

State of Oregon
Oregon Department of Geology and Mineral Industries
Ruairi J. Day-Stirrat, State Geologist

OPEN-FILE REPORT O-25-06

MULTI-HAZARD RISK REPORT FOR HARNEY COUNTY, OREGON
INCLUDING THE CITIES OF BURNS, HINES, AND THE BURNS PAIUTE
RESERVATION AND TRUST LANDS

by Matt C. Williams¹ and Laura L. S. Gabel²



2025

¹Oregon Department of Geology and Mineral Industries, 800 NE Oregon Street, Suite 965, Portland, OR 97232

²Oregon Department of Geology and Mineral Industries, Coastal Field Office, P.O. Box 1033, Newport, OR 97365

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.

Cover photo: Oregon DOT closed and breached U.S. 20 at milepost 132.6 on April 8, 2011, for flood relief. The breach was done at the request of Harney County Emergency Operations Center.

*Credit: Oregon Department of Transportation. Photograph obtained from ODOT's flickr photostream.
<https://www.flickr.com/photos/oregondot/5600666113/in/photostream/>*

WHAT'S IN THIS REPORT?

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



Expires: 1/1/2026

Oregon Department of Geology and Mineral Industries Open-File Report O-25-06
Published in conformance with ORS 516.030

For additional information:
Administrative Offices
800 NE Oregon Street, Suite 965
Portland, OR 97232
Telephone (971) 673-1555
<http://oregon.gov/DOGAMI/>

TABLE OF CONTENTS

Executive Summary	1
1.0 Introduction	2
1.1 Purpose.....	3
1.2 Study Area	3
1.3 Project Scope.....	4
1.4 Previous Studies	6
2.0 Methods.....	6
2.1 Hazus Loss Estimation	7
2.2 Exposure	9
2.3 Building Inventory	10
2.4 Population	12
3.0 Assessment Overview and Results	13
3.1 Earthquake	13
3.2 Flooding.....	17
3.3 Landslide Susceptibility	20
3.4 Wildfire.....	23
4.0 Conclusions	25
5.0 Limitations	26
6.0 Recommendations.....	27
6.1 Awareness and Preparation	27
6.2 Planning.....	28
6.3 Emergency Response.....	28
6.4 Mitigation Funding Opportunities.....	28
6.5 Hazard-Specific Risk Reduction Actions	29
7.0 ACKNOWLEDGMENTS	29
8.0 REFERENCES	30
9.0 Appendices.....	33
Appendix A. Community Risk Profiles	34
Appendix B. Detailed Risk Assessment Tables	39
Appendix C. Hazus Methodology	46
Appendix D. Acronyms and Definitions.....	51
Appendix E. Map Plates.....	53

LIST OF FIGURES

Figure 1-1. Study area: Harney County with communities in this study identified.....	4
Figure 2-1. 100-year flood zone and building loss estimates example in Burns, Oregon	8
Figure 2-2. Landslide susceptibility and building exposure example in Hines, Oregon	9
Figure 2-3. Building occupancy types in Burns, Oregon	10
Figure 2-4. Community building value in Harney County by occupancy class	11
Figure 2-5. Population by Harney County community	13
Figure 3-1. Harney Fault location.....	14
Figure 3-2. Harney Fault Mw 6.7 earthquake loss ratio by Harney County community	15
Figure 3-3. Harney Fault Mw 6.7 earthquake loss ratio in Harney County with simulated seismic building code upgrades	16

Figure 3-4. Flood depth grid example in Burns, Oregon 18
 Figure 3-5. Ratio of flood loss estimates by Harney County community 20
 Figure 3-6. Landslide susceptibility exposure by Harney County community..... 22
 Figure 3-7. Exposure to wildfire hazard by Harney County community..... 24
 Figure C-1. Seismic design level by Harney County community..... 49

LIST OF TABLES

Table 1-1. Hazard data sources for Harney County 6
 Table 2-1. Harney County building inventory 11
 Table 2-2. Harney County critical facilities inventory 12
 Table A-1. Unincorporated Harney County (rural) hazard profile..... 35
 Table A-2. Unincorporated Harney County (rural) critical facilities 35
 Table A-3. City of Burns hazard profile..... 36
 Table A-4. City of Burns critical facilities 36
 Table A-5. Burns-Paiute Tribe hazard profile 37
 Table A-6. Burns-Paiute Tribe critical facilities..... 37
 Table A-7. City of Hines hazard profile 38
 Table A-8. City of Hines critical facilities 38
 Table B-1. Harney County building inventory 40
 Table B-2. CSZ Mw 9.0 Earthquake loss estimates..... 41
 Table B-3. Flood loss estimates 42
 Table B-4. Flood exposure..... 43
 Table B-5. Landslide exposure..... 44
 Table B-6. Wildfire exposure 45
 Table C-1. Harney County seismic design level benchmark years 48
 Table C-2. Seismic design level in Harney County..... 49

LIST OF MAP PLATES

Appendix E

Plate 1. Population Density Map of Harney County, Oregon..... 54
 Plate 2. Harney Fault Mw 6.7 Shaking Map of Harney County, Oregon 55
 Plate 3. Coseismic Landslide Susceptibility (Wet) Map of Harney County, Oregon..... 56
 Plate 4. Liquefaction Susceptibility Map of Harney County, Oregon 57
 Plate 5. Site Amplification Class Map of Harney County, Oregon 58
 Plate 6. Flood Hazard Map of Harney County, Oregon 59
 Plate 7. Landslide Susceptibility Map of Harney County, Oregon..... 60
 Plate 8. Wildfire Hazard Map of Harney County, Oregon 61

GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

*See the digital publication folder for files.
Geodatabase is Esri® version 10.7 format. Metadata are embedded in the geodatabase
and are also provided as separate .xml format files.*

Harney_County_MHRA.gdb

feature classes:

Building_metadata (polygons)

Communities_metadata (polygons)

UDF_EQ_Local_metadata (points)

UDF_Main_metadata (points)

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

This report was prepared for communities in Harney 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 by the Oregon Department of Geology and Mineral Industries (DOGAMI) within Harney 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 supporting the decision-making process in planning for disaster.

We arrived at our results and conclusions by completing three main tasks: compiling an asset database, identifying and using the best hazard data available, and performing a natural hazard risk assessment.

- In the first task, we created a comprehensive asset database for Harney County by synthesizing assessor data, U.S. Census information, Federal Emergency Management Agency (FEMA) Hazus 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, etc.) Using these data, we were able to represent accurate spatial locations and vulnerabilities on a building-by-building basis. We also estimated the number of residents occupying residential structures so that we were able 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 Harney County include flooding, earthquakes, landslides, and wildfires. Most of the hazard datasets used in this report were created by DOGAMI and produced using peer-reviewed methods and with 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, we analyzed risk using Esri® ArcGIS Desktop® software. We took two risk assessment approaches, depending on the nature of the hazard data: (1) estimated building losses (in dollars) were calculated for floods and earthquakes using the Hazus methodology, and (2) we calculated 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 show the wide range of potential impacts hazards could have on the communities of Harney County. A hypothetical magnitude (Mw) 6.7 Harney Fault earthquake is expected to cause mild damage in the area east of the Burns Municipal Airport and only slight damage for the rest of the county. We exhibit the potential for reduction in losses through simulating seismic retrofits of buildings using the Hazus earthquake model. Flooding is identified as a very high-risk hazard for communities in the county and we quantify the number of elevated structures because they are more resilient to flood hazard. Our analysis shows that there are very few areas that are at risk from landslide hazards. Wildfire exposure analysis shows a very high risk for buildings throughout the county, including

20 of the 38 critical facilities. Nearly 60% of the residents of Harney County are at risk from being displaced from wildfire hazards.

Results were broken out for the following geographic areas:

- Incorporated communities:
 - Burns
 - Hines
- Tribal communities:
 - Burns Paiute Tribe*
- Unincorporated communities:
 - Unincorporated Harney County

*This federally recognized Indian Tribal Government is referred to as the Burns Paiute Tribe within this report.

Selected countywide results	
Total buildings: 8,320 Total estimated building value: \$2.5 billion	
<p>Hypothetical Earthquake Scenario Red-tagged buildings^a: 99 Yellow-tagged buildings^b: 241 Loss estimate: \$74 million</p> <p>Landslide Exposure (High and Very High Susceptibility) Number of buildings exposed: 52 Exposed building value: \$10 million</p>	<p>100-year Flood Scenario Number of buildings damaged: 1,056 Loss estimate: \$39 million</p> <p>Wildfire Exposure (High Risk): Number of buildings exposed: 5,521 Exposed building value: \$1.6 billion</p>
<p>^aRed-tagged buildings are considered uninhabitable due to complete damage ^bYellow-tagged buildings are considered limited habitability due to extensive damage</p>	

The information presented in this report is designed to increase awareness of natural hazard risk, to support public outreach efforts, and to aid local decisionmakers 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 are designed to be used to help communities identify and prioritize mitigation actions that will improve community resilience.

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*. 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.

Key Terms:

- **Vulnerability:** Characteristics that make people or assets more susceptible to a natural hazard.
- **Risk:** Likelihood of occurrence multiplied by consequence; the degree of probability that a loss or injury may occur as a result of a natural hazard.

This is a multi-hazard risk assessment analyzing the consequences to buildings and people in Harney 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 Harney County communities.

Harney County is located in the southeastern part of Oregon in a region typically characterized as high desert. It is subject to a variety of natural hazards, including earthquakes, riverine flooding, landslides, and wildfire. This region of the state is also sparsely populated with most of the development occurring in the county's two incorporated cities.

1.1 Purpose

The purpose of this project is to help communities in Harney County to better understand their natural hazards and risks, and increase resilience to earthquakes (including ground shaking, liquefaction and coseismic landslides), riverine flooding, landslides, and wildfire. 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 are to:

- compile a database of critical facilities, tax assessor data, buildings, and population distribution data,
- incorporate and use existing data from the most current geologic, hydrologic, and wildfire hazard studies,
- perform exposure and Hazus-based risk analyses, and
- share this report widely so that all interested parties have access to its information and data.

The body of this report describes our methods and results. Two primary methods (Hazu loss estimation and exposure) were used to assess risk, depending on the type of hazard. These methods are described in the **Methods** section. Countywide results are reported for each hazard in **Community Risk Profiles**. 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** provides additional explanation of the Hazus methodology. **Appendix D** defines acronyms and other terms used in this report. **Appendix E** contains tabloid-size maps showing the spatial extent of the hazards, assets, and population across Harney County. These appendices can be helpful in clarifying the summarized results in each hazard section.

1.2 Study Area

The study area for this project includes the entirety of Harney County, Oregon. (**Figure 1-1**). Harney County is located in southeastern Oregon; the county is bordered by Grant County on the north, Crook and Deschutes Counties on the northwest, Lake County on the west, Malheur County on the east, and the state of Nevada to the south. The total area of Harney County is 10,228 mi² (26,490 km²). A significant portion of the county (75%) is federally owned, including ~10% of the county composed of the Ochoco or Malheur National Forests.

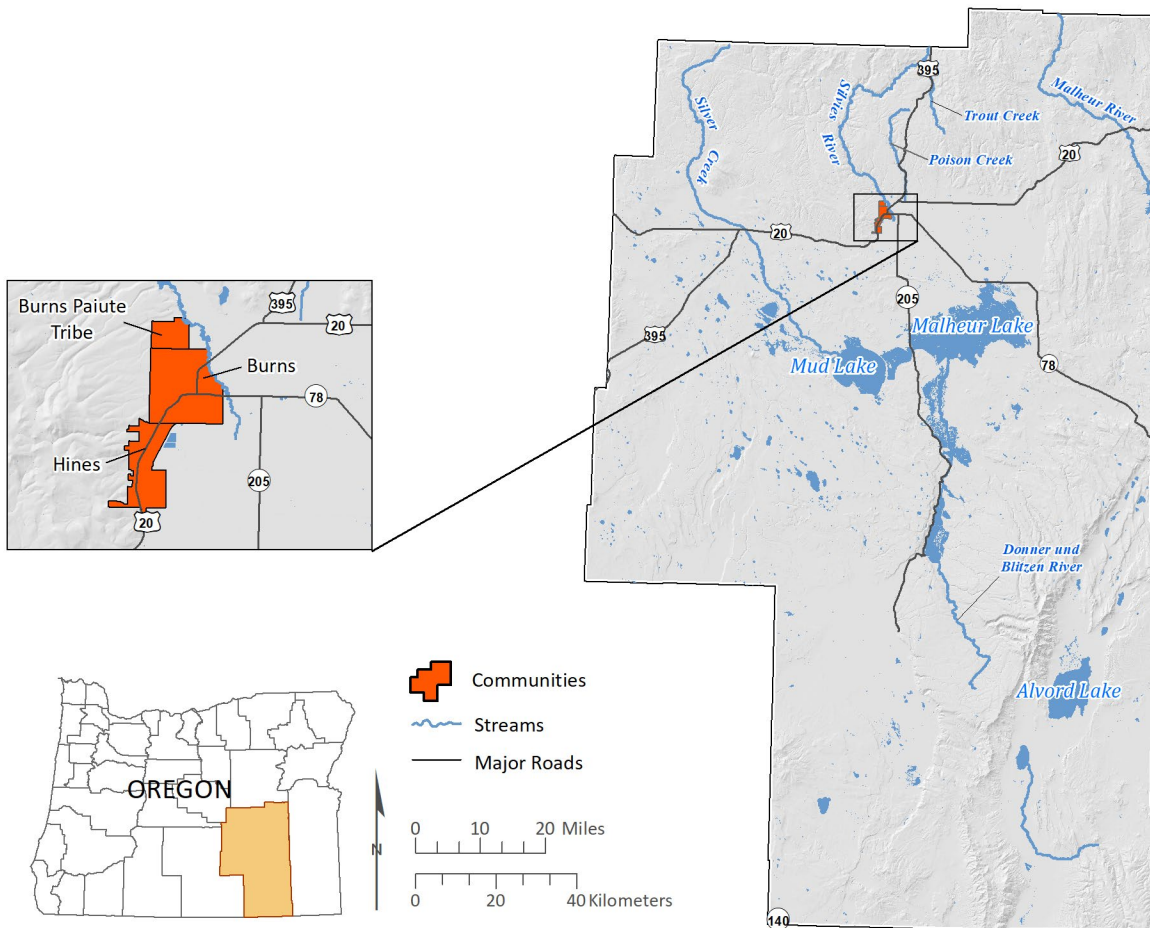
The geography of Harney County consists mostly of basin and range topography (characterized by alternating parallel mountain ridges and valleys), exemplified best by the Harney Basin and Steens

Mountain. The Harney Basin features extensive wetlands and contains both Harney Lake and Malheur Lake. Water is transported within the basin by the Silvies River in the north and the Donner und Blitzen River in the south (**Figure 1-1**). Steens Mountain is the highest point within the county and is the most prominent feature in the area, at 9,733 ft (2,967 m) above sea level.

Harney County has a population of approximately 7,600 people based on a 2022 estimates from the Portland State University (PSU) Population Research Center <https://www.pdx.edu/population-research/population-estimate-reports>. The county seat and largest community is the City of Burns. Most of the residents in the county reside in one of the two incorporated cities: Burns and Hines (**Figure 1-1**).

The Burns Paiute Tribe of the Burns Paiute Indian Colony of Oregon will be referred to as the Burns Paiute Tribe for the remainder of this report. The Burns Paiute Tribe is a federally recognized tribe and community within the study area with a population of 97. DOGAMI used the tribal lands boundary that serves as the primary community area of the Burns Paiute Tribe in the risk analyses and for reporting of results.

Figure 1-1. Study area: Harney County with communities in this study identified.



1.3 Project Scope

For this risk assessment, we limited the project scope to natural hazards affecting buildings and population because of data availability, the strengths and limitations of the risk assessment methodology,

and funding availability. We did not directly analyze the consequences to the local economy, stored hazardous materials, land values, socially vulnerable populations, infrastructure (e.g., transportation, power, water, gas, communication, and sewage), or the natural environment. Depending on the natural hazard, we used one of two methodologies: 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 method, in which buildings are categorized based on their location relative to various hazard zones. Differences between loss estimation and exposure methods are described in the **Methods** section of the report. City and county population numbers from the PSU Population Research Center data were used to distribute people into residential structures based on square footage (<https://www.pdx.edu/population-research/population-estimate-reports>).

A critical component of this risk assessment is a countywide building inventory developed from building footprint data and the Harney County tax assessor database (acquired 2016 and updated in 2024). The other key component are datasets representing the best science available 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; most datasets are DOGAMI publications. In addition to geologic hazards, we included wildfire hazard in this risk assessment. The following is a list of hazards considered in this study and what risk assessment methodologies were applied. See **Table 1-1** for data sources.

- Earthquake Risk Assessment
 - Hazus loss estimation from a Harney Fault deterministic Mw 6.7 scenario
- Flood Risk Assessment
 - Hazus loss estimation to four recurrence intervals (10%, 2%, 1%, and 0.2% annual chance)
 - Exposure to 1% annual chance recurrence interval
- Landslide Risk Assessment
 - Exposure based on Landslide Susceptibility Index
- Wildfire Risk Assessment
 - Exposure based on Burn Probability (Low to High)

Table 1-1. Hazard data sources for Harney County.

Hazard	Scenario or Classes	Spatial Extent	Data Source
Earthquake	Harney Fault Mw 6.7	Regional	USGS (Personius and Haller, 2002)
Coseismic landslide	Susceptibility – wet (3-10 hazard classes)	Statewide	DOGAMI (Madin and others, 2021)
Coseismic liquefaction	Susceptibility (1-5 classes)	Statewide	DOGAMI (Madin and others, 2021)
Coseismic soil amplification class	National Earthquake Hazards Reduction Program (A-F classes)	Statewide	DOGAMI (Madin and others, 2021)
Flood	Depth Grids: 10% (10-yr), 2% (50-yr), 1% (100-yr), 0.2% (500-yr)	Countywide	Developed by FEMA for Harney County FIRMs (FEMA, 2024)
Landslide	Susceptibility (Low, Moderate, High, Very High)	Statewide	DOGAMI (Burns and others, 2016)
Wildfire	Burn Probability (Low, Moderate, High)	Regional (Pacific Northwest, US)	ODF (Gilbertson-Day and others, 2018)

1.4 Previous Studies

Two previous risk assessments that include Harney County have been conducted by DOGAMI. Wang and Clark (1999: DOGAMI Special Paper 29) ran two general level Hazus earthquake analyses, a Mw 8.5 Cascadia Subduction Zone (CSZ) earthquake and a 500-year probabilistic earthquake scenario, for the entire state of Oregon. In those analyses Harney County was estimated to experience a negligible amount of damage. Because of these differences, comparative analysis was not beneficial to the scope of this project.

In the Harney County Natural Hazard Mitigation Plan (HCNHMP) of 2008, DOGAMI ran two Hazus earthquake analyses within Harney County. One a Mw 6.5 arbitrary crustal fault scenario and the other a 2500-year (2% in 50 years) probabilistic scenario (Burns, 2008). The Hazus default general building stock was used in damage modeling. A very slight amount of damage was predicted in both scenarios. This analysis also was not suitable for comparison in this report due to very different resolutions of input data (i.e., census tract level vs. building level).

2.0 METHODS

Where natural hazards have the potential to damage assets or harm people, the result is natural hazard *risk*. We 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.

2.1 Hazus Loss Estimation

We used Hazus version 6.0 (FEMA, 2022a), which was the latest version available when we began this risk assessment study in 2022. 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, we chose the user-defined facility (UDF) mode. This mode makes loss estimations for individual buildings relative to their “cost,” which we then aggregate 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. We estimated damage and loss 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 0 to 15%. Buildings with a first-floor height above the level of flooding and those outside the flood zone are expected to experience no losses.

Key Terms:

- *Loss estimation*: 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.
- *Loss ratio*: Percentage of estimated loss relative to the total value.

Figure 2-1. 100-year depth grid (in feet) and building loss estimates example in Burns, Oregon.

