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Oregon Department of Geology and Mineral Industries
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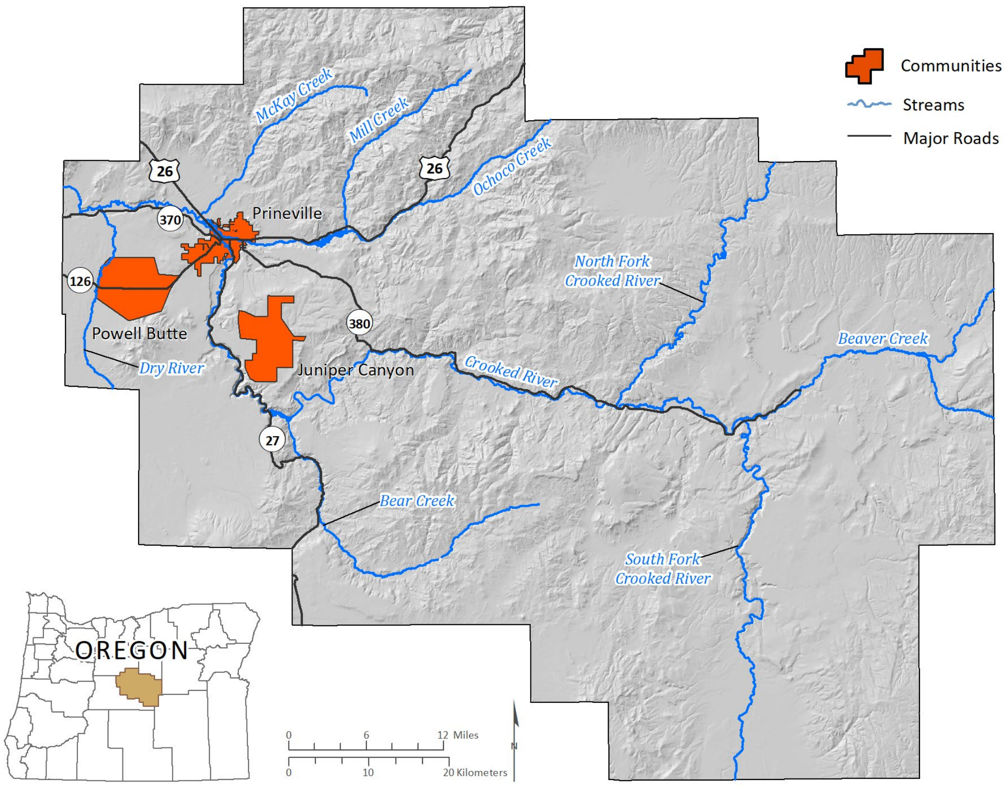
OPEN-FILE REPORT O-26-03

MULTI-HAZARD RISK REPORT FOR CROOK COUNTY, OREGON

INCLUDING THE CITY OF PRINEVILLE AND THE UNINCORPORATED COMMUNITIES OF JUNIPER CANYON AND POWELL BUTTE

by Matt C. Williams[1] and Laura L. Stimely[1,2]



2026

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Cover image: Study area of the Crook County Risk Report. Map depicts Crook County, Oregon and communities included in this report.

WHAT'S IN THIS REPORT?

This report describes the methods and results of a natural hazard risk assessment for communities in Crook County. The results quantify the impacts of natural hazards to each community and enhance the decision-making process in planning for disaster.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAP PLATES

See the digital publication folder for files.

GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

See the digital publication folder for files.
Geodatabase is Esri® version ArcGIS Pro 3.0. Metadata are embedded in the geodatabase and are also provided as separate .xml format files.

Crook_County_Risk_Report_Data.gdb

- **Feature dataset: Asset_Data**
  - feature classes:
    - Building_footprints (polygons)
    - UDF_Hexagons (polygons)
    - Communities (polygons)
    - UDF_points (points)
    - RVS_Points

Crook_County_Depth_Grids.gdb:

- FL_Depth_10
- FL_Depth_50
- FL_Depth_100
- FL_Depth_500

Metadata in .xml file format:

Each dataset listed above has an associated, standalone .xml file containing metadata in the Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata format.

EXECUTIVE SUMMARY

The information presented in this report is intended to increase awareness of natural hazard risk, to support public outreach efforts, and to aid local decision makers in developing comprehensive plans and natural hazard mitigation plans. This study can help emergency managers identify vulnerable critical facilities and develop contingencies in their response plans. The results of this study may be used to help communities identify and prioritize mitigation actions that will improve community resilience.

This report was prepared for communities in Crook County, Oregon, with funding provided by the Federal Emergency Management Agency (FEMA). It describes the methods and results of a natural hazard risk assessment performed in 2024 and 2025 by the Oregon Department of Geology and Mineral Industries (DOGAMI) for Crook County (herein referred to as the study area). The purpose of this project is to provide communities with detailed risk assessment information to enable them to understand and compare hazards on a community-by-community basis and act to reduce their risk. The risk assessment results quantify the consequences of natural hazards to each community by estimating the number of people and buildings at risk and support the decision-making process in planning for disaster. Also included in this study is an inventory of bridges and dams in the county along with their level of risk from natural hazards.

This study includes an update to the Seismic Safety Needs Assessment database developed by DOGAMI in 2007. The original database was compiled through site inspection of critical facilities across the state and assessing them for their seismic vulnerability using FEMA's Rapid Visual Screening methodology. For this study, DOGAMI staff reassessed Crook County's critical facilities and added any new critical facilities that had been built after the initial assessment in 2007.

The authors arrived at these results and conclusions by completing three main tasks: compiling an asset database, identifying and using the best available hazard data, and performing a natural hazard risk assessment. In the first task, the authors created a comprehensive asset database for Crook County by synthesizing assessor data, U.S. Census information, Federal Emergency Management Agency (FEMA) Hazus®-MH general building stock information, and building footprint data. This work resulted in a single dataset of building points and their associated characteristics (e.g., construction materials, number of floors, usage). Using these data, the authors represented accurate spatial locations and vulnerabilities on a building-by-building basis. The study also estimated the number of residents occupying residential structures to approximate the number of people that might be at risk to a given hazard.

The second task was to identify and use the most current and appropriate hazard datasets for the study area. The significant natural/geologic hazards affecting Crook County include flooding, earthquakes, landslides, and wildfires. Most of the hazard datasets used in this report were produced by DOGAMI scientists using peer-reviewed methods and lidar (high-resolution topographic data). Although not all the data sources used in the report provide complete, countywide information, each hazard dataset used was the best available at the time of the analysis. Data sources and coverage are discussed in detail for each hazard in **Section 3.0 Assessment Overview and Results**.

In the third task, the authors analyzed risk using Esri® ArcGIS Desktop® software. The study presents two risk assessment approaches, depending on the nature of the hazard data: (1) estimating building losses (in dollars) for floods and earthquakes using the Hazus methodology and (2) calculating the number of buildings, their value, and associated populations exposed to earthquake, and flood scenarios, or susceptible to varying levels of hazard from landslides and wildfire. Details on recurrence intervals, susceptibility, hazard levels, and other particulars are discussed for each hazard in **Section 3.0 Assessment Overview and Results**.

The findings and conclusions of this report indicate the wide range of potential impacts hazards could have on the communities of Crook County. A Southeast Newberry Fault earthquake scenario is expected to cause slight damage and losses throughout the county, with losses in the region of $53 million (see results summary below). The authors demonstrate the potential for reduction in earthquake damages and losses through seismic retrofits using building code simulations in the Hazus earthquake model. Flooding in Prineville can be expected to cause relatively small amounts of damage to low-lying homes and businesses. Study results estimate ~300 buildings will be affected, with potential losses in the region of $5 million. Notably, 231 structures are elevated above 100-year-flood levels and accordingly are less vulnerable to flood hazards. Analysis of landslide susceptibility demonstrates that areas with moderate to steep slopes or at the base of steep hillsides are at the greatest risk from landslide hazards. Landslides thus have the potential to result in damages totaling ~$180 million; areas of highest risk are in the unincorporated areas surrounding Prineville. Wildfire exposure analysis shows a high risk for buildings in the Wildland Urban Interface (WUI) surrounding Prineville, including 3 of 22 critical facilities. Total losses for wildfire could reach ~$570 milion. The highest potential for population displacement is associated with wildfire hazards (~3,400).

Results were broken out for the following geographic areas:

- Unincorporated Crook County (rural)
- Community of Powell Butte
- Community of Juniper Canyon
- City of Prineville

Selected countywide results are based on a total of 19,978 buildings and total estimated building value of $5 billion; results are summarized below.

- Southeast Newberry Fault Magnitude (Mw) 7.2 earthquake scenario:
  - Red-tagged buildings: 41
  - Yellow-tagged buildings: 215
  - Loss estimate: $53 million
- Landslide exposure (high and very high susceptibility):
  - Number of buildings exposed: 882
  - Value of total number of exposed buildings: $177 million
- 100-year flood scenario:
  - Number of buildings damaged: 302
  - Loss estimate: $5 million
- Wildfire exposure (high burn probability):
  - Number of buildings exposed: 3,103
  - Exposed building value: $573 million

1.0 INTRODUCTION

A **natural hazard** is an environmental phenomenon that can have negative consequences for humans. Where natural hazards have the potential to damage assets or harm people, the result is **natural hazard risk**. **Risk** is defined as the likelihood of occurrence multiplied by consequence (the degree of probability that a loss or injury may occur because of a natural hazard). Additionally, **vulnerability** is defined as the characteristics that make people or assets more susceptible to a natural hazard. A **natural hazard risk assessment** identifies the applicable hazards and analyzes their consequences on the built environment and population, including the cost of recovery. Risk assessments provide key foundational information that can be used to develop mitigation plans, strategies, and actions, so that steps can be taken to prepare for a potential hazard event.

This study presents the results from a multi-hazard risk assessment that evaluates the potential effects on buildings and people in Crook County. It provides a detailed and comprehensive analysis of natural hazard risk and provides a comparative perspective for communities within the study area not previously available. In this report, we describe our assessment results, which quantify the various levels of risk that each hazard presents to Crook County communities.

1.1 Purpose

The purpose of this report is to help communities in Crook County better understand their exposure and risk to a variety of natural hazards. In undertaking such an analysis, the study goal is to provide relevant information to the communities of Crook County, which may be used to increase resilience to a variety of hazards, including earthquakes (including ground shaking, liquefaction, and coseismic landslides), riverine flooding, landslides, and wildfires. This is accomplished by using the best available, most accurate and detailed information about these hazards to assess the number of people and buildings at risk.

The main objectives of this study included the following tasks:

- Compilation of a database of critical facilities, tax assessor data, buildings, and population distribution data
- Incorporation and use of existing data from the most current geologic, hydrologic, and wildfire hazard studies
- Performance of exposure and Hazus–based risk analyses
- Sharing this publication widely (especially to the communities and people of Crook County) so that all interested parties have access to its information and data.

The body of this report describes study methods and results. Depending on the hazard type, the authors used two approaches, Hazus loss estimation and exposure, to assess risk, as described in the **Methods** section. Results for individual communities are detailed in **Appendix A: Community Risk Profiles**. **Appendix B** contains the detailed risk assessment tables used to generate the countywide results and community risk profiles. **Appendix C** contains results of vulnerability assessments for bridges and high hazard dams. **Appendix D** provides additional explanation of the Hazus methodology. **Appendix E** contains acronyms and definitions used throughout the report. **Appendix F** contains tabloid-size maps showing the spatial extent of the hazards, assets, and population across Crook County. These appendices may be helpful in clarifying the summarized results in each hazard section.

1.2 Study Area

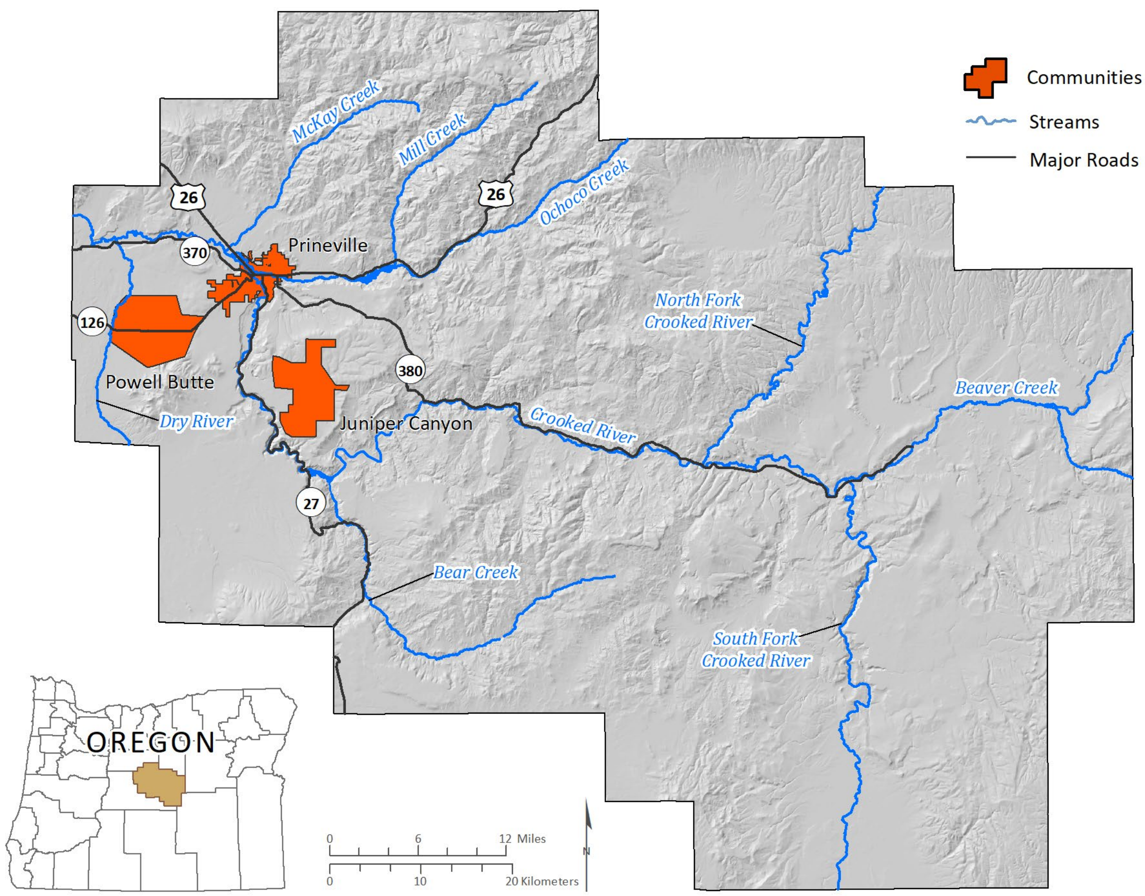
The study area for this project is Crook County, Oregon (**Figure 1-1**). Crook County is located just east of the Cascade Mountains in the geographic center of the state. The county is bordered by Jefferson County and Wheeler County to the north, Grant County to the east, Harney County to the south, and Deschutes County to the west. The total area of Crook County is 2,986 square miles (7,734 square kilometers). Nearly half of the county (49%) is federally owned, with ~20% of the county lying within the Ochoco National Forest.

Crook County is located in the central part of Oregon, situated at a convergence of the High Lava Plains, Blue Mountains, and the Deschutes Columbia Plateau (McClaughry and others, 2009), and is subject to a variety of natural hazards, including earthquakes, riverine flooding, landslides, and wildfires. This region of Oregon includes an urban area that transitions to suburban development in unincorporated parts of the study, but much of the area is sparsely developed. Much of Crook County consists of vast uninhabited areas.

The geography of Crook County consists of a variety of terrains from mountain to high desert plains. The Ochoco Mountains in the northern portion of the county are the source for many of the streams that flow through Crook County, including the Crooked River. Lookout Mountain is the highest point in the county at 6,930 feet (2,112 meters). The southeast portion of the county is composed of the Maury Mountains with its highest point, Drake Butte, at 6,266 feet (1,910 meters). The more densely populated western half of the county is mostly high plains and is primarily composed of farmland and lightly urbanized development.

The population of Crook County is approximately 26,000 people based on an estimated population for each community in 2023 from the [Portland State University (PSU) Population Research Center](). Most people reside in the western half of the county. The City of Prineville, which is the only incorporated city in the county, is the county seat and has a population of over 11,000. The unincorporated communities examined in this study are Juniper Canyon and Powell Butte, whose boundaries were estimated in this study to encompass the concentrations of buildings for each of these communities (**Figure 1-1**).

Figure 1-1. Crook County study area and identified communities evaluated in this study.



1.3 Project Scope

For this risk assessment, the project scope is limited to natural hazards affecting buildings and population because of data availability, the strengths and limitations of the risk assessment methodology, and funding availability. The authors did not directly analyze consequences to the local economy, stored hazardous materials, land values, socially vulnerable populations, infrastructure (e.g., transportation, power, water, gas, communication, sewage), or the natural environment. Depending on the natural hazard, the authors used either loss estimation or exposure. Loss estimation was modeled using Hazus®-MH (FEMA, 2022a, 2022b, 2022c), a tool developed by FEMA for calculating damage to buildings from floods and earthquakes. Exposure is a simpler approach, in which buildings are categorized based on their location relative to various hazard zones. Differences between loss estimation and exposure methods are described in **Section 2.0** of the report. City and county population numbers from the PSU data were used to distribute people into residential structures based on square footage.

A critical component of this risk assessment is a countywide building inventory developed from building footprint data and the Crook County tax assessor database (acquired in 2024). The other key components are datasets representing the best available science for a variety of natural hazards. The geologic hazard scenarios were selected by DOGAMI staff based on their expert knowledge of the area and the available hazard data. In addition to geologic hazards, wildfire hazard is also included in this risk assessment. The following summarizes the hazards considered in this study and what risk assessment methodologies were applied.

Table 1-1. Hazards examined in this study and the methodology by which they were assessed.

Hazard	Methodology	Data source
Earthquake – Shaking	Hazus loss estimation using a hypothetical Southeast Newberry Fault Mw 7.2 scenario	USGS (Personius, 2016), accessed via the Hazus fault database
Earthquake – Coseismic landslides	Buildings assigned to one of seven susceptibility (wet) classes (low to high)	DOGAMI (Madin and others, 2021)
Earthquake – Liquefaction	Buildings assigned to one of five susceptibility classes (low to high)	DOGAMI (Madin and others, 2021)
Earthquake – Soil amplification	Buildings assigned to NEHRP soil/rock classes A–F	DOGAMI (Madin and others, 2021)
Flood	Hazus loss estimation using FEMA flood-depth grids (10-, 50-, 100-, and 500-year recurrence intervals)	DOGAMI, derived from FEMA (2012)
Landslide	Building exposure based on Landslide Susceptibility Zones (low, moderate, high, very high)	DOGAMI (Burns and others, 2016)
Wildfire	Building exposure based on Burn Probability (low, moderate, high)	PSU and Pyrologix (McEvoy and others, 2023)

1.4 Previous Studies

The authors are aware of one previous risk assessment for Crook County. Wang (1998) used Hazus to estimate the impacts from a Mw 8.5 Cascadia Subduction Zone (CSZ) earthquake and 500-year probabilistic earthquake scenarios for the entire state of Oregon. The results of the Wang (1998) study were arranged into individual counties. Crook County was estimated to experience <1% loss ratio in both scenarios due to the low levels of shaking estimated for Crook County. Wang (1998) utilized a much lower level of detailed building information and site-specific earthquake hazard inputs. Because of these differences, comparative analysis was not beneficial to the scope of this project.

While not a risk assessment, Madin and Burns (2013) conducted a statewide evaluation of the impacts of a CSZ event, estimated vulnerabilities to earthquake hazards, and recommended policies to address vulnerabilities. The results of the study confirmed the findings of Wang (1998). The key finding of the report relevant to the risk assessment of Crook County was that the effects of an earthquake generated by a CSZ event would have few direct impacts on the buildings and people of Crook County.

2.0 METHODS

Where natural hazards have the potential to damage assets or harm people, the result is **natural hazard risk**. This study used a quantitative approach through two modes of analysis, Hazus loss estimation and exposure, to assess the level of risk to assets and people using building value ($) and displaced population, respectively. **Loss estimation** is defined as damage in terms of value that occurs to a building in an earthquake or flood scenario, as modeled with Hazus methodology. This is measured as the cost to repair or replace the damaged building in US dollars. Additionally, **loss ratio** is defined as the percentage of estimate loss relative to the total value.

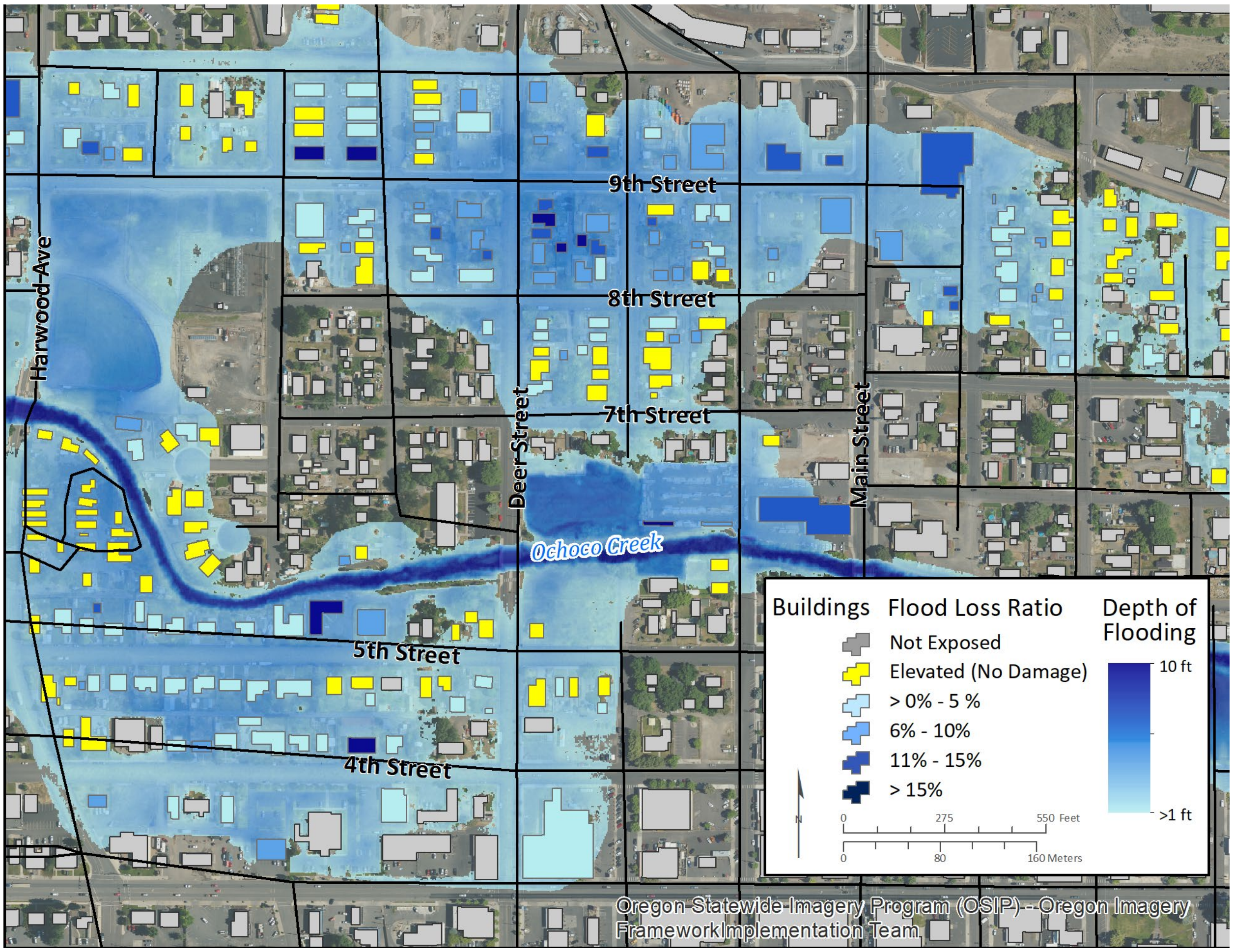
2.1 Hazus Loss Estimation

This study used Hazus version 6.0 (FEMA, 2022a), which was the latest version available when the authors began this risk assessment. According to FEMA (FEMA, 2022a, p. 1-1), "The Hazus Loss Estimation Methodology provides state, local, tribal, and territorial officials with a decision-support software for estimating potential losses from four natural hazards: floods, hurricanes, earthquakes, and tsunamis. This loss estimation capability enables users to anticipate the consequences of natural hazard events and develop plans and strategies for reducing risk…. The use of this standardized methodology provides nationally comparable estimates that allow the federal government to plan natural hazard responses and guide the allocation of resources to stimulate risk mitigation efforts."

