; some studies were completed very recently using new technologies, like lidar-derived topography, and some studies were performed more than 50 years ago. Consequently, SLIDO data vary greatly in scale, scope, and focus and thus in accuracy and resolution across the state. Landslide inventory mapping for Baker County was done before lidar was available for high-accuracy mapping.

W.J. Burns and others (2016) used SLIDO inventory data along with maps of generalized geology and slope to create a landslide susceptibility overview map of Oregon that shows zones of relative susceptibility: Very High, High, Moderate, and Low. SLIDO data directly define the Very High landslide susceptibility zone, while SLIDO data coupled with statistical results from generalized geology and slope maps define the other relative susceptibility zones.[82] Statewide landslide susceptibility map data have the inherent limitations of SLIDO and of the generalized geology and slope maps used to create the map. Therefore, the statewide landslide susceptibility map varies significantly in quality across the state, depending on the quality of the input datasets. Another limitation is that susceptibility mapping does not include some aspects of landslide hazard, such as runout, where the momentum of the landslide can carry debris beyond the zone deemed to be a high hazard area.

DOGAMI used the data from the statewide landslide susceptibility map[83] in this report to identify the general level of susceptibility of given area to landslide hazards, primarily shallow and deep landslides. We overlaid building and critical facilities data on landslide susceptibility zones to assess the exposure for each community. The total dollar value of exposed buildings was summed for Baker County and is reported below. We also estimated the number of people threatened by landslides. Land value losses due to landslides were not examined for this report, in addition to potentially hazardous unmapped areas that may pose real risk to communities.

DOGAMI's risk analysis for Baker County combined high and very high susceptibility zones as the primary scenarios to provide a general sense of community risk for planning purposes. DOGAMI staff determined that it was useful to combine exposure for both susceptibility zones to accurately depict the level of landslide risk to communities. These susceptibility zones represent areas most prone to landslides with the highest impact to the community.

For this risk assessment DOGAMI staff compared building locations to geographic extents of the landslide susceptibility zones. The exposure results shown below are for the high and very high susceptibility zones.

[81] Burns, W. J., and Watzig, R. J., 2014, Statewide landslide information layer for Oregon, release 3 [SLIDO-3.0]: Oregon Department of Geology and Mineral Industries, 35 p., 1:750,000, geodatabase.

[82] Burns, W. J., Mickelson, K. A., and Madin, I. P., 2016, Landslide susceptibility overview map of Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-16-02, 48 p. https://www.oregongeology.org/pubs/ofr/p-O-16-02.htm

[83] Ibid.

Baker County countywide landslide exposure (High and Very High susceptibility):

- Number of buildings: 463
- Exposure Value: $53,399,000
- Ratio of Exposure Value: 1.7%
- Critical facilities exposed: 1
- Potentially Displaced Population: 254

Summary

The purpose of this study is to provide a better understanding of potential impacts from multiple natural hazards at the community scale. This was accomplished by using the latest natural hazard mapping and loss estimation tools to quantify expected damage to buildings and potential displacement of permanent residents. The comprehensive and fine-grained approach to the analysis provides new context for the county's risk reduction efforts. Based on the results of this study several important findings were made:

1. **Hazus®-MH earthquake analysis show a moderate amount of damage and losses for the study area**—The results indicate that Baker County would incur a moderate amount of damage (6.6%) from an earthquake similar to the one simulated in this report. Areas of liquefaction have a strong influence on the damage results. Building vulnerability was a strong factor due to the general age of the building inventory being built before seismic building code enforcement in Oregon. In addition, several high value buildings in downtown Baker City are constructed with materials that are highly vulnerable to earthquake shaking. The high vulnerability of the building inventory (primarily because of the age of construction), building construction materials, and the areas of high liquefaction all contribute to the estimated levels of losses expected in the study area.
2. **Retrofitting buildings to modern seismic building codes can reduce damages and loses from earthquake**—Seismic building codes have a major influence on earthquake shaking damage estimated by Hazus®-MH, a software tool developed by the Federal Emergency Management Agency (FEMA) for calculating loss from natural hazards. We examined potential loss reduction from seismic retrofits (modifications that improve building's seismic resilience) in simulations by using Hazus®-MH building code "design level" attributes of pre, low, moderate, and high codes (FEMA, 2012b) in earthquake scenarios where permanent ground deformation (PGD) has been removed. The simulations were accomplished by upgrading every pre (non-existent) and low seismic code building to moderate seismic code levels in one scenario, and then further by upgrading all buildings to high (current) code in another scenario. We found that retrofitting to at least moderate code was the most cost-effective mitigation strategy because the additional benefit from retrofitting to high code was minimal. In our simulation of upgrading buildings to at least moderate code, the estimated loss for the entire study area went from 4.8% to 1.2%. We found further reduction in estimated loss in our simulation to 0.8% only by upgrading all buildings to high code. Some communities would see greater loss reduction than the study area as a whole due to older building stock constructed at pre or low code seismic building code standards. An example is Baker City, which would see a significant loss reduction (from 4.2% to 0.9%) by retrofitting all buildings to at least moderate code. While seismic retrofits are an effective strategy for reducing earthquake shaking damage, it should be noted that earthquake-