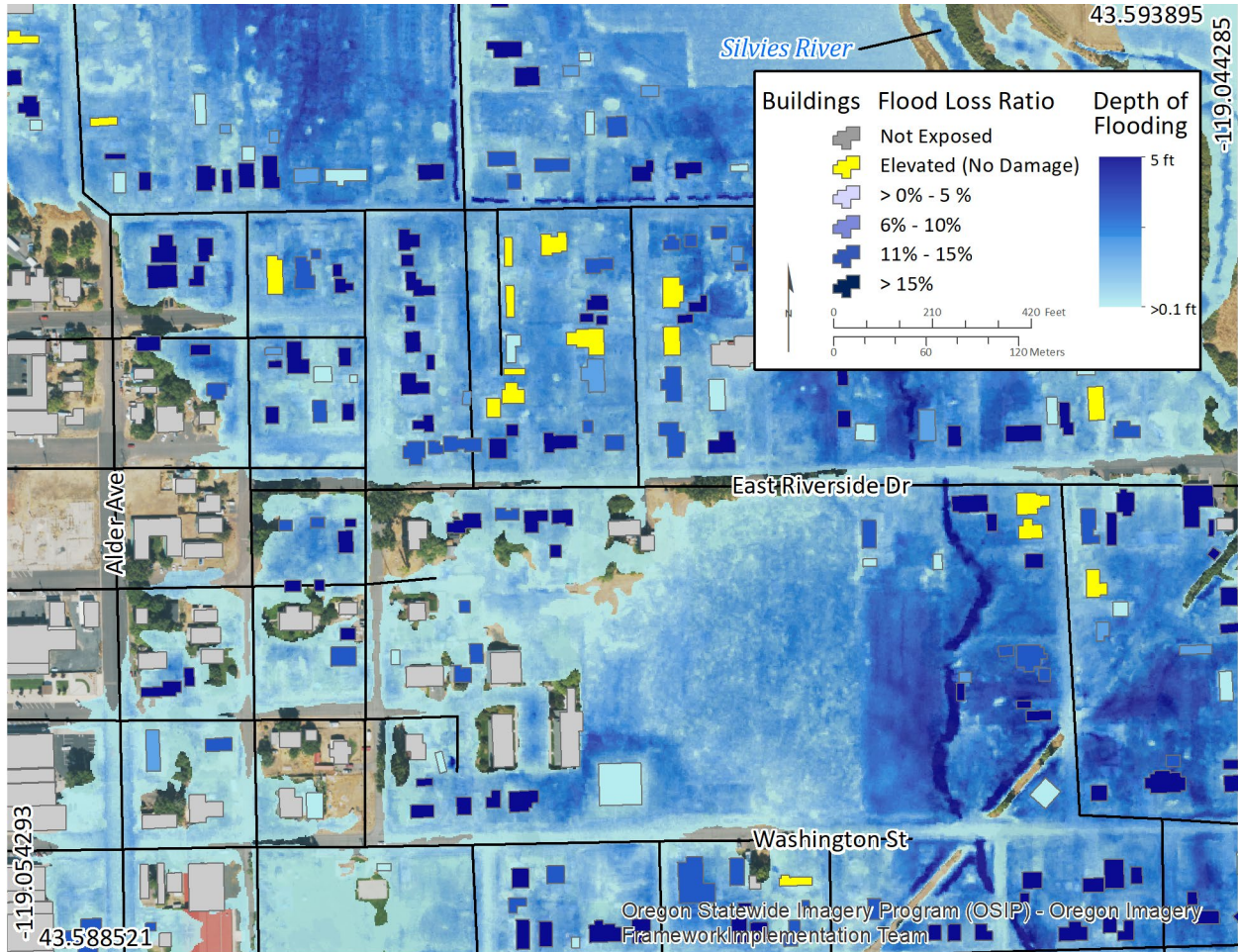


Image source: Oregon Statewide Imagery Program, 2018

Depth grid: Derived from the effective FEMA Flood Insurance Rate Map data for Harney County, 2024

2.2 Exposure

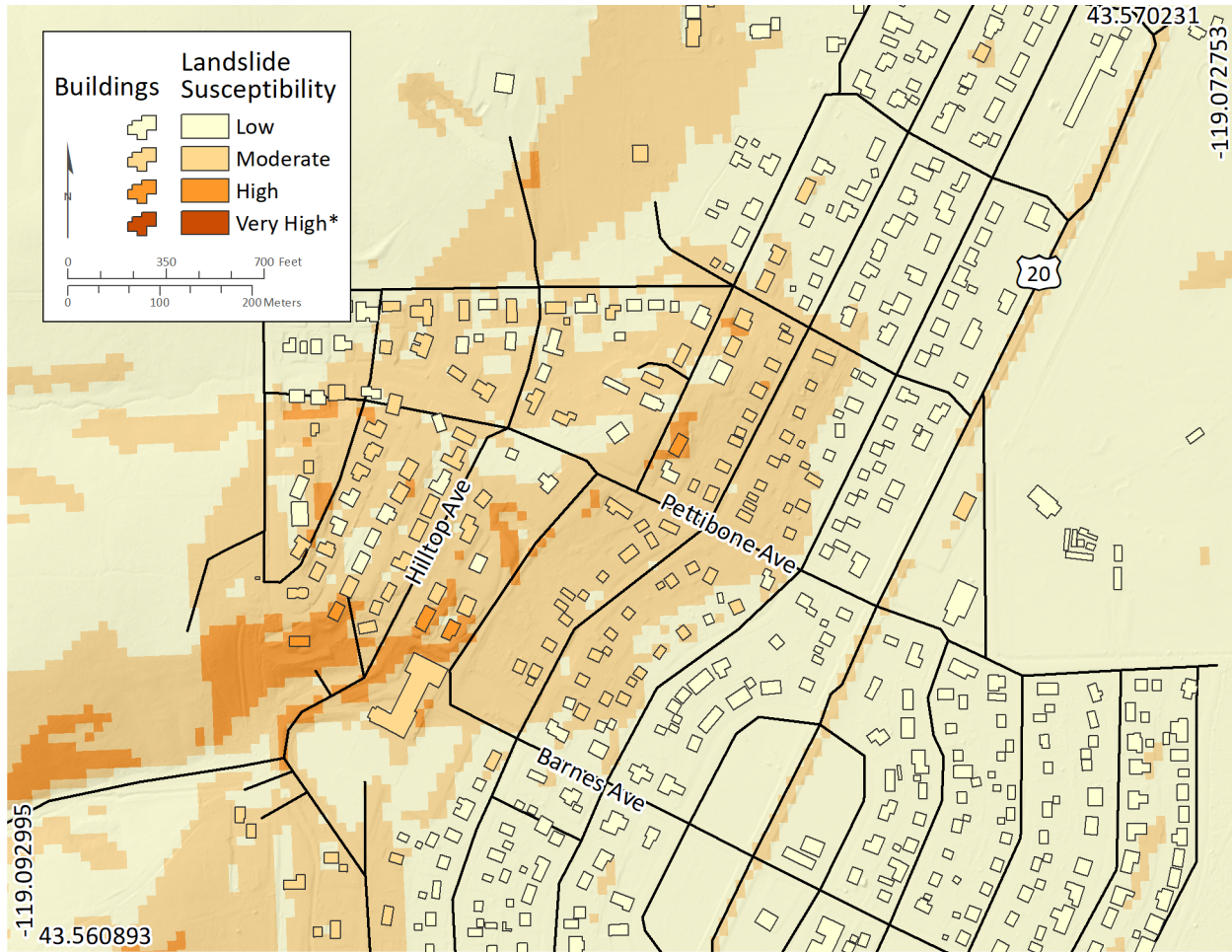
Since loss estimation using Hazus is not available for all types of natural hazards, we used exposure analysis to assess landslide and wildfire risk. Exposure methodology identifies the buildings and population that are within a particular natural hazard zone. This is an alternative to the more detailed loss estimation method for those natural hazards that do not have available damage models as in 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. 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.

Key Terms:

- *Exposure:* Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.
- *Building value:* Total monetary value of a building. This term is used in the context of exposure.

Exposure is used for landslide and wildfire hazards. We perform both analyses for the 100-year flood hazard scenario to allow for a broader perspective of the flood risk.

Figure 2-2. Landslide susceptibility and building exposure example in Hines, Oregon.



Landslide data source: Landslide susceptibility overview map of Oregon, (Burns and others, 2016)

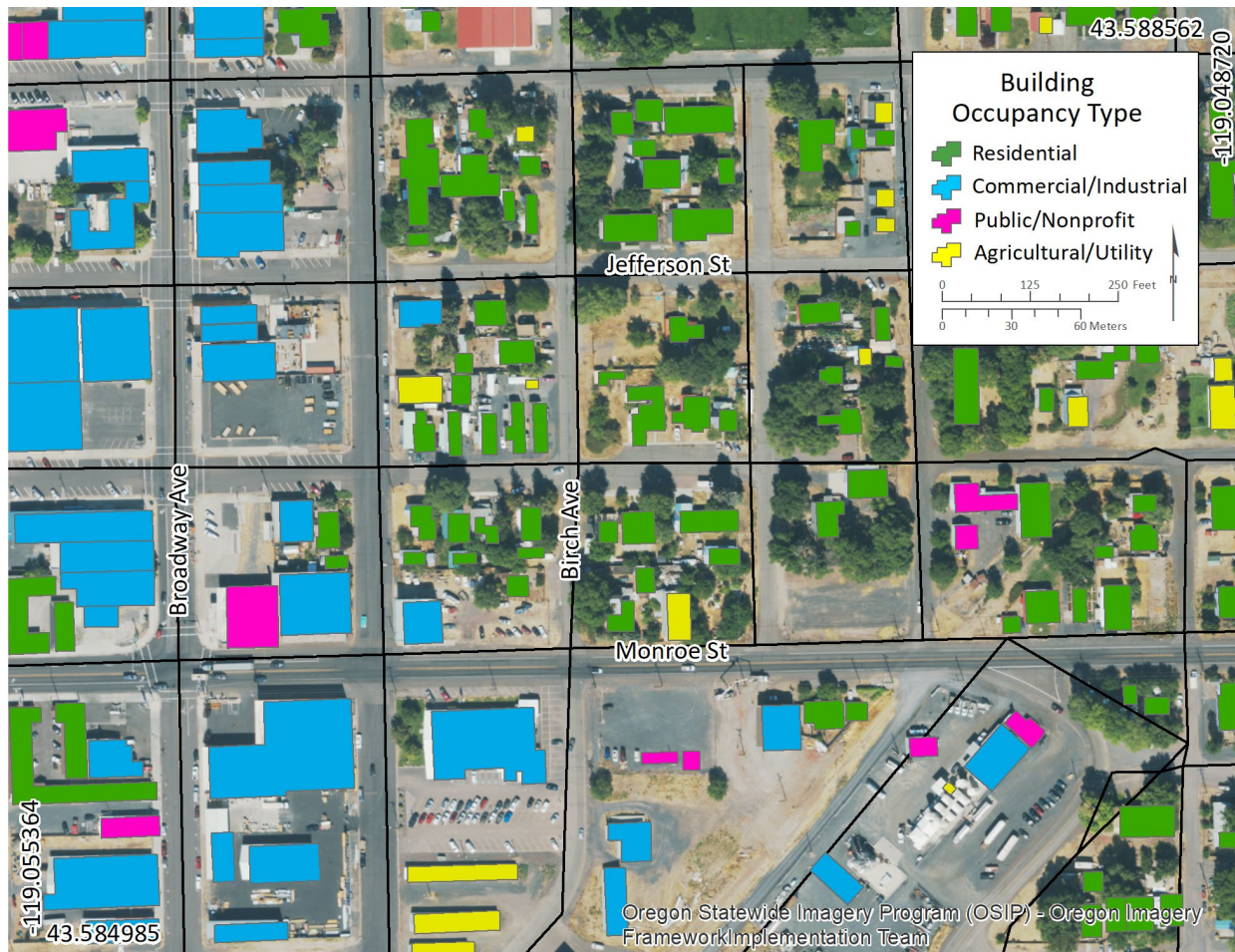
*No Very High landslide susceptibility category shown on this map.

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 ft² (9.3 m²), 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**.

To use the building inventory within Hazus, we 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 the correct damage function to be applied to each building. Hazus version 2.1 technical manuals (FEMA, 2022a, 2022b, 2022c) 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 C.2.2**.

Figure 2-3. Building occupancy types in Burns, Oregon.



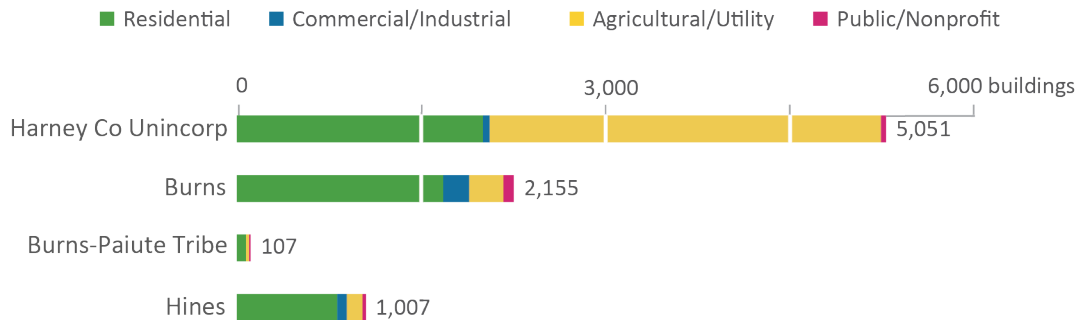
The number of buildings and total building value per community does not vary widely in Harney County, with 107 buildings and \$22 million for the Burns Paiute Tribe to 2,155 buildings and \$732 million for Burns (**Table 2-1**). A table detailing the occupancy class distribution by community is included in **Appendix B: Detailed Risk Assessment Tables**.

Table 2-1. Harney County building inventory.

Community	Total Number of Buildings	Percentage of Total Buildings	Estimated Total Building Value (\$)	Percentage of Total Building Value
Unincorp. Harney Co. (rural)	5,051	61%	1,263,063,000	51%
Burns	2,155	26%	732,084,000	30%
Burns Paiute Tribe	107	1.3%	21,842,000	0.9%
Hines	1,007	12%	449,431,000	18%
Total Study Area	8,320	100%	2,466,421,000	100%

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 are a total of 8,320 buildings within the study area. We define buildings to be 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 Harney County assessor data that was incorporated into building footprints was first developed for an unpublished multi-hazard risk assessment by DOGAMI in 2018. The assessor data contains an array of information about each improvement (e.g., building). We added and attributed additional buildings from the SBFO-1 that were not included in the 2018 report. The building footprints were converted into points and were used in the risk assessment. Burns is the community with the highest total number of buildings and residential use is the most common countywide ([Figure 2-4](#)).

Figure 2-4. Community building value in Harney 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 include public works and water treatment facilities. We embedded identifying characteristics 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). We updated the SSNA data by reviewing Google Maps™. 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 Burns ([Table 2-2](#)). Critical facilities are listed for each community in [Appendix A](#).

Table 2-2. Harney County critical facilities inventory by community.

Facility Type	Burns		Burns-Paiute Tribe		Hines		Total Study Area	
	Count ²	Value (\$) ³	Count	Value (\$)	Count	Value (\$)	Count	Value (\$)
Hospital & Clinic	3	7,986	1	772	0	0	4	8,758
School	2	20,318	0	0	1	3,594	10	42,447
Police & Fire	1	939	1	366	2	3,987	4	5,292
Emergency Services	1	1,781	0	0	1	433	2	2,214
Military	0	0	0	0	0	0	0	0
Other ¹	5	5,277	1	518	6	9,654	16	26,034
Total Study Area	13	38,049	3	1656	10	15,056	38	83,882

¹ 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).

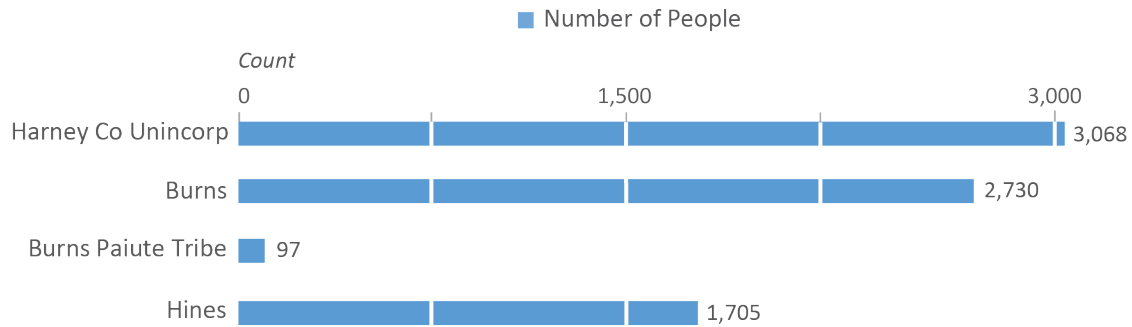
² Facilities with multiple buildings were consolidated into one building.

³ All dollar amounts in thousands.

2.4 Population

One purpose of the UDF database design was so that we could 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](#)). We 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 database, we cannot distinguish between vacation homes and primary residences. Therefore, our method distributes some of the permanent residents into possible vacation homes.

From the PSU Population Research Center data, we assessed the risk of the 7,600 residents within the study area. For each natural hazard, with the exception of the earthquake scenario, a simple exposure analysis was used to find the number of potentially displaced residents within a hazard zone. For the earthquake scenario the number of potentially displaced residents was based on the number of residents in buildings estimated to be significantly damaged by the earthquake.

Figure 2-5. Population by Harney County community.

3.0 ASSESSMENT OVERVIEW AND RESULTS

In this risk assessment, we considered four natural hazards (earthquake, flood, landslide, and wildfire) that pose a risk to Harney 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 greater understanding of the potential consequences of natural disasters. Communities can become more resilient to future disasters by utilizing the results in plan updates and developing future action items for risk reduction.

In this section, results are presented for the entire study area. The study area includes all unincorporated areas and cities within Harney County. Individual community results are in [Appendix A: Community Risk Profiles](#).

3.1 Earthquake

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 in addition to ground shaking 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 (Harp and Jibson, 1996). Both of these hazards are site-specific and will only occur in locations where conditions permit. All earthquake losses in this report include damages derived from shaking as well as liquefaction and landslide factors.

Southeast Oregon is a relatively inactive area seismically, with very few historical quakes. Most of the earthquake activity in the area has occurred further to the south in Nevada. There are a few active faults in Harney County that have the capacity to produce shaking at damaging levels, such as the Steens Mountain Fault, but they are too far away from people and development to pose much of a risk.

3.1.1 Scenario: Harney Fault

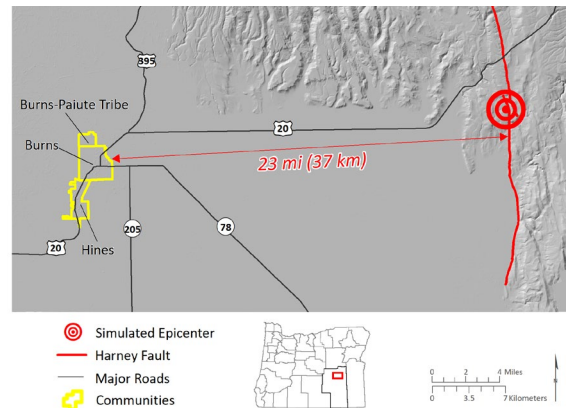
The scenario examined for this report is a crustal source earthquake focused on the Quaternary Harney Fault (**Figure 3-1**). Unlike the CSZ, which is a tectonic plate boundary system and a source of very large earthquakes, crustal faults are the result of planar fractures within a single tectonic plate (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.

The Harney Fault is a north-trending crustal fault located approximately 23 mi (37 km) east of Burns and is mapped for 19 mi (30 km) and crosses Highway 20 near the Buchanan Springs rest stop. It has an estimated average slip rate of less than 0.008 in/yr (0.2 mm/yr) (Personius and Haller, 2002 and citations therein). The fault occurs locally and is not capable of generating an earthquake of the magnitude of those produced by the CSZ. Such planar fractures occur in the Earth's crust where rocks are displaced relative to one another. The estimated maximum fault displacement for the Harney Fault could produce relatively large (Mw 6.7) earthquakes, enough to pose a significant hazard to nearby Burns (Personius and Haller, 2002). The current understanding of this fault and various aspects of its earthquake frequency and magnitude are limited and require additional study to update the fault's contribution to the hazard from earthquakes, however, we include it in this analysis to portray the possible damage and losses that could arise from a crustal fault rupture near a population center.

3.1.2 Data sources: Harney Fault scenario

The default Hazus faults database did not contain this fault, but Hazus allows for custom earthquake scenarios, and in this report, we relied on a scenario identified via the 2023 National Seismic Hazard Model (NSHM). The Mw 6.7 Harney Fault scenario was selected as the most appropriate for communicating earthquake risk for Harney County. This was determined from the interpretation of the 2023 NSHM (Petersen and others, 2024) and the disaggregation tool. The tool allows practitioners to view the earthquake hazard model results for a given location in the United States and identify the anticipated magnitude and the likely source fault of that earthquake given a specific probability (Chase and others, 2024). We used a 2% probability of exceedance in 50 years, which means that the chance for this scenario is very low, but it could occur. Said another way, within a cycle of 2,475 years, an earthquake of this magnitude will impact the area, and the disaggregation tool breaks down the probability of nearby active faults that are considered for the hazard model. According to the 2023 NSHM, there is a 2% chance in 2,475 years of a Mw 6.7 earthquake impacting Burns, and the largest contribution to the hazard comes from the Harney Fault, shown in (**Figure 3-1**). The parameters necessary for a custom scenario were sourced from the USGS Quaternary Fault and Fold Database.¹ The epicenter was manually selected and was located at the closest proximity to the majority of buildings

Figure 3-1. Harney Fault location.



¹ <https://www.usgs.gov/programs/earthquake-hazards/faults>

within the study area; in effect, the scenario we present in this report could be considered the highest-impact scenario given the data available at this time.

The following hazard layers used for our loss estimation are sourced from work conducted by 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 6.7.