Hazus can be used in different modes depending on the level of detail required. Given the high spatial precision of the building inventory data and quality of the natural hazard data available for this study, the authors chose the user-defined facility (UDF) mode. This mode makes loss estimations for individual buildings relative to their cost, which is then aggregated to the community level to report loss ratios. Costs used in this mode are associated with rebuilding using new materials, also known as replacement cost. Replacement cost is determined using a method called RSMeans valuation (Charest, 2017) and is calculated by multiplying the building area (in square feet) by a standard cost per square foot. These standard rates per square foot are in tables within the default Hazus database.

Damage functions are at the core of Hazus. The damage functions stored within the Hazus data model were developed and calibrated from the observed results of past disasters. In this study, damage and loss were estimated by intersecting building locations with natural hazard layers and applying damage functions based on the hazard severity (e.g., depth of flooding) and building characteristics (e.g., first floor height). **Figure 2-1** illustrates the range of building loss estimates from a Hazus flood analysis. In this example, most buildings within the 100-year flood zone are estimated to experience losses ranging from 3 to 6%. Buildings with a first-floor height above the level of flooding and those outside the flood zone are expected to experience no losses. We perform both Hazus and exposure analyses for the 100-year flood hazard scenario to allow for a broader perspective of the flood risk.

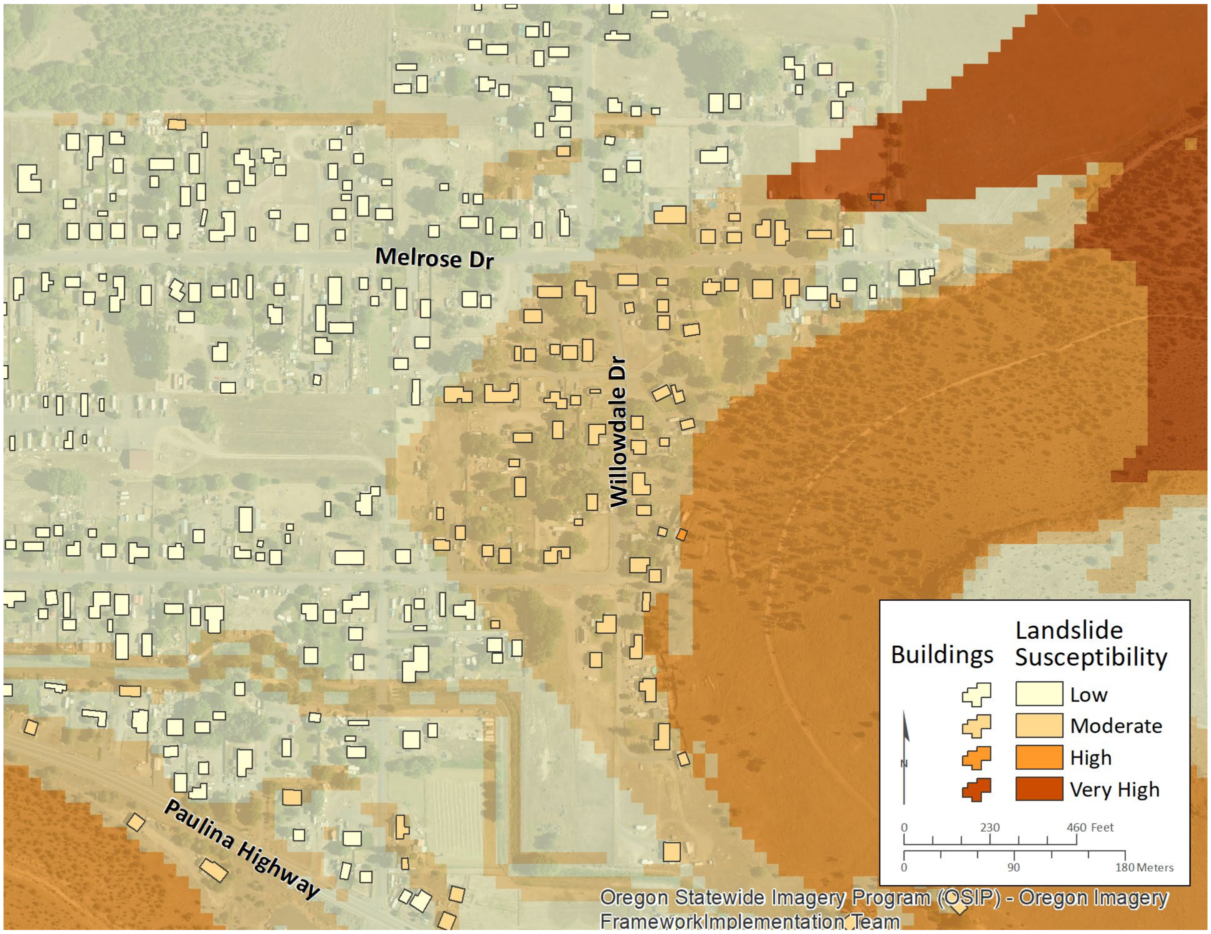
Figure 2-1. 100-year flood zone and building loss estimates example in Prineville, Oregon. The depth grid is derived from the effective FEMA Flood Insurance Rate Map (2012) data for Crook County.



2.2 Exposure

Since loss estimation using Hazus is not available for all types of natural hazards, this study used exposure analysis to assess landslide and wildfire risk. Here, **exposure** is whether a building is within or outside of a hazard zone (without modeling of loss estimation). Exposure methodology identifies the buildings and population that are within a particular natural hazard zone. This is an alternative to the more detailed loss estimation method for those natural hazards that do not have available damage models like Hazus. It provides a way to easily quantify what is and is not threatened. Exposure results are communicated in terms of total building value exposed, rather than a loss estimate, where **building value** is the total monetary value of a building within the context of exposure. For example, **Figure 2-2** shows buildings that are exposed to different levels of landslide susceptibility, with building footprints colored based on what susceptibility zone the center of the building is within.

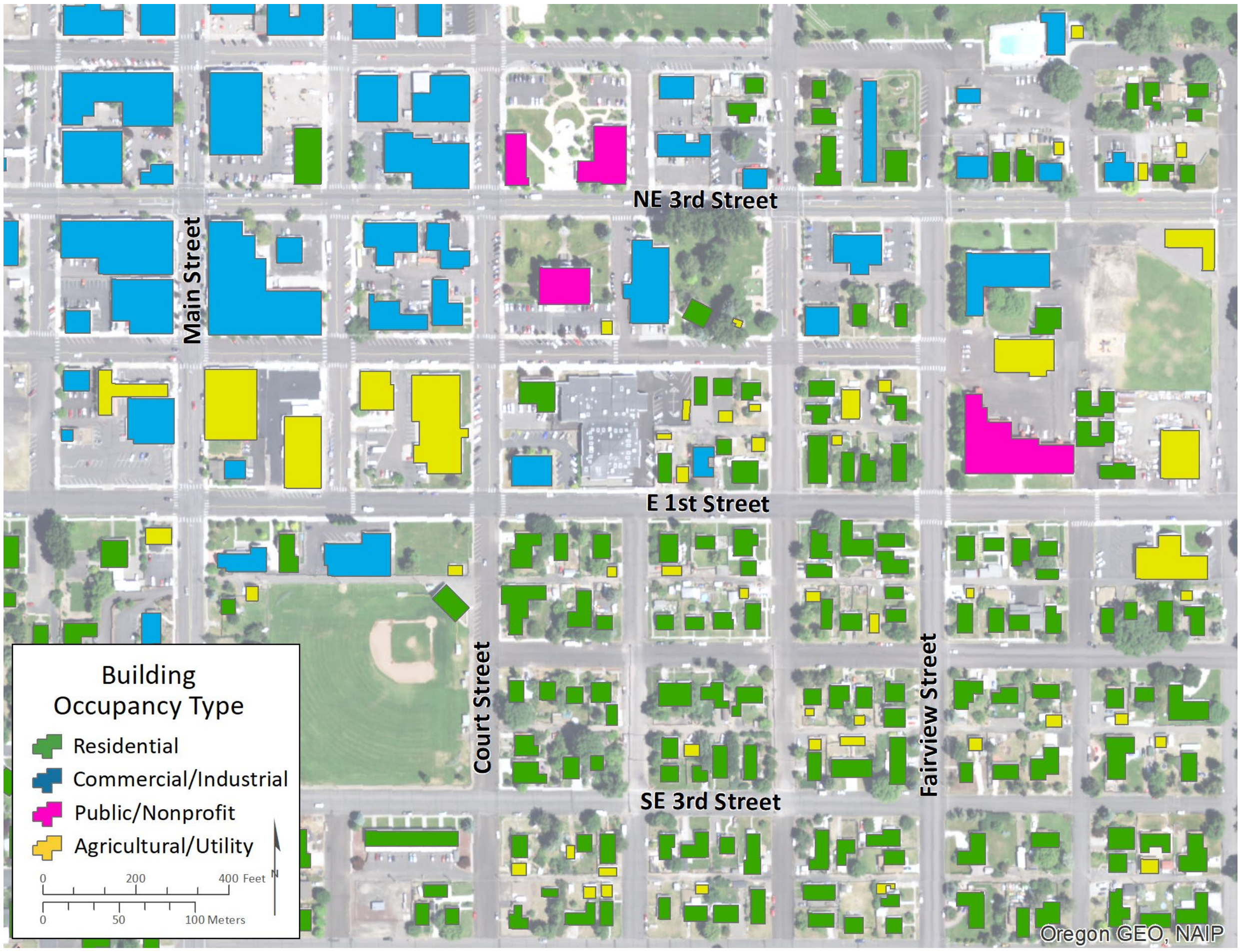
Figure 2-2. Landslide susceptibility and building exposure example in Prineville, Oregon (Burns and others, 2016).



2.3 Building Inventory

A key piece of the risk assessment is the countywide building inventory. This inventory consists of all buildings larger than 100 square feet (9.3 square meters), as determined from existing building footprints (Williams, 2021). **Figure 2-3** shows an example of building inventory occupancy types used in this study; see also **Appendix B: Table B-1.**

Figure 2-3. Building occupancy types, City of Prineville, Oregon.



To use the building inventory within Hazus, the authors converted the building footprint polygons to points and migrated them into a UDF database with standardized field names and attribute domains. The UDF database formatting allows for application of the correct damage function to each building. Hazus version 5.1 technical manuals (FEMA, 2022a, b, c) provide references for acceptable field names, field types, and attributes. The fields and attributes used in the UDF database (including building seismic codes) are discussed in more detail in **Appendix D.2.2**.

The number of buildings and total building value per community varies significantly in Crook County, with 1,307 buildings and $285 million for Juniper Canyon, to 5,290 buildings and $2.3 billion for Prineville (**Table 2-1**). A table detailing the occupancy class distribution by community is included in **Appendix B: Detailed Risk Assessment Tables**.

Table 2-1. Crook County building inventory.

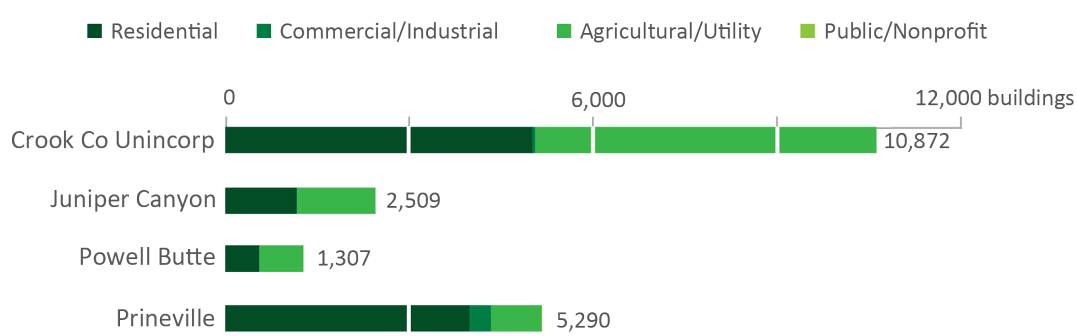
Community	Total Number of Buildings	Percentage of Total Buildings	Estimated Total Building Value ($)	Percentage of Total Building Value
Unincorporated Crook County (rural)	10,872	54%	2,172,583,000	43%
Juniper Canyon*	2,509	13%	330,657,000	7%
Powell Butte*	1,307	7%	285,473,000	6%
Total Unincorporated Crook County	**14,688**	**74%**	**2,788,713,000**	**55%**
Prineville	5,290	27%	2,281,832,000	45%
Total Study Area	**19,978**	**100%**	**5,070,545,000**	**100%**

*Unincorporated communities

The building inventory was developed from the Statewide Building Footprints for Oregon, release 1 (SBFO-1; Williams, 2021). The building footprints provide a location and 2D outline of each structure. There is a total of 19,978 buildings within the study area. This study defines buildings as permanent structures with walls and a roof that can be occupied by people (Williams, 2021). Other structures, such as dams, water tanks/towers, sewage and water treatment tanks, tents, small garden sheds, hoop-houses or other plastic-covered greenhouses, and grain silos, were not considered buildings and were not included in this analysis.

The Crook County Assessment Office supplied assessor data that was then formatted for use in this study. The assessor data contains an array of information about each improvement (i.e., building). Tax lot data, which contains property boundaries and other information regarding the property, was also obtained from the county assessor and was used to link the buildings with assessor data. The linkage between the two datasets resulted in a database of UDF points that contain attributes for each building. These points are used in the risk assessment for both loss estimation and analyses. The community of Prineville has the largest concentration of buildings (5,290) in Crook County; 4,086 are residential structures (**Figure 2-4**). Unincorporated Crook County contains 10,872 buildings, as can be seen in **Figure 2-4**.

Figure 2-4. **Community building value in Crook County by occupancy class.**



Some buildings are defined as critical facilities because they function in support of public safety, disaster recovery, relief efforts, and other emergency operations before, during, and after a natural disaster. Typical critical facilities include hospitals, schools, fire stations, police stations, emergency operations, and military facilities. Other critical infrastructure considered in this study includes public works and water treatment facilities. Identifying characteristics are embedded into the critical facilities in the UDF database so they could be highlighted in the results. Critical facilities data came from the DOGAMI Statewide Seismic Needs Assessment (SSNA; Lewis, 2007). The authors updated the SSNA data through coordination with Crook County officials. Communities that have critical facilities that can function during and immediately after a natural disaster are more resilient than those with critical facilities that are inoperable after a disaster. Critical facilities are present throughout the county with most in Prineville (**Table 2-2** and **Table 2-3**). Critical facilities are listed for each community in **Appendix A**.

Table 2-2. Crook County critical facilities inventory by building count.

Community	Hospitals & Clinics	Schools	Police/Fire Depts.	Emergency Services*	Military	Other†	Total
Unincorporated Crook County (rural)	0	1	2	0	0	0	3
Juniper Canyon	0	0	1	0	0	0	1
Powell Butte	0	1	0	0	0	0	1
Total Unincorporated County	**0**	**2**	**3**	**0**	**0**	**0**	**5**
Prineville	1	7	5	2	0	4	17
Total Study Area	**1**	**9**	**8**	**2**	**0**	**4**	**22**

*Emergency services in Prineville are located within the Prineville Police Department building and in the Crook County Sheriff's Office. The count of these critical facilities is not included in the total.

†Category includes buildings that are not traditional (emergency response) critical facilities but considered critical during an emergency based on input from local stakeholders (e.g., water treatment facilities or airports).

Table 2-3. Crook County critical facilities inventory by value (in thousands of dollars).

Community	Hospital & Clinic	School	Police/Fire Depts.	Emergency Services*	Military	Other†	Total
Unincorporated Crook County (rural)	0	2,162	1,583	0	0	0	3,745
Juniper Canyon	0	0	888	0	0	0	888
Powell Butte	0	24,847	0	0	0	0	24,847
Total Unincorporated County	0	27,008	2,471	0	0	0	29,479
Prineville	2,927	128,567	9,995	1,846	0	9,760	151,249
Total Study Area	2,927	155,575	12,466	1,846	0	9,760	180,728

*Emergency services in Prineville are located within the Prineville Police Department building and in the Crook County Sheriff's Office. The value of these critical facilities is not included in the total.

†Category includes buildings that are not traditional (emergency response) critical facilities but considered critical during an emergency based on input from local stakeholders (e.g., water treatment facilities or airports).

2.4 Rapid Visual Screening

Rapid visual screening (RVS) is FEMA's procedure of identifying and assessing buildings for their potential vulnerability from seismic hazard. The methods of RVS were first published in FEMA 154 (FEMA,

1988) and since then these methods have been implemented throughout the United States for building evaluation. Two updates have subsequentially been published (FEMA, 2002; FEMA, 2015) as architectural methods and building technologies have improved vulnerabilities from seismic hazard.

RVS uses a walk-around assessment that does not require detailed calculations or invasive inspections and is supported by checklists and scoring forms to identify key building characteristics, including construction type, structural irregularities, age, and observed damage. The outcome is a numerical score that helps classify buildings based on expected seismic risk. Communities use RVS results to prioritize more detailed engineering evaluations, guide mitigation planning, and support emergency preparedness.

In 2005, the Oregon Legislature via Senate Bill 2 directed DOGAMI to develop a statewide seismic needs assessment (SNNA) that included RVS seismic safety surveys of certain categories of critical facilities. These building type categories include:

- K-12 public school buildings
- Community college buildings that have a capacity of 250 or more persons
- Hospital buildings with acute inpatient care facilities
- Police and fire stations
- Sheriffs' offices and other law enforcement buildings.

DOGAMI developed an enhanced RVS scoring method (E-RVS) that refined soil/rock modifiers and seismicity zone designations. For each assessment, the authors used a Low-Very High scoring scale for non-technical stakeholders (**Table 2-4**).

DOGAMI's 2007 SNNA assessed 3,349 of Oregon's critical facilities (Lewis, 2007). Each building was assigned to one of four risk categories based on its RVS score: Low, Moderate, High, and Very High potential for collapse in a major earthquake (**Table 2-4**). Based on vulnerability estimates determined through the RVS assessment, buildings with higher risk could be flagged for more detailed engineering study or retrofitting, the modification of existing structures to make them more resistant to seismic activity. Retrofitted buildings were typically observed during the field visit, but DOGAMI may have potentially missed seismic upgrades.

Table 2-4. RVS scoring categories.

Category	RVS Score Range	Collapse Potential
Low	≥2.0	<1%
Moderate	2.0–1.0	>1%
High	1.0–0	>10%
Very High	<0	100%

In the summer of 2025, DOGAMI staff resurveyed all 30 of the original 2007 SSNA buildings in Crook County, as well as 10 additional critical facilities that could be categorized as one of the above RVS building types. Critical facilities listed below each community in **Appendix A** include additional critical facilities that were not one of the RVS building types (e.g., public works). The RVS results can be found in **Appendix C: Vulnerability Assessment of Lifelines**. The assessment conducted by Lewis in 2007 used methods outlined in Wang and Goettel (2007), which were also used in this study. Buildings that were still in use and had no noticeable changes that would affect the RVS score were verified in the field and retained their RVS score from the 2007 survey. Previously mapped buildings were surveyed for changes, such as seismic retrofits, so that an updated RVS score could be calculated. Buildings constructed after the 2007 survey were scored and assessed based on DOGAMI's E-RVS scoring system.

Through Business Oregon's Seismic Rehabilitation Grant Program (Business Oregon, 2024), Crook County was able to secure funding to seismically upgrade their two fire and rescue buildings in 2024. This improved their original RVS vulnerability scores from -0.1 (Very High) to 1.1 (Moderate), significantly lowering their risk from earthquake hazard.

Five school buildings were surveyed in 2007, all of which are still considered to be in the Very High category of collapse potential. These buildings were resurveyed in 2025 and no seismic retrofits were observed, although it is possible that retrofits may have occurred. Four of the buildings were built prior to 1950 and all five buildings were built in highly reactive soil. These factors contribute greatly to the Very High category designation.

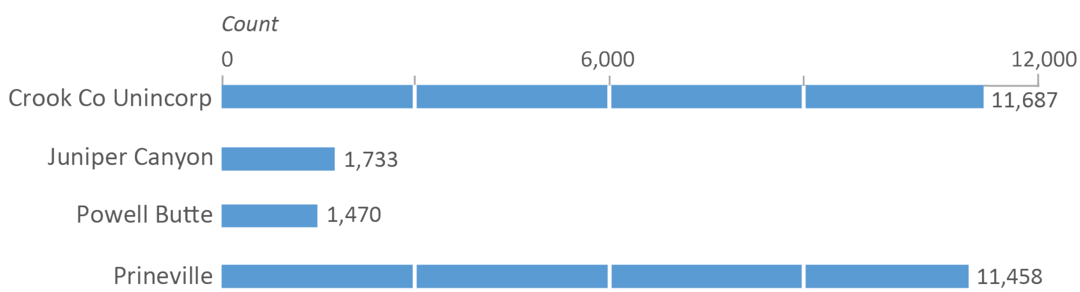
The main benefit from RVS assessments is that it is a resource for stakeholders to prioritize which buildings need detailed evaluation from a structural engineer. This evaluation can be a first step in obtaining seismic retrofit funding. This work is also a very cost-effective way to support emergency planning and policy decisions.

2.5 Population

One purpose of the UDF database design was to estimate the number of people at risk from natural hazards. Within the UDF database, the PSU Population Research Center estimates of permanent residents were distributed proportionally among residential buildings based on building area. Estimates for every incorporated community, as well as the entire county, were available from the PSU data (**Figure 2-5**). The authors did not examine the impacts of natural hazards on nonpermanent populations (e.g., tourists), whose total numbers fluctuate seasonally. Due to lack of information within the assessor and census databases, the authors could not distinguish between vacation homes and primary residences. Therefore, the study method distributes some of the permanent residents into possible vacation homes.

From the PSU Population Research Center data, the authors assessed the risk of the 26,347 residents within the study area. For each natural hazard, except for the earthquake scenarios, a simple exposure analysis was used to find the number of potentially displaced residents within a hazard zone. For the earthquake scenarios, the number of potentially displaced residents was based on residents in buildings estimated to be significantly damaged by the earthquake.

Figure 2-5. Population by Crook County community. The total population of Crook County is 26,347.



3.0 ASSESSMENT OVERVIEW AND RESULTS

This risk assessment considered four natural hazards (earthquake, flood, landslide, and wildfire) that pose a risk to Crook County. The assessment describes both localized vulnerabilities and the widespread challenges that affect all communities. While results of this risk assessment do not typically represent singular hazard events, they do quantify the potential overall level of risk for assets and residents. The loss estimation and exposure results, as well as the rich dataset and map plates included with this publication, can lead to a greater understanding of the potential consequences of natural disasters affecting Crook County and its communities.