induced landslide and liquefaction hazards will also be present in some areas, and these hazards require different geotechnical mitigation strategies.

3. **Flooding is a threat for some areas in the study area**—Most of the development in Baker County is located in the flatter agricultural lands where flooding can occur. Many buildings in the study area, primarily within the Powder River floodplain in and north of Baker City, are vulnerable to flooding. We estimate a moderate amount of damage from flooding in this area and many buildings exposed to flooding. Several streams in Baker County that may be prone to flooding have never been studied for flood hazard, so the level of risk from flooding may be higher. The effective stream studies that are currently in use may be out-of-date due to their age and new studies may be beneficial. During a 100-year flood event, the current stream models show that Baker City is expected to sustain losses near 0.1% of total building value.
4. **Elevating structures in the flood zone reduces vulnerability**—Flood exposure analysis was used in addition to Hazus®-MH loss estimation to identify buildings that were not damaged but were within the area expected to experience a 100-year flood. By using both analyses in this way, the number of elevated structures within the flood zone could be quantified. This showed possible mitigation needs in flood loss prevention and the effectiveness of past activities. Baker City was identified as a community with a large number of buildings (98) in the floodplain elevated above the estimated flood height.
5. **New landslide mapping would increase the accuracy of future risk assessments**—Exposure analysis was used to assess the threat from landslide hazard. Landslide is a widespread hazard for much of the undeveloped portions of the county. The landslide data suggests that a cluster of residential buildings in the northeastern portion of Sumpter are exposed to very high landslide hazard as they are currently mapped, but interpretations from the lidar indicate that this may be incorrect. The landslide hazard data used in this risk assessment was created before modern mapping technology and future risk assessments using lidar derived landslide hazard data would provide more accurate results. Earthquake analysis would also benefit from better landslide mapping since Hazus®-MH analysis uses landslide probability as an input dataset.
6. **Wildfire is a natural hazard threat for many areas in Baker County**—Exposure analysis shows that buildings throughout the study area are at high risk to wildfire hazard. Several communities within the county have a minimum of 30% of exposure to at least moderate wildfire hazard and some communities are at much greater risk. The communities of Sumpter, Greenhorn, Halfway, and Huntington are particularly at risk to high wildfire hazard. Additionally, wildfire risk is high throughout the unincorporated county.
7. **Several of Baker County's critical facilities are at risk to earthquake hazard**—Critical facilities were identified and were specifically examined within this report. DOGAMI has estimated that 14 of Baker County's 33 critical facilities are at risk to be non-functioning due to an earthquake similar to the one simulated in this report. DOGAMI has also found that 1 critical facility is exposed to landslide hazard. No critical facilities were found to be exposed to flood or wildfire.
8. **Biggest displacement to population was wildfire**—Displacement of permanent residents from natural hazards was quantified within this report. We estimate that of the 16,134 total residents in Baker County 5.1% of the population or 830 residents could be potentially displaced due to wildfire. Flood hazard is a potential threat to 2% or (359) of permanent residents, and landslide hazard makes 1.6% or (254) residents vulnerable to displacement.

9. **Community needs can be prioritized**—Each community within Baker County was assessed for natural hazard exposure and loss. This allowed for comparison of risk between communities and impacts from each natural hazard. In using Hazus®-MH and exposure analysis, these results can assist in developing plans that address the concerns for those individual communities.