3.1.3 Countywide results: Harney Fault scenario

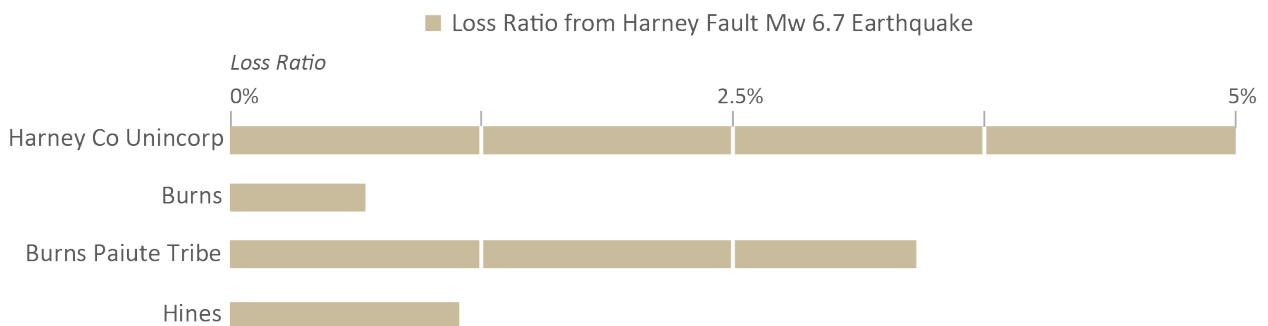
Because an earthquake can affect a wide area, most buildings in Harney County will be shaken by a Harney Fault Mw-6.7 earthquake. Hazus loss estimates (see **Appendix B: Table B-2**) for each building are based on a formula where coefficients of damage contribution are multiplied by each of the five damage-state percentages (e.g., 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 Harney fault earthquake scenario are presented in **Figure 3-2**.

In keeping with earthquake-damage reporting conventions, we used the Applied Technology Council (ATC)-20 postearthquake 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 we report for each community is based on an aggregation of the probabilities for individual buildings (FEMA, 2022b).

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 also due to their importance after a disaster, we chose to report the results of these buildings individually.

The number of potentially displaced residents from our Harney Fault earthquake scenario was based on the formula (FEMA, 2022b): $[(\text{Number of Occupants}) * (\text{Probability of Complete Damage})] + (0.9 * [\text{Number of Occupants}] * [\text{Probability of Extensive Damage}])$.

Figure 3-2. Harney Fault Mw 6.7 earthquake loss ratio by Harney County community.



The results indicate that Harney County could incur slight losses (3%) due to a Harney Fault Mw 6.7 earthquake. Most of the communities in Harney County can expect approximately 1% to 3% damage from a Harney Fault event. Much of the damage is due to the proximity to the hypothetical epicenter, however

the liquefiable soils that are present in parts of Burns and Hines also contribute significantly to the damage. The floodplains of the many large rivers in the study area are composed of seismically reactive soils where many of the buildings in Harney County are located. Since these soils amplify ground shaking, the probability of earthquake damage is greater for structures built in these areas. The community of Hines has higher estimated loss ratios due to the prevalence of this soil type.

Harney County Harney Fault 6.7 earthquake results:

- Number of red-tagged buildings: 99
- Number of yellow-tagged buildings: 241
- Loss estimate: \$73,965,000
- Loss ratio: 3.0%
- Nonfunctioning critical facilities: 3 of 38
- Potentially displaced population: 138

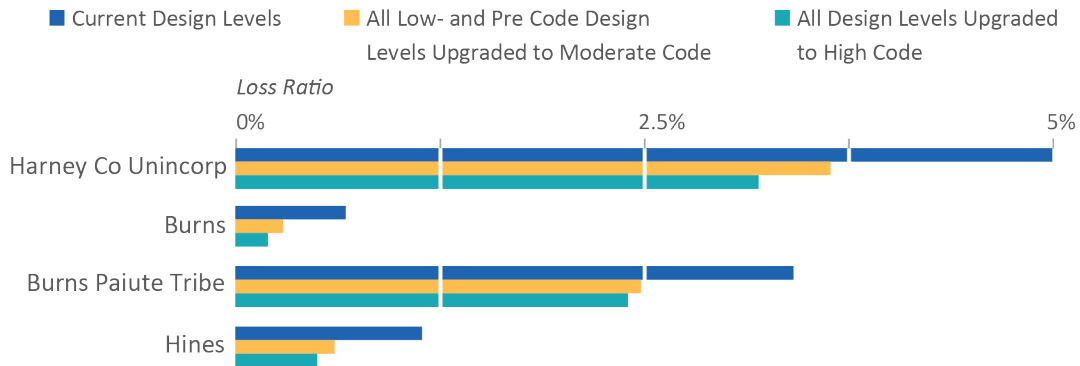
Building vulnerabilities, such as the age of the building stock and occupancy type, are also contributing factors in loss estimates. The first seismic building codes were implemented in Oregon in the 1970s (Judson, 2012) and by the 1990s, modern seismic building codes were being enforced. Nearly 90% of Harney County’s buildings were built before the 1990s. In Hazus, manufactured homes are one occupancy type that perform poorly in earthquake damage modeling. Communities that are composed of an older building stock and more vulnerable occupancy types are expected to experience more damage from earthquakes than communities with fewer of these vulnerabilities.

If pre- and low-code buildings could be seismically retrofitted to higher code standards, earthquake risk would be greatly reduced. In this study, a simulation in Hazus earthquake analysis shows that loss ratios drop from 3% to 2%, 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 have an effect on losses.

Key Terms:

- *Seismic retrofit:* Structural modification to a building that improves its resilience to earthquake.
- *Design level:* Hazus terminology referring to the quality of a building’s seismic building code (i. e. pre, low, moderate, and high). Refer to [Appendix C.2.3](#) for more information.

Figure 3-3. Harney Fault Mw 6.7 earthquake loss ratio in Harney County with simulated seismic building code upgrades.



3.1.4 Areas of significant risk

Structures near the hypothetical epicenter of a Harney Fault earthquake scenario are likely to incur a minor amount of damage. The area east of the Burns Municipal Airport will experience higher levels of shaking and damage from this earthquake scenario. Three of the 38 critical facilities in the study area are estimated to be nonfunctioning due to a Harney Fault earthquake like the one simulated in this study.

3.2 Flooding

The frequency and severity of flooding may change over time due to changes in land use (e.g., development, waterways, and watershed management), as well as natural phenomenon such as precipitation patterns and changes in climate. This study represents our current understanding of flood hazards and flood risk, but we recognize that flood models and risk assessments will need to be updated with changing conditions.

In its most basic form, a flood is an accumulation of water over normally dry areas, typically due to excessive rain or snowmelt. Floods become hazardous to people and property when they inundate an area where development has occurred, causing losses. Floods are a commonly occurring natural hazard in Harney County and have the potential to create public health hazards and public safety concerns, close and damage major highways, destroy railways, damage structures, and cause major economic disruption. More rare flood issues such as flash flooding, ice jams, postwildfire 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 of a given size occurring and the impacts of a flood of that size, primarily inundation extents and water depths. 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, is influenced by modeling advancements, better understanding of hydrologic factors, and longer periods of record for the stream or water body in question.

Most of the streams within the county drain into the Harney Basin. The major streams within the county are the Silvies River, Donner und Blitzen River, Malheur River, Trout Creek, Silver Creek, and Poison Creek. In addition, there are several tributaries to these major streams that have mapped flood zones. Any stream, mapped or unmapped, is subject to flooding and could cause damage to buildings in the floodplain.

Harney County's largest flood in the historic record occurred in 1897 on the Silvies River. At the time, no stream gage was installed so the level of flooding can only be approximated as a 300-year event (FEMA, 2024). Within the last 100 years, there have been several major floods of note in Harney County, which occurred in 1943, 1952, 1957, 1964, 1983, 1984, 1986, and 2011. Floods of the Silvies River and its tributaries tend to be winter or spring floods, where rain-on-snow events cause rapid snowmelts. Flooding is further exacerbated during this time of year, due to highly saturated soil. Eyewitness accounts describe Silvies River floods as spreading out like a fan for many miles, with floodwaters flowing to the south and west into Malheur Lake. During periods of prolonged flooding, areas along the Silvies River can appear to be a very large lake (FEMA, 2024).

The consequences of flooding are determined by adverse effects to human activities within the natural and built environment, such as the destruction of homes and displacement from residences. These adverse conditions can be reduced through mitigation efforts, such as 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 flood.

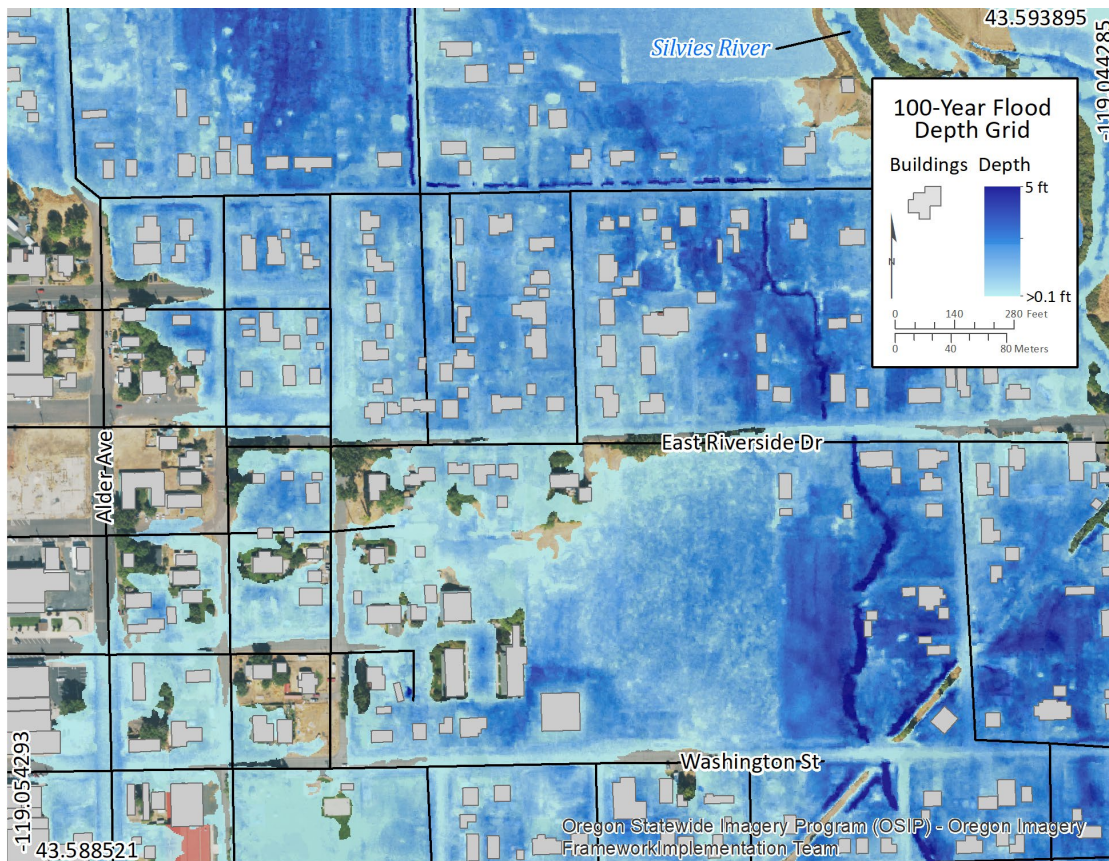
3.2.1 Data sources

The most recent Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) (FEMA, 2024) were used to assess flood risk in this study. Specifically, the depth grids generated from this mapping were used to estimate damage to buildings from floods. Further information regarding the National Flood Insurance Program (NFIP) can be found at FEMA's website: <https://nfipservices.floodsmart.gov/reports-flood-insurance-data>. Additional areas in Harney County might be susceptible to flood hazard that were not included in this study because they were never mapped or are not publicly available. The NFIP flood data was the only data source used in this risk assessment.

In 2021, the Federal Emergency Management Agency (FEMA) funded a project to update stream models for much of the Silvies River Watershed for inclusion in the digital FIRMs of Harney County. Previous Harney County stream models used in FIRMs were completed in 1982, 2012, and 2016. Since that time, better base map data and methods have increased the accuracy of flood mapping. The Effective FIRMs for Harney County include the latest maps in the Silvies River watershed, as well as the older mapping in other areas.

Depth grids are raster GIS datasets in which each digital pixel value represents the depth of flooding at that location within the flood zone (**Figure 3-4**). Depth grids for four riverine flooding scenarios (10-, 50-, 100-, and 500-year) were used for loss estimations and, for comparative purposes, exposure analysis.

Figure 3-4. Flood depth grid example in Burns, Oregon.



Building loss estimates are determined in Hazus by overlaying building data on a depth grid. 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 Harney County, occupancy type and basement presence attributes were available from the assessor database for most buildings. Where individual building information was not available from assessor data, we used street-level imagery to estimate these important building attributes. Only buildings in a flood zone or within 500 ft (152 m) of a flood zone were examined closely in this manner for more accurate information on first floor height and basement presence. Because our analysis accounted for building first floor height, buildings that have been elevated above the flood level were not given a loss estimate—but we did count residents in those structures as displaced. We did not look at the duration that residents would be displaced from their homes due to flooding. For information about structures exposed to flooding but not damaged, see the [Exposure analysis](#) section.

3.2.2 Countywide results

For this risk assessment, we imported the countywide UDF data and depth grids into Hazus and ran a flood analysis for four scenarios (10, 50, 100, and 500 year). We used the 100-year flood as the primary scenario for reporting results (also see [Appendix E: 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. See [Appendix B: Table B-4](#) for multiple scenario cumulative results.

Harney Countywide 100-year flood loss:

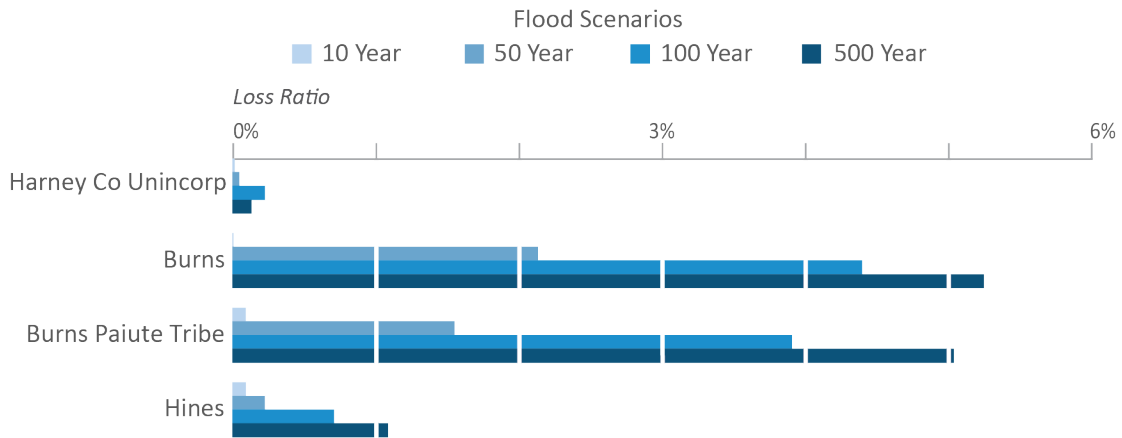
- Number of buildings damaged: 1,056
- Loss estimate: \$39,120,000
- Loss ratio: 1.6%
- Damaged critical facilities: 6 of 38
- Potentially displaced population: 1,474

3.2.3 Hazus analysis

The countywide loss estimate for the 100-year flood scenario is over \$39 million. While the loss ratio of flood damage for the entirety of Harney County is 1.6%, the impact to areas of development near flood-prone streams is significant, specifically Burns and Burns Paiute Tribe ([Figure 3-5](#)). In communities where most residents are not within flood zones, the loss ratio may not be as helpful as the actual replacement cost and number of residents displaced to assess the level of risk and impact from flooding. The Hazus analysis also provides useful information for individual communities so that planners can identify problems and consider which mitigating activities will provide the greatest resilience to flooding.

The primary flooding issues in Harney County are concentrated in the areas of Burns and the Burns Paiute Tribe, with several High-risk flood zones. Most of these areas are composed of residential structures located in the Silvies River floodplain, primarily on the eastern edge of Burns. Also, the unincorporated county has some areas near the Silvies River that are at High risk from flood hazard ([Figure 3-5](#)).

Figure 3-5. Ratio of flood loss estimates by Harney County community.



3.2.4 Exposure analysis

We performed a separate exposure analysis in addition to the Hazus loss estimation. By overlaying building locations on the 100-year flood zone, we can count the number of buildings that are sited below the 100-year inundation zone and estimate the number of displaced residents based on building occupancy. A very high percentage (15%) of Harney County’s buildings were found to be within designated flood zones. Despite the high number of buildings exposed to flood, damages are relatively low due to the shallowness of the estimated flood depth. Of the 1,239 buildings that are exposed to flooding, we estimate that 183 are above the height of the 100-year flood. This evaluation also estimates that 1,474 residents (19%) might have mobility or access issues due to being surrounded and cut off by rising floodwater. See [Appendix B: Table B-5](#) for community-based results of flood exposure.

3.2.5 Areas of significant risk

Many residential structures in the eastern portions of Burns and the Burns Paiute Reservation along the Silvies River floodplain and south of King Avenue in Hines from Drainage D are at risk from flood hazard. A very large percentage (15%) of buildings in Burns, Burns Paiute Tribe, and Hines are exposed to a 100-year flood. Because floods in these areas are shallow and wide, the majority of exposed buildings are estimated to be above the level of flooding. Throughout the county and in every community, due to the shallowness of Silvies River flooding, the overall damage is not high relative to the very high number of buildings exposed to flood hazard. This result can indicate that substantial evacuation could be necessary even though damages are low.

3.3 Landslide Susceptibility

Landslides are mass movements of rock, debris, or soil down a slope. Landslides can occur in many sizes, at different depths, and with varying rates of movement. Generally, they 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 a landslide: intense rainfall, earthquakes, or human-induced factors like water concentration, excavation along a landslide toe, or loading at the top. Landslides can cause severe damage to buildings and infrastructure. Fast-moving landslides may pose life safety risks

and can occur throughout Oregon (Burns and others, 2016). The most common landslide types in Harney County are debris flows and shallow- and deep-seated 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. 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 pre-existing landslides.

This study represents our current understanding of landslide susceptibility to measure the risk in Harney County. However, changing climate, precipitation patterns, land use, wildfire events, and land and forest management strategies may increase or decrease the susceptibility to landslides.

3.3.1 Data sources

We used data from the Statewide Landslide Susceptibility Map (Burns and others, 2016), which derives from multiple datasets created using methods outlined in DOGAMI Special Paper 42 (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. Therefore, the statewide landslide susceptibility map varies significantly in scale across the state and care should be taken when using the data. Another limitation is that susceptibility mapping does not include some aspects of landslide hazard, such as runout, where the momentum of the landslide can carry debris beyond the zone deemed to be high hazard. Most of the landslide mapping in Harney County occurred approximately 30 years ago, before modern landslide mapping techniques were available.

We used data from Burns and others (2016) in this report to identify the general level of susceptibility of a given area to landslide hazards, primarily shallow and deep landslides. We overlaid building and critical facilities data on landslide susceptibility zones to assess the exposure for each community (see [Appendix B: Table B-6](#)). 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

We combined High and Very High susceptibility areas as the primary scenario to provide a general sense of community risk for planning purposes (see [Appendix E: Plate 7](#)). We 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.

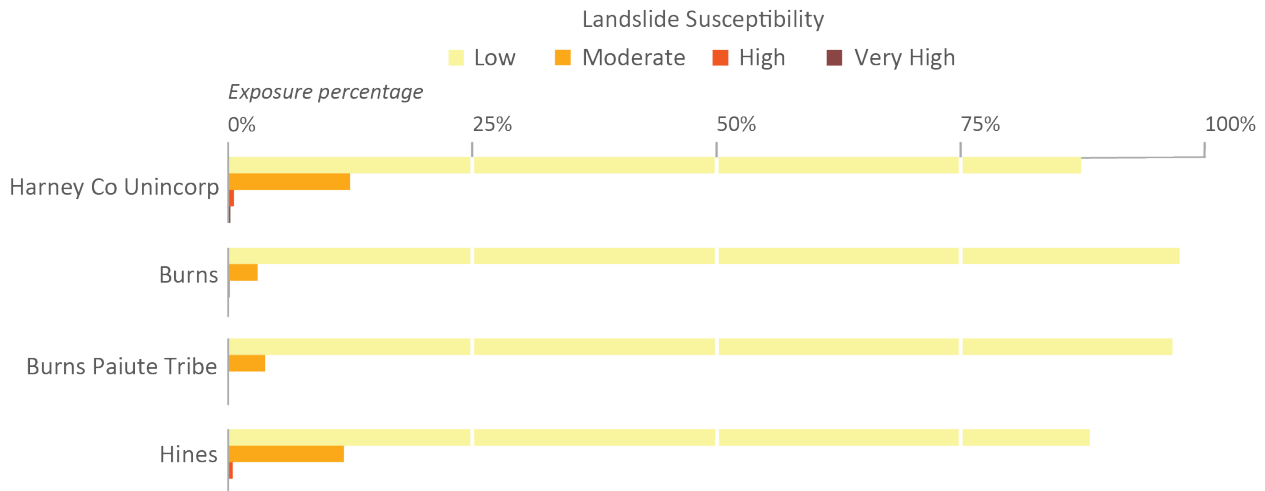
None of the buildings contained in the building database were exposed to Very High landslide hazard according to our analysis. A small number of buildings on the western foothills of Hines have exposure to High landslide hazard. Areas of terrain with moderate to steep slopes or at the base of steep hillsides throughout the county are more likely to be exposed to landslides. The percentage of building value exposed to Very High and High landslide susceptibility is approximately 0.4%, which is 52 buildings in the entire study area, which equates to a value over \$10 million.

For this risk assessment we compared building locations to geographic extents of the landslide susceptibility zones (**Figure 3-6**). See **Appendix B: Detailed Risk Assessment Tables** for exposure analysis results of all susceptibility categories.

Harney Countywide landslide exposure (High and Very High susceptibility):

- Number of buildings exposed: 52
- Value of buildings exposed to landslides: \$10,100,000
- Percentage of total county value exposed to landslides: 0.4%
- Critical facilities exposed to landslides: 0 of 38
- Potentially displaced population: 31

Figure 3-6. Landslide susceptibility exposure by Harney County community.