In this section, results are presented for the entire study area. Individual community results are in **Appendix A: Community Risk Profiles.**

3.1 Earthquakes

An **earthquake** is a sudden movement of rock along a fault in the earth's crust, which abruptly releases strain that has accumulated over time. This movement produces waves of shaking that spread in all directions. If an earthquake occurs near populated areas, it may cause casualties, economic disruption, and extensive property damage (Madin and Burns, 2013).

Two earthquake-induced hazards are liquefaction and landslides. **Liquefaction** occurs when 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 (Kramer, 1996). **Coseismic landslides** are mass movement of rock, debris, or soil induced by ground shaking. Both hazards are factors only in locations where seismic risk exists. All earthquake losses in this report include damage derived from shaking, as well as liquefaction and landslide factors.

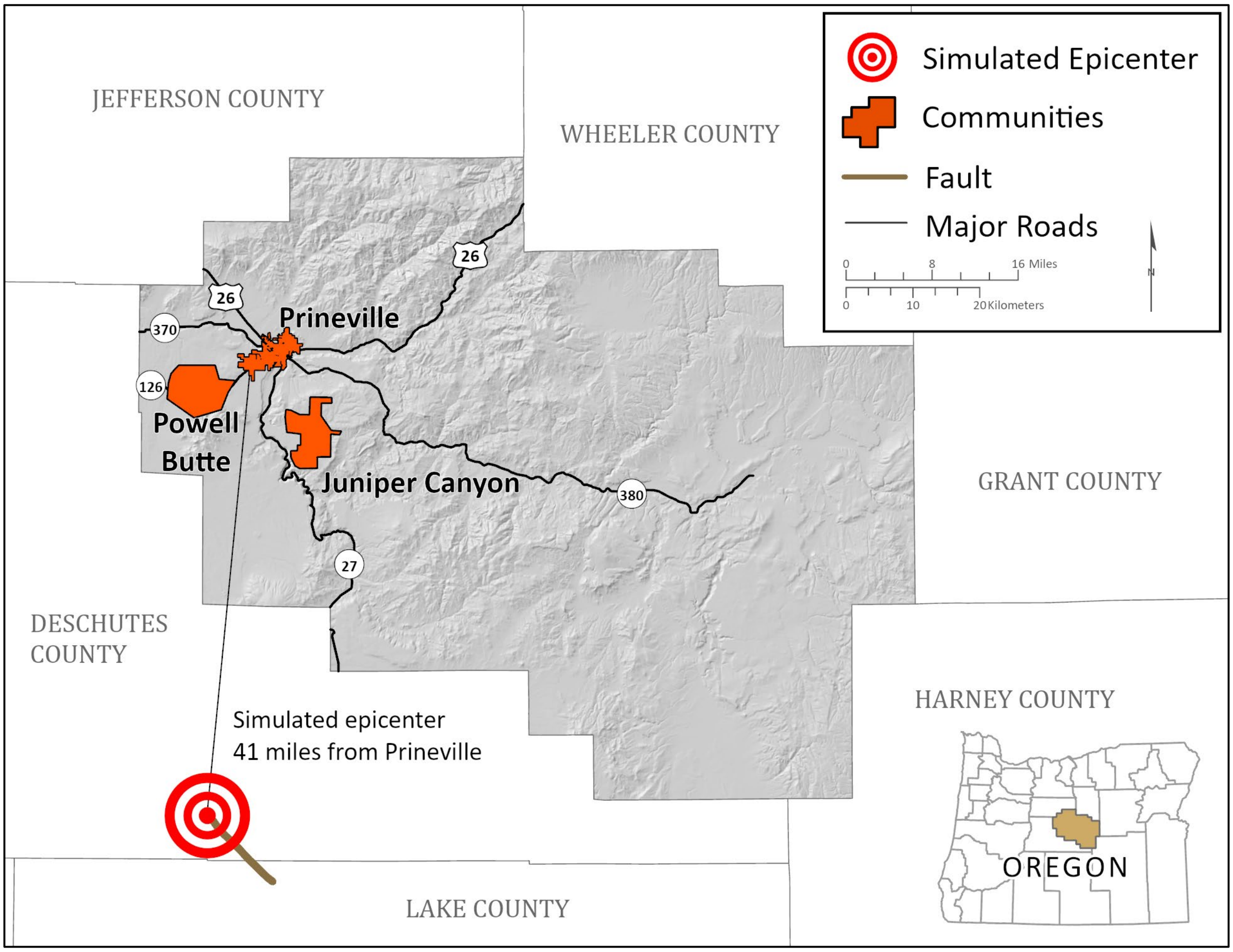
Central Oregon is a relatively inactive area seismically, with very few historical quakes. Most of the earthquake activity in the area has occurred to the south in the Klamath Falls area and to the north in Milton-Freewater. Like the Southeast Newberry Fault (the scenario simulated in this report), a few active faults near Crook County have the capacity to produce shaking at damaging levels, but they are too far away from people and development to pose a significant risk. An earthquake on the Cascadia Subduction Zone is not expected to cause damage in Crook County because it is too far away (Madin and others, 2021). However, because a CSZ earthquake will cause significant disruptions for every community and lifeline west of the Cascades, such an earthquake will likely have a cascading effect on life in Crook County (e.g. availability of fuel, food, other supplies), particularly, if a large number of residents in western Oregon are temporarily relocated to eastern Oregon.

3.1.1 Southeast Newberry Fault Mw 7.2 Scenario

Unlike the CSZ, which is a tectonic plate boundary system and a source of very large earthquakes, crustal faults are the result of planar fractures within a single tectonic plate (i.e., intraplate). When blocks of crustal rock are displaced relative to one another, the released energy manifests as shaking spread over an area proportional to the earthquake rupture. Despite their comparatively small size, crustal earthquakes can cause significant damage due to their proximity to the surface and the built environment, particularly if the earthquake rupture is shallow.

The scenario examined for this report is an earthquake focused on the Quaternary Southeast Newberry Fault (**Figure 3-1**), which is a shallow crustal fault. This northwest-trending crustal fault is located approximately 40 miles (64 kilometers) south of Prineville and is mapped for 36 miles (58 kilometers). It has an estimated average slip rate between 0.008 and 0.004 in/yr (0.2 and 1.0 mm/yr) (Personius, 2016, and citations therein). The estimated maximum fault displacement for the Southeast Newberry Fault could produce relatively large (Mw 7.2) earthquakes, enough to pose a significant hazard to the nearby city of Prineville (Personius, 2016). The current understanding of this fault and various aspects of its frequency and magnitude is limited. However, it is included in this analysis to portray the possible damage and losses that could arise from such an earthquake near a major population center like Prineville.

Figure 3-1. Southeast Newberry Fault and simulated epicenter location.



3.1.1.1 Data Sources

The Mw 7.2 Southeast Newberry Fault deterministic scenario was selected as the most appropriate for assessing earthquake risk for Crook County. This determination resulted from interpretation of the USGS disaggregation tool, which identifies the most damaging earthquake scenario based on location. This tool suggested that the Southeast Newberry Fault is the largest earthquake threat to the population centers in Crook County, the likelihood that this fault will affect the county is very low. Although the default Hazus faults database does not contain this fault, Hazus allows for custom earthquake scenarios. The parameters necessary for a custom scenario were sourced from the USGS Quaternary Fault and Fold Database. The epicenter was manually selected and was located at the closest proximity to the majority of buildings within the study area.

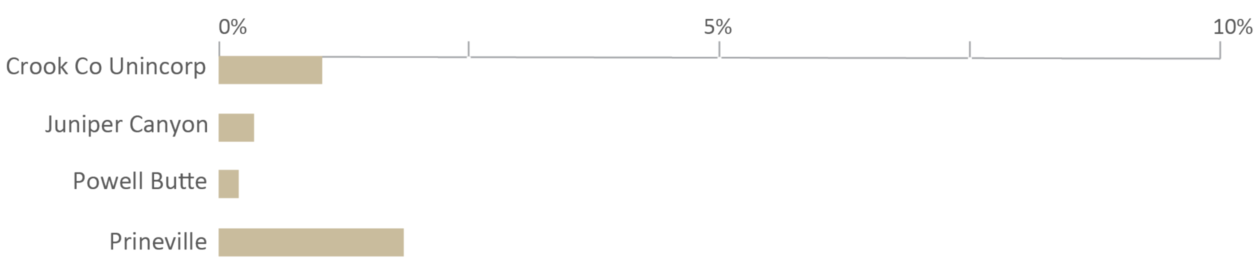
The following hazard layers were used for loss estimation (Madin and others, 2021): NEHRP soil classification, landslide susceptibility (wet), and liquefaction susceptibility. The liquefaction and landslide susceptibility layers were used in the Hazus tool to calculate the probability and magnitude of permanent ground deformation caused by these factors. Hazus uses a characteristic magnitude value to calculate the impacts of liquefaction and landslides. For this study, we followed the details provided in the default Hazus database and used Mw 7.2.

3.1.1.2 Countywide Results

Light shaking produced from a hypothetical Southeast Newberry Fault Mw 7.2 earthquake will occur for nearly all buildings in Crook County. Hazus loss estimates (see **Table B-2**) for each building are based on a formula where coefficients of damage contribution 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 total building replacement value to obtain a loss estimate (FEMA, 2022b). Loss ratio estimates from a Southeast Newberry Fault earthquake scenario are presented in **Figure 3-2**.

In keeping with earthquake-damage reporting conventions, this study used the Applied Technology Council (ATC)-20 post-earthquake building safety evaluation color-tagging system to represent damage states (Applied Technology Council, 2015). Red-tagged buildings correspond to a Hazus 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 red- or yellow-tagged buildings reported for each community is based on an aggregation of the probabilities for individual buildings (FEMA, 2022b).

Figure 3-2. Southeast Newberry Fault Mw 7.2 earthquake loss ratio by Crook County community.



Critical facilities were considered nonfunctioning if the Hazus earthquake analysis showed that a building, or complex of buildings, had a greater than 50% chance of being at least moderately damaged (FEMA, 2022b). Because building-specific information is more readily available for critical facilities and because of their importance after a disaster, the results for these buildings are reported individually.

The number of potentially displaced residents from our Southeast Newberry Fault earthquake scenario was based on the formula (FEMA, 2022b):

$$([\text{number of occupants}] \times [\text{probability of complete damage}]) + (0.9 \times [\text{number of occupants}] \times [\text{probability of extensive damage}])$$

The results indicate that Crook County could incur slight losses (1.1%) due to a Southeast Newberry Fault earthquake (**Figure 3-2**); communities in Crook County can expect approximately 0.5% to 1.5% damage (**Figure 3-3**). None of the Crook County communities are estimated to experience a large amount of damage from this earthquake scenario. The small amount of damage estimated by Hazus is primarily damaged due to the liquefiable soils that are present in parts of Prineville (**Appendix F: Plate 4**). These seismically reactive soils are present in the floodplains of the large rivers in the study area.

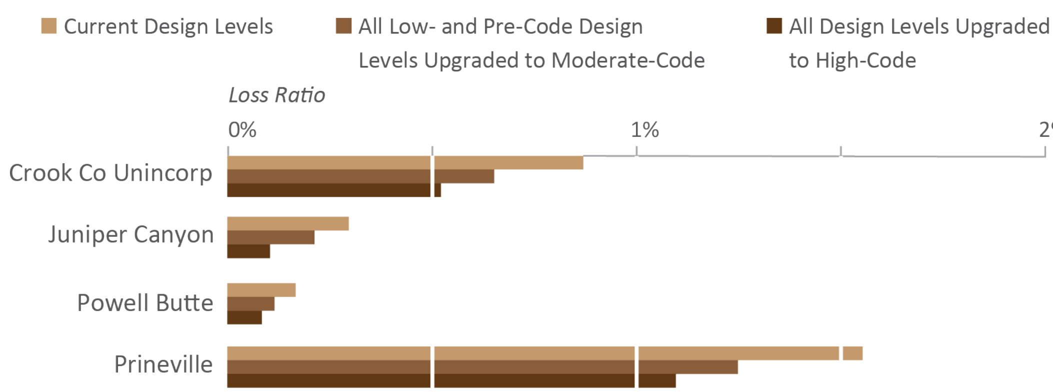
The following summarizes the results of the Crook County Southeast Newberry Fault Mw 7.2 earthquake scenario:

- Number of red-tagged buildings: 41
- Number of yellow-tagged buildings: 215
- Loss estimate: $53,462,000
- Loss ratio: 1.1%
- Non-functioning critical facilities: 0 of 22
- Potentially displaced population: 397

Building vulnerabilities, such as the age of the building stock and certain construction types (e.g., manufactured homes, unreinforced masonry), are also contributing factors in loss estimates. The first seismic building codes were implemented in Oregon in the 1970s (Judson, 2012) and by the 1990s, better seismic building codes were being enforced and continued to be improved. Nearly 55% of Crook County's buildings were built before the 1990s. While the communities of Crook County have low levels of risk from earthquakes, some parts of Prineville are composed of older buildings and are more vulnerable to shaking caused by an earthquake.

Seismic retrofitting is the structural modification of a building to improve its resilience to earthquakes. In Hazus, **design level** refers to the quality of a building's seismic building code: Pre, Low, Moderate, and High (refer to **Appendix D.2.3** for more information.) If pre- and low-code buildings could be seismically retrofitted to higher code standards, earthquake risk would be reduced. In this study, a simulation in Hazus earthquake analysis shows that loss ratios drop from 1.1% to 0.8%, when all Pre- and Low-Code buildings are upgraded to at least Moderate-Code level. The further upgrade to High-Code standards produced negligible improvement to the loss ratio (**Figure 3-3**). While retrofits can decrease earthquake vulnerability, for areas of high landslide or liquefaction susceptibility, additional geotechnical mitigation may be necessary to significantly influence losses (**Figure 3-3**).

Figure 3-3. Southeast Newberry Fault loss ratio in Crook County, with simulated seismic building code upgrades.

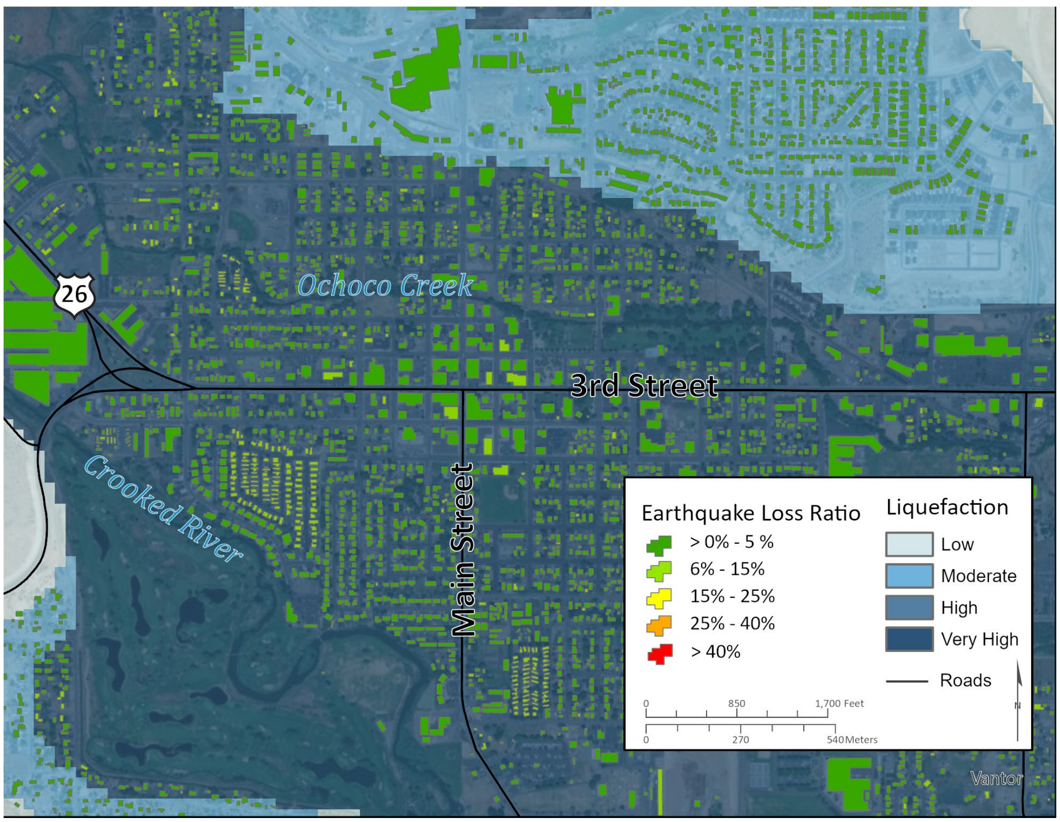


3.1.1.3 Areas of Significant Risk

Certain locations within the study area are at comparatively higher risk to earthquake hazard:

- Highly liquefiable soils deposited by the Crooked River and Ochoco Creek in the central portion of Prineville will increase the likelihood of damage in that area from an earthquake produced from the Southeast Newberry Fault (**Figure 3-4**).
- A sparsely spaced development in the southeastern part of Crook County is estimated to be more likely to experience damage from a Southeast Newberry Fault earthquake due to the proximity to the simulated epicenter used in this report.
- None of the 22 critical facilities in the study area are impacted by the Southeast Newberry Fault earthquake simulated in this study.

Figure 3-4. Central Prineville liquefaction soils.



3.2 Flooding

In its most basic form, a **flood** is an accumulation of water over normally dry areas, typically due to excessive rain or snowmelt or a combination of both (e.g., rain on snow). Floods become hazardous to people and property when they inundate an area where development has occurred, and can potentially result in very significant losses, including the displacement of people. The frequency and severity of flooding may change over time due to changes in land use (e.g., development, watershed management), as well as natural phenomena such as precipitation patterns and changes in climate. Flood hazards can be mitigated by elevating structures above the expected level of flooding, removing structures through FEMA's property acquisition (buyout) program, or land use planning that considers risk from flooding.

This study provides the current understanding of flood hazard and flood risk, but flood models and risk assessments will need to be updated with changing conditions.

Floods are a common hazard in Crook County and have the potential to create public health hazards and safety concerns, close and damage major highways, destroy railways, damage structures, and cause major economic disruption. Floods associated with rare events like flash flooding, ice jams, post-wildfire floods, and inundation due to a dam breach were not examined in this report.

A typical method for determining flood risk is to identify the probability that a given size of flood will occur and the impacts of such a flood, primarily inundation extents and depth. The annual probabilities calculated for flood hazard used in this report are 10%, 2%, 1%, and 0.2%, henceforth referred to as 10-year, 50-year, 100-year, and 500-year scenarios, respectively. The ability to assess the probability of a flood occurring and the level of accuracy of that assessment are influenced by modeling advancements, better understanding of hydrologic factors, and longer periods of record for the stream or water body in question.

The major rivers and creeks within the county are the Crooked River and the North Fork and South Fork Crooked Rivers, and Beaver, Bear, Ochoco, Mill, and McKay Creeks. In addition, several tributaries to these major streams have mapped flood zones. All the mapped streams are subject to flooding and can cause damage to buildings in the floodplain.

Damaging floods from the Crooked River and Ochoco Creek have occurred in Crook County in the past. The largest of these floods occurred in 1890 on the Crooked River, but instead of a single flood event it was a series of floods that occurred in late winter/early spring (January to May). Floods also occurred in 1894, 1897, 1901, 1904, and 1998 (FEMA, 2012). A stream gage was installed in the Crooked River in 1909, which provided data regarding the natural hydrological regime of the river (FEMA, 2012). Ochoco Creek also has a history of flooding, but since no stream gage has been installed, those levels can only be estimated. With the construction of dams on the Crooked River and Ochoco Creek, flooding has been greatly reduced (FEMA, 2012). Dams are discussed in more detail in **Section 3.2.5**.

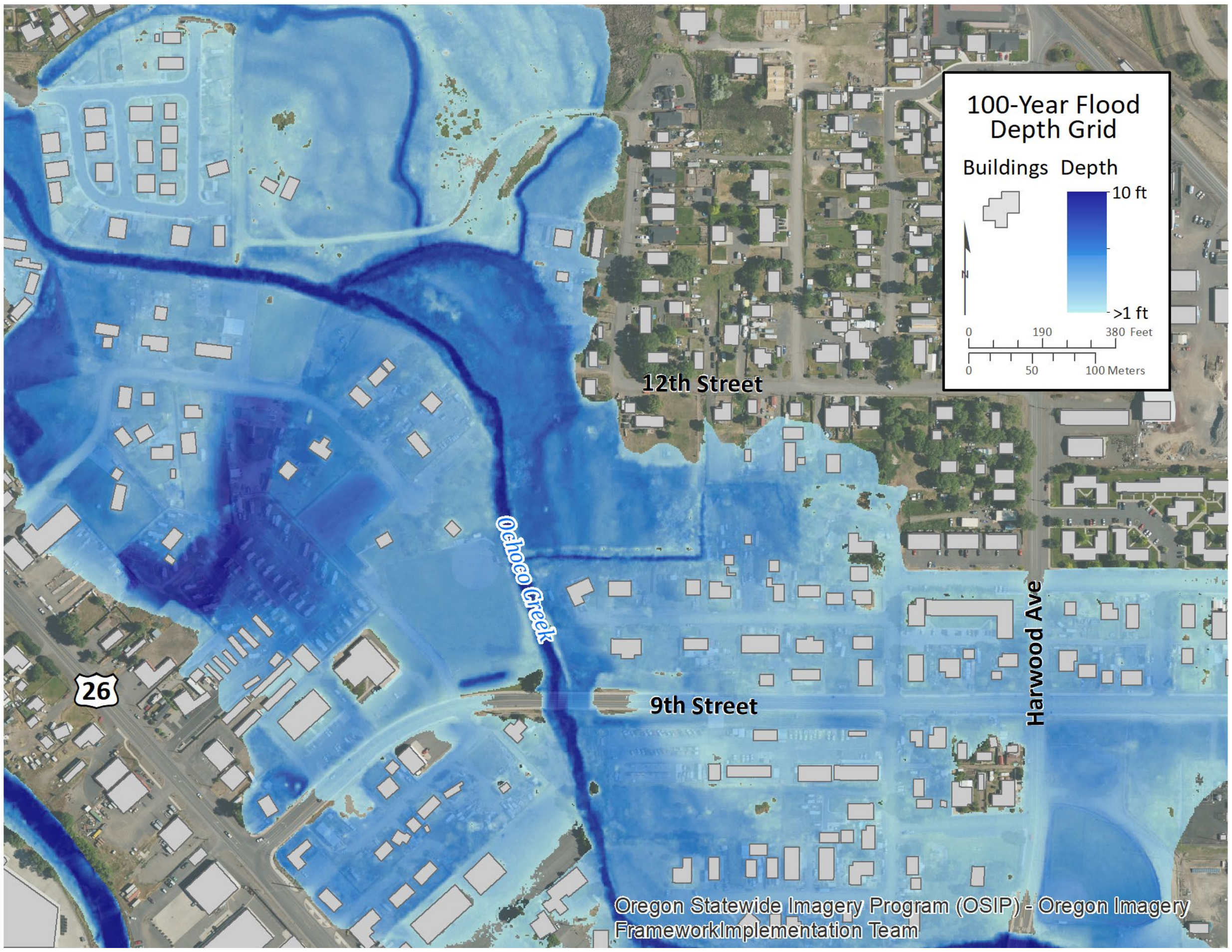
Floods in early 2025 from the Crooked River and Ochoco Creek closed portions of Paulina Highway east of Prineville. Several ranches in the area were impacted by the floodwaters, primarily due to damage caused by erosion (Enebrad, 2025).

3.2.1 Data Sources

The Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for Crook County were updated in 2012 (FEMA, 2012); this was the primary data input for this risk assessment. These data were adopted in 2012 by Crook County to regulate flood zones. Further information regarding the National Flood Insurance Program (NFIP) is on FEMA's website. While no place is completely risk-free from flood hazard, this was the only flood data source that was available for this analysis.

DOGAMI developed depth grids for four riverine flooding scenarios (10-, 50-, 100-, and 500-year) from detailed stream information and high-resolution lidar collected in 2023 (Southeast Oregon 3DEP - Oregon Lidar Consortium). Depth grids are raster GIS datasets where each digital pixel value represents the depth of flooding at that location (**Figure 3-5**). They were used in this risk assessment to determine the level to which buildings could be impacted by flooding through loss estimation and exposure analyses.

Figure 3-5. Flood depth grid example along Ochoco Creek in Prineville, Oregon. The deepest depths (dark blue) indicate the current position of Ochoco Creek.



Building loss estimates are determined in Hazus by overlaying building data on a depth grid (e.g., **Figure 3-5**). Hazus 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 Crook County, occupancy type was available from the assessor database for most buildings. Where individual building information was not available from assessor data, street level imagery (i.e., Google Street Maps) was used to estimate these important building attributes. Only buildings in a flood zone or within 500 feet (152 meters) of a flood zone were examined in this manner. Because this analysis accounted for building first-floor height, buildings that have been elevated above the flood level were not given a loss estimate, but residents in those structures were considered displaced. This study did not examine the duration that residents would be displaced from their homes due to flooding. For information about structures exposed to flooding but not damaged, see **Section 3.2.4: Exposure Analysis**.

3.2.2 Countywide Results

For this risk assessment, the authors imported the countywide UDF data and depth grids into Hazus and ran a flood analysis for four scenarios (10-, 50-, 100-, and 500-year). This study used the 100-year flood as the primary scenario for reporting results (see **Appendix F: Plate 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.

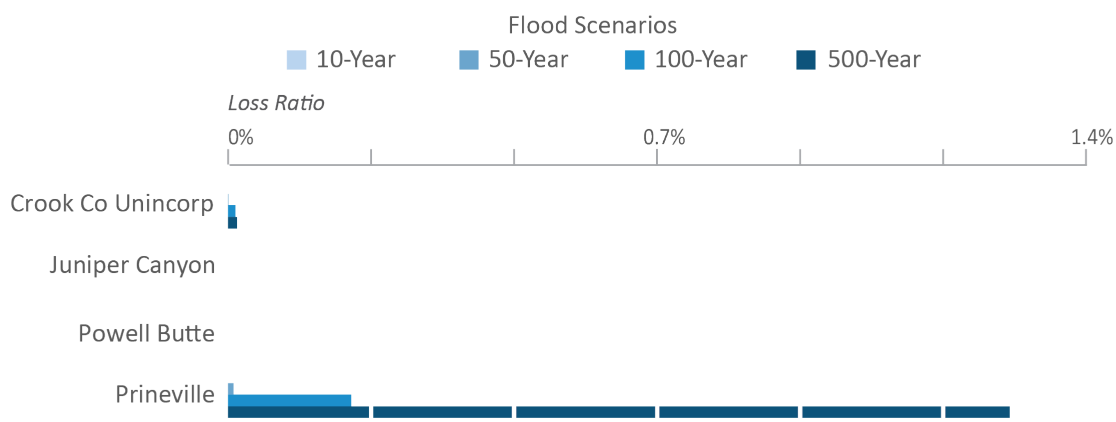
The following summarizes the multi-scenario cumulative results for 100-year flood loss:

- Number of buildings damaged: 302
- Loss estimate: $4,975,000
- Loss ratio: 0.1%
- Damaged critical facilities: 0 of 22
- Potentially displaced population: 869

3.2.3 Hazus Analysis

As shown above, the countywide loss estimate for the 100-year flood scenario is nearly $5 million. While the loss ratio of flood damage for the entirety of Crook County is 0.1%, the impact to portions of Prineville, near flood-prone streams, could be costly to homeowners (**Figure 3-6**). In communities where most residents live outside of flood zones, the overall countywide loss ratio may not be as helpful as the actual replacement cost (determined by Hazus analysis) and number of residents displaced (determined by exposure analysis) to assess the level of risk and impact from flooding. Results from these analyses are described in the next section. The Hazus analysis also provides useful information for individual communities so that planners can identify potential problems and consider which mitigation activities will provide the greatest resilience to flooding.

Figure 3-6. Ratio of flood loss estimates by Crook County community.



The area of damage from a 100-year flood is constrained to a few portions of Prineville near Ochoco Creek. The structures exposed to flooding are estimated to incur damage ranging from 3% to 6% of the total value of the structure. However, larger flooding could be far more damaging. Estimated damages from the 500-year flood are significantly higher in Prineville; nearly $30 million total damage compared to less than $5 million for the 100-year flood (**Figure 3-6**). These events are more uncommon, but their effects can be highly consequential and disruptive to the community.

3.2.4 Exposure Analysis

For comparison purposes, this study includes a separate exposure analysis in addition to the Hazus loss estimation. By overlaying building locations on the 100-year flood zone, the authors calculated the number of buildings that are elevated above the level of flooding and estimated the number of displaced residents by comparing the number of nondamaged buildings from Hazus with the number of exposed buildings in the flood zone. A significant proportion (9.1%) of Prineville's buildings were within designated flood zones. Of those 480 buildings, nearly half (215) are above the height of the 100-year flood. This evaluation also estimates that 869 residents might have mobility or access issues due to being surrounded by rising floodwaters. See **Appendix B: Table B-4** for community-based results of flood exposure.

3.2.5 Dam Safety

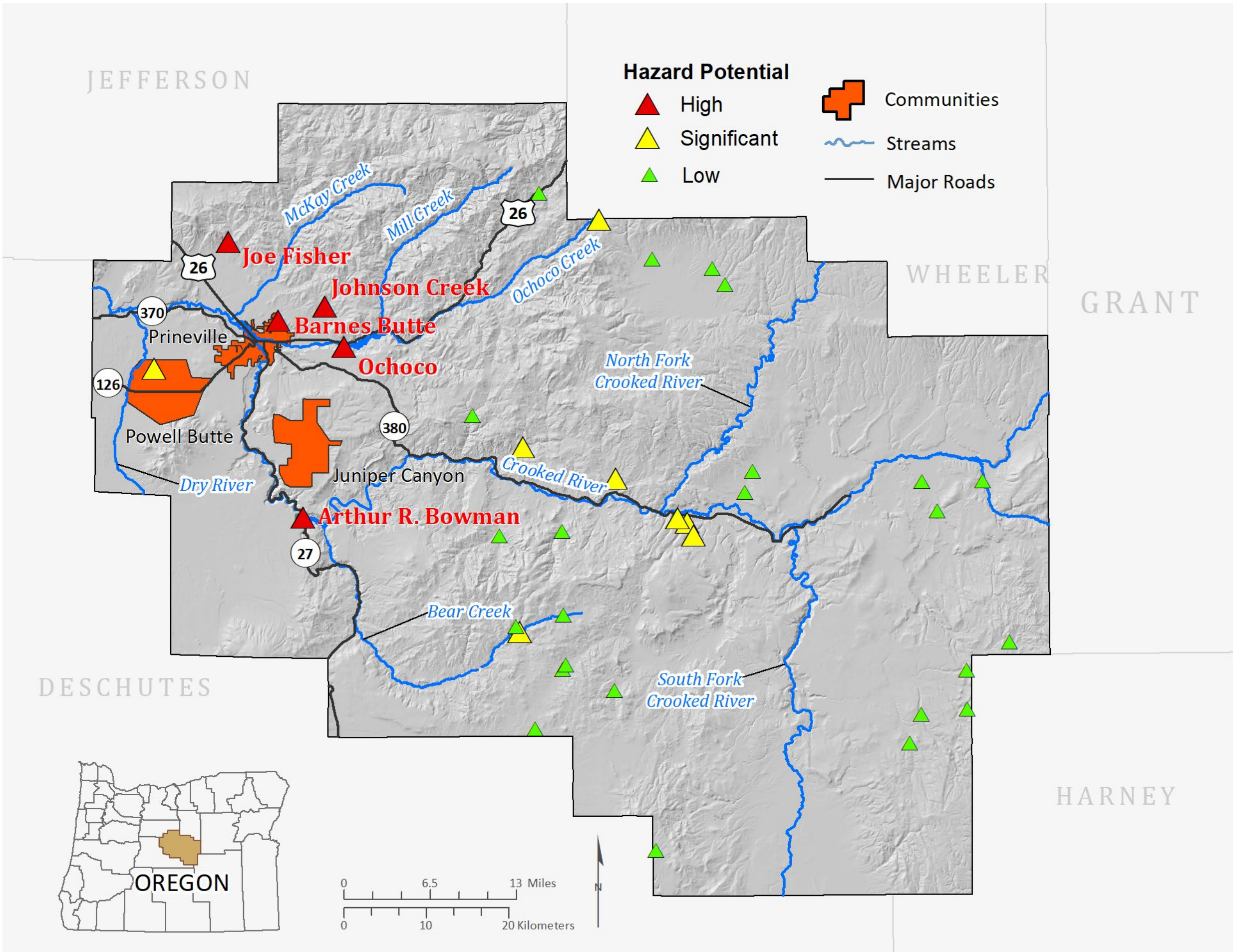
Dam safety is highly important when considering flood hazards. Dams are crucial structures designed to store and control water flow, but their failure can lead to catastrophic consequences during periods of heavy rainfall and flooding. Ensuring the safety of dams involves rigorous monitoring, regular inspections, and maintenance procedures. Structural integrity is a key concern, as any weaknesses or deficiencies in the dam's construction could be exacerbated by the force of floodwaters, potentially leading to a breach. Thus, it is crucial to implement stringent engineering standards and employ advanced technologies to assess the stability and reliability of dams, especially in flood-prone areas. Regular evaluation of spillways, embankments, and foundation conditions is necessary to identify potential risks and promptly address them to minimize the likelihood of dam failure during floods.

In addition to structural considerations, dam safety also encompasses effective flood management strategies. These strategies include establishing comprehensive flood forecasting and warning systems to provide timely alerts to downstream communities and emergency responders. Such systems rely on real-time data collection and analysis, which enables authorities to anticipate flood events and take appropriate actions. Regular communication and coordination among dam operators, local authorities, and the public are vital to ensure that evacuation plans and emergency protocols are in place and well understood. By implementing a holistic approach to dam safety, including both structural integrity and effective flood management, the risks associated with flood hazards can be minimized, protecting lives and infrastructure in flood-prone regions.

The U.S. Army Corps of Engineers (USACE) dam inventory provides a comprehensive dataset of dams throughout the United States and its territories. The dataset allows users to download information about dams for a specific location. The type, size, function, and hazard potential, among other details, are available from the dam inventory. The USACE first published a dam inventory in 1975 and since that time has continued to update the dam inventory dataset.

DOGAMI used the USACE dam inventory to identify specific dams that potentially present High, Significant, or Low risk from a natural hazard impact perspective, meaning a dam failure or breach could cause loss of life or other significant damage. There are 37 dams in Crook County that serve several functions, including agricultural, hydroelectric, water supply, and flood reduction (**Appendix C: Vulnerability Assessment of Lifelines**). Five of those dams are considered high hazard, including the two largest dams, Ochoco and Arthur R. Bowman dams (**Figure 3-7**). Completed in 1920, the Ochoco Dam is operated by the Ochoco Irrigation District, whose primary purpose is for public utility and recreation. It dams Ochoco Creek and is located approximately 5 miles upstream of Prineville. The Arthur R. Bowman Dam, completed in 1960, is owned and operated by the U.S. Bureau of Reclamation for the purpose of flood control. It dams the Crooked River and is located approximately 13 miles south of Prineville along the Crooked River.

Figure 3-7. **Dams in Crook County.**



3.2.6 Areas of Significant Risk

This study identified several locations within the study area that are at a comparatively greater risk of flood hazard. Ochoco Creek poses concentrated flood risk to three areas in the central portion of Prineville. The buildings impacted are primarily residential and are located along 5th St (west of Deer St.), the general area around 8th and Deer St., and the area around 9th and Highway 26 (**Figure 2-1**). Additionally, frequent flooding occurs along Paulina Highway from the Crooked River, but the FEMA flood study information for Crook County is limited to Prineville so the potential magnitudes of these floods are unknown.

3.3 Landslide Susceptibility

Landslides are mass movements of rock, debris, or soil down a slope. They can occur in many sizes, at different depths, and with varying rates of movement. Generally, landslides are large, deep, and slow moving or small, shallow, and rapid. Factors that influence landslide type include slope steepness, water content, and underlying geology. Many triggers can cause landslides: intense rainfall, earthquakes, or human-induced factors like water concentration caused by poor drainage, excavation along a landslide toe, loading at the top of a slope, or excessive vegetation removal. Landslides can cause severe damage to buildings and infrastructure, and fast-moving landslides, which can occur throughout Oregon, may pose life safety risks (Burns and others, 2016). In Crook County, the most common landslide types are debris flows and shallow- and deep-seated landslides.

Landslide susceptibility measures the likelihood that a given location will experience a landslide in the future based on a variety of factors including slope, geology, soil type, and the presence of preexisting landslides. Because landslides are a site-specific hazard that occur over much smaller spatial extents than most other natural hazards, measuring the risk associated with future landslides for a large area can be difficult. This study represents the current understanding of landslide susceptibility to measure the risk in Crook County. However, changing climate, precipitation patterns, land use, wildfire events, and land and forest management strategies may increase or decrease susceptibility to landslides at particular locations.

3.3.1 Data sources

This study used data from the Statewide Landslide Susceptibility Map (Burns and others, 2016), which derives from multiple datasets created using methods presented in Burns and Madin (2009). Burns and others (2016) used the Statewide Landslide Information Database for Oregon (SLIDO), 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. Mapped landslides from SLIDO data directly define the Very High susceptibility zone, while SLIDO data coupled with statistical results from generalized geology and slope maps define the other relative susceptibility zones (Burns and others, 2016).

SLIDO, release 3.2 (Burns and Watzig, 2014), is an inventory of mapped landslides in the state of Oregon and was used to create the Statewide Landslide Susceptibility Map. These data have the inherent limitations of SLIDO as well as the generalized geology and slope maps, namely differing levels of accuracy and resolution in different locations. Therefore, the statewide landslide susceptibility map varies significantly in scale across the state and consequently, attention to these details should be taken when using the data. Another limitation is that susceptibility mapping does not include certain aspects of landslide hazard, such as runout, where the momentum of the landslide can carry debris beyond the zone deemed to be High hazard.

The most recent landslide mapping in SLIDO for Crook County mapped the northern half of the county (McClaughry and others, 2021); other areas were mapped in various studies ranging from 1969 to the early 2000s (compiled in Burns and others, 2016). The lack of lidar-based landslide mapping in southern Crook County means the statewide landslide susceptibility layer in Crook County relies heavily on modeled slope and generalized geology. The scale of mapping in much of Crook County is considered the "least detail[ed]", meaning smaller than 1:62,500 map scale.

This report used data from Burns and others (2016) to identify the general level of susceptibility of a given area to landslide hazards, primarily shallow and deep landslides. Building and critical facilities data were overlaid on landslide susceptibility zones to assess the exposure for each community (see **Appendix B: Detailed Risk Assessment Tables**). The following section presents the estimated total dollar value of exposed buildings, and the number of people potentially threatened by landslides. Land value losses due to landslides and potentially hazardous unmapped areas that may pose real risk to communities were not examined for this report.

3.3.2 Countywide results

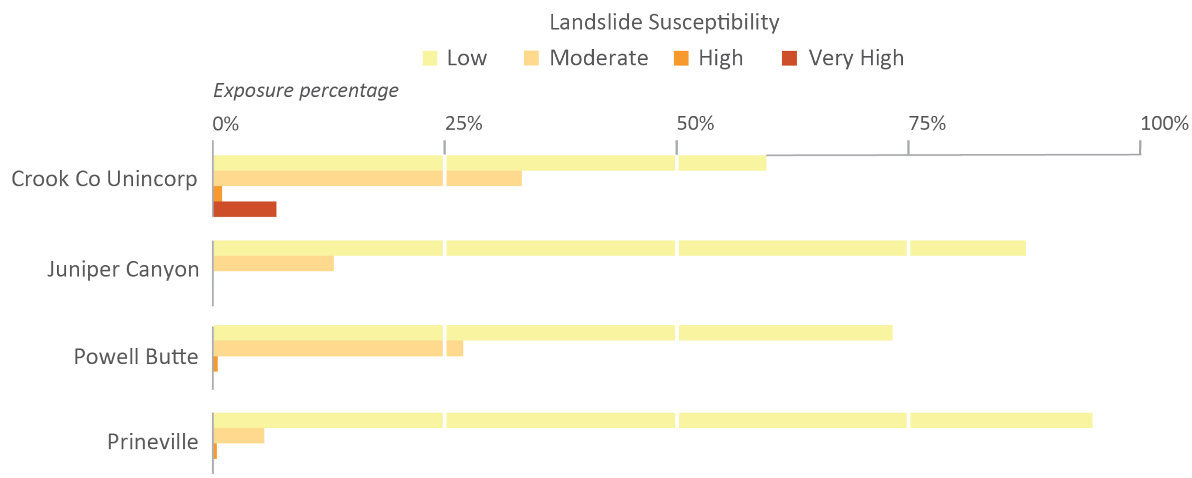
Some areas along Paulina Highway and O'Neil Highway have high level of exposure to landslide hazard. Generally, structures at the base of the buttes or in terrain with moderate to steep slopes are exposed to landslide hazard. The percentage of building value exposed to Very High and High landslide susceptibility is approximately 3.5%, equating to nearly 900 buildings, with a value approaching $178 million.

This study combines High and Very High susceptibility areas as the primary scenarios to provide a general sense of community risk for planning purposes (see **Appendix F: Plate 7**). The authors determined the best way to communicate the level of landslide risk to communities was by combining the exposure results for both susceptibility zones. The High and Very High susceptibility zones represent areas most susceptible to landslides with the greatest impact to the community.

This risk assessment compared building locations to geographic extents of the landslide susceptibility zones (**Figure 3-8**). See **Appendix B: Detailed Risk Assessment Tables** for exposure analysis results of all susceptibility categories. The following summarizes High and Very High susceptibility to landslide exposure across Crook County:

- Number of buildings: 882
- Value of exposed buildings: $177,331,000
- Percentage of total county value exposed: 3.5%
- Critical facilities exposed: 1 of 22
- Potentially displaced population: 869

Figure 3-8. Landslide susceptibility exposure by Crook County community.



Most of the developed land in Crook County is located on the low-relief terrain found in the flat, wide river valleys formed by Ochoco Creek and Crooked River, as well as the tops of the flat buttes. This type of terrain is predominately classified as having a Low landslide susceptibility. However, certain developed areas along Paulina Highway near the Ochoco Reservoir (**Figure 3-9**), Quail Canyon Road (**Figure 3-10**), and at the base of the very steep terrain below the Prineville airport along O'Neil Highway (**Figure 3-11**) are highly susceptible to landslide hazard. Landslide hazard is also common in the eastern portion of Crook County, but with few inhabitants present, the level of risk is small. Awareness of nearby areas of landslide hazard is nonetheless beneficial to reducing risk for every community, rural area, and future development of Crook County.

Figure 3-9. Landslide risk near Ochoco Reservoir.

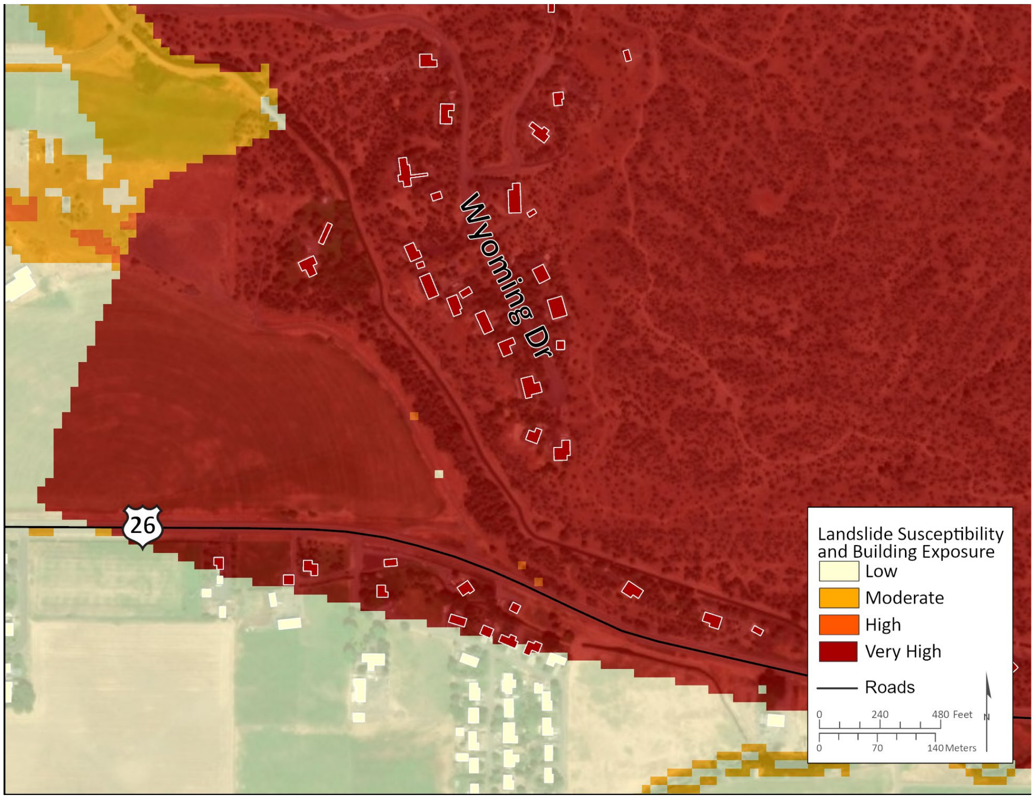


Figure 3-10. Landslide risk west of Quail Canyon Rd.