3.3.3 Areas of significant risk

Based on current landslide mapping, there is little to no landslide risk in Harney County. New landslide mapping based on modern methods using lidar 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 criteria that increase risk include hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). Once a fire has started, its behavior is influenced by numerous conditions, including fuel, topography, weather, drought, and development (Gilbertson-Day and others, 2018). 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 2013 Harney Community Wildfire Protection Plan (Walsh, 2013) recommended that the county develop information materials to homeowners, build defensible spaces around structures, and introduce building code enforcement related to emergency access. Grasslands and scrub brush cover large portions of the county and play an important role in local agriculture but also can increase the risk of wildfire (HCWPP, 2018). Contact the Harney County Planning Department for specific wildfire requirements.

In the Summer of 2024, two large wildfires occurred north of Burns, with the Telephone Fire and Falls Fire, which combined burned over 200,000 acres. The Falls Fire, which grew to approximately 150,000 acres, was considered a “megafire” because it was greater than 100,000 acres (400 km²) in size (Northwest Large Fire Interactive Web Map website, accessed 10/28/2024)².

The frequency, intensity, and severity of wildfires may change over time due to changes in climate, drought conditions, urbanization, and how we manage our forested lands. This study represents our current understanding of wildfire hazards and wildfire risk, but we recognize that 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 (Gilbertson-Day and others, 2018) 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, a dataset included in the PNRA database, was used to measure the risk to communities in Harney County.

Using guidance from ODF, we 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 (Gilbertson-Day and others, 2018).

Burn probabilities (mean annual burn probability) were grouped into three hazard categories:

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

We 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 which indicates areas that have minimal risk to

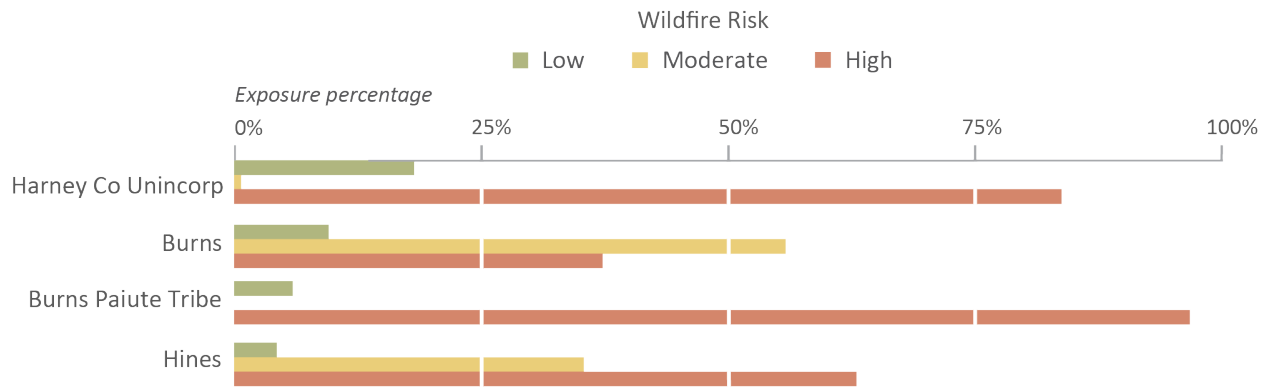
² (<https://gacc.nifc.gov/nwcc/firemap.php>)

wildfire hazard (see [Appendix B: Table B-8](#)). 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 focuses on the High hazard because it represents areas that have the highest potential for losses. Under certain conditions, Moderate hazard zones can be very susceptible to burn and also are a risk consideration. However, in Harney 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 the entire county being at risk. Exposure to High wildfire risk exists throughout the unincorporated county and in all the communities of Harney County ([Figure 3-7](#)).

Figure 3-7. Exposure to wildfire hazard by Harney County community.



Harney Countywide wildfire exposure (High or Moderate risk):

- Number of buildings: 5,521
- Value of buildings exposed to wildfire: \$1,592,532,000
- Percentage of total county value exposed to wildfire: 65%
- Critical facilities exposed to wildfire: 20 of 38
- Potentially displaced population: 4,485

For this risk assessment, the building locations were compared to the geographic extent of the wildfire risk categories. Most of Harney County's buildings (65%) are exposed to High wildfire risk (see [Appendix E: Plate 8](#)). The steeper western portions of Burns, the Burns Paiute Tribe, and Hines all have very significant risk from wildfire. Nearly all rural parts of Harney County are in High wildfire risk areas. See [Appendix B: Detailed Risk Assessment Tables](#) for multiple scenario analysis results.

3.4.3 Areas of significant risk

Every community in Harney County has very significant exposure to High wildfire risk, including nearly 95% of the buildings in the Burns Paiute Tribe and 65% in Hines. High risk of wildfire exists for nearly all areas in the unincorporated county. The heavily forested portions of the northern county and the grasslands and scrub brush vegetation found in the rest county are both areas at a high risk from wildfire.

4.0 CONCLUSIONS

The purpose of this study is to provide a better understanding of potential impacts from multiple natural hazards at the community scale. We accomplished this by using the latest natural hazards data and methods to quantify risk to buildings and people. This detailed approach provides new context for the county's risk reduction efforts. We note several important findings based on the results of this study:

- **Slight damage and losses can occur from a hypothetical Harney Fault Mw 6.7 earthquake**—Based on the results of the hypothetical Harney Fault Mw 6.7 earthquake scenario, communities in Harney County may experience slight impact and disruption from a crustal fault. Results show that this hypothetical earthquake could cause some building value losses in areas east of the Burns Municipal Airport, closer to the hypothetical epicenter.
- **Retrofitting buildings to modern seismic building codes can reduce damages and losses from earthquake shaking**—Seismic building codes have a major influence on earthquake-shaking damage estimated in this study. We found that retrofitting to at least Moderate Code was the most efficient mitigation strategy because the additional benefit from retrofitting to High Code was minimal. In our simulation of upgrading buildings to at least Moderate Code, the estimated loss for the entire study area was reduced from 3% to 2% (340 buildings to 265 buildings) for a hypothetical Harney Fault event. Communities with older buildings that were 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, it should be noted that earthquake-induced liquefaction hazards will also be present in areas along the floodplains and these hazards require different geotechnical mitigation strategies.
- **Many buildings in the study area are located in areas that are prone to flooding**—Many buildings within the Silvies floodplain are exposed to flooding. A large portion of the Silvies River floodplain can be characterized as sheet flow during large floods, which is flooding that is very wide and very shallow. While 15% of buildings in Harney County are within 100-year flood zones, the depth of flooding is very shallow and would only damage 1.6% of the total countywide building value. Because a significant number of residential structures are predicted to be surrounded by water during a flood, a high number of people (1,424 residents or 19% of the total population) may need to evacuate their homes. Areas most vulnerable to flood hazard within the study are in Burns along the Silvies River and in the south part of the city.
- **Landslide risk is very low for most areas in the county**—Based on the best available landslide data, nearly all buildings in Harney County are not located on steep slopes or existing landslide deposits. However, the landslide hazard data used in this risk assessment was created before modern mapping technology; future risk assessments using lidar-derived landslide hazard data would provide more accurate results. Exposure analysis was used to assess the threat from landslide hazard. Existing landslides are located in undeveloped portions of northern Harney County. With most of the development occurring in the floodplain of the Silvies River, which is also a Low landslide susceptibility area, there is very little overall risk from landslide to buildings.
- **Wildfire risk is very high throughout the county**—Exposure analysis shows that buildings throughout Harney County are vulnerable to wildfire hazard. Nearly all areas in Harney County, including much of the communities of Burns and Hines, are within High or Moderate wildfire hazard areas. When every building in the county is considered, 65% are exposed to High wildfire hazard. In Burns, 36% of the buildings are exposed to High wildfire hazard and 54% are exposed

to Moderate wildfire hazard. In Hines, 61% of the buildings are exposed to High wildfire hazard and 34% are exposed to Moderate wildfire hazard. The rural county is extremely vulnerable to wildfire risk with 82% of rural buildings exposed to High hazard.

- **Most of the study area’s critical facilities are at greatest risk from wildfire hazard, relative to other hazards in the study area**—Because of their importance during and after a natural disaster, we identified and examined critical facilities. We have estimated that 53% (20 of 38) of Harney County’s critical facilities are at risk from wildfire hazard. We found that a small number of critical facilities are exposed to flood (6) and earthquake (3) hazards.
- **The biggest cause of displacement of population is wildfire hazard**—Potential displacement of permanent residents from natural hazards was estimated within this report. We estimated that 59% of the population in the county are exposed to High or Moderate wildfire risk. A 100-year flood is estimated to displace 19% of the county’s population. Very few residents are vulnerable to displacement from earthquake and landslide hazards.
- **The results allow communities to compare across hazards and prioritize their needs**—Each community within the study area was assessed for natural hazard exposure and loss. This allowed for comparison of risk for a specific hazard between communities. It also allowed for a comparison between different hazards, though care must be taken to distinguish loss estimates and exposure results. These results can assist in developing plans that address the concerns of individual communities.

5.0 LIMITATIONS

There are several limitations to keep in mind when interpreting the results of this risk assessment.

- **Spatial and temporal variability of natural hazard occurrence**—With the exception of earthquakes, other hazards like flood, landslide, and wildfire 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 we report the overall impacts of a given hazard scenario, the losses from a single hazard event probably will not 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, due to a lack of building material information, assumptions were made 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**—We recommend careful interpretation of exposure results. This is 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 is not the case. 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 Harney County have vacation homes and rentals, which are more often occupied during the summer. Our estimates of potentially displaced

people rely on permanent populations published in the PSU Population Research Center estimates of permanent residents. As a result, we are slightly underestimating the number of people that may be in harm's way on a summer weekend.

- **Data accuracy and completeness**—Some datasets in our risk assessment had incomplete coverage or lacked high-resolution data within the study area. We used lower-resolution data where there was incomplete coverage or where high-resolution data was not available. We 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 are 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 are areas needing additional research. We 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 slight.
- **Changing Conditions**—This assessment did not account for potential changes in climate, land use, or population; it is a snapshot of Harney County's current risk from natural hazards. Human-induced climate change poses a significant and widespread risk to people around the world. In Oregon, climate change is expected to increase the frequency and intensity of floods, wildfires, and landslides, but quantifying this change was beyond the scope of this study.

6.0 RECOMMENDATIONS

The following actions are needed to better understand hazards and reduce risk to natural hazard through mitigation planning. These implementation areas, 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 lessening the impacts of natural hazards. When community members understand their risk and know the role that they play in preparedness, the community will become a much safer place to live. Awareness and preparation not only reduce the initial impact from natural hazards, but they 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 stakeholder groups. For example, outreach to homeowners could focus on actions they can take to reduce risk to their property. The DOGAMI Homeowners Guide to Landslides³ 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.

³ https://www.oregon.gov/dogami/Landslide/Documents/Landslide_Hazards_Land_Use_Guide_2019.pdf

6.2 Planning

This report can help local decision makers develop their local plans by identifying geohazards and associated risks to the community. The primary framework for accomplishing this 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 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 for informing the vulnerability assessment section of the NHMP plan.

While there are many similarities between this report and an NHMP, the primary difference is that the risk assessment is not a planning document. Additional differences can be the hazards or critical facilities examined in each report. Differences between the reports may be due to 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 nonbuilding structures 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 after a natural disaster. This study can help emergency managers identify vulnerable critical facilities and develop contingency plans. Additionally, detailed mapping of potentially displaced residents can be used to reevaluate evacuation routes and identify vulnerable populations to target for early warning.

The building database that accompanies 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 in 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 funds⁴.

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

⁴ https://www.oregon.gov/OEM/Documents/Oregon_Hazard_Mitigation_Grant_Program_Handbook.pdf

program, and Flood Mitigation Assistance (FMA)⁵. The SHMO can help with finding further opportunities for earthquake and tsunami assistance and funding.

6.5 Hazard-Specific Risk Reduction Actions

6.5.1 Earthquake

- Evaluate critical facilities for seismic preparedness by identifying structural deficiencies and vulnerabilities to dependent systems (e.g., water, fuel, power).
- Evaluate vulnerabilities of critical facilities. We estimate that 61% of critical facilities be damaged by the CSZ earthquake scenario described in this report, which will have many direct and indirect negative effects on first response and recovery efforts.
- Identify communities and buildings that would benefit from seismic upgrades.

6.5.2 Flood

- 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.
- Additional risk reduction strategies may be found on FEMA's website at <https://www.ready.gov/floods>.

6.5.3 Landslide

- 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 experience channel erosion at the toe of the landslide.
- Additional risk reduction strategies may be found on FEMA's website at <https://www.ready.gov/landslides-debris-flow>.

6.5.4 Wildfire-related geologic hazards

- Evaluate post wildfire geologic hazards including flood, debris flows, and landslides.
- Additional risk reduction strategies may be found on FEMA's website at <https://www.ready.gov/wildfires>.

7.0 ACKNOWLEDGMENTS

This natural hazard risk assessment was conducted by the Oregon Department of Geology and Mineral Industries (DOGAMI) in 2024. It was funded by FEMA Region 10 through its Risk Mapping, Assessment, and Planning (Risk MAP) program (Cooperative Agreement EMS-2022-CA-00019). Many people contributed to this report at different points during the analysis phase and during the writing phase and at various levels. We are grateful to everyone who contributed, especially the following from DOGAMI: Lalo Guerrero, William Burns, Jason McClaughry, Alex Lopez, and Robert Hairston-Porter.

⁵ <https://www.fema.gov/grants/mitigation>

Additionally, we would like to thank the people from FEMA, Rynn Lamb, and Marshall Rivers, who also assisted on this project.

8.0 REFERENCES

- Applied Technology Council, 2015, Rapid visual screening of buildings for potential seismic hazards: a handbook (3rd ed.): Redwood City, Calif., FEMA Publication 154. https://www.fema.gov/sites/default/files/2020-07/fema_earthquakes_rapid-visual-screening-of-buildings-for-potential-seismic-hazards-a-handbook-third-edition-fema-p-154.pdf.
- Bauer, J. M., 2018, ArcGIS Python script alternative to the Hazus Flood Model for User-Defined Facilities: Oregon Department of Geology and Mineral Industries Open-File Report O-18-04, 28 p. <https://pubs.oregon.gov/dogami/ofr/p-O-18-04.htm>.
- Burns, W. J. and Madin, I. P., 2009, Protocol for Inventory Mapping of Landslide Deposits from Light Detection and Ranging (Lidar) Imagery: Oregon Department of Geology and Mineral Industries Special Paper 42, 30 p. <https://pubs.oregon.gov/dogami/sp/p-SP-42.htm>.
- Burns, W. J., and Watzig, R. J., 2014, Statewide landslide information layer for Oregon, release 3 [SLIDO-3.0]: Oregon Department of Geology and Mineral Industries, 35 p., 1:750,000, geodatabase.
- Burns, W. J., Mickelson, K. A., and Madin, I. P., 2016, Landslide susceptibility overview map of Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-16-02, 48 p. <https://pubs.oregon.gov/dogami/ofr/p-O-16-02.htm>.
- Business Oregon, 2022, Oregon benefit-cost analysis tool for evaluation of seismic rehabilitation grant program applications: User's guide: Salem, Ore., Infrastructure Finance Authority Division, 66 p. <https://www.oregon.gov/biz/programs/SRGP/Pages/default.aspx>.
- Charest, A. C. (ed.), 2017, Square foot costs with RSMMeans® data (38th annual edition): Rockland, Md., Gordian Group, Inc., 563 p. <https://www.rsmeans.com/products/books/2017-cost-databooks/2017-square-foot-costs-book.aspx>.
- Chase, R.E., Jaiswal, K.S., and Petersen, M.D., 2024, Earthquake scenario development in conjunction with the 2023 USGS National Seismic Hazard Model: *Earthquake Spectra*, v. 40, no. 3, p. 1818-1844 <https://www.usgs.gov/publications/earthquake-scenario-development-conjunction-2023-usgs-national-seismic-hazard-model>.
- Federal Emergency Management Agency, 2022a, Hazus®-MH 5.1 User manual, Flood model: Washington, D.C., 236 p. https://www.fema.gov/sites/default/files/documents/fema_hazus-5.1-flood-model-user-guidance.pdf.
- Federal Emergency Management Agency, 2022b, Hazus®-MH 5.1 Technical manual, Earthquake model: Washington, D.C., 467 p. https://www.fema.gov/sites/default/files/documents/fema_hazus-earthquake-model-technical-manual-5-1.pdf.
- Federal Emergency Management Agency, 2022c, Hazus®-MH 5.1, Technical manual, Flood model: Washington, D.C., 110 p. https://www.fema.gov/sites/default/files/documents/fema_hazus-flood-model-technical-manual-5-1.pdf.
- Federal Emergency Management Agency, 2022d, Hazus™ 6.0 Release notes. https://www.fema.gov/sites/default/files/documents/fema_hazus-6-release-notes.pdf.
- Federal Emergency Management Agency, 2024, Flood insurance study: Harney County, Oregon and incorporated areas: Washington D.C., Flood Insurance Study Number 41025CV000B, v. 1, 103 p. <https://map1.msc.fema.gov/mipdata/41025CV000B.pdf?LOC=0af228dd024733d153401591d79a5b79>.

- Gilbertson-Day, J. W., Stratton, R. D., Scott, J. H., Vogler, K. C., and Brough, A., 2018, Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results: Missoula, Montana, Pyrologix 86 p. https://oe.oregonexplorer.info/externalcontent/wildfire/reports/20170428_PNW_Quantitative_Wildfire_Risk_Assessment_Report.pdf.
- Harp, E. L., and Jibson, R. W., 1996, Landslides triggered by the 1994 Northridge, California, earthquake. *Bulletin of the Seismological Society of America* 1996; 86 (1B): S319–S332. doi: <https://doi.org/10.1785/BSSA08601BS319>.
- Judson, S., 2012, Earthquake design history: a summary of requirements in the State of Oregon: State of Oregon, Building Codes Division, Feb. 7, 2012, 7 p. <https://eugenesciencecenter.org/wp-content/uploads/2022/12/inform-2012-oregon-sesmic-codes-history.pdf>.
- Kramer, S. L., 1996, Geotechnical earthquake engineering: Prentice Hall, New Jersey, 653 p.
- Lewis, D., 2007, Statewide seismic needs assessment: Implementation of Oregon 2005 Senate Bill 2 relating to public safety, earthquakes, and seismic rehabilitation of public buildings: Oregon Department of Geology and Mineral Industries Open-File Report O-07-02, 140 p. <https://pubs.oregon.gov/dogami/ofr/p-O-07-02.htm>.
- Madin, I. P., and Burns, W. J., 2013, Ground motion, ground deformation, tsunami inundation, coseismic subsidence, and damage potential maps for the 2012 Oregon Resilience Plan for Cascadia subduction zone earthquakes: Oregon Department of Geology and Mineral Industries Open-File Report O-13-06, 36 p. 38 pl., GIS data. <https://pubs.oregon.gov/dogami/ofr/p-O-13-06.htm>.
- Madin, I. P., Franczyk, J. J., Bauer, J. M., and Azzopardi, C. J. M., 2021, Oregon Seismic Hazard Database, release 1.0: Oregon Department of Geology and Mineral Industries Digital Data Series OSHD-1. <https://pubs.oregon.gov/dogami/dds/p-OSHD-1.htm>.
- Oregon Building Codes Division, 2002, Oregon manufactured dwelling and park specialty code, 2002 ed.: Oregon Manufactured Housing Association and Oregon Building Codes Division, Department of Consumer and Business Services, 176 p. <http://www.oregon.gov/bcd/codes-stand/Documents/md-2002-mdparks-code.pdf>.
- Oregon Building Codes Division, 2010, 2010 Oregon manufactured dwelling installation specialty code: Department of Consumer and Business Services, Building Codes Division, 67 p. <http://www.oregon.gov/bcd/codes-stand/Documents/md-2010omdisc-codebook.pdf>.
- Oregon Statewide Imagery Program, 2018, 2018 Western OR <https://imagery.oregonexplorer.info/arcgis/rest/services>.
- Petersen, M.D., Shumway, A.M., Powers, P.M., Field, E.H., Moschetti, M.P., Jaiswal, K.S., Milner, K.R., Rezaeian, S., Frankel, A.D., Llenos, A.L., and Michael, A.J., 2024, The 2023 US 50-state national seismic hazard model—Overview and implications: *Earthquake Spectra*, v. 40, no. 1, p. 5–88 <https://www.sciencebase.gov/catalog/item/644af897d34e45f6ddcd13b3>.
- Personius, S. F. and Haller, K. M., compilers, 2002, Fault number 1802, Harney fault, in Quaternary Fault and Fold Database of the United States: U. S. Geological Survey website, <https://earthquake.usgs.gov/static/lfs/nshml/qfaults/Reports/1802.pdf>.
- Walsh Environmental Scientists and Engineers, LLC, 2013, Harney County, Oregon Community Wildfire Protection Plan, 84 p. <https://harneycountyor.gov/wp-content/uploads/2023/03/2013-Harney-County-CWPP.pdf>.
- Wang, Y., 1998, Earthquake damage and loss estimate for Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-98-3, 10 p. 2 app. <https://pubs.oregon.gov/dogami/ofr/O-98-03.pdf>.