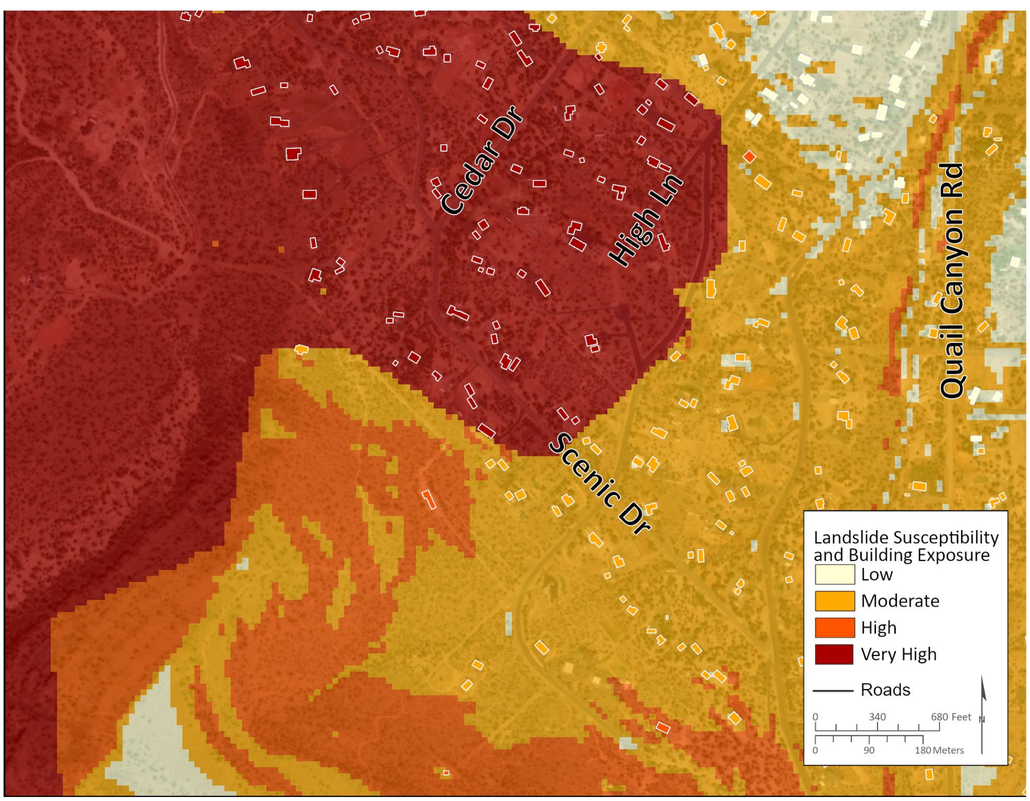
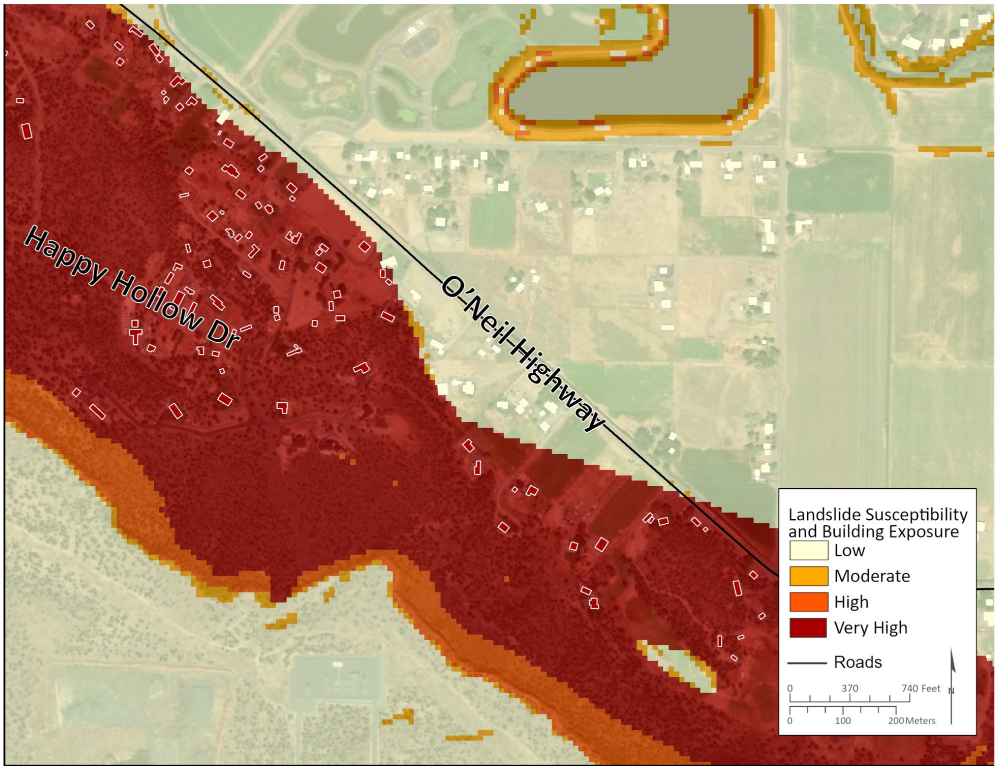


Figure 3-11. Landslide risk along O'Neil Highway.



3.3.3 Areas of Significant Risk

Several locations within the study area are at comparatively greater risk to landslide hazard:

- Residential structures along the Ochoco Reservoir and an area just to the west of the dam are exposed to Very High landslide hazard (**Figure 3-9**).
- Several residential structures to the west of SE Quail Canyon Road are exposed to Very High landslide hazard (**Figure 3-10**).
- Many residential structures below the airport along O'Neil Highway are within zones deemed Very High landslide susceptibility (**Figure 3-11**).

Future efforts to map landslides based on modern lidar-based methods will be far more accurate and could show areas of high risk that are previously unknown.

3.4 Wildfire

Wildfires are a natural part of the ecosystem in Oregon. However, wildfires can present a substantial hazard to life and property in communities, especially those experiencing rapid growth. The most common wildfire conditions include hot, dry, and windy weather; situations where fire protection forces cannot 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 (McEvoy and others, 2023). Post-wildfire natural hazards can also present risk. These usually include floods, debris flows, and landslides. These post-wildfire hazards were not evaluated in this project.

The 2024 Crook County Community Wildfire Protection Plan (CCCWPP) recommended that the county adhere to the Oregon Fire Code, follow guidance outlined by WUI, and building code enforcement related to emergency access. Forests cover large portions of the study area and play an important role in the local economy, but also surround homes and businesses (CCCWPP, 2024).

Over the past 20 years, several very large wildfires have occurred in Crook County. Most of these have occurred in the less inhabited central and eastern portions of the county. Several smaller wildfires have occurred near the inhabited western portion of the county but were able to be contained quickly with minimal levels of damage.

The frequency, intensity, and severity of wildfires may change over time due to changes in climate, drought conditions, urbanization, and how forested lands are managed. This study represents the current understanding of wildfire hazards and wildfire risk, but wildfire models and risk assessments will need to be updated with time and changing conditions.

3.4.1 Data Sources

The Pacific Northwest Quantitative Wildfire Risk Assessment (PNRA): Methods and Results (McEvoy and others, 2023) is a comprehensive report that includes a database of spatial information related to wildfire hazard 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, one of the datasets included in the PNRA database, was used to measure the risk to communities in Crook County.

Using guidance from ODF, the authors categorized the Burn Probability dataset into low, moderate, and high-hazard zones for the wildfire exposure analysis. Burn probability is derived from simulations using many elements, such as weather, ignition frequency, ignition density, and fire modeling landscape (McEvoy and others, 2023).

Burn probability values were grouped into three hazard categories:

- Low wildfire hazard (0–0.001)
- Moderate wildfire hazard (0.001–0.0046)
- High wildfire hazard (0.0046–0.1)

The authors overlaid the buildings layer and critical facilities on each of the wildfire hazard zones to determine exposure. In certain areas, no wildfire data is present, indicating areas with minimal risk to wildfire hazard (see **Appendix B: Table B-6**). The following section presents the estimated total dollar value of exposed buildings and the number of people potentially displaced from wildfires. Land value losses as well as impacts on infrastructure and the natural environment were not examined for this report.

3.4.2 Countywide Results

This study focused on the High hazard areas because they represent areas having the highest potential for losses. Under certain conditions, like prolonged dry weather, Moderate hazard zones can be susceptible to burning and are also a risk consideration. However, in Crook County, only the High wildfire risk scenario was used to characterize wildfire risk in communities because so much of the county is considered High risk and including the Moderate category would result in a very large portion of the county being at risk. Exposure to High wildfire risk exists throughout the unincorporated county and especially in areas considered to be WUI.

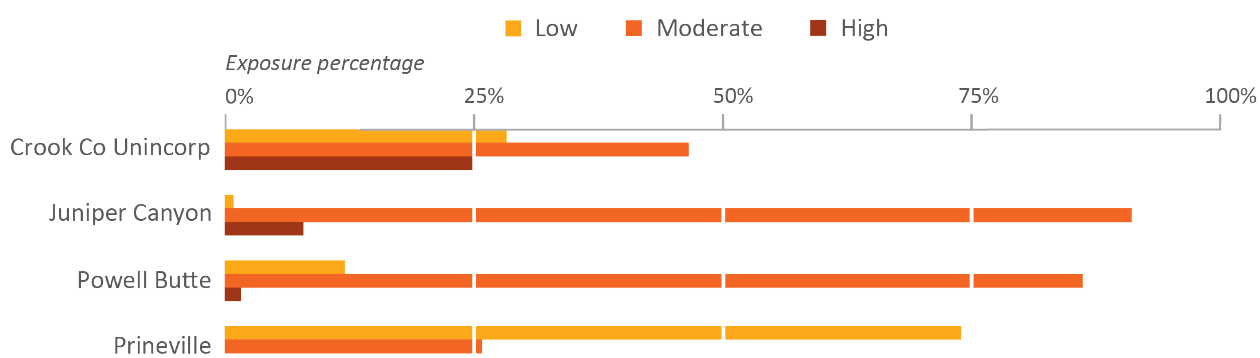
The following summarizes the countywide exposure to High-risk wildfires:

- Number of buildings: 3,103
- Value of exposed buildings: $572,898,000
- Percentage of total county value exposed: 11%
- Critical facilities exposed: 3 of 22
- Potentially displaced population: 3,378

For this assessment, the building locations were compared to the geographic extent of the wildfire risk categories. Approximately 3,100 buildings in the forested parts of central and eastern Crook County are exposed to High burn probability zones (see **Appendix F: Plate 8**). Wildfires are also a significant risk to residential structures in the WUI adjacent to Prineville.

Figure 3-12 illustrates the level of risk from wildfire for the different communities of Crook County. See **Appendix B: Detailed Risk Assessment Tables** for multi-scenario analysis results.

Figure 3-12. Wildfire risk exposure by Crook County community



3.4.3 Areas of Significant Risk

Several locations within the study area are at higher risk to wildfire hazard:

- The sparsely populated areas of central and eastern Crook County are exposed to High wildfire probability areas.
- The WUI zones surrounding Prineville are at a greater risk from wildfire relative to other populated portions of the county (**Figure 3-13, Figure 3-14, Figure 3-15**).

Figure 3-13. Wildfire risk northeast of Prineville.

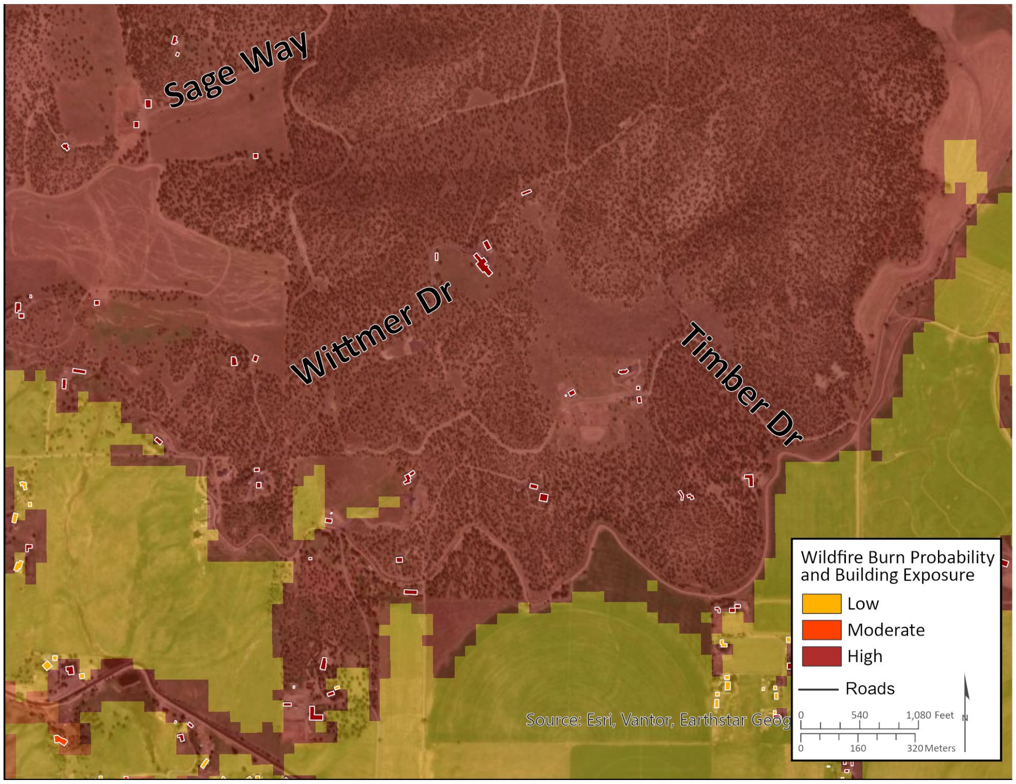


Figure 3-14. Wildfire risk northwest of Prineville.

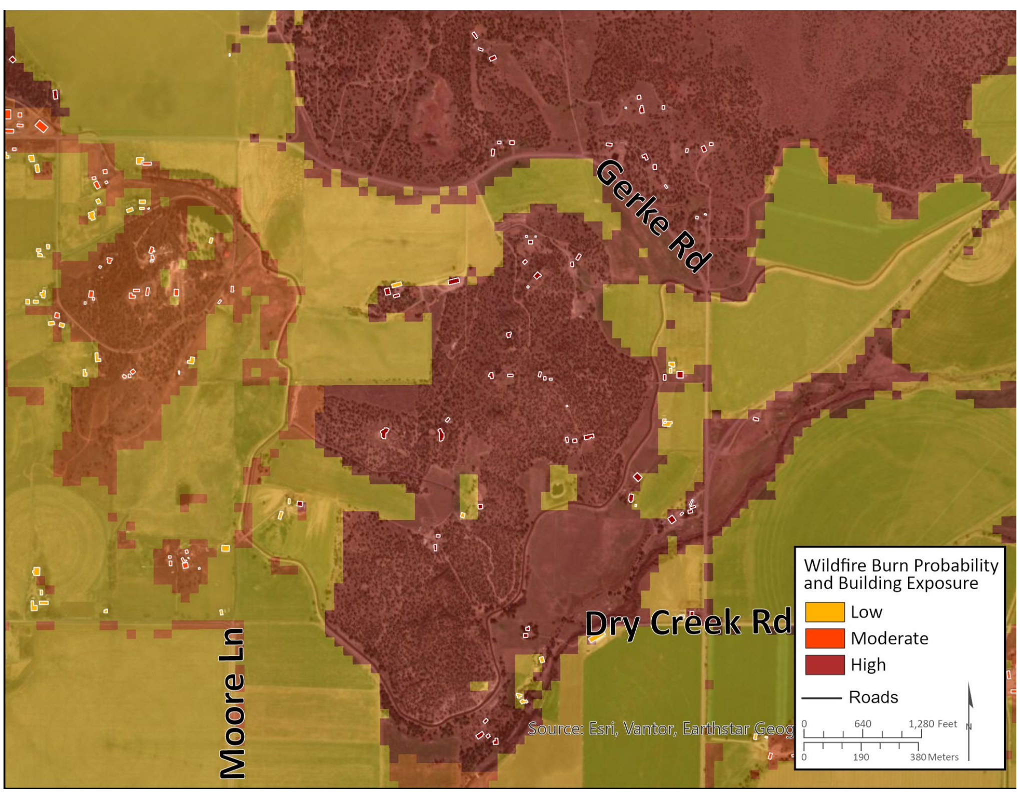
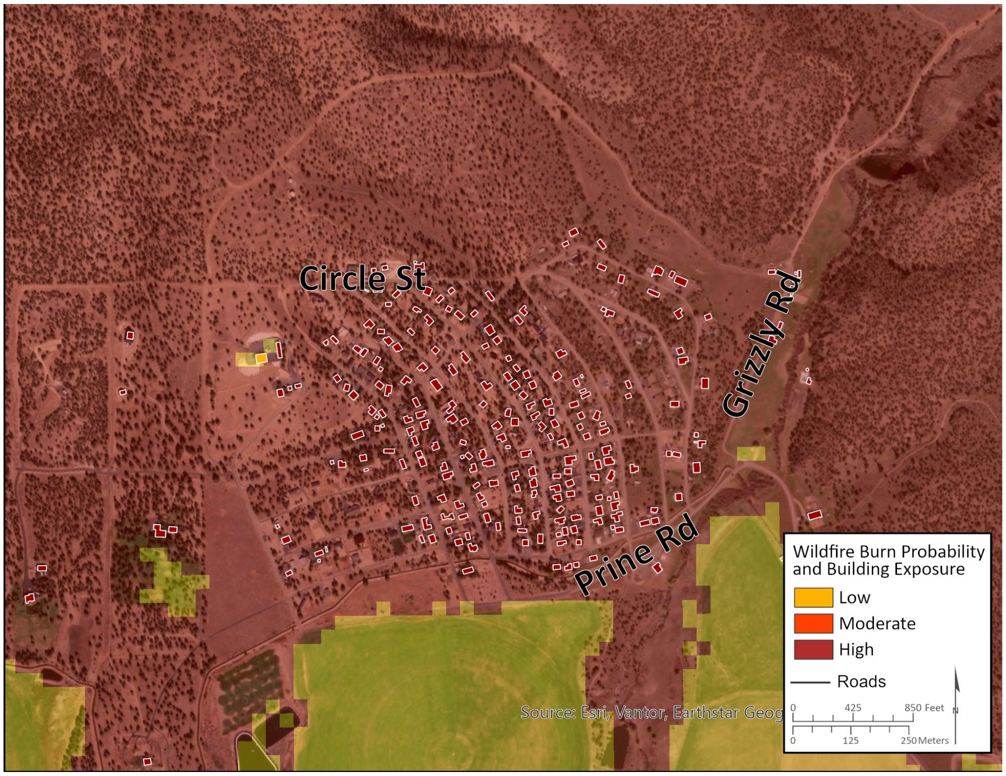


Figure 3-15. Wildfire Risk northeast of Prineville.



4.0 CONCLUSIONS

The purpose of this study is to provide an improved understanding of the potential impacts from multiple natural hazards on the community scale. This study accomplishes this goal by using the best available natural hazard data and information to quantify both risk and exposure to buildings and people. These data are fundamental to the county's risk reduction efforts. Notable key findings include the following:

- **Slight damage and losses can occur from a hypothetical Southeast Newberry Fault Mw 7.2 earthquake**: Based on the results of the hypothetical Southeast Newberry Fault Mw 7.2 earthquake scenario, communities in Crook County may experience minor impact and disruption from a potential crustal fault earthquake occurring ~42 miles south of the city of Prineville. Results from the Hazus modeling indicate that buildings located on highly liquefiable soils in the central portion of Prineville are more likely to experience damage from such an earthquake. Buildings located in the southwestern corner of Crook County are at higher risk from a Southeast Newberry Fault earthquake due to their proximity to the source of the earthquake shaking.
- **Retrofitting buildings to modern seismic building codes can reduce damages and losses from earthquake shaking**: Seismic building codes have a demonstrated influence on reducing earthquake-shaking damage. Study results clearly demonstrate that efforts to retrofit buildings to at least a Moderate Code level would significantly reduce the seismic risk. Furthermore, adhering to a moderate code is the most efficient mitigation strategy because the additional benefit from retrofitting to High Code was minimal. The simulation of upgrading buildings to at least Moderate Code reduced the estimated loss for the entire study area from 1% to 0.5% (340 buildings to 265 buildings). Communities with older buildings constructed below the Moderate

seismic code standards are both the most vulnerable and have the greatest potential for risk reduction. While seismic retrofits are an effective strategy for reducing earthquake-shaking damage, earthquake-induced liquefaction hazards will also be present in areas along the floodplains, and these hazards require different geotechnical mitigation strategies.

- **Prineville is at significant risk from flooding**: Ochoco Creek flows through the middle of Prineville and has the potential cause significant flooding to buildings, including many residential structures. Damage estimates from a 100-year flood are ~$4.7 million in losses, with 265 buildings exposed. The risk from flooding increases substantially with low frequency but large magnitude flood events; a 500-year flood could cause nearly $30 million in damages. Areas in the central portion of Prineville are at greatest risk from flooding compared to the rest of the county.
- **Elevating structures in the flood zone reduces vulnerability**: In addition to Hazus loss estimation, an exposure analysis identified buildings located in areas expected to experience 100-year flooding but unlikely to be damaged. By using both forms of analysis, the number of elevated structures within the flood zone could be quantified. This quantification showed possible mitigation needs in flood loss prevention and the effectiveness of past activities. For example, in the City of Prineville an estimated 269 out of 571 (47%) buildings exposed to flooding are elevated above the base flood elevation. Many buildings in Prineville are already elevated above the 100-year flood and by elevating more buildings the flood risk Prineville could be further reduced.
- **Landslide risk is low for most areas in the county**: Most buildings in Crook County are not located on steep terrain or existing landslide deposits, which may be susceptible to mass movements. However, higher landslide risk and exposure occurs at the base of buttes (high landslide susceptibility areas), especially along Paulina and O'Neil Highways.
- **Wildfire risk is higher in the WUI portions of the county**: Exposure analysis shows that buildings in rural central and eastern portions of the county are at higher risk from wildfire than other areas in the county. Exposure to wildfire hazard is greatest in the unincorporated areas surrounding Prineville.
- **Most of the critical facilities in Crook County are not at risk from hazards examined in this study**: Because of their importance during and after a natural disaster, this study examined the risk to critical facilities for each hazard. ~14% (3 of 22) of Crook County's critical facilities are in High wildfire hazard areas and 4.5% (1 of 22) are at risk from landslide hazard. No critical facilities are at risk from flood or earthquake hazards.
- **People are most likely to be displaced from their homes due to wildfire hazard**: ~13% of the permanent residents in the county could be displaced from wildfire hazard. In contrast, residents are much less vulnerable to being displaced by floods and landslide hazards (~3.3%). A small percentage of residents (1.5%) are vulnerable to displacement from earthquake hazard.
- **These results allow communities to compare risk across hazards and prioritize their needs**—The impact of multiple natural hazards was assessed for each community in Crook County, allowing for comparison of risk for a specific hazard between communities. Results also allow for a comparison between different hazards, though care must be taken to distinguish loss estimates and exposure results. The loss estimates and exposure analyses can assist in developing plans that address the concerns of those individual communities.

5.0 LIMITATIONS

Several noteworthy limitations should be considered when interpreting the results of this risk assessment.

- **Spatial and temporal variability of natural hazard occurrence**: The hazards analyzed in this study are extremely unlikely to occur across the fully mapped extent of the hazard zones. For example, areas mapped in the 100-year flood zone will be prone to flooding on occasion in certain watersheds during specific events, but not all at once throughout the entire county or even an entire community. While this report presents the overall impacts of a given hazard scenario, the losses from a single hazard event probably are unlikely to be as severe and widespread.
- **Loss estimation for individual buildings**: Hazus is a model, not reality, which is an important factor when considering the loss ratio of an individual building. On-the-ground mitigation, such as elevation of buildings to avoid flood loss, has been only minimally captured. Also, in the absence of detailed information about a building's design, structure, and material information, assumptions are made by Hazus about the distribution of wood, steel, and unreinforced masonry buildings. Loss estimation is most insightful when individual building results are aggregated to the community level because it reduces the impact of data outliers.
- **Loss estimation versus exposure:** The authors recommend careful interpretation of exposure results due to the spatial and temporal variability of natural hazards (described above) and the inability to perform loss estimations due to the lack of Hazus damage functions. Exposure is reported in terms of total building value, which could imply a total loss of the buildings in a particular hazard zone, but this situation is unlikely. Exposure is simply a calculation of the number of buildings and their value and does not make estimates about the level to which an individual building could be damaged.
- **Population variability:** Some of the communities in Crook County contain vacation homes and rentals, which are mostly occupied by nonresidents. Study estimates of potentially displaced people rely on permanent populations based on PSU data. As a result, study modeling is likely to slightly underestimate the actual number of at-risk people due to an unknown number of nonresidents at any given time.
- **Data accuracy and completeness:** Some datasets in the risk assessment had incomplete coverage or lacked high-resolution data. Lower-resolution data was used in areas with incomplete coverage or where high-resolution data was not available. The authors made assumptions to amend areas of incomplete data coverage based on reasonable methods described within this report. Data layers in which assumptions were made to fill gaps include building footprints, population, some building specific attributes, and landslide susceptibility. Many of the datasets included known or suspected artifacts, omissions, and errors; however, repairing these issues was beyond the scope of the project and will require further evaluation and research. Study authors are aware that some uncertainty has been introduced from these data amendments at an individual building scale, but at community-wide scales the effects of the uncertainties are probably relatively minor.
- **Changing conditions:** This assessment did not account for potential changes in climate, land use, or population. Thus, the analyses presented here reflect a snapshot of Crook County's current risk from natural hazards. Human-induced climate change poses a potential significant and widespread risk to people around the world. In Oregon, climate change is expected to impact the

frequency and intensity of floods, wildfires, and landslides, but quantifying this impact was beyond the scope of this study.