Williams, M. C., 2021, Statewide Building Footprints for Oregon, Release 1.0: Oregon Department of Geology and Mineral Industries Digital Data Series SBFO-1. <https://pubs.oregon.gov/dogami/dds/p-SBFO-1.htm>.

9.0 APPENDICES

Appendix A. Community Risk Profiles.....	34
Appendix B. Detailed Risk Assessment Tables	39
Appendix C. Hazus Methodology.....	46
Appendix D. Acronyms and Definitions	51
Appendix E. Map Plates	53

APPENDIX A. COMMUNITY RISK PROFILES

A risk analysis summary for each community is provided in this section to encourage ideas for natural hazard risk reduction. Increasing 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. This appendix contains community specific data to provide an overview of the community and the level of risk from each natural hazard analyzed. In addition, for each community a list of critical facilities and assumed impact from individual hazards is provided.

A.1 Unincorporated Harney County (Rural)	35
A.2 City of Burns	36
A.3 Burns-Paiute Tribe.....	37
A.4 City of Hines	38

A.1 Unincorporated Harney County (Rural)

Table A-1. Unincorporated Harney County (rural) hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Unincorporated Harney County (rural)	3,068	5,051	11	1,263,063,000			

Hazus Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate (\$)	Loss Ratio
Flood ²	1% Annual Chance	174	5.7%	138	0	2,867,000	0.2%
Earthquake	Harney Fault Mw 6.7 Deterministic	0	0.0%	323	2	63,156,330	5.0%

Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value (\$)	Exposure Ratio
Landslide	High and Very High Susceptibility	18	0.6%	46	0	8,058,000	0.6%
Wildfire	High Probability	2,522	82.2%	4,202	11	1,030,412,000	81.6%

¹ Facilities with multiple buildings were consolidated into one building complex.

² No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Table A-2. Unincorporated Harney County (rural) critical facilities.

Critical Facilities by Community	>50% Probability of Harney Fault Mw 6.7			
	Exposed to Flood 1% Annual Chance	Moderate to Complete Damage	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High Burn Probability
Burns Municipal Airport	—	—	—	X
Crane Elementary School	—	X	—	X
Crane Union High School	—	X	—	X
Diamond Elementary School	—	—	—	X
Double O Elementary School	—	—	—	X
Drewsey School	—	—	—	X
Frenchglen Elementary School	—	—	—	X
Harney Substation	—	—	—	X
Pine Creek School	—	—	—	X
Suntex Elementary	—	—	—	X
Wastewater Treatment	—	—	—	X

A.2 City of Burns

Table A-3. City of Burns hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Burns	2,730	2,155	12	732,084,000			
Hazus Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate (\$)	Loss Ratio
Flood ²	1% Annual Chance	1,095	40.1%	810	5	32,205,000	4.4%
Earthquake	Harney Fault Mw 6.7 Deterministic	0	0.0%	8	0	4,931,070	0.7%
Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value (\$)	Exposure Ratio
Landslide	High and Very High Susceptibility	2	0.1%	1	0	331,000	0.0%
Wildfire	High Probability	968	35.5%	755	4	265,886,000	36.3%

¹ Facilities with multiple buildings were consolidated into one building complex.

² No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Table A-4. City of Burns critical facilities.

Critical Facilities by Community	>50% Probability of Harney Fault Mw 6.7 Moderate to Complete Damage			
	Exposed to Flood 1% Annual Chance	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High Burn Probability	
Burns City Maintenance	X	—	—	—
Burns Fire Dept and Burns Police Dept	X	—	—	—
Burns High School	X	—	—	X
Burns Paiute Tribe	X	—	—	—
Burns Power Company	—	—	—	—
Burns Public Works	X	—	—	—
Burns-Hines VA Clinic	—	—	—	—
Harney County Health Department	—	—	—	—
Harney County Roads Department	—	—	—	X
Harney County Sheriff Department	—	—	—	—
Harney District Hospital - Burns	—	—	—	X
Henry L Slater Elementary School	—	—	—	X

A.3 Burns Paiute Tribe

Table A-5. Burns Paiute Tribe hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Burns Paiute Tribe	97	107	3	21,842,000			
Hazus Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate (\$)	Loss Ratio
Flood ²	1% Annual Chance	33	34.4%	39	1	854,000	3.9%
Earthquake	Harney Fault Mw 6.7 Deterministic	0	0.0%	7	0	745,509	3.4%
Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value (\$)	Exposure Ratio
Landslide	High and Very High Susceptibility	0	0.0%	0	0	0	0.0%
Wildfire	High Probability	92	94.8%	92	3	20,579,000	94.2%

¹ Facilities with multiple buildings were consolidated into one building complex.

² No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Table A-6. Burns Paiute Tribe critical facilities.

Critical Facilities by Community	Exposed to Flood 1% Annual Chance	>50% Probability of Harney Fault Mw 6.7 Moderate to Complete Damage	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High Burn Probability
Burns Paiute Tribal Office	—	—	—	X
Burns Paiute Tribal Police	X	—	—	X
Wada-Tika Health Center	—	—	—	X

A.4 City of Hines

Table A-7. City of Hines hazard profile

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Hines	1,705	1,007	8	449,432,000			
Hazus Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate (\$)	Loss Ratio
Flood ²	1% Annual Chance	171	10.0%	69	0	3,194,000	0.7%
Earthquake	Harney Fault Mw 6.7 Deterministic	0	0.0%	3	0	5,131,736	1.1%
Exposure Analysis Summary							
Hazard	Scenario	Potentially Displaced Residents	% Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value (\$)	Exposure Ratio
Landslide	High and Very High Susceptibility	11	0.6%	5	0	1,712,000	0.4%
Wildfire	High Probability	903	52.9%	472	2	275,655,000	61.3%

¹ Facilities with multiple buildings were consolidated into one building complex.

² No damage is estimated for exposed structures with “First floor height” above the level of flooding (base flood elevation).

Table A-8. City of Hines critical facilities.

Critical Facilities by Community	Exposed to Flood 1% Annual Chance	>50% Probability of Harney Fault Mw 6.7 Moderate to Complete Damage	Exposed to Landslide High and Very High Susceptibility	Exposed to Wildfire High Burn Probability
City of Hines	—	—	—	—
Emigrant Creek Ranger Station	—	—	—	—
Harney Electric Cooperative	—	—	—	—
Hines City Hall	—	—	—	—
Hines Fire Dept.	—	—	—	—
Hines Middle School	—	—	—	X
State Police	—	—	—	—
Substation	—	—	—	X

APPENDIX B. DETAILED RISK ASSESSMENT TABLES

Table B-1.	Harney County building inventory	40
Table B-2.	CSZ Mw 9.0 Earthquake loss estimates.....	41
Table B-4.	Flood loss estimates.....	42
Table B-5.	Flood exposure.....	43
Table B-6.	Landslide exposure	44
Table B-8.	Wildfire exposure.....	45

Table B-1. Harney County building inventory.

Community	Residential			Commercial and Industrial			Agricultural			Public and Non-Profit			All Buildings			
	Number of Buildings	Building Value (\$)¹	Building Value per Community Total	Number of Buildings	Building Value (\$)	Building Value per Community Total	Number of Buildings	Building Value (\$)	Building Value per Community Total	Number of Buildings	Building Value (\$)	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. Harney Co (rural)	1,915	515,486	41%	53	20,974	1.7%	3,044	704,011	56%	39	22,592	1.8%	5,051	61%	1,263,063	51%
Burns	1,606	492,202	67%	203	120,347	16.4%	267	57,759	7.9%	79	61,776	8.4%	2,155	25.9%	732,084	29.7%
Burns Paiute Tribe	73	16,332	75%	0	0	0.0%	25	2,110	10%	9	3,400	15.6%	107	1.3%	21,842	0.9%
Hines	783	271,138	60%	74	136,372	30.3%	123	22,447	5.0%	27	19,475	4.3%	1,007	12.1%	449,432	18.2%
Total Study Area	4,377	1,295,158	53%	330	277,693	11%	3,459	786,327	31.9%	154	107,243	4.3%	8,320	100.0%	2,466,421	100.0%

Table B-2. CSZ Mw 9.0 Earthquake loss estimates.

	<i>(all dollar amounts in thousands)</i>									
	Total Earthquake Damage									
	Buildings Damaged						All Buildings Changed to At Least Moderate Code			
	Total Number of Buildings	Total Estimated Building Value (\$)¹	Yellow- Tagged Buildings	Red- Tagged Buildings	Sum of Economic Loss	Loss Ratio	Yellow- Tagged Buildings	Red- Tagged Buildings	Sum of Economic Loss	Loss Ratio
Unincorp. Harney Co (rural)	5,051	1,263,063	226	97	63,156	5.0%	195	59	45,984	4%
Burns	2,155	732,084	7	1	4,931	0.7%	4	1	2,124	0%
Burns Paiute Tribe	107	21,842	6	1	746	3.4%	4	1	542	2%
Hines	1,007	449,432	2	0	5,132	1.1%	1	0	2,725	1%
Total Study Area	8,320	2,466,421	241	99	73,965	3.0%	204	61	51,375	2%

Table B-3. Flood loss estimates.

Community	Total Number of Buildings	Total Estimated Building Value (\$)	<i>(all dollar amounts in thousands)</i>											
			10% (10-yr)			2% (50-yr)			1% (100-yr)			0.2% (500-yr)		
			Number of Buildings	Loss Estimate	Loss Ratio	Number of Buildings	Loss Estimate	Loss Ratio	Number of Buildings	Loss Estimate	Loss Ratio	Number of Buildings	Loss Estimate	Loss Ratio
Unincorp. Harney Co (rural)	5,051	1,263,063	5	203	0.0%	23	619	0.0%	138	2,867	0.2%	57	1,682	0.1%
Burns	2,155	732,084	5	48	0.01%	409	15,624	2.1%	810	32,205	4.4%	880	38,435	5.3%
Burns Paiute Tribe	107	21,842	4	20	0.1%	22	339	1.6%	39	854	3.9%	46	1,101	5.0%
Hines	1,007	449,432	11	424	0.1%	25	1,014	0.2%	69	3,194	0.7%	92	4,888	1.1%
Total Study Area	8,320	2,466,421	25	695	0.0%	479	17,596	0.7%	1,056	39,120	1.6%	1,075	46,107	1.9%

Table B-4. Flood exposure.

Community	Total Number of Buildings	Total Population	1% (100-yr)				
			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. Harney Co (rural)	5,051	3,068	174	5.7%	183	3.6%	45
Burns	2,155	2,730	1,095	40.1%	928	43.1%	118
Burns Paiute Tribe	107	97	33	34.4%	54	50.5%	15
Hines	1,007	1,705	171	10.0%	74	7.3%	5
Total Study Area	8,320	7,600	1,474	19.4%	1,239	14.9%	183

Table B-5. Landslide exposure.

Community	Total Number of Buildings	Total Estimated Building Value (\$)	<i>(all dollar amounts in thousands)</i>								
			Very High Susceptibility			High Susceptibility			Moderate Susceptibility		
			Number of Buildings	Building Value (\$)	Percent of Building Value Exposed	Number of Buildings	Building Value (\$)	Percent of Building Value Exposed	Number of Buildings	Building Value (\$)	Percent of Building Value Exposed
Unincorp. Harney Co (rural)	5,051	1,263,063	8	1,906	0.2%	38	6,152	0.5%	747	156,367	12%
Burns	2,155	732,084	0	0	0.0%	1	331	0.0%	54	21,345	3%
Burns Paiute Tribe	107	21,842	0	0	0%	0	0	0.0%	2	809	4%
Hines	1,007	449,432	0	0	0.0%	5	1,712	0.4%	148	52,775	12%
Total Study Area	8,320	2,466,421	8	1,906	0.1%	44	8,195	0.3%	951	231,296	9%

Table B-6. Wildfire exposure.

Community	Total Number of Buildings	Total Estimated Building Value (\$)	<i>(all dollar amounts in thousands)</i>								
			High Hazard			Moderate Hazard			Low Hazard		
			Number of Buildings	Building Value (\$)	Percent of Building Value Exposed	Number of Buildings	Building Value (\$)	Percent of Building Value Exposed	Number of Buildings	Building Value (\$)	Percent of Building Value Exposed
Unincorp. Harney Co (rural)	5,051	1,263,063	4,202	1,030,412	82%	46	8,805	1%	803	223,846	18%
Burns	2,155	732,084	755	265,886	36%	1,205	398,015	54.4%	195	68,183	9%
Burns Paiute Tribe	107	21,842	92	20,579	94%	0	0	0%	15	1,263	6%
Hines	1,007	449,432	472	275,655	61%	476	154,912	34%	59	18,864	4%
Total Study Area	8,320	2,466,421	5,521	1,592,532	64.6%	1,727	561,732	23%	1,072	312,157	13%

APPENDIX C. HAZUS METHODOLOGY

C.1 Software

We performed all loss estimations using Hazus 6.0 and ArcGIS® Desktop® 10.7.1.

C.2 User-Defined Facilities (UDF) Database

A UDF database was compiled for all buildings in Harney County for use in both the flood and earthquake modules of Hazus. The Harney County assessor database (acquired in 2016 and updated in 2024) was used to determine which taxlots had improvements (i.e., buildings) should be included in the UDF database.

C.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.

C.2.2 Attributing building points

Populating the required attributes for Hazus was achieved through a variety of approaches. The Harney 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 Harney 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 Harney County assessor database. When not available, the year of “1970” was applied.
- **Square feet** – The size of the UDF is used to pro-rate the total improvement value for taxlots with multiple UDFs. The value distribution method will ensure that UDFs with the highest square footage will be the most expensive on a given taxlot. This value is also used to pro-rate the **Number of People** field for Residential UDFs. The value was obtained from PSU Population Research Center estimates for Harney County and incorporated communities, where number of people are distributed based on square footage.
- **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 Harney 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 Harney 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 Harney 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 (Harney 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 PSU Population Research Center estimates for Harney County and incorporated communities, where number of people are distributed based on square footage.
- **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.

C.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 retrofiting information for structures would be ideal for this analysis but was not available for Harney County. **Table C-1** outlines the benchmark years that apply to buildings within Harney County.

Table C-1. Harney County seismic design level benchmark years.

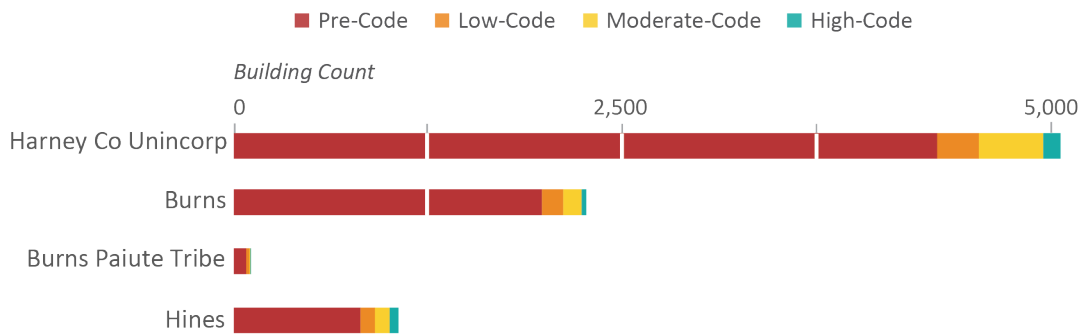
Building Type	Year Built	Design Level	Basis
Single-family dwelling (includes duplexes)	Pre-1976	Pre-Code	Interpretation of Judson (Judson, 2012)
	1976–1991	Low Code	
	1992–2003	Moderate Code	
	2004–2016	High Code	
Manufactured housing	Pre-2003	Pre-Code	Interpretation of OR BCD 2002 Manufactured Dwelling Special Codes (Oregon Building Codes Division, 2002)
	2003–2010	Low Code	
	2011–2016	Moderate Code	Interpretation of OR BCD 2010 Manufactured Dwelling Special Codes Update (Oregon Building Codes Division, 2010)
All other buildings	Pre-1976	Pre-Code	Business Oregon 2022 Oregon Benefit-Cost Analysis Tool, p. 24 (Business Oregon, 2022)
	1976–1990	Low Code	
	1991–2016	Moderate Code	

Table C-2 and corresponding **Figure C-1** illustrate the current state of seismic building codes for the county.

Table C-2. Seismic design level in Harney County.

Community	Total Number of Buildings	Pre Code		Low Code		Moderate Code		High Code	
		Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings	Number of Buildings	Percentage of Buildings
Unincorp. Harney Co (rural)	5,051	4,299	85%	255	5%	392	8%	105	2.1%
Burns	2,155	1,884	87%	129	6.0%	114	5.3%	28	1.3%
Burns Paiute Tribe	107	77	72%	21	20%	4	4%	5	4.7%
Hines	1,007	776	77%	88	9%	90	9%	53	5.3%
Total Study Area	8,320	7,036	85%	493	5.9%	600	7.2%	191	2.3%

Figure C-1. Seismic design level by Harney County community.



C.3 Flood Hazard Data

DOGAMI developed depth grids from detailed stream model information within the study area. These 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 for determining 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 [OccCls], which was used to determine the loss ratio for a given amount of flood depth, relative to the UDF’s first-floor height.

C.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 of the five damage states (None, Slight, Moderate, Extensive, Complete) from which losses in dollar amounts were derived.

C.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 can be done by sorting the results based on the loss estimates and closely scrutinizing the top 10 to 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 taxlot 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 D. ACRONYMS AND DEFINITIONS

D.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

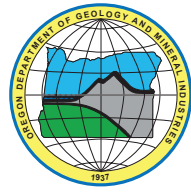
D.2 Definitions

- **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 as a result 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 E. MAP PLATES

See appendix folder for individual map PDFs.

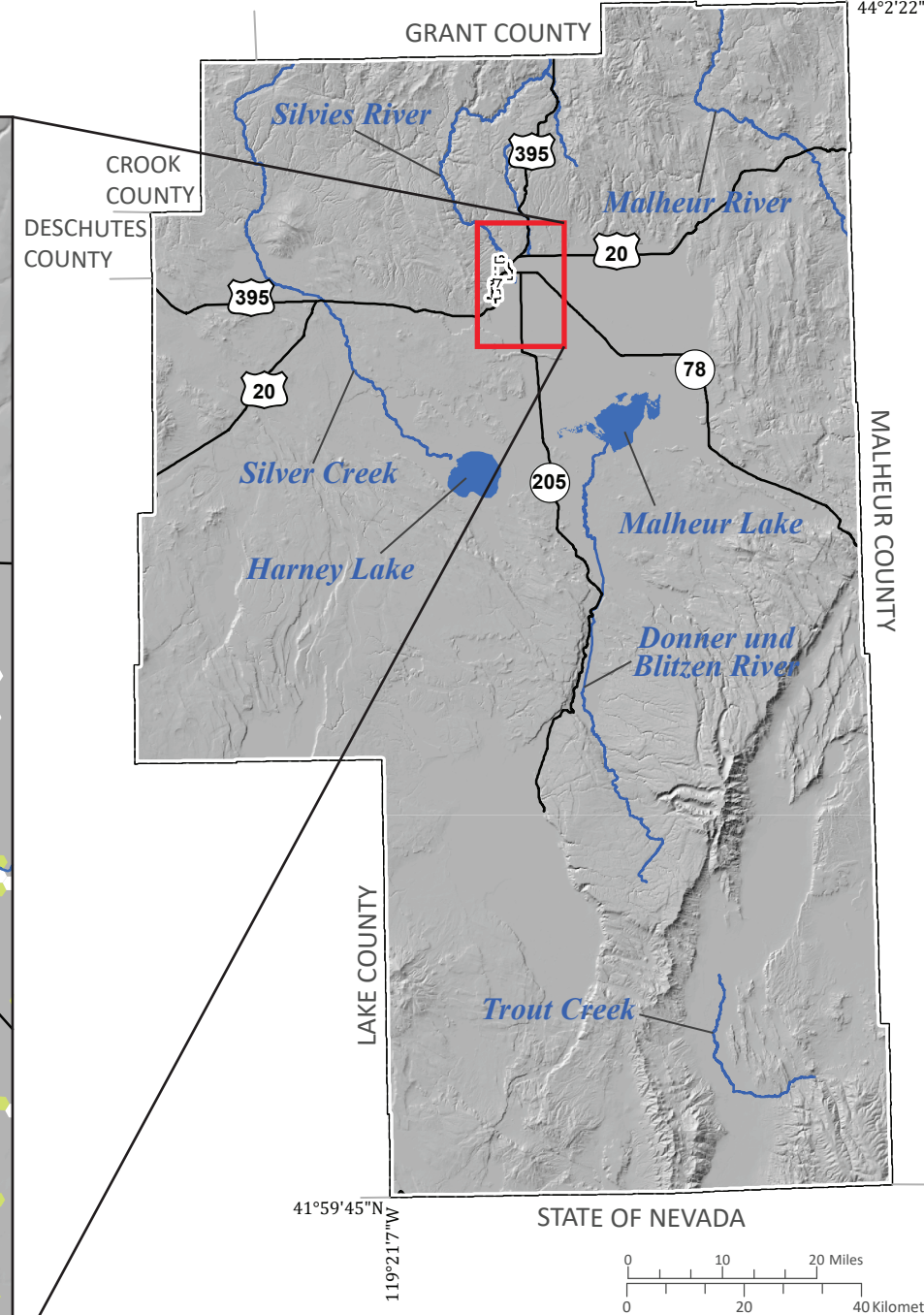
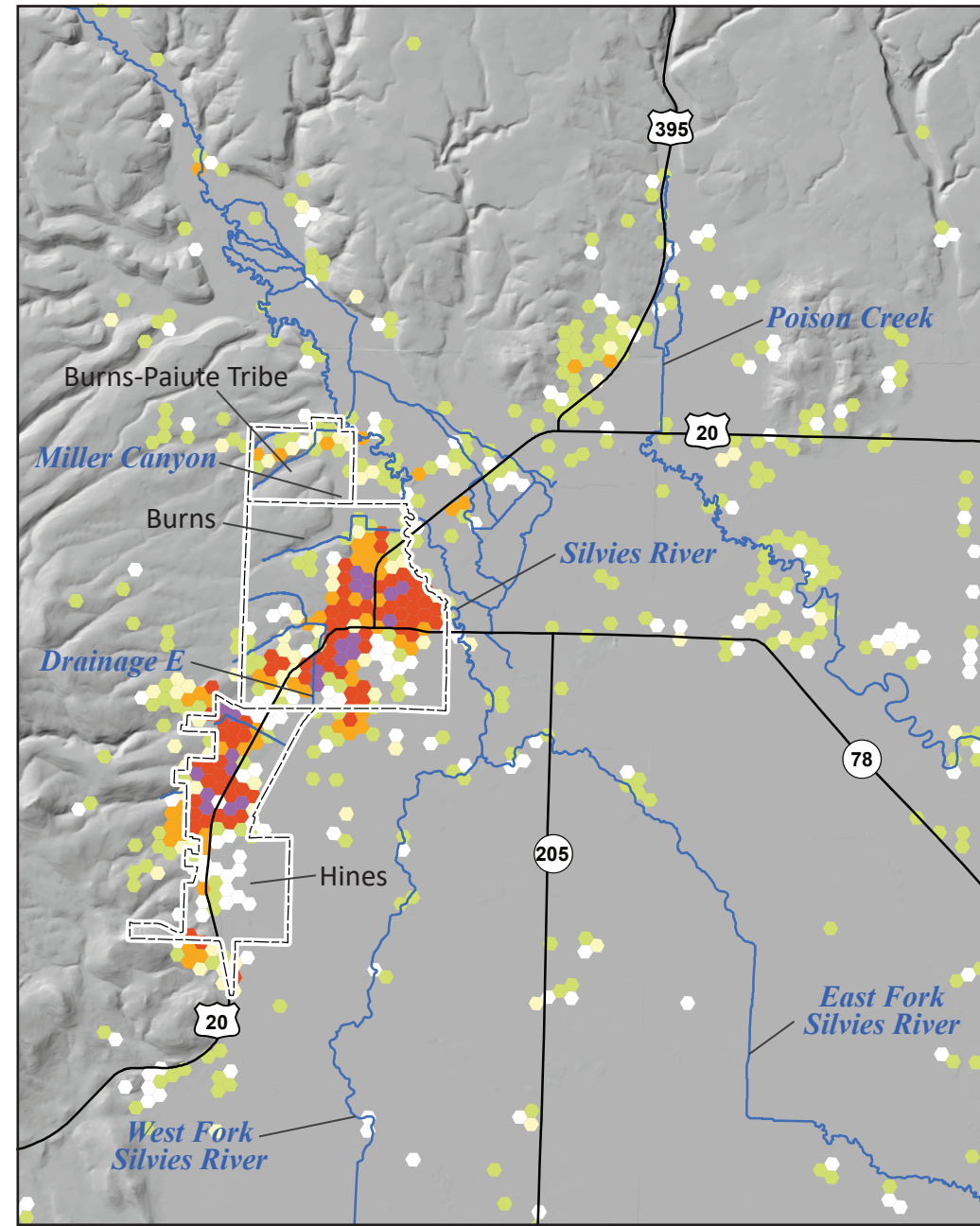
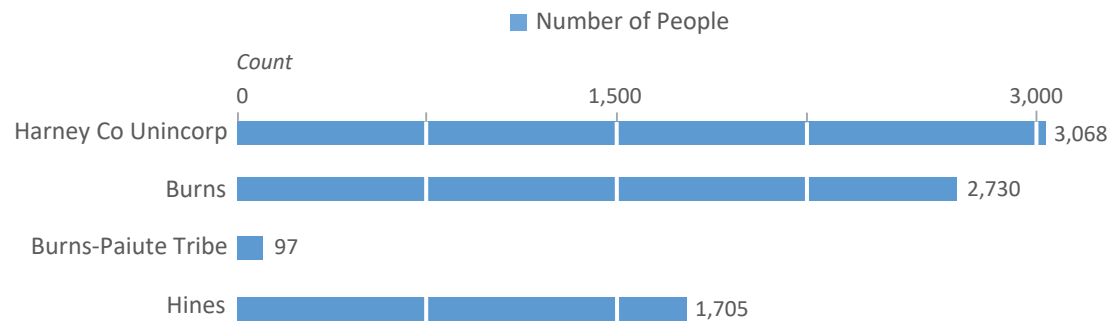
Plate 1.	Population Density Map of Harney County, Oregon.....	54
Plate 2.	Harney Fault Mw 6.7 Shaking Map of Harney County, Oregon	55
Plate 3.	Coseismic Landslide Susceptibility (Wet) Map of Harney County, Oregon.....	56
Plate 4.	Liquefaction Susceptibility Map of Harney County, Oregon.....	57
Plate 5.	Site Amplification Class Map of Harney County, Oregon.....	58
Plate 6.	Flood Hazard Map of Harney County, Oregon.....	59
Plate 7.	Landslide Susceptibility Map of Harney County, Oregon.....	60
Plate 8.	Wildfire Hazard Map of Harney County, Oregon	61



Population Density Map of Harney County, Oregon

People per 100 acres

- Building(s) present
no permanent residents
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 40
- 40 +

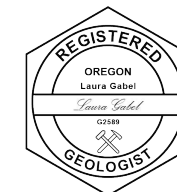


Data Sources:
 Population data: PSU Population Research Center (2022)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (2014)
 Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025

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

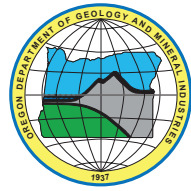
Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication 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.



Expires: 1/1/2026



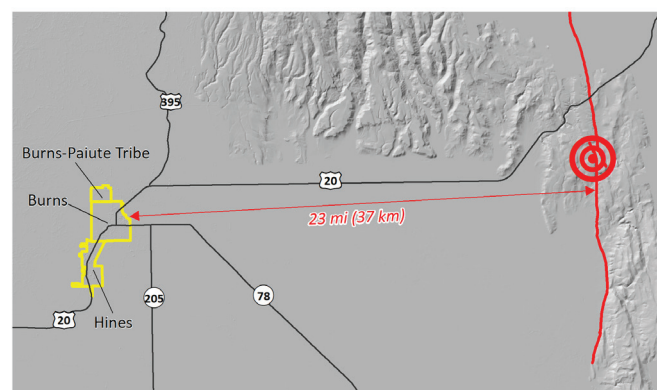
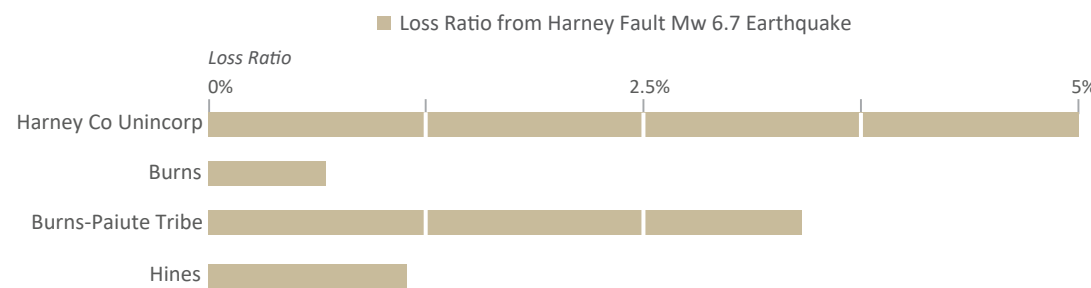
Study Location Map



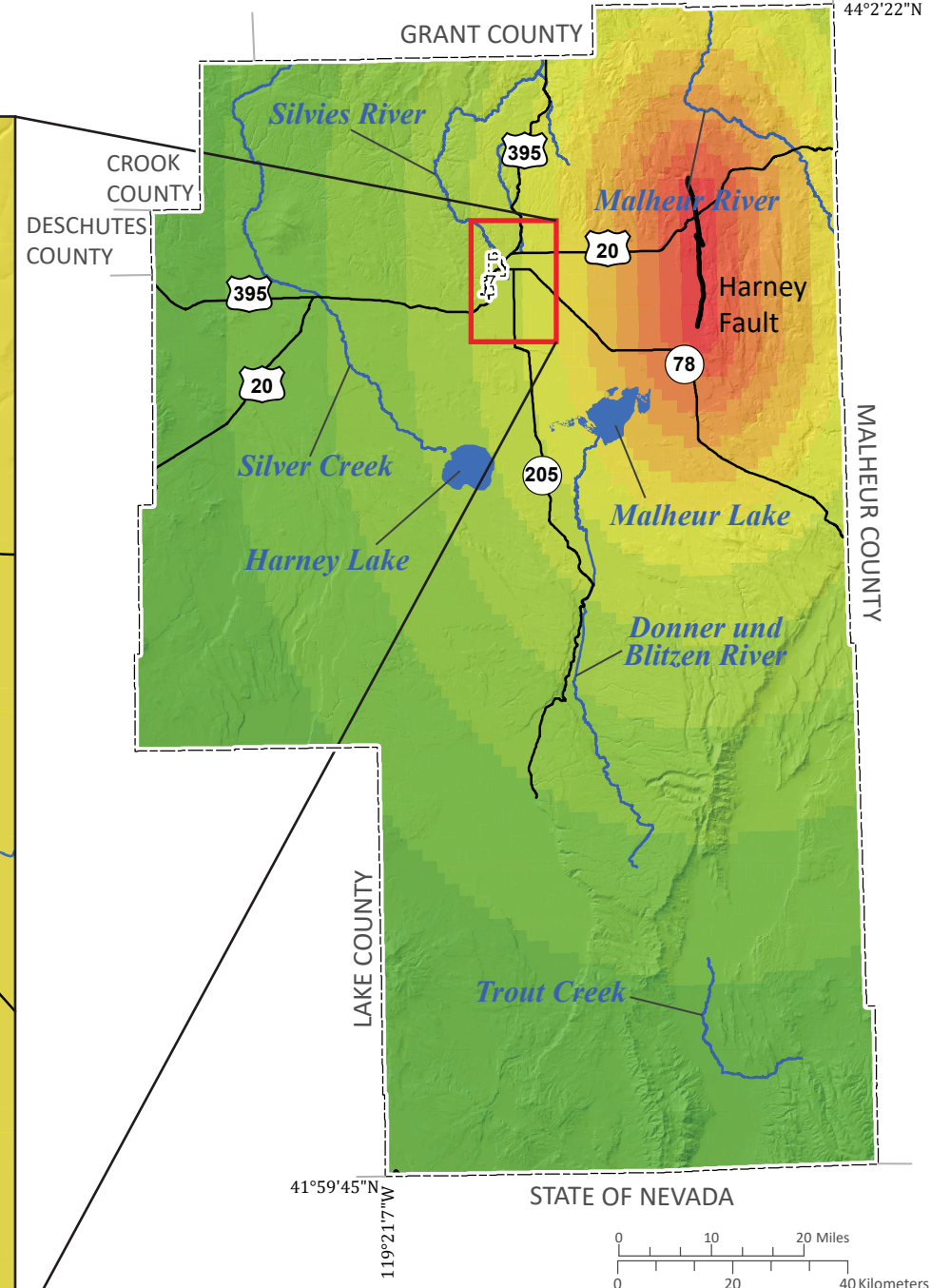
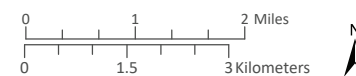
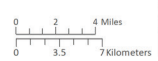
Harney Fault Magnitude-6.7 Earthquake Shaking Map of Harney County, Oregon

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.



- Simulated Epicenter
- Harney Fault
- Major Roads
- Communities

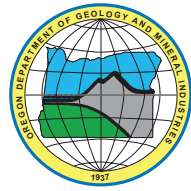


Expires: 1/1/2026

Study Location Map

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

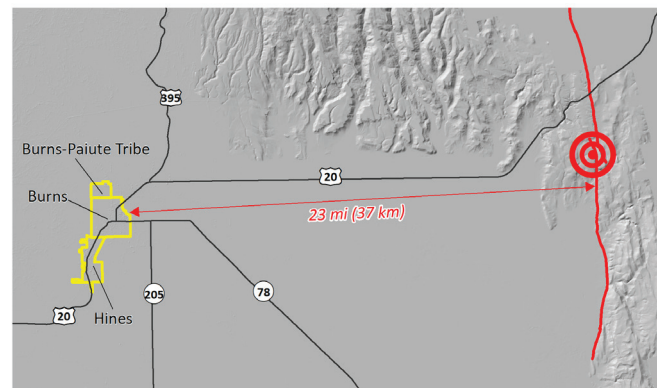
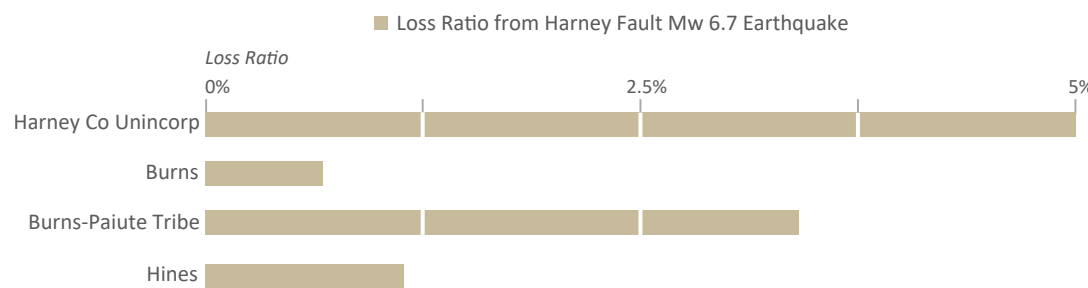
Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication 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.



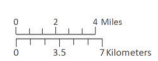
Coseismic Landslide Susceptibility (Wet) Map of Harney County, Oregon

Coseismic landslide is a type of ground deformation that occurs during an earthquake where slope failure creates a mass movement of rock and debris. Saturated ground increases the susceptibility of a landslide occurring from seismic shaking. Coseismic landslides are a significant factor in the risk from earthquake hazard.

Coseismic Landslide Susceptibility (Wet)

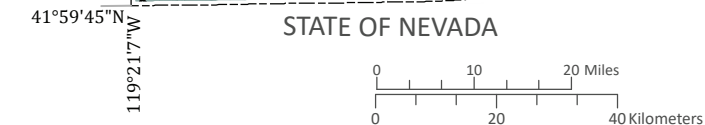
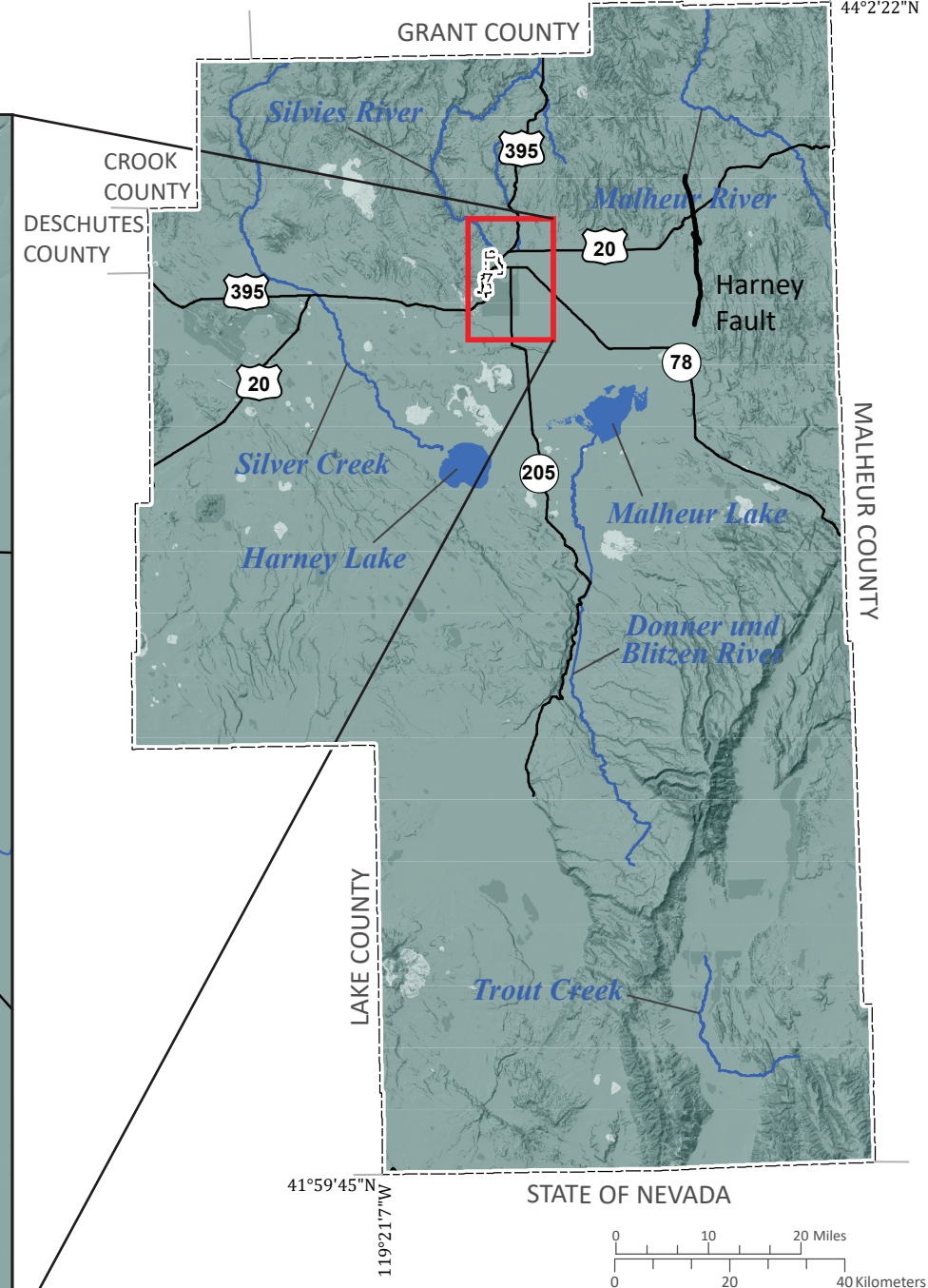
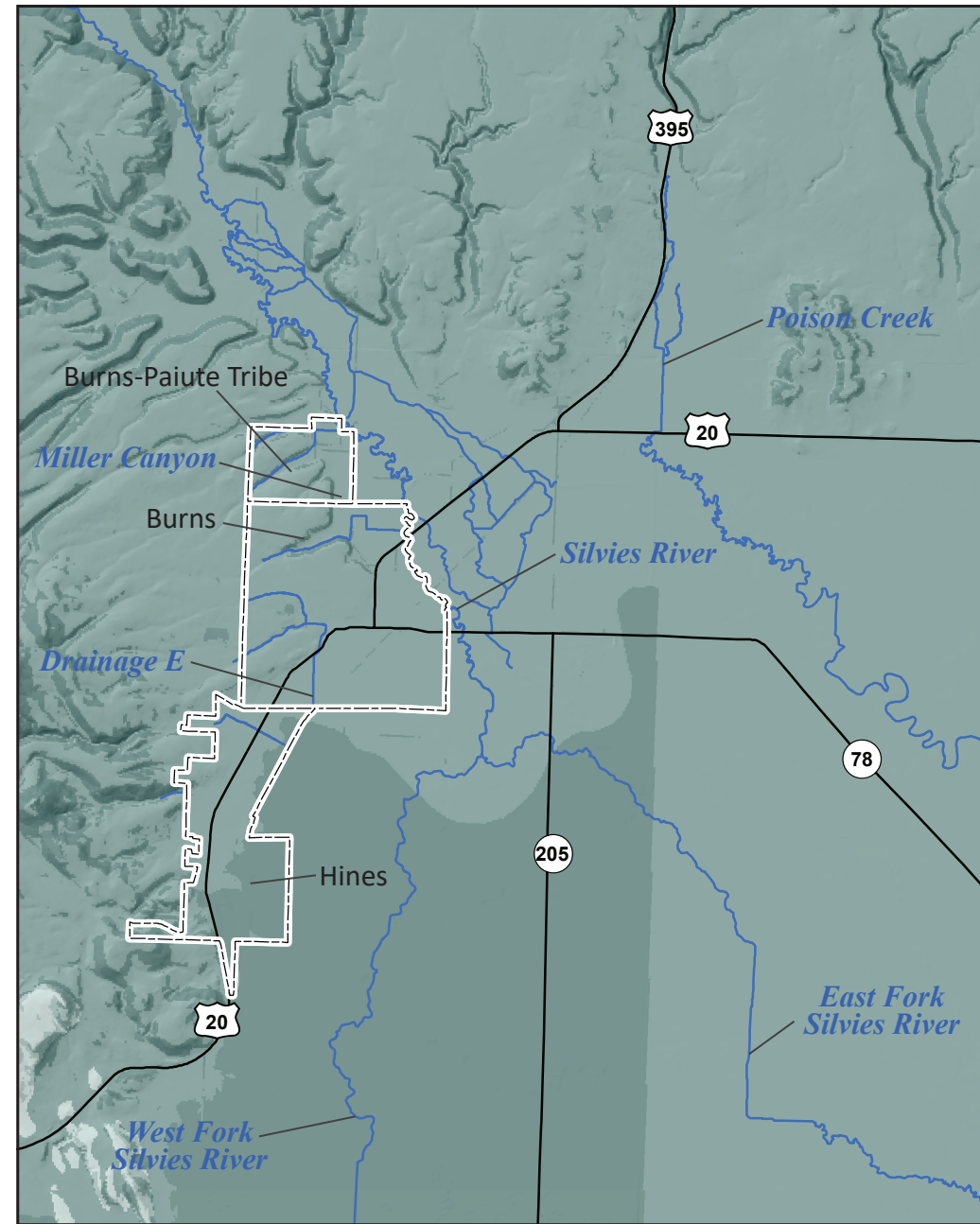


- Simulated Epicenter
- Harney Fault
- Major Roads
- Communities



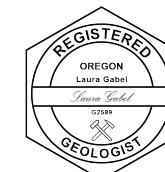
Data Sources:
 Coseismic Landslide (wet): Oregon Department of Geology and Mineral Industries (2021)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (2014)
 Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

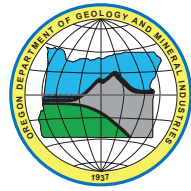
Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025



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

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.



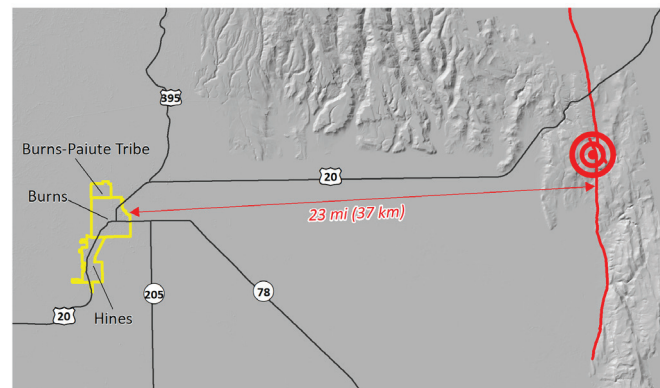
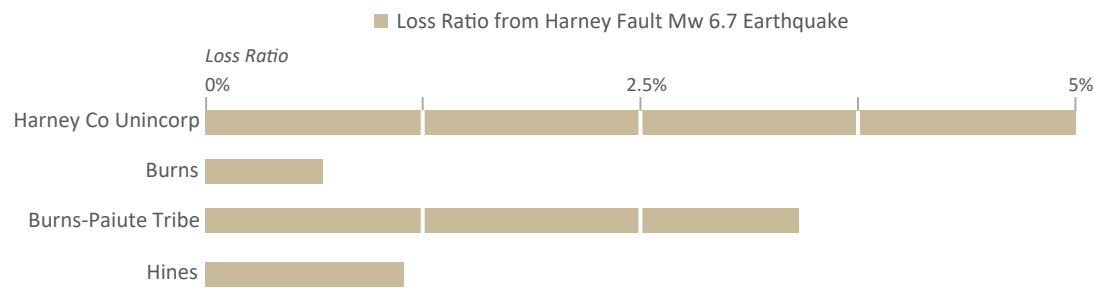


Liquefaction Susceptibility Map of Harney County, Oregon

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

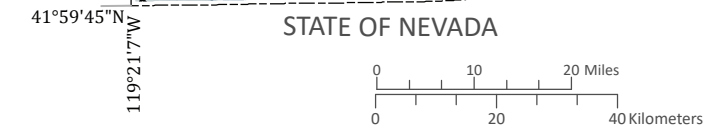
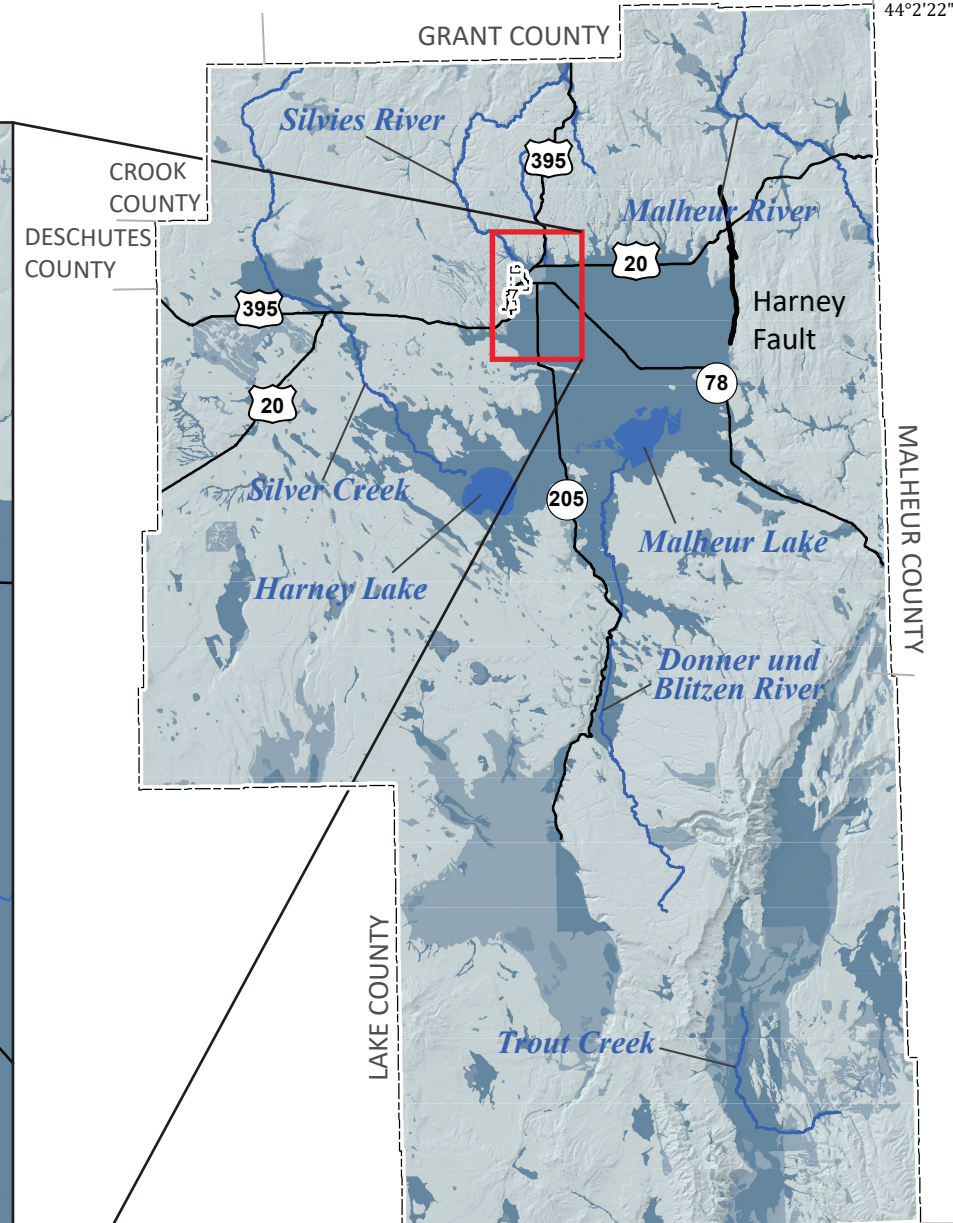
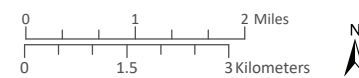
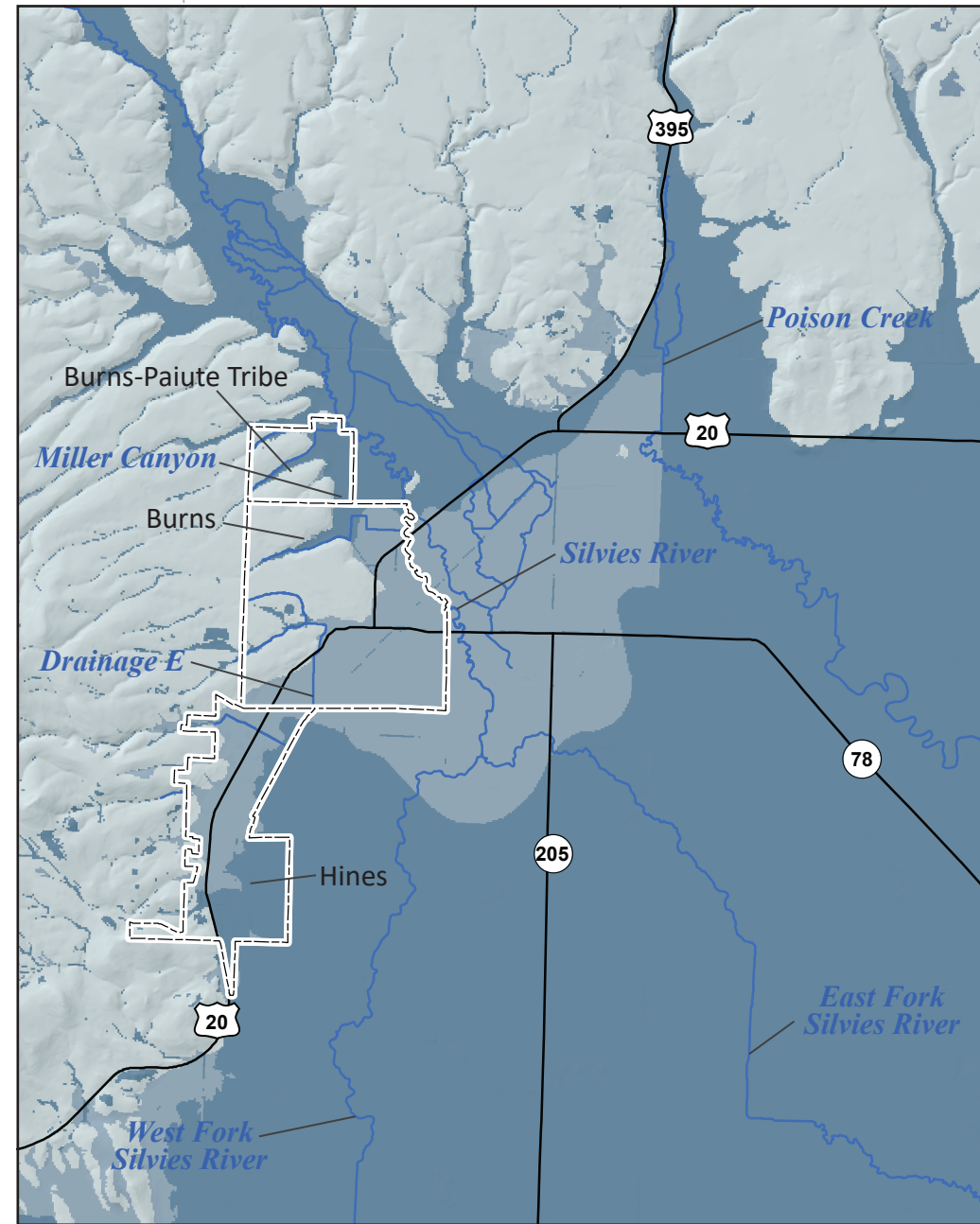
- Low or None
- Moderate
- High
- Very High



- ⊙ Simulated Epicenter
- Harney Fault
- Major Roads
- + Communities

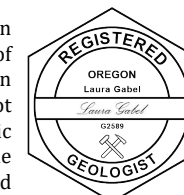
Data Sources:
 Liquefaction susceptibility: Oregon Department of Geology and Mineral Industries (2021)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (2014)
 Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025



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

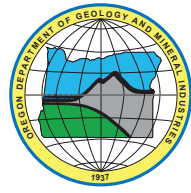
Disclaimer: This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. This publication 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.



Expires: 1/1/2026



Study Location Map



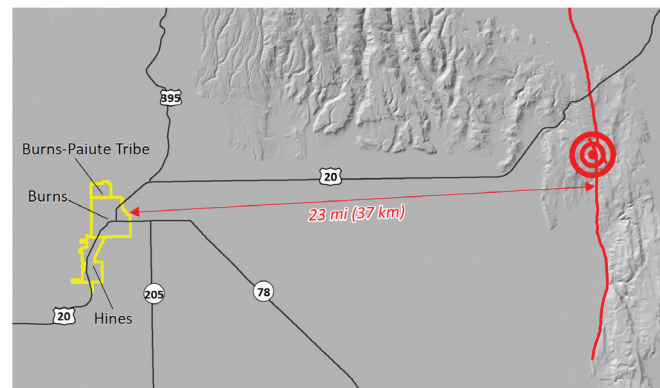
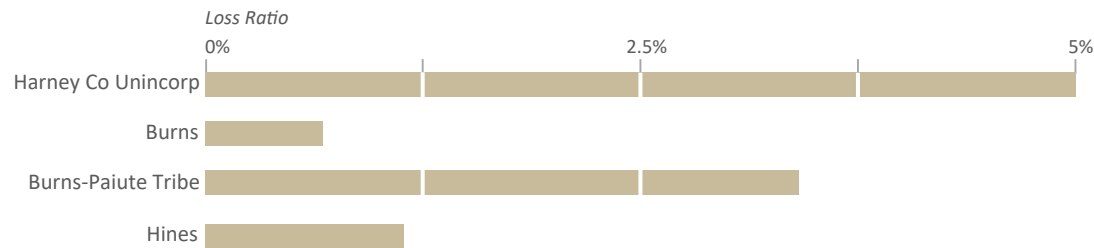
Site Amplification Class Map of Harney County, Oregon

Site Amplification is the degree to which soil types attenuate (weaken) or amplify (strengthen) seismic waves produced from an earthquake. The National Earthquake Hazards Reduction Program (NEHRP) classifies these geologic units into soft rock (B), dense soil or soft rock (C), stiff soil (D), and soft clay or soil (E, F). NEHRP soils can significantly affect the level of shaking and amount of damage that occurs at a specific location during an earthquake

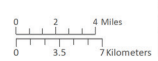
NEHRP Class

- B
- C
- D
- E, F

■ Loss Ratio from Harney Fault Mw 6.7 Earthquake



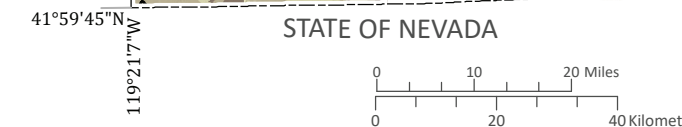
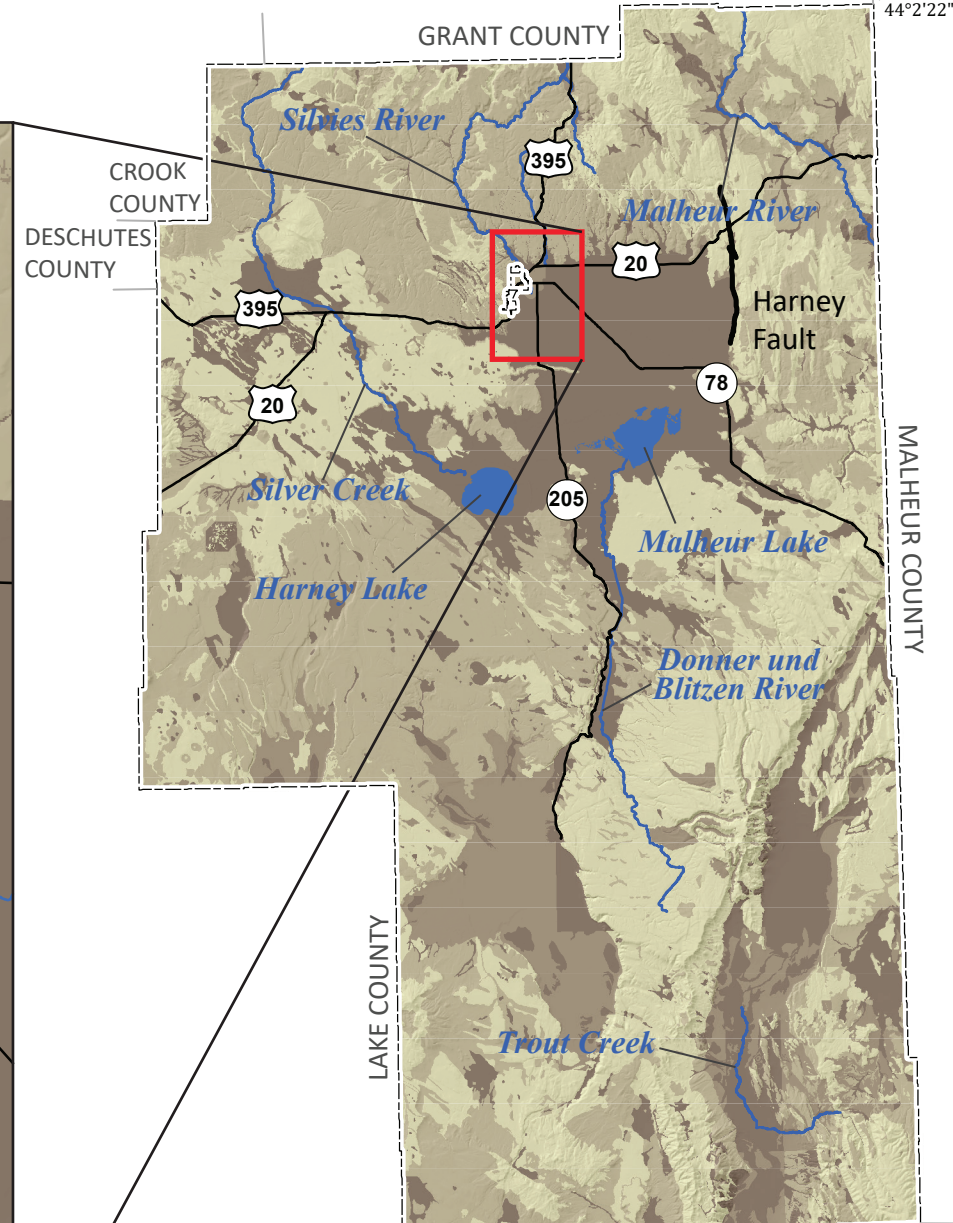
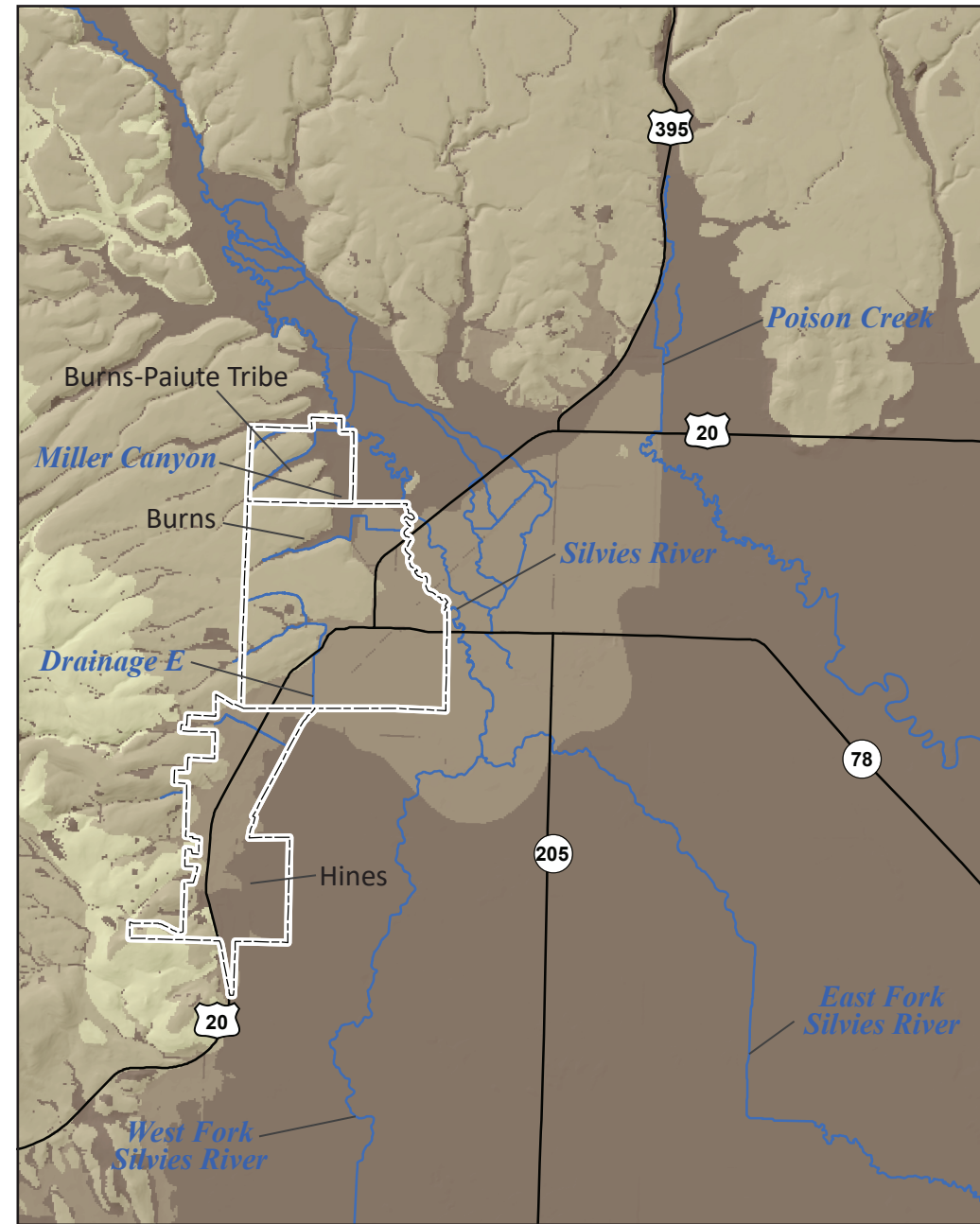
- Simulated Epicenter
- Harney Fault
- Major Roads
- Communities



Data Sources:

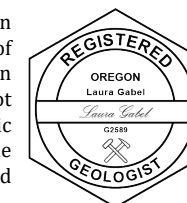
- Soil amplification: Oregon Department of Geology and Mineral Industries (2021)
- Roads: Oregon Department of Transportation Signed Routes (2013)
- Place names: U.S. Geological Survey Geographic Names Information System (2015)
- City limits: Oregon Department of Transportation (2014)
- Basemap: Oregon Lidar Consortium (2014)
- Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025



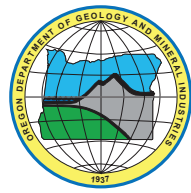
This map is an overview map and not intended to provide details at the community scale. The GIS data that are published with the Harney County Multi-Hazard Risk Assessment can be used to inform regarding queries at the community scale.

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.



Expires: 1/1/2026



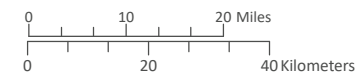
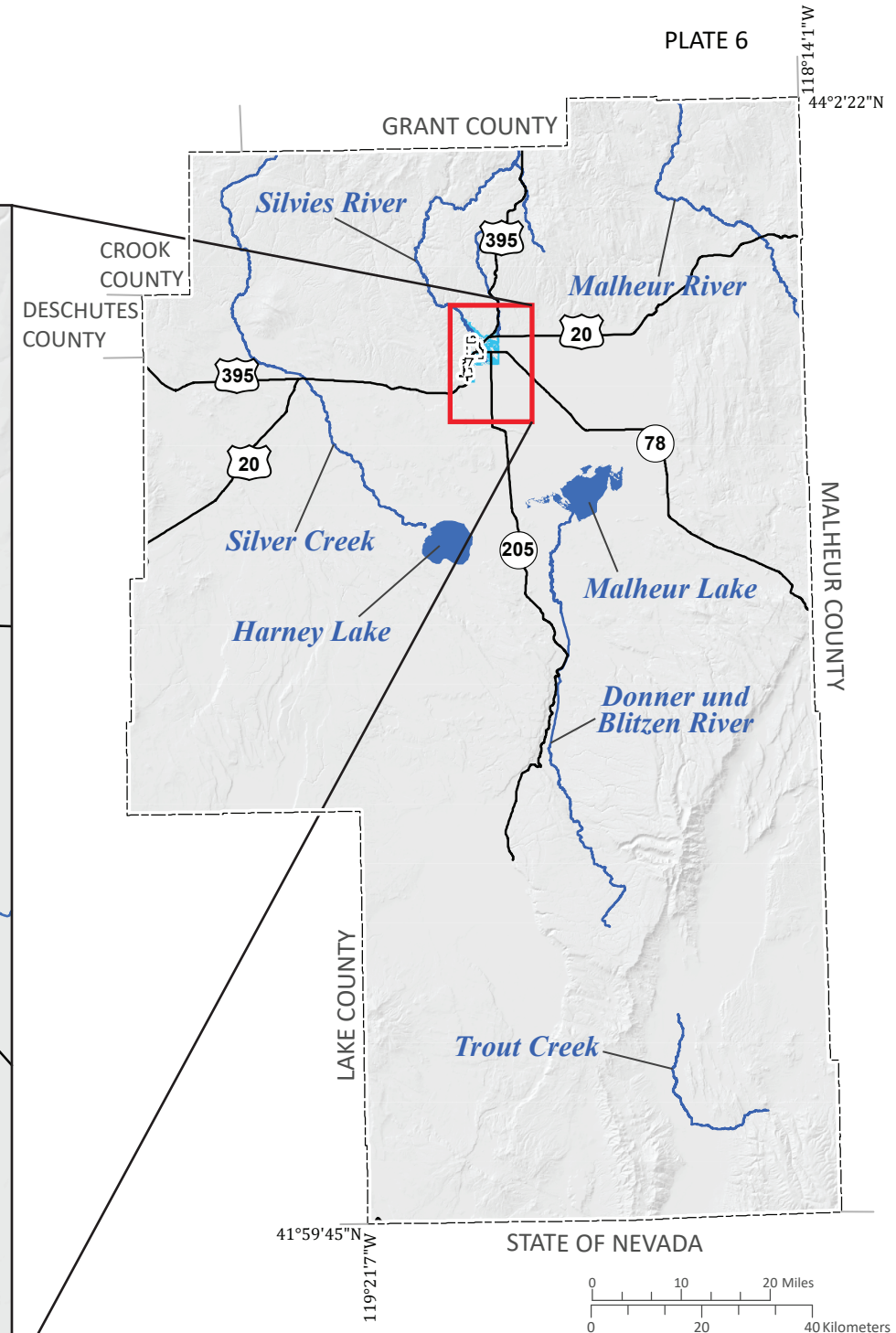
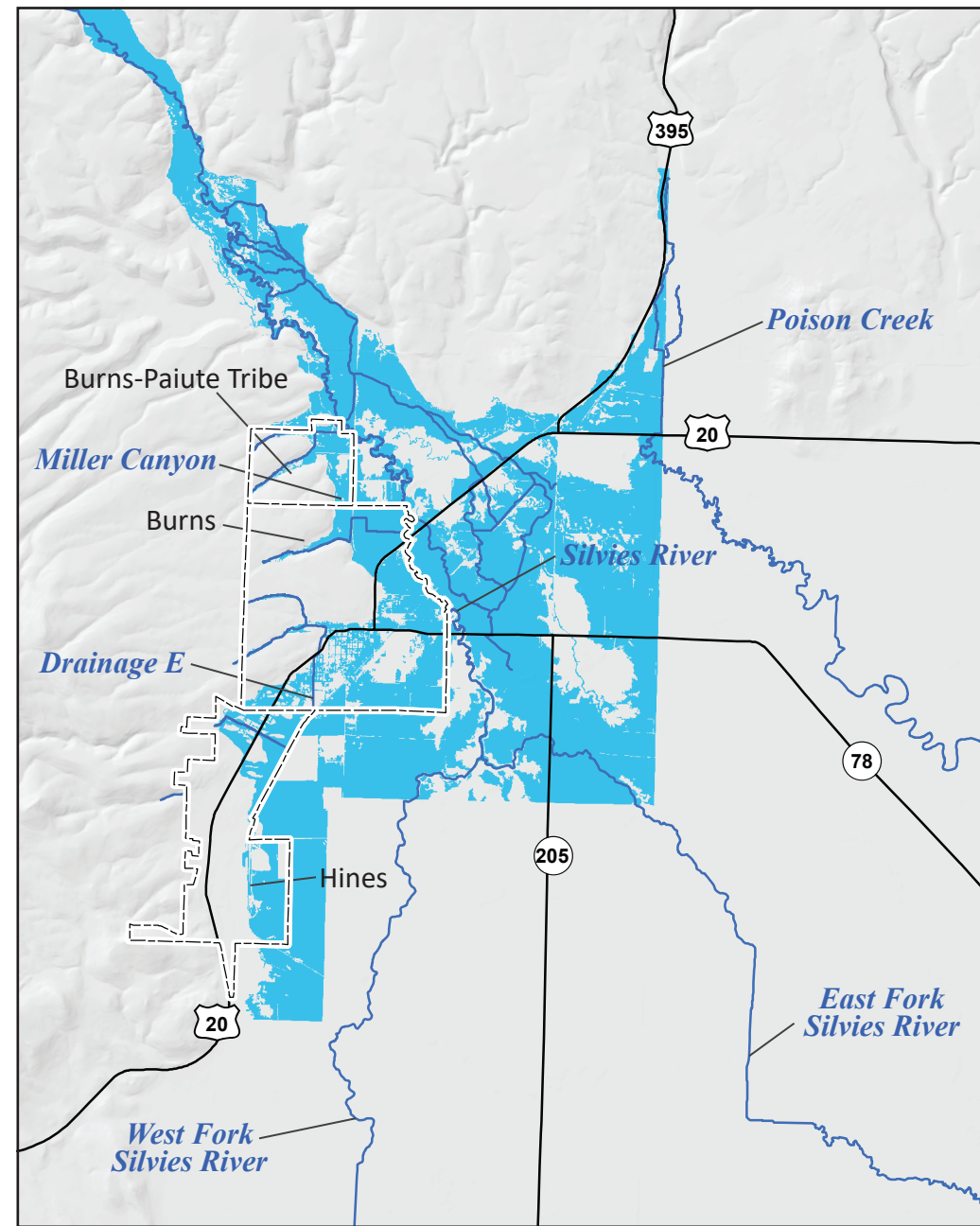
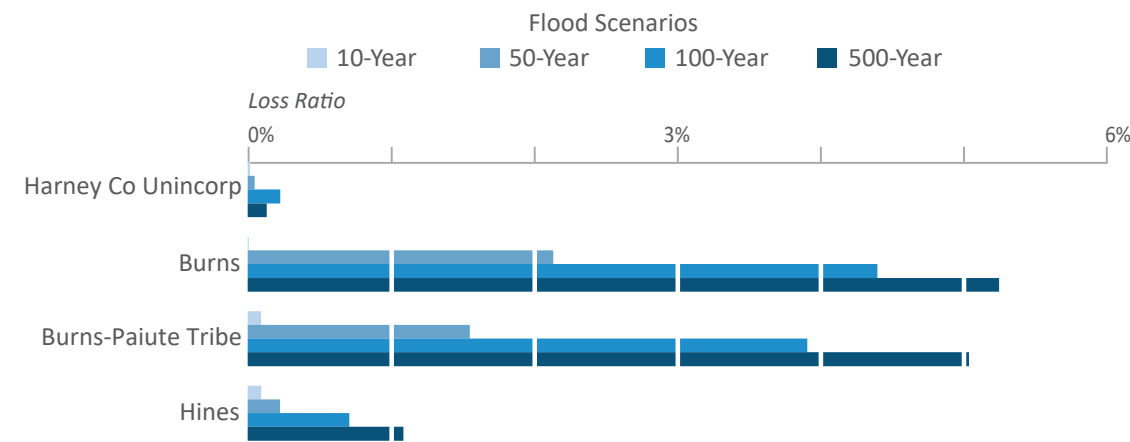


Flood Hazard Map of Harney County, Oregon

The flood hazard data show areas expected to be inundated during a 100-year flood event. Flooding sources include riverine. Areas are consistent with the regulatory flood zones depicted in Harney County's Digital Flood Insurance Rate Maps.

Flood Hazard Zone

100-Year Flood (1% annual chance)



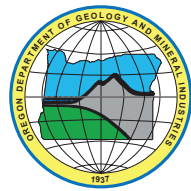
Data Sources:
 Flood hazard zone (100-year): Harney County Flood Insurance Rate Map (2024)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (2014)
 Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025

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

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.

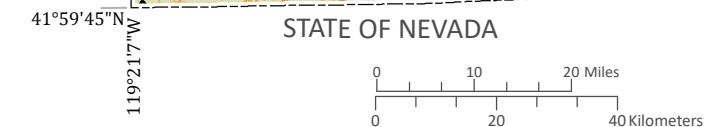
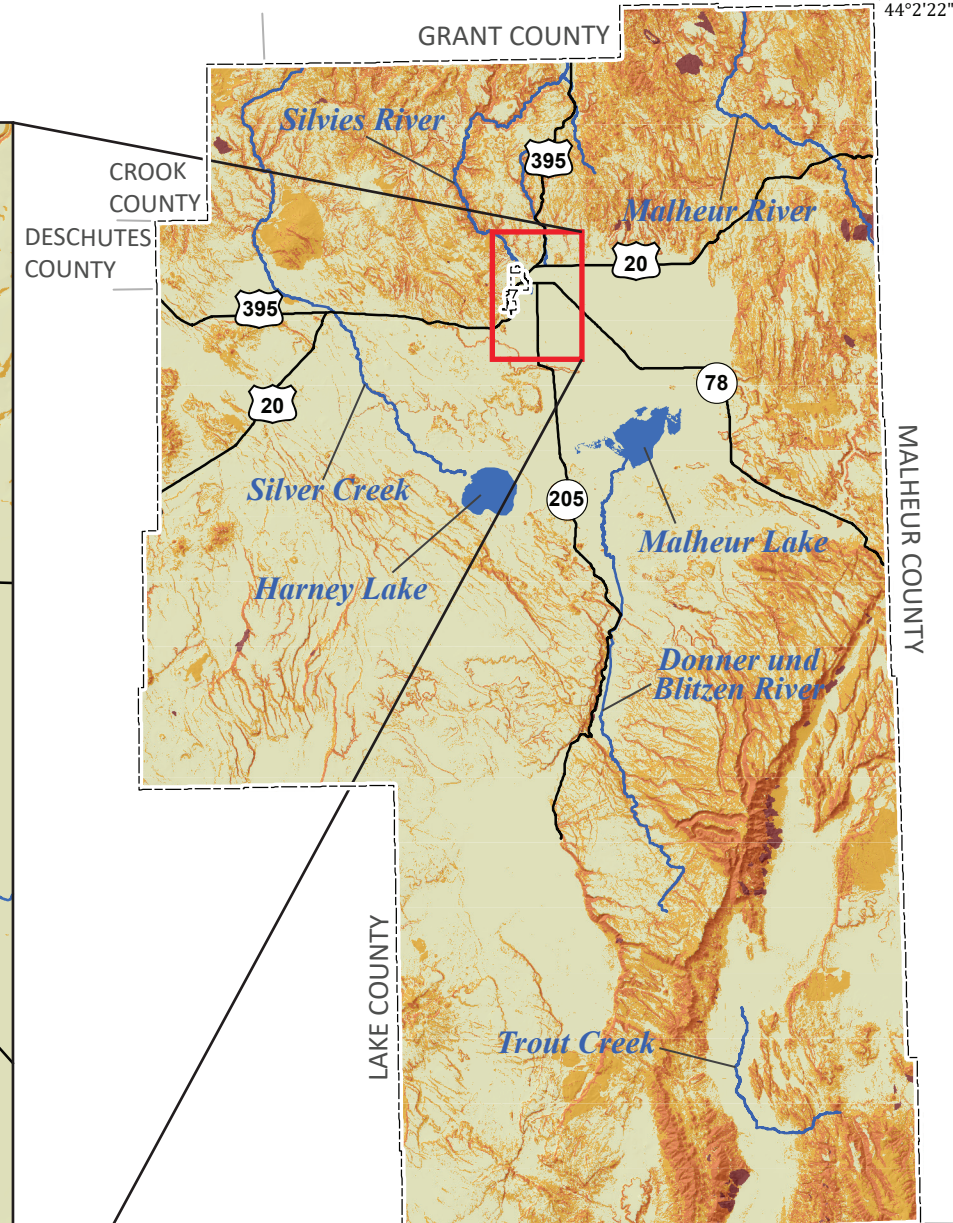
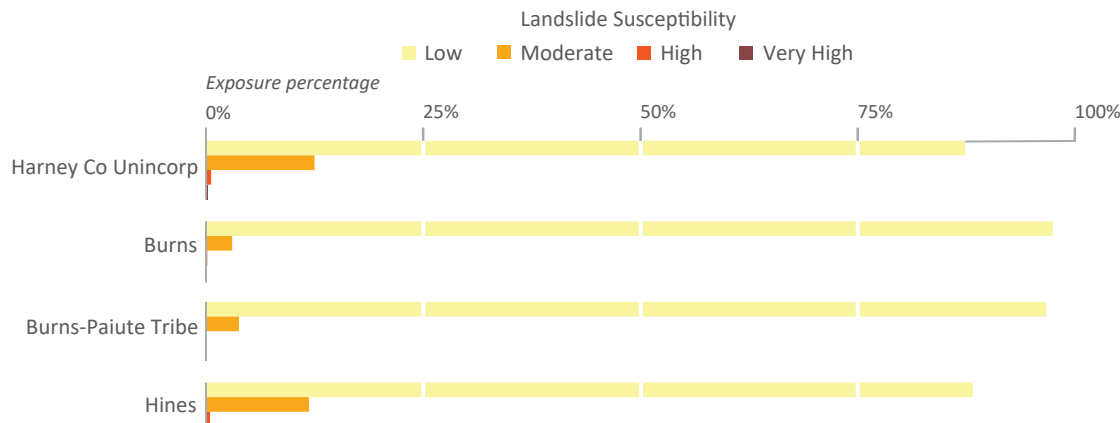
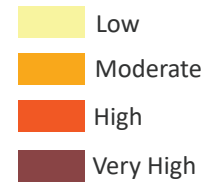




Landslide Susceptibility Map of Harney County, Oregon

Landslide susceptibility is categorized as Low, Moderate, High, and Very High which describes the general level of susceptibility to landslide hazard. The dataset is an aggregation of three primary sources: landslide inventory (SLIDO), generalized geology, and slope.

Landslide Susceptibility

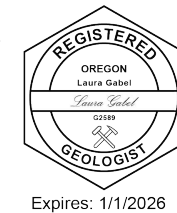


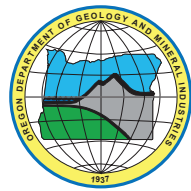
Data Sources:
 Landslide susceptibility: Oregon Department of Geology and Mineral Industries, Burns and others (2016)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (2014)
 Hydrography: U.S. Geological Survey National Hydrography Dataset (2017)

Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025

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

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.

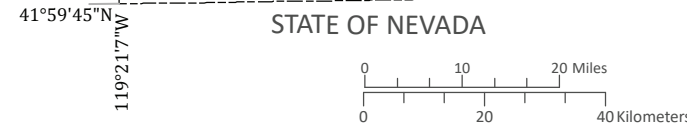
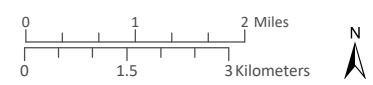
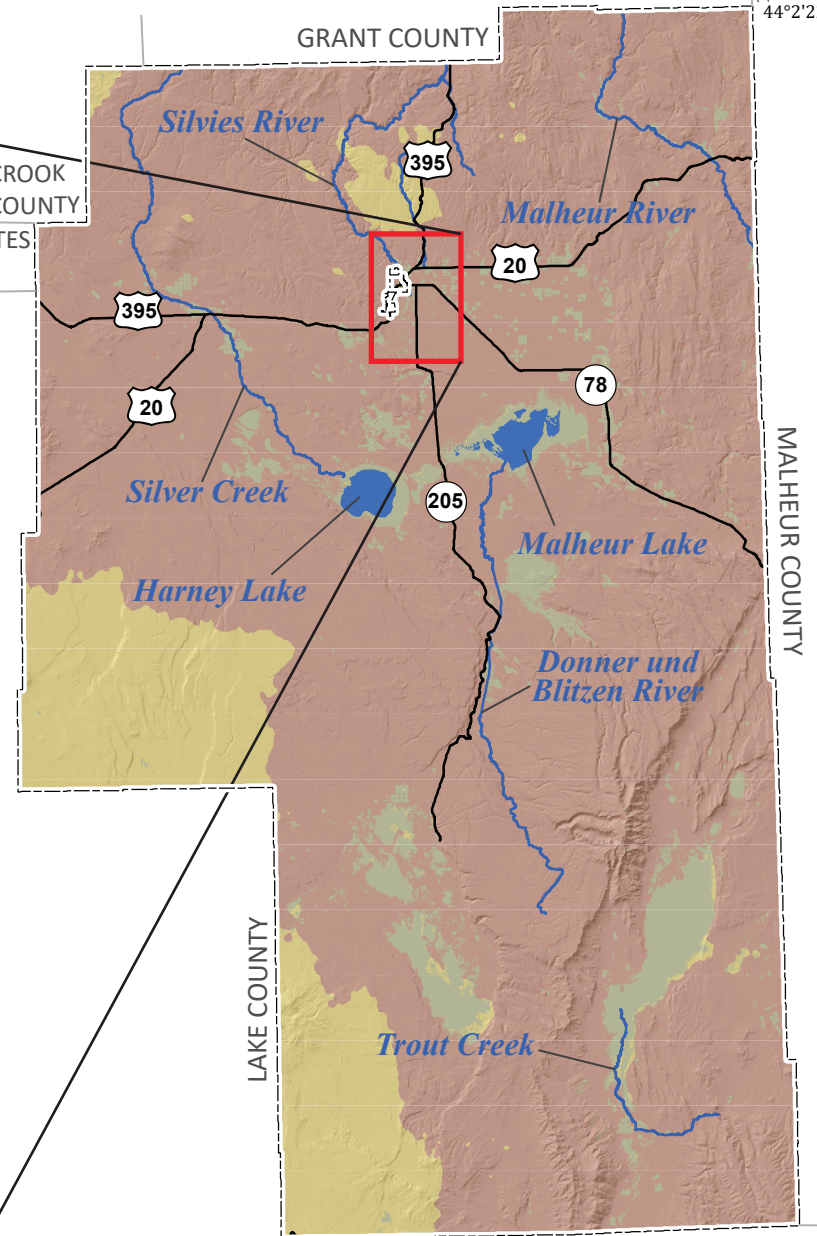