6.0 RECOMMENDATIONS

The following actions are needed to better understand hazards and reduce risk to natural hazards through mitigation planning. These actions, while not comprehensive, touch on all phases of risk management and focus on awareness and preparation, planning, emergency response, mitigation funding opportunities, and hazard-specific risk reduction activities.

6.1 Awareness and Preparation

Natural hazard awareness is crucial to lowering risk and reducing the impacts of natural hazards. When community members understand their risk and know the role that they play in preparedness, the community becomes a much safer place to live. Awareness and preparation not only reduce the initial impact from natural hazards but also reduce the time a community needs to recover from a disaster, commonly referred to as **resilience**. This report is intended to provide local officials with a comprehensive and authoritative profile of natural hazard risk to underpin their public outreach efforts.

Messaging can be tailored to specific stakeholder groups. For example, outreach to homeowners could focus on actions they can take to reduce risk to their property; the Washington Geological Survey and DOGAMI Homeowners Guide to Landslides provides a variety of risk reduction options for homeowners who live in high landslide susceptibility areas. This guide is one of many existing resources. Agencies partnering with local officials in the development of additional effective resources could help reach a broader community and user groups.

6.2 Planning

This report can help local decision makers develop local plans by identifying geohazards and associated risks to the community. The primary framework for accomplishing this goal is through the comprehensive planning process. The comprehensive plan sets the long-term trajectory of capital improvements, zoning, and urban growth boundary expansion, all of which are planning tools that can be used to reduce natural hazard risk.

Another framework is the natural hazard mitigation plan (NHMP) process. NHMP plans focus on characterizing natural hazard risk and identifying actions to reduce risk. Additionally, the information presented here can be a resource when updating the mitigation actions and can inform the vulnerability assessment section of the NHMP plan.

While many similarities exist between this report and an NHMP, the primary difference is that the risk assessment is not a planning document. Additional differences include the specific hazards or critical facilities examined in each report. Differences between the reports may result from data availability or limited methodologies for specific hazards. The critical facilities considered in this report may not be identical to those listed in a typical NHMP due to the lack of damage functions in Hazus for structures other than buildings and to different considerations about emergency response during and after a disaster.

6.3 Emergency Response

Critical facilities will play a major role during and immediately following a natural disaster. This study can help emergency managers identify vulnerable critical facilities and develop contingency plans. Additionally, detailed mapping of potentially displaced residents may be used to reevaluate evacuation routes and identify vulnerable populations to target for early warning.

The building database accompanying this report presents many opportunities for future pre-disaster mitigation, emergency response, and community resilience improvements. Vulnerable areas can be identified and targeted for awareness campaigns. These campaigns can be aimed at pre-disaster mitigation through, for example, improvements of the structural connection of a building's frame to its foundation. Emergency response entities can benefit from the use of the building dataset through identification of potential hazards and populated buildings before and during a disaster. Both reduction of the magnitude of the disaster and a decrease in the response time contribute to a community's overall resilience.

6.4 Mitigation Funding Opportunities

Several state and federal funding options are available to communities that are susceptible to natural hazards and have specific cost-effective mitigation projects they wish to accomplish. The Oregon Office of Emergency Management (OEM) State Hazard Mitigation Officer (SHMO) can provide communities assistance with determining eligibility, finding mitigation grants, and navigating the mitigation grant application process. OEM has produced a document that can assist local officials in applying for mitigation funds.

At the time of writing this report, FEMA has five programs that assist with mitigation funding for natural hazards: Hazard Mitigation Grant Program (HMGP), HMGP Post-Fire Assistance, Pre-Disaster Mitigation (PDM) Grant Program, Building Resilient Infrastructure and Communities (BRIC) grant program, and Flood Mitigation Assistance (FMA). The SHMO can help with finding further opportunities for earthquake and tsunami assistance and funding.

6.5 Hazard-Specific Risk Reduction Actions

The following sections outline actions that communities can take to reduce risk to specific hazards.

6.5.1 Earthquake

Communities can offset risk from earthquakes through the following actions:

- Evaluate critical facilities for seismic preparedness by identifying structural deficiencies and vulnerabilities to dependent systems (e.g., water, fuel, power).
- Evaluate the vulnerabilities of critical facilities. Notably, none of the critical facilities in Crook County (**Appendix A: Community Risk Profiles**) are likely to incur damage by a CSZ earthquake scenario or a Southeast Newberry Fault crustal fault earthquake. However, the county and much of eastern Oregon will almost certainly play a critical role in post-disaster humanitarian support following a Cascadia megathrust earthquake.
- Identify communities and buildings that would benefit from seismic upgrades.

6.5.2 Flood

Communities can offset risk from floods through the following actions:

- Map areas of potential flood water storage areas.
- Identify structures that have repeatedly flooded in the past and would be eligible for FEMA's "buyout" program.
- Evaluate vulnerabilities of critical facilities. We estimate that none of critical facilities (**Appendix A: Community Risk Profiles**) would be damaged by a 100-year flood.
- Additional risk reduction strategies may be found on FEMA's flood website.

6.5.3 Landslide

Communities can offset risk from landslides through the following actions:

- Create modern landslide inventory and susceptibility maps.
- Monitor ground movement in high susceptibility areas.
- Evaluate risks to transportation networks and land value losses due to landslides in future risk assessments.
- Study the risk from landslides that are susceptible to river or creek channel erosion at the toe of the landslide.
- Additional risk reduction strategies may be found on FEMA's landslide website.

6.5.4 Wildfire-Related Geologic Hazards

Communities can offset risk from wildfires through the following actions:

- Evaluate post-wildfire geologic hazards including flood, debris flows, and landslides.
- Additional risk reduction strategies may be found on FEMA's wildfire website.

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Many people contributed to this report at different points during the analysis and writing phases. We are grateful to everyone who contributed, especially the following from DOGAMI: Jason McClaughry, Kellum Tate-Jones, and Alex Lopez. We also appreciate the work of Jonathan Allan and Jon Franczyk from DOGAMI's Technical Review Committee for their contributions to this project. A special thanks to Natalie Culhane (formerly DOGAMI) for her contribution during the RVS data collection portion of this study.

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9.0 APPENDICES

APPENDIX A. COMMUNITY RISK PROFILES

This appendix contains community specific data to provide an overview and a better understanding of the relative levels of risk from each natural hazard analyzed for the purpose of fostering risk reduction efforts. Improving disaster preparedness, public hazards communication, and education; ensuring functionality of emergency services; and ensuring access to evacuation routes are actions that every community can take to reduce their risk.

A.1 Unincorporated Crook County (Rural)

Table A-1. Community overview of unincorporated Crook County (rural) hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Community Name	Population	Number of Buildings	Critical Facilities	Total Building Value ($)
Unincorporated Crook County (rural)	11,687	10,872	6	2,172,583,000

Table A-2. Summary of Hazus analysis for unincorporated Crook County (rural) hazard profile. For floods, no damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood	1% Annual Chance	36	0.3%	36	0	218,601	0.0%
Earthquake	Southeast Newberry Fault Mw-7.2 Deterministic	77	0.7%	90	0	18,114,698	0.8%

Table A-3. Summary of exposure analysis for unincorporated (rural) Crook County hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Exposed Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	800	7%	845	1	168,132,000	8%
Wildfire	High and Moderate Risk	3,201	27%	2,901	3	542,242,000	25%

Table A-4. Unincorporated Crook County (rural) critical facilities.

Critical Facilities by Community	Exposed to Flood 1% Annual Chance	>50% Probability Moderate to Complete Damage from Southeast Newberry Fault	Exposed to High and Very High Landslide Susceptibility	Exposed to High Risk from Wildfire
Crook County Fire and Rescue - Station 1202	—	—	—	—
Goering Ranches Airport	—	—	—	X
Ochoco National Forest Ranger Station	—	—	—	X
Paulina Elementary School	—	—	—	X
Shotgun Ranch Airstrip	—	—	—	—
Tailwheel Airport	—	—	X	—

A.2 Unincorporated Community of Juniper Canyon

Table A-5. Community overview of Juniper Canyon hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Community Name	Population	Number of Buildings	Critical Facilities	Total Building Value ($)
Juniper Canyon	1,733	2,509	1	330,657,000

Table A-6. Summary of Hazus analysis for unincorporated Crook County (rural) hazard profile. For floods, no damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood	1% Annual Chance	0	0.0%	0	0	0	0.0%
Earthquake	Southeast Newberry Fault Mw-7.2 Deterministic	5	0.3%	8	0	940,341	0.3%

Table A-7. Summary of exposure analysis for unincorporated (rural) Crook County hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Exposed Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	1	0.1%	4	0	180,000	0.1%
Wildfire	High and Moderate Risk	140	8.1%	193	0	26,070,000	7.9%

Table A-8. Unincorporated Community of Juniper Canyon critical facilities.

Critical Facilities by Community	Exposed to Flood 1% Annual Chance	>50% Probability of Southeast Newberry Fault Moderate to Complete Damage	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High or Moderate Risk
Crook County Fire and Rescue - Station 1203	—	—	—	—

A.3 Unincorporated Community of Powell Butte

Table A-9. Community overview of Powell Butte hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Community Name	Population	Number of Buildings	Critical Facilities	Total Building Value ($)
Powell Butte	1,470	1,307	1	285,473,000

Table A-10. Summary of Hazus analysis for unincorporated Crook County (rural) hazard profile. For floods, no damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood	1% Annual Chance	0	0.0%	0	0	0	0.0%
Earthquake	Southeast Newberry Fault Mw-7.2 Deterministic	2	0.1%	1	0	456,566	0.2%

Table A-11. Summary of exposure analysis for unincorporated (rural) Crook County hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Exposed Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	3	0.2%	6	0	1,281,000	0.4%
Wildfire	High and Moderate Risk	38	2.6%	9	0	4,585,000	1.6%

Table A-12. Unincorporated Community of Powell Butte critical facilities.

Critical Facilities by Community	Exposed to Flood 1% Annual Chance	>50% Probability of Southeast Newberry Fault Moderate to Complete Damage	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High or Moderate Risk
Powell Butte Community Charter School	—	—	—	—

A.4 City of Prineville

Table A-13. Community overview of Prineville hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Community Name	Population	Number of Buildings	Critical Facilities	Total Building Value ($)
Prineville	11,458	5,290	17	2,281,832,000

Table A-14. Summary of Hazus analysis for unincorporated Crook County (rural) hazard profile. For floods, no damage is estimated for exposed structures with "First floor height" above the level of flooding (base flood elevation).

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate ($)	Loss Ratio
Flood	1% Annual Chance	762	6.6%	253	0	4,172,000	0.2%
Earthquake	Southeast Newberry Fault Mw-7.2 Deterministic	54	0.5%	118	0	33,950,000	1.5%

Table A-15. Summary of exposure analysis for unincorporated (rural) Crook County hazard profile. Critical facilities with multiple buildings were consolidated into one building for the sake of the count.

Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Exposed Building Value ($)	Exposure Ratio
Landslide	High and Very High Susceptibility	65	0.6%	27	0	7,739,000	0.3%
Wildfire	High and Moderate Risk	0	0.0%	0	0	0	0.0%

Table A-16. City of Prineville critical facilities.

Critical Facilities by Community	Exposed to Flood 1% Annual Chance	>50% Probability of Southeast Newberry Fault Moderate to Complete Damage	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High or Moderate Risk
Barnes Butte Elementary	—	—	—	—
Bureau of Land Management - Prineville District Office	—	—	—	—
Cecil Sly Elementary School	—	—	—	—
Crook County Christian School	—	—	—	—
Crook County Fire and Rescue - Station 1201	—	—	—	—
Crook County High School	—	—	—	—
Crook County Middle School	—	—	—	—
Crook County Public Works	—	—	—	—
Crook County Sheriff’s Office	—	—	—	—
Crooked River Elementary School	—	—	—	—
Ochoco Elementary School	—	—	—	—
Ochoco National Forest Services	—	—	—	—
Pioneer Memorial Hospital - Prineville	—	—	—	—
Prineville Sewage Treatment Plant	—	—	—	—
Prineville City Hall	—	—	—	—
Prineville Police Department	—	—	—	—
Prineville Public Works	—	—	—	—

APPENDIX B. DETAILED RISK ASSESSMENT TABLES

Table B-1. Crook County building inventory. All dollar amounts are in thousands. RS = Residential, CI = Commercial and Industrial, AG = Agricultural, PN = Public or Nonprofit.

Community	Number of RS Buildings	RS Building Value ($)	RS Building Value per Community Total	Number of CI Buildings	CI Building Value ($)	CI Building Value per Community Total	Number of AG Buildings	AG Building Value ($)	AG Building Value per Community Total	Number of PN Buildings	PN Building Value ($)	PN Building Value per Community Total	Number of Buildings	Number of Buildings per Study Area Total	Building Value ($)	Value of Buildings per Study Area Total
Unincorp. Crook Co.	5,131	1,078,525	50%	47	59,504	2.7%	5,692	1,031,304	47%	2	3,250	0.1%	10,872	54%	2,172,583	43%
Juniper Canyon*	1,197	166,270	50%	5	1,861	0.6%	1,307	162,526	49%	0	0	0.0%	2,509	12.6%	330,657	6.5%
Powell Butte*	568	143,900	50%	4	1,137	0.4%	733	134,756	47.2%	2	5,680	2.0%	1,307	6.5%	285,473	5.6%
Total Unincorp. County	**6,896**	**1,388,695**	**50%**	**56**	**62,502**	**2.2%**	**7,732**	**1,328,585**	**47.6%**	**4**	**8,930**	**0.3%**	**14,688**	**73.5%**	**2,788,713**	**55.0%**
Prineville	4,086	957,728	42%	355	905,131	40%	838	363,264	15.9%	11	55,710	2.4%	5,290	26.5%	2,281,832	45.0%
Total	**10,982**	**2,346,423**	**46%**	**411**	**967,633**	**19.1%**	**8,570**	**1,691,849**	**33.4%**	**15**	**64,639**	**1.3%**	**19,978**	**100%**	**5,070,545**	**100%**

*Unincorporated communities

Table B-2. Southeast Newberry Mw 7.2 Earthquake loss estimates for both current code and simulated all buildings upgraded to Moderate Code ("MC" in table). All dollar amounts are in thousands.

Community	Total Number of Buildings	Total Estimated Building Value ($)	Yellow-Tagged Buildings	Red-Tagged Buildings	Sum of Economic Loss	Loss Ratio	MC Yellow-Tagged Buildings	MC Red-Tagged Buildings	MC Sum of Economic Loss	MC Loss Ratio
Unincorp. Crook Co.	10,872	2,172,583	90	15	18,115	0.8%	61	13	13,578	0.6%
Juniper Canyon*	2,509	330,657	7	1	940	0.3%	5	1	675	0.2%
Powell Butte*	1,307	285,473	1	0	457	0.2%	0	0	214	0.1%
Total Unincorp. County	**14,688**	**2,788,713**	**98**	**16**	**19,512**	**0.7%**	**66**	**14**	**14,467**	**0.5%**
Prineville	5,290	2,281,832	118	25	33,950	1.5%	100	24	27,276	1.2%
Total	**19,978**	**5,070,545**	**215**	**41**	**53,462**	**1.1%**	**166**	**38**	**41,743**	**0.8%**

*Unincorporated communities

Table B-3. Flood loss estimates. All dollar amounts are in thousands.

Community	Total Number of Buildings	Total Estimated Building Value ($)	(10-yr) Number of Buildings	(10-yr) Loss Estimate	(10-yr) Loss Ratio	(50-yr) Number of Buildings	(50-yr) Loss Estimate	(50-yr) Loss Ratio	(100-yr) Number of Buildings	(100-yr) Loss Estimate	(100-yr) Loss Ratio	(500-yr) Number of Buildings	(500-yr) Loss Estimate	(500-yr) Loss Ratio
Unincorp. Crook Co.	10,872	2,172,583	0	0	0.0%	3	8	0.0%	36	219	0.0%	130	1,654	0.1%
Juniper Canyon*	2,509	330,657	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Powell Butte*	1,307	285,473	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Total Unincorp. County	**14,688**	**2,788,713**	**0**	**0**	**0.0%**	**3**	**8**	**0.0%**	**36**	**219**	**0.0%**	**130**	**1,654**	**0.1%**
Prineville	5,290	2,281,832	0	0	0.0%	8	17	0.0%	253	4,172	0.2%	1,472	53,914	2.4%
Total	**19,978**	**5,070,545**	**0**	**0**	**0.0%**	**11**	**25**	**0.0%**	**289**	**4,391**	**0.1%**	**1,602**	**55,568**	**1.1%**

*Unincorporated communities

Table B-4. Flood exposure for the 100-year (1% annual chance) scenario. All dollar amounts are in thousands.

Community	Total Number of Buildings	Total Population	Potentially Displaced Residents from Flood Exposure	% Potentially Displaced Residents from flood Exposure	Number of Flood Exposed Buildings	% of Flood Exposed Buildings	Number of Flood Exposed Buildings Without Damage
Unincorp. Crook Co	10,872	11,687	36	0.3%	77	0.7%	41
Juniper Canyon*	2,509	1,733	0	0.0%	0	0.0%	0
Powell Butte*	1,307	1,470	0	0.0%	0	0.0%	0
Total Unincorp. County	**14,688**	**14,890**	**36**	**0.2%**	**77**	**0.5%**	**41**
Prineville	5,290	11,458	762	6.6%	443	8.4%	190
Total	**19,978**	**26,347**	**798**	**3.0%**	**520**	**2.6%**	**231**

*Unincorporated communities

Table B-5. Landslide exposure. All dollar amounts are in thousands. VHS = Very High Susceptibility, HS = High Susceptibility, MS = Moderate Susceptibility.

Community	Total Number of Buildings	Total Estimated Building Value ($)	VHS Number of Buildings	VHS Building Value ($)	VHS Percent of Building Value Exposed	HS Number of Buildings	HS High Building Value ($)	HS Percent of Building Value Exposed	MS Number of Buildings	MS Building Value ($)	MS Percent of Building Value Exposed
Unincorp. Crook Co.	10,872	2,172,583	708	147,398	6.8%	137	20,734	1.0%	3,797	717,422	33%
Juniper Canyon*	2,509	330,657	0	0	0.0%	4	180	0.1%	310	42,480	13%
Powell Butte*	1,307	285,473	0	0	0.0%	6	1,281	0.4%	359	76,386	27%
Total Unincorp. County	**14,688**	**2,788,713**	**708**	**147,398**	**5.3%**	**147**	**22,194**	**0.8%**	**4,466**	**836,288**	**30%**
Prineville	5,290	2,281,832	1	14	0.0%	26	7,725	0.3%	475	123,808	5%
Total	**19,978**	**5,070,545**	**709**	**147,412**	**3.0%**	**173**	**29,919**	**0.6%**	**4,941**	**960,096**	**19%**

*Unincorporated communities

Table B-6. Wildfire exposure. All dollar amounts are in thousands. HH = High Hazard, MH = Moderate Hazard, LH = Low Hazard

Community	Total Number of Buildings	Total Estimated Building Value ($)	HH Number of Buildings	HH Building Value ($)	HH Percent of Building Value Exposed	MH Number of Buildings	MH Building Value ($)	MH Percent of Building Value Exposed	LH Number of Buildings	LH Building Value ($)	LH Percent of Building Value Exposed
Unincorp. Crook Co.	10,872	2,172,583	2,901	542,242	25.0%	4,988	1,013,990	47%	2,983	616,350	28%
Juniper Canyon*	2,509	330,657	193	26,070	7.9%	2,288	301,734	91%	28	2,853	1%
Powell Butte*	1,307	285,473	9	4,585	1.6%	1,087	246,387	8%	211	34,501	12%
Total Unincorp. County	**14,688**	**2,788,713**	**3,103**	**572,898**	**21.0%**	**8,363**	**1,562,111**	**56%**	**3,222**	**653,704**	**23%**
Prineville	5,290	2,281,832	0	0	0.0%	821	590,879	26%	4,469	1,690,953	74%
Total	**19,978**	**5,070,545**	**3,103**	**572,898**	**11.0%**	**9,184**	**2,152,990**	**43%**	**7,691**	**2,344,657**	**46%**

*Unincorporated communities

APPENDIX C. VULNERABILITY ASSESSMENT OF LIFELINES

Table C-1. Inventory of Crook County high hazard potential dams.

Dam Name	NID ID	Hazard Potential	Owner/Operator	State Regulated	Purpose
Allen Creek	OR00313	Low	Private	Yes	Irrigation
Antelope Flat (Crook)	OR00378	Low	Private	Yes	Irrigation
Arthur R. Bowman Dam	OR00579	High	Federal	No	Flood Risk Reduction
Barnes Butte	OR00284	High	Private	Yes	Irrigation
Bear Creek (Crook)	OR00689	Significant	Private	Yes	Irrigation
Black Snag Reservoir	OR03777	Low	Private	Yes	Fish and Wildlife Pond
Bonnie View Dam	OR00213	Significant	Private	Yes	Irrigation
Camp Creek No.2 (Crook)	OR00339	Low	Private	Yes	Irrigation
Camp Creek Reservoir (Crook)	OR00150	Low	Private	Yes	Irrigation
Desert Creek Dam	OR03839	Low	Private	Yes	Hydroelectric
Dick Dam	OR00161	Significant	Private	Yes	Irrigation
Freezeout Reservoir	OR03715	Low	Private	Yes	Irrigation
Gillen Reservoir	OR03776	Low	Private	Yes	Irrigation
Grindstone Reservoir	OR00419	Low	Private	Yes	Irrigation
Joe Fisher	OR00248	High	Private	Yes	Irrigation
Johnson Creek (Crook)	OR00232	High	Private	Yes	Irrigation
Kluchman Creek Dam	OR00242	Low	Private	Yes	Irrigation
Layton #2 Reservoir	OR00642	Low	Private	Yes	Irrigation
Layton Reservoir 1	OR00717	Low	Private	Yes	Irrigation
Lillard Dam	OR00163	Low	Private	Yes	Irrigation
Logan Butte Reservoir	OR00208	Low	Private	Yes	Irrigation
Lower Twelvemile (Buker Res)	OR00162	Low	Private	Yes	Irrigation
Mainline 1	OR00452	Significant	Private	Yes	Irrigation
Mainline 3	OR00493	Significant	Private	Yes	Irrigation
Marks Lake Dam	OR00423	Low	Private	Yes	Recreation
Merwin Reservoir #2	OR00397	Low	Private	Yes	Irrigation
Ochoco Dam	OR00098	High	Public Utility	No	Fish and Wildlife Pond
Palmer Reservoir	OR00336	Low	Private	Yes	Irrigation
Peterson Creek Reservoir	OR00503	Low	Private	Yes	Irrigation
Pine Creek Dam (Crook)	OR00191	Low	Private	Yes	Irrigation
Pringle Flat Reservoir	OR00091	Low	Private	Yes	Irrigation
Sarvis	OR00509	Significant	Private	Yes	Irrigation
Shady Creek	OR03875	Low	Private	Yes	Irrigation
Sherwood Creek Reservoir	OR03042	Low	Private	Yes	Irrigation
Walton Lake Dam	OR00261	Significant	Federal	No	Recreation
Wampler-Werth	OR00745	Significant	Private	Yes	Water Supply
Watson Reservoir	OR00521	Low	Private	Yes	Irrigation

Table C-2. RVS Surveyed Buildings in Crook County.

Building Identifier	Building Name	Site Type	Field Verified	Year Built	Seismic Upgrade	Hazus Building Type	RVS Score	Collapse Potential
Croo_emo01A	Crook County Sheriffs Special Services	EM	New RVS	1960	N	MH	2.9	Low (<1%)
Croo_emo01B	Crook County Sheriffs Special Services	EM	New RVS	1990	N	W2	3.8	Low (<1%)
Croo_fir02A	Crook County Fire & Rescue - Main Station	Fire	Retrofit	2000	Y	RM1	1.1	Moderate (>1%)
Croo_fir02B	Crook County Fire & Rescue - Main Station	Fire	Retrofit	1970	Y	RM1	1.1	Moderate (>1%)
Croo_fir03A	Crook County Fire & Rescue - Powell Butte	Fire	Verified	2000	N	W1	2.6	Low (<1%)
Croo_fir04A	Crook County Fire & Rescue - Juniper Canyon	Fire	New RVS	2003	N	RM2	4.3	Low (<1%)
Croo_hos01A	St. Charles Hospital	Hospital	New RVS	2015	N	PC2	1.8	Moderate (>1%)
Croo_hos01B	St. Charles Hospital	Hospital	New RVS	2010	N	W2	4.4	Low (<1%)
Croo_pol01A	Crook County Justice Center	Police	New RVS	2024	N	PC2	2.3	Low (<1%)
Croo_pol02A	Prineville Police	Police	New RVS	2021	N	RM2	2.9	Low (<1%)
Croo_sch01A	Crook County High	School	Verified	1996	N	RM2	-0.2	Very High (100%)
Croo_sch01B	Crook County High	School	New RVS	1990	N	MH	2.0	Moderate (>1%)
Croo_sch01C	Crook County High	School	New RVS	2000	N	W2	4.4	Low (<1%)
Croo_sch01D	Crook County High	School	New RVS	2000	N	W2	4.4	Low (<1%)
Croo_sch01E	Crook County High	School	New RVS	2010	N	W2	3.5	Low (<1%)
Croo_sch02A	Crooked River Elementary	School	Verified	1937	N	C2	-0.1	Very High (100%)
Croo_sch02B	Crooked River Elementary	School	New RVS	2020	N	MH	2.0	Moderate (>1%)
Croo_sch02B	Crooked River Elementary	School	Verified	1937	N	RM1	1.9	Moderate (>1%)
Croo_sch02C	Crooked River Elementary	School	Verified	1937	N	RM1	2.4	Low (<1%)
Croo_sch03A	Crooked River Alternative	School	Verified	1937	N	C2	-0.5	Very High (100%)
Croo_sch03B	Steins Pillar Elementary	School	Verified	1939	N	C2	1.5	Moderate (>1%)
Croo_sch03C	Steins Pillar Elementary	School	Verified	1940	N	RM1	0.4	High (>10%)
Croo_sch03D	Steins Pillar Elementary	School	New RVS	2010	N	MH	2.0	Moderate (>1%)
Croo_sch05A	Crook County Middle	School	Verified	1950	N	C2	-0.1	Very High (100%)
Croo_sch05C	Crook County Middle	School	Verified	1950	N	RM1	-0.1	Very High (100%)
Croo_sch07A	Powell Butte Community Charter	School	Verified	1930	N	C2	0.7	High (>10%)
Croo_sch07B	Powell Butte Community Charter	School	Verified	1990	N	RM1	1.1	Moderate (>1%)
Croo_sch07C	Powell Butte Community Charter	School	Verified	1980	N	W2	6.4	Low (<1%)
Croo_sch08A	Paulina Elementary	School	New RVS	1950	N	RM2	2.0	Moderate (>1%)
Croo_sch08B	Paulina Elementary	School	New RVS	1990	N	MH	4.5	Low (<1%)
Croo_sch08C	Paulina Elementary	School	New RVS	1990	N	MH	4.5	Low (<1%)
Croo_sch09A	Barnes Butte Elementary	School	New RVS	2015	N	RM2	2.9	Low (<1%)
Croo_sch09B	Barnes Butte Elementary	School	New RVS	2010	N	RM2	2.9	Low (<1%)
Croo_sch09C	Barnes Butte Elementary	School	New RVS	2010	N	RM2	2.9	Low (<1%)

APPENDIX D. HAZUS METHODOLOGY

D.1 Software

We performed all loss estimations using Hazus®-MH 5.0 and ArcGIS® Pro 3.0.0.

D.2 User-Defined Facilities (UDF) Database

A UDF database was compiled for all buildings in Crook County for use in both the flood and earthquake modules of Hazus. The Crook County assessor database (acquired in 2023) was used to determine which taxlots had improvements (i.e., buildings) and how many building points should be included in the UDF database.

D.2.1 Locating Buildings Points

The Oregon Department of Geology and Mineral Industries (DOGAMI) used the SBFO-1 (Williams, 2021) dataset to help precisely locate the centroid of each building. Extra effort was spent to locate building points along the 1% and 0.2% annual chance inundation fringe. When buildings were partially within the inundation zone, the building point was moved to the centroid of the portion of the building within the inundation zone. An iterative approach was used to further refine locations of building points for the flood module by generating results, reviewing the highest value buildings, and moving the building point over a representative elevation on the lidar digital elevation model to ensure an accurate first floor height.

D.2.2 Attributing Building Points

Populating the required attributes for Hazus was achieved through a variety of approaches. The Crook County assessor database was used whenever possible, but in many cases that database did not provide the necessary information. The following is a list of attributes and their sources.

- **Longitude** and **Latitude:** Location information that provides Hazus the x- and y-position of the UDF point. This allows for an overlay to occur between the UDF point and the flood or earthquake input data layers. The hazard model uses this spatial overlay to determine the correct hazard risk level that will be applied to the UDF point. The format of the attribute must be in decimal degrees. A simple geometric calculation using GIS software is done on the point to derive this value.
- **Occupancy class:** An alphanumeric attribute that indicates the use of the UDF (e.g., "RES1" is a single-family dwelling). The alphanumeric code is composed of seven broad occupancy types (RES = residential, COM = commercial, IND = industrial, AGR = agricultural, GOV = public, REL = non-profit/religious, EDU = education) and various suffixes that indicate more specific types. This code determines the damage function to be used for flood analysis. It is also used to attribute the Building Type field, discussed below, for the earthquake analysis. The code was interpreted from "Stat Class" or "Description" data found in the Crook County assessor database. When data was not available, the default value of RES1 was applied throughout.
- **Cost:** The replacement cost of an individual UDF. Loss ratio is derived from this value. Replacement cost is based on a method called RSMeans valuation (Charest, 2017) and is calculated by multiplying the building square footage by a standard cost per square foot. These standard rates per square foot are in tables within the default Hazus database.

- **Year built:** The year of construction that is used to attribute the Building Design Level field for the earthquake analysis (see "Building Design" below). The year a UDF was built is obtained from Crook County assessor database. When not available, the year of "1900" was applied.
- **Square feet:** The size of the UDF is used to pro-rate the total improvement value for tax lots with multiple UDFs. The value distribution method will ensure that UDFs with the highest square footage will be the most expensive on a given tax lot. This value is also used to prorate the **Number of People** field for Residential UDFs within a census block. The value was obtained from DOGAMI's building footprints; where (RES) footprints were not available, we used the Crook County assessor database.
- **Number of stories:** The number of stories for an individual UDF, along with Occupancy Class, determines the applied damage function for flood analysis. The value was obtained from the Crook County assessor database when available. For UDFs without assessor information for number of stories that are within the flood zone, closer inspection using Google Street View™ or available oblique imagery was used for attribution.
- **Foundation type:** The UDF foundation type correlates with First Floor Height values in feet (see Table 3.11 in the Hazus Technical Manual for the Flood Model [FEMA, 2022a]). It also functions within the flood model by indicating if a basement exists or not. UDFs with a basement have a different damage function from UDFs that do not have one. The value was obtained from the Crook County assessor database when available. For UDFs without assessor information for basements that are within the flood zone, closer inspection using Google Street View™ or available oblique imagery was used to ascertain if one exists or not.
- **First floor height:** The height in feet above grade for the lowest habitable floor. The height is factored during the depth of flooding analysis. The value is used directly by Hazus, where Hazus overlays a UDF location on a depth grid and using the **first-floor height** determines the level of flooding occurring to a building. It is derived from the Foundation Type attribute or observation via oblique imagery or Google Street View™ mapping service.
- **Building type:** This attribute determines the construction material and structural integrity of an individual UDF. It is used by Hazus for estimating earthquake losses by determining which damage function will be applied. This information was unavailable from the Crook County assessor data, so instead it was derived from a statistical distribution based on **Occupancy class**.
- **Building design level:** This attribute determines the seismic building code for an individual UDF. It is used by Hazus for estimating earthquake losses by determining which damage function will be applied. This information is derived from the **Year Built** attribute (Crook County Assessor) and state/regional Seismic Building Code benchmark years.
- **Number of people:** The estimated number of permanent residents living within an individual residential structure. It is used in the post-analysis phase to determine the amount of people affected by a given hazard. This attribute is derived from default Hazus database (United States Census Bureau, 2020a) of population per census block and distributed across residential UDFs and adjusted based on population growth estimates from PSU Population Research Center.
- **Community:** The community that a UDF is within. These areas are used in the post-analysis for reporting results. The communities were based on incorporated area boundaries; unincorporated community areas were based on building density.

D.2.3 Seismic Building Codes

Oregon initially adopted seismic building codes in the mid-1970s (Judson, 2012). The established benchmark years of code enforcement are used in determining a "design level" for individual buildings. The design level attributes (Pre-Code, Low-Code, Moderate-code, and High-code) are used in the Hazus earthquake model to determine what damage functions are applied to a given building (FEMA, 2022b). The year built or the year of the most recent seismic retrofit are the main considerations for an individual design level attribute. Seismic retrofitting information for structures would be ideal for this analysis but was not available for Crook County. **Tables D-1**, **D-2**, **D-3**, and **D-4** outlines the benchmark years that apply to buildings within Crook County.

Table D-1. Crook County seismic design level benchmark years for single-family dwellings, including duplexes. Design levels derive from the interpretation of Judson (2012).

Year Built	Design Level
Prior to 1976	Pre-Code
1976–1991	Low-Code
1992–2003	Moderate-Code
2004–2016	High-Code

Table D-2. Crook County seismic design level benchmark years for manufactured houses. Design levels derived from an interpretation of OR BCD 2002 Manufactured Dwelling Special Codes (Oregon Building Codes Division, 2002).

Year Built	Design Level
Prior to 2003	Pre-Code
2003–2010	Low-Code
2011–2016	Moderate-Code

Table D-3. Crook County seismic design level benchmark years for all non–single-family residences and non-manufactured houses. Design levels derive from Business Oregon 2024 Oregon Benefit-Cost Analysis Tool, p. 24 (Business Oregon, 2024).

Year Built	Design Level
Prior to 1976	Pre-Code
1976–1990	Low-Code
1991–2016	Moderate-Code

Table D-4. Seismic design level in Crook County.

Community	Total Number of Buildings	Number of Pre-Code Buildings	Percentage of Pre-Code Buildings	Number of Low-Code Buildings	Percentage of Low-Code of Buildings	Number of Moderate-Code Buildings	Percentage of Moderate-Code Buildings	Number of High-Code Buildings	Percentage of High-Code Buildings
Unincorp. Crook Co	10,872	5,326	49%	962	9%	1,174	11%	3,410	31.4%
Juniper Canyon*	2,509	967	39%	100	4%	360	14.3%	1,082	43.1%
Powell Butte*	1,307	475	36%	157	12%	222	17%	453	34.7%
Total Unincorp. County	14,688	6,768	**46%**	1,219	**8%**	1,756	12%	4,945	**33.7%**
Prineville	5,290	2,588	49%	526	9.9%	551	10.4%	1,625	30.7%
Total	19,978	9,356	**47%**	1,745	**9%**	2,307	12%	6,570	**32.9%**

D.3 Flood Hazard Data

DOGAMI developed depth grids from detailed stream model information within the study area. The depth grids were used in this risk assessment to determine the level to which buildings are impacted by flooding.

A study-area-wide, 2-meter, lidar-based depth grid was developed for each of the 10-, 50-, 100-, and 500-year annual chance flood events. The depth grids were imported into Hazus to determine the depth of flooding for areas within the FEMA flood zones.

Once the UDF database was developed into a Hazus-compliant format, the Hazus methodology was applied using a Python (programming language) script developed by DOGAMI (Bauer, 2018). The analysis was then run for a given flood event, and the script cross-referenced a UDF location with the depth grid to find the depth of flooding. The script then applied a specific damage function, based on a UDF's Occupancy Class, which was used to determine the loss ratio for a given amount of flood depth, relative to the UDF's first-floor height.

D.4 Earthquake Hazard Data

The following hazard layers used for our loss estimation are derived from work conducted by Madin and others (2021): National Earthquake Hazard Reduction Program (NEHRP) soil classification, liquefaction susceptibility, and wet landslide susceptibility. The liquefaction and landslide susceptibility layers together with NEHRP were used by the Hazus tool to calculate ground motion layers and permanent ground deformation and associated probability. The default value of 5 feet was used for the water table depth value.

During the Hazus earthquake analysis, each UDF was analyzed given its site-specific parameters (ground deformation) and evaluated for loss, expressed as a probability of a damage state. Specific damage functions based on building type and building design level were used to calculate the damage states given the site-specific parameters for each UDF. The output provided probabilities for the five damage states (None, Slight, Moderate, Extensive, Complete) from which losses in dollar amounts were derived.

D.5 Post-Analysis Quality Control

Ensuring the quality of the results from Hazus flood and earthquake modules is an essential part of the process. A primary characteristic of the process is that it is iterative. A UDF database without errors is highly unlikely, so this part of the process is intended to limit and reduce the influence these errors have on the final outcome. Before applying the Hazus methodology, closely examining the top 10 largest area UDFs and the top 10 most expensive UDFs is advisable. Special consideration can also be given to critical facilities due to their importance to communities.

Identifying, verifying, and correcting (if needed) the outliers in the results is the most efficient way to improve the UDF database. This removal can be done by sorting the results based on the loss estimates and closely scrutinizing the top 10–15 records. If corrections are made, then subsequent iterations are necessary. We continued checking the “loss leaders” until no more corrections were needed.

Finding anomalies and investigating possible sources of error are crucial in making corrections to the data. A wide range of corrections might be required to produce a better outcome. For example, floating homes may need to have a first-floor height adjustment or a UDF point position might need to be moved due to issues with the depth grid. Incorrect basement or occupancy type attribution could be the cause of a problem. Commonly, inconsistencies between assessor data and tax lot geometry can be the source of an error. These are just a few of the many types of problems addressed in the quality control process.

APPENDIX E. ACRONYMS AND DEFINITIONS

E.1 Acronyms

CRS	Community Rating System
CSZ	Cascadia subduction zone
DLCD	Oregon Department of Land Conservation and Development
DOGAMI	Department of Geology and Mineral Industries (State of Oregon)
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FRI	Fire Risk Index
GIS	Geographic Information System
NFIP	National Flood Insurance Program
NHMP	Natural hazard mitigation plan
NOAA	National Oceanic and Atmospheric Administration
ODF	Oregon Department of Forestry
OEM	Oregon Emergency Management
OFR	Open-File Report
OPDR	Oregon Partnership for Disaster Resilience
PGA	Peak ground acceleration
PGD	Permanent ground deformation
PGV	Peak ground velocity
Risk MAP	Risk Mapping, Assessment, and Planning
SHMO	State Hazard Mitigation Officer
SLIDO	State Landslide Information Layer for Oregon
UDF	User-defined facilities
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WUI	Wildland-urban interface
WWA	West Wide Wildfire Risk Assessment

E.2 Definitions

- **1% annual chance flood:** The flood elevation that has a 1-percent chance of being equaled or exceeded each year. Sometimes referred to as the 100-year flood.
- **0.2% annual chance flood:** The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year. Sometimes referred to as the 500-year flood.
- **Base flood elevation (BFE):** Elevation of the 1-percent-annual-chance flood. This elevation is the basis of the insurance and floodplain management requirements of the NFIP.
- **Critical facilities:** Facilities that, if damaged, would present an immediate threat to life, public health, and safety. As categorized in HAZUS, critical facilities include hospitals, emergency operations centers, police stations, fire stations and schools.
- **Exposure:** Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.
- **Flood Insurance Rate Map (FIRM):** An official map of a community, on which FEMA has delineated both the SFHAs and the risk premium zones applicable to the community.
- **Flood Insurance Study (FIS):** Contains an examination, evaluation, and determination of the flood hazards of a community and, if appropriate, the corresponding water-surface elevations.
- **Hazus:** A GIS-based risk assessment methodology and software application created by FEMA and the National Institute of Building Sciences for analyzing potential losses from floods, hurricane winds, and earthquakes.
- **Lidar:** A remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. Lidar is popularly used as a technology to make high-resolution maps.
- **Liquefaction:** Describes a phenomenon whereby a saturated soil substantially loses strength and stiffness in response to an applied stress, usually an earthquake, causing it to behave like liquid.
- **Loss Ratio:** The expression of loss as a fraction of the value of the local inventory (total value/loss).
- **Magnitude:** A scale used by seismologists to measure the size of earthquakes in terms of energy released.
- **Risk:** Probability multiplied by consequence; the degree of probability that a loss or injury may occur because of a natural hazard. Sometimes referred to as vulnerability.
- **Risk MAP:** The vision of this FEMA strategy is to work collaboratively with State, local, and tribal entities to deliver quality flood data that increases public awareness and leads to action that reduces risk to life and property.
- **Riverine:** Of or produced by a river. Riverine floodplains have readily identifiable channels.
- **Susceptibility:** Degree of proneness to natural hazards that is determined based on physical characteristics that are present.
- **Vulnerability:** Characteristics that make people or assets more susceptible to a natural hazard.

APPENDIX F. MAP PLATES

See appendix folder for individual map PDFs.

Plate 1. Population density map of Crook County, Oregon.

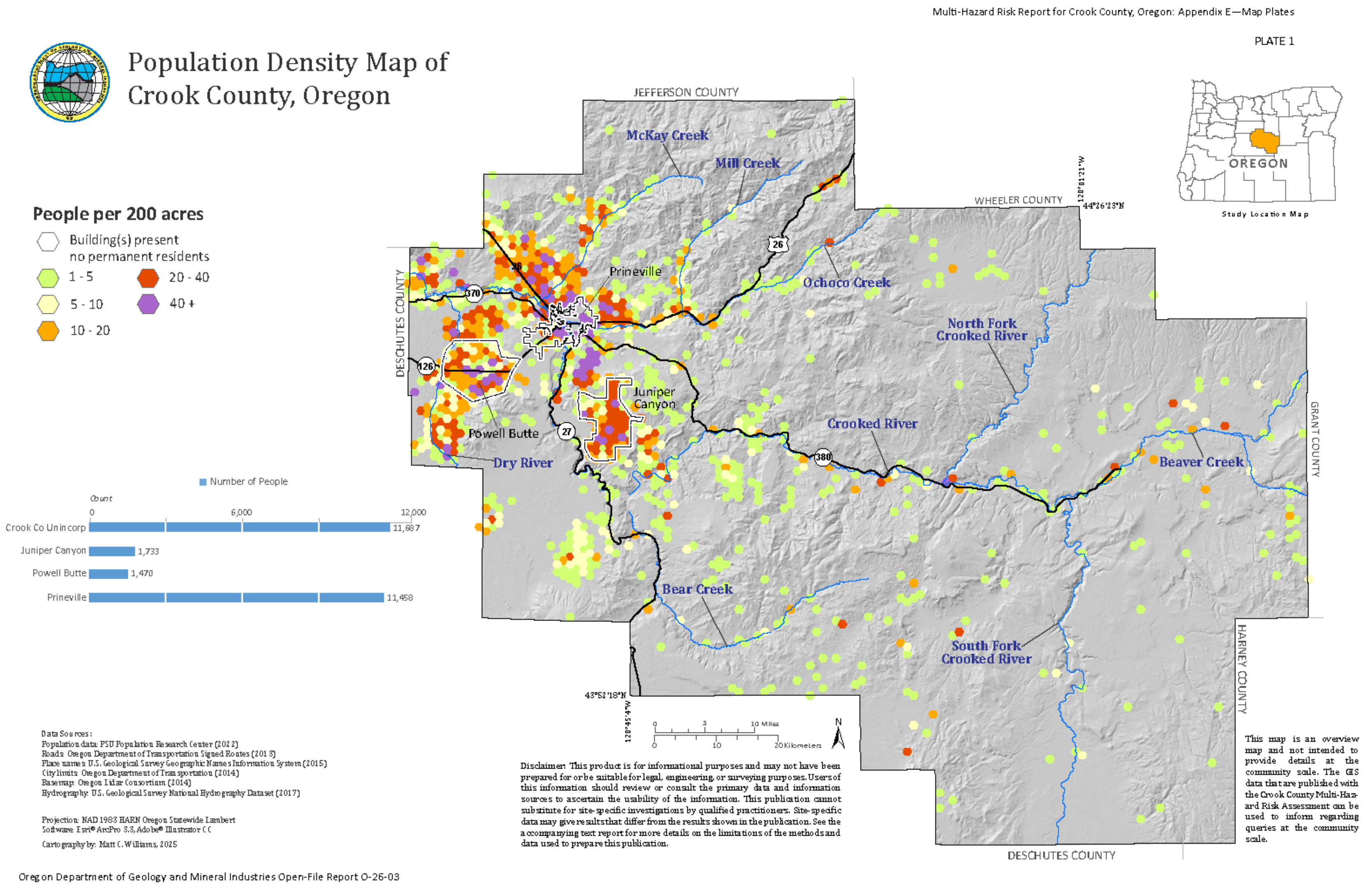
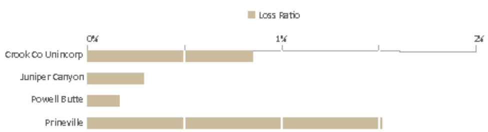


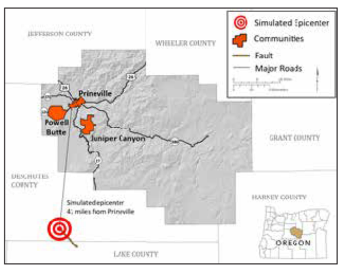
Plate 2. Southeast Newberry Fault Mw-7.2 earthquake shaking map of Crook County, Oregon.

PLATE 2

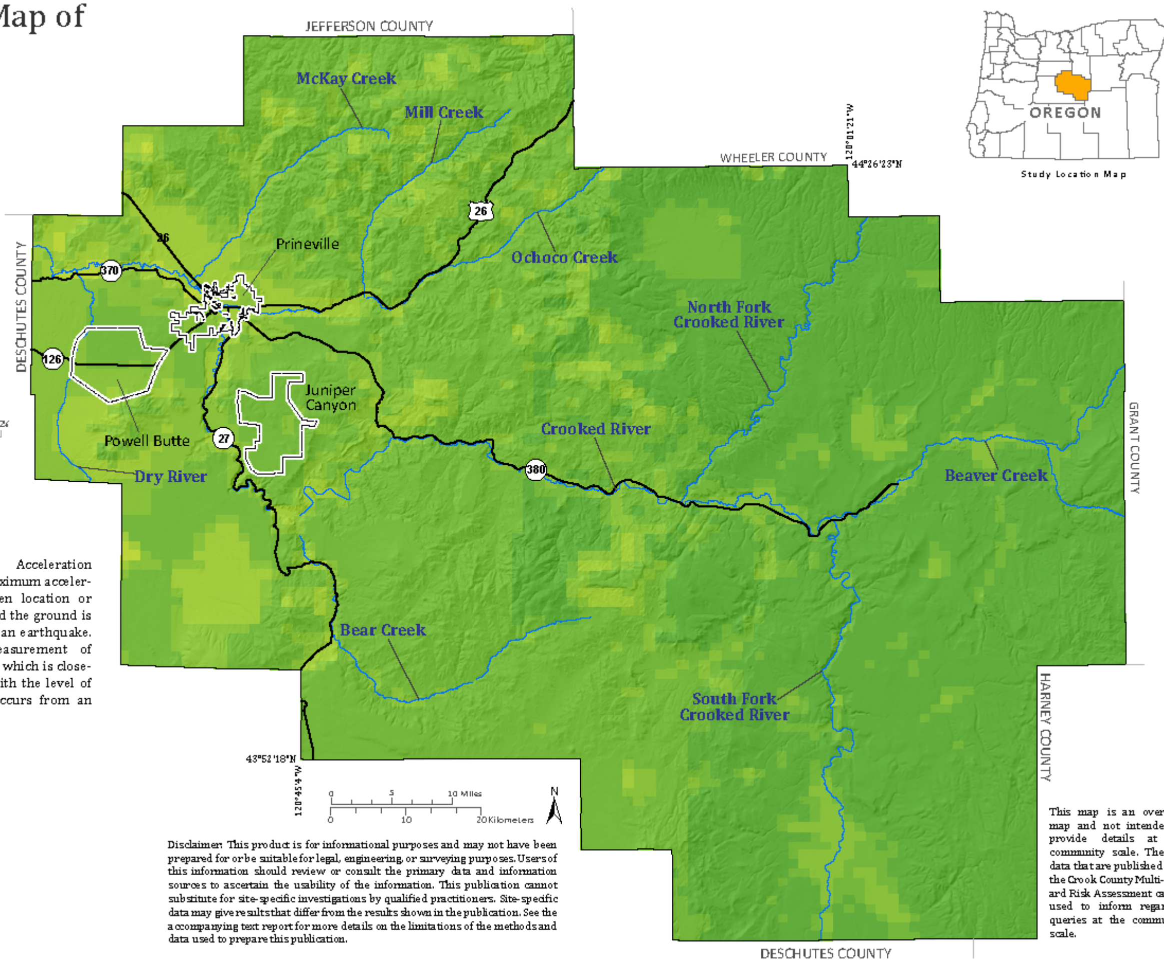
Southeast Newberry Fault Magnitude-7.2 Earthquake Shaking Map of Crook County, Oregon

Modified Mercalli	Perceived Shaking	Potential Damage	Peak Ground Acceleration (g)
I	Not felt	None	< 0.000464
II	Weak	None	0.000464 - 0.00297
III	Weak	None	0.000464 - 0.00297
IV	Light	None	0.00297 - 0.0276
V	Moderate	Very Light	0.0276 - 0.115
VI	Strong	Light	0.115 - 0.215
VII	Very Strong	Moderate	0.215 - 0.401
VIII	Severe	Mod./Heavy	0.401 - 0.747
IX	Violent	Heavy	0.747 - 1.39
X	Extreme	Very Heavy	> 1.39





Peak Ground Acceleration (PGA) is the maximum acceleration in a given location or rather how hard the ground is shaking during an earthquake. It is one measurement of ground motion, which is closely associated with the level of damage that occurs from an earthquake.



Data Sources:
Earthquake peak ground acceleration: Generated from Hazus 5.0 earthquake analysis (2024)
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 (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
Software: Esri® ArcPro 3.3, Adobe® Illustrator CC

Cartography by: Matt C. Williams, 2025

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 are published with the Crook County Multi-Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Plate 3. Coseismic landslide susceptibility (wet) map of Crook County, Oregon.

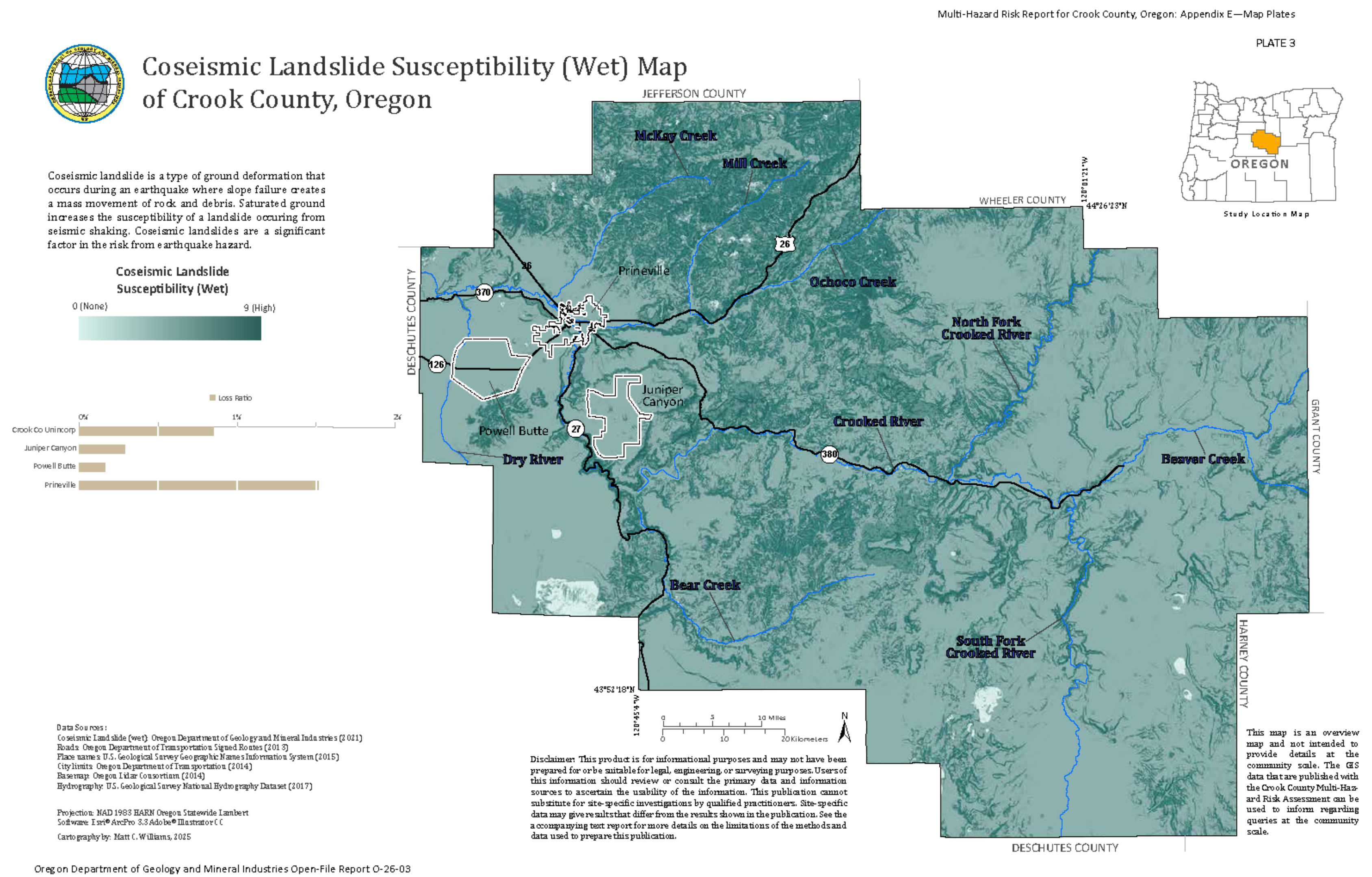


Plate 4. Liquefaction susceptibility map of Crook County, Oregon.

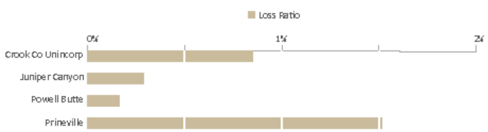
PLATE 4

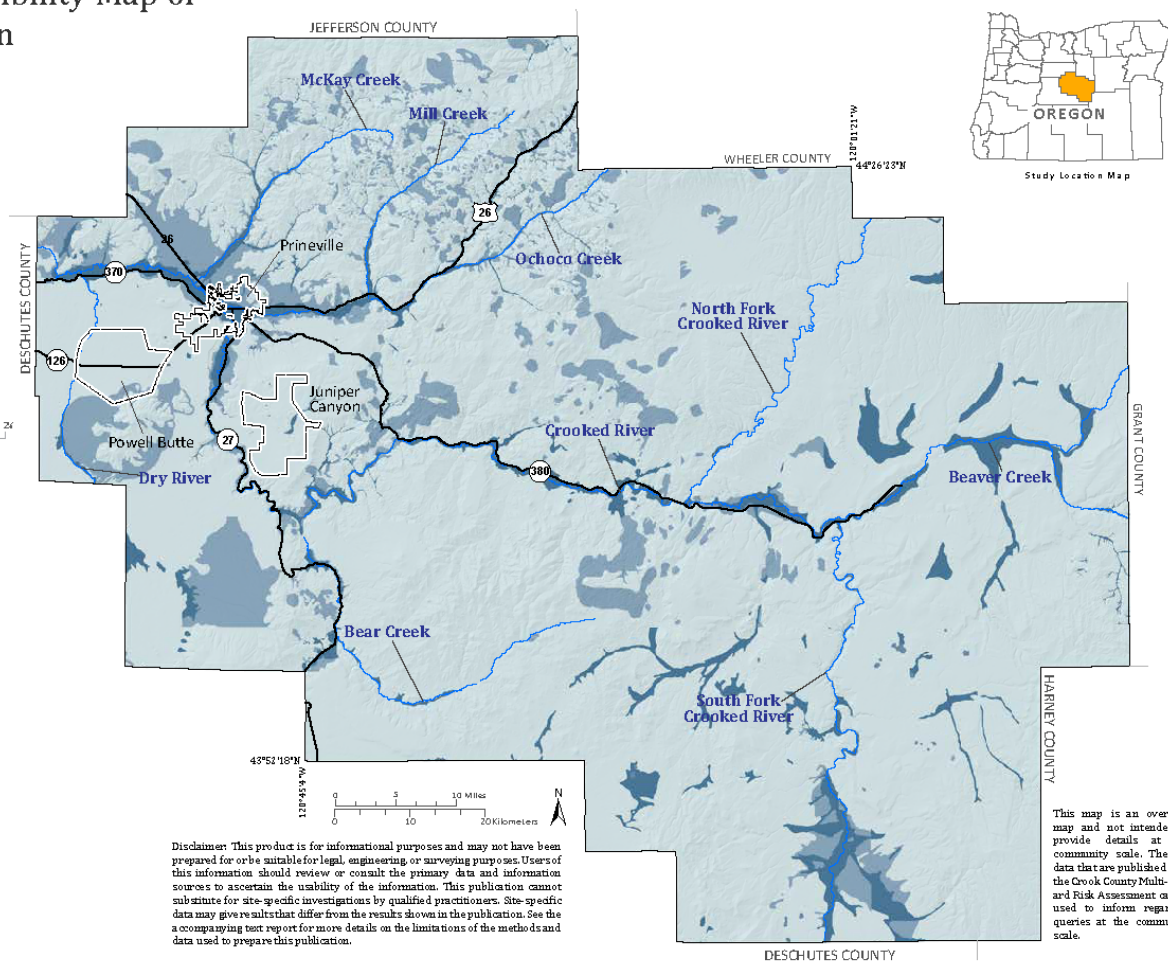
Liquefaction Susceptibility Map of Crook County, Oregon

Liquefaction is a type of ground deformation that occurs during an earthquake where saturated, non-cohesive soil contracts and liquefies. The ground that becomes liquefied can no longer support heavy structures that are built on top of it. Liquefaction is a significant factor in the risk from earthquake hazard.

Liquefaction Susceptibility

- Low or None
- Moderate
- High
- Very High





Data Sources:
Liquefaction susceptibility: Oregon Department of Geology and Mineral Industries (2021)
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 (2014)
Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
Software: Esri® ArcPro 3.3, Adobe® Illustrator CC

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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 are published with the Crook County Multi-Hazard Risk Assessment can be used to inform regarding queries at the community scale.

Plate 5. Site class amplification map of Crook County, Oregon.

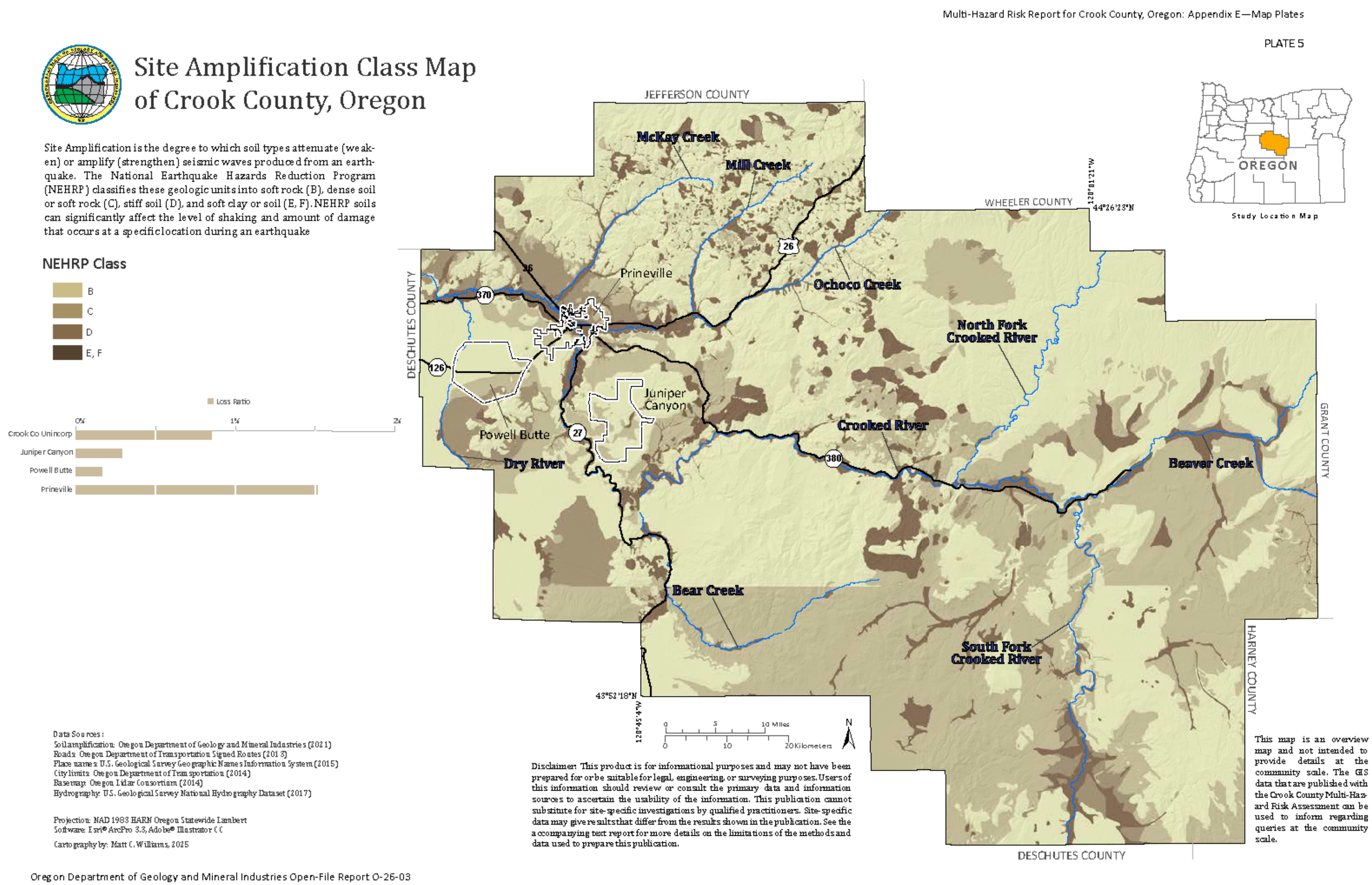

Plate 6. Flood hazard map of Crook County, Oregon.

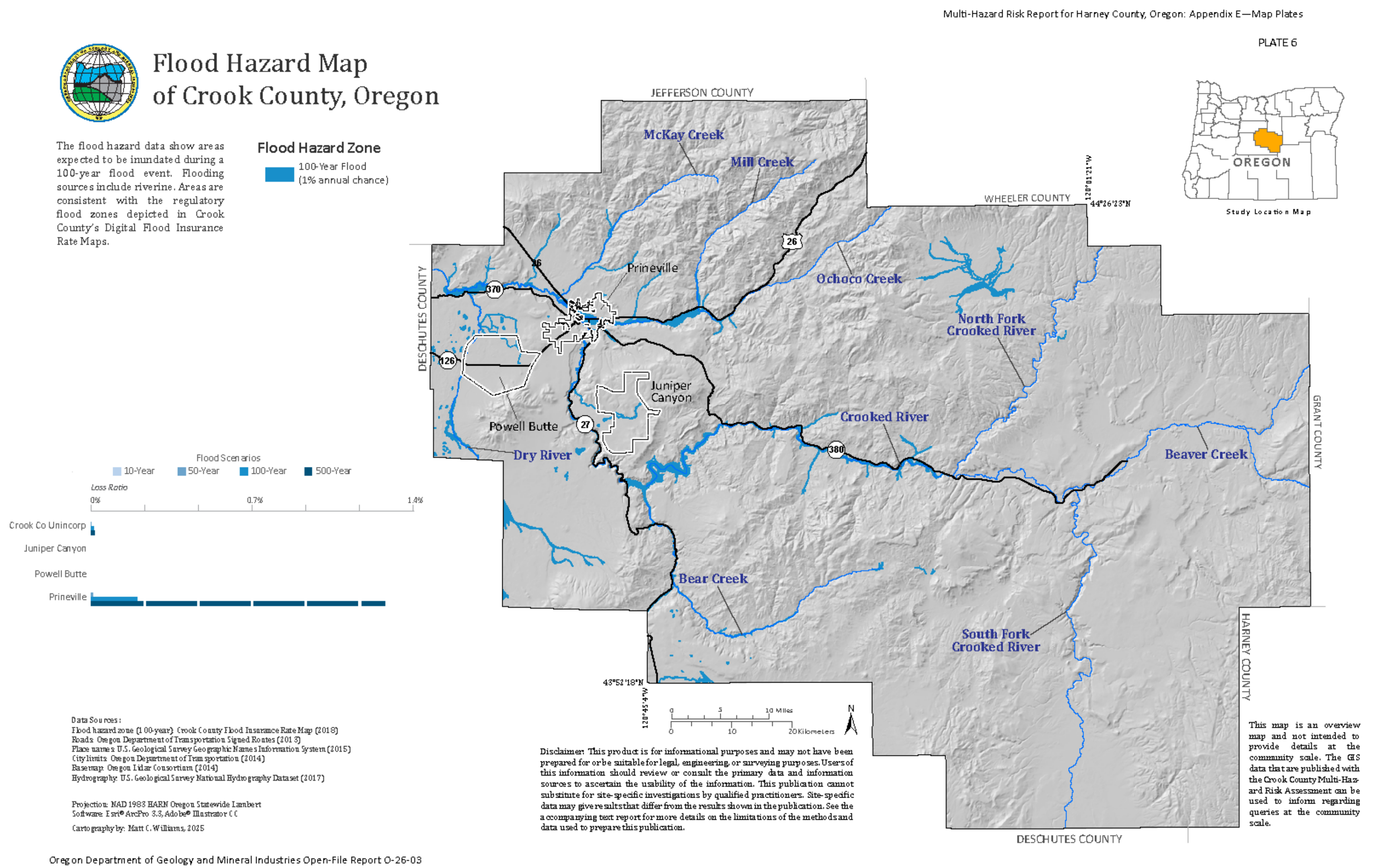

Plate 7. Landslide susceptibility map of Crook County, Oregon.

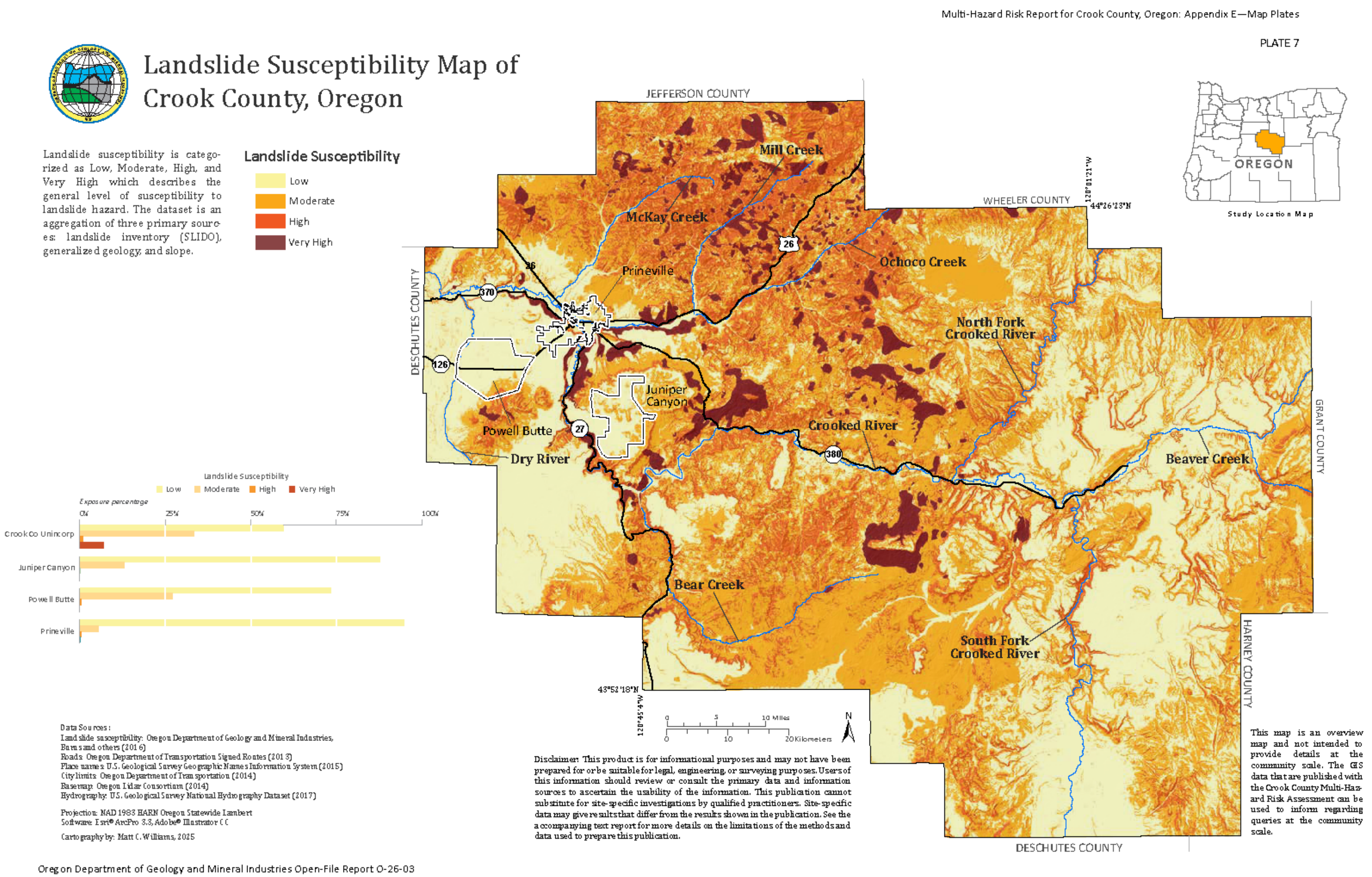

Plate 8. Wildfire hazard map of Crook County, Oregon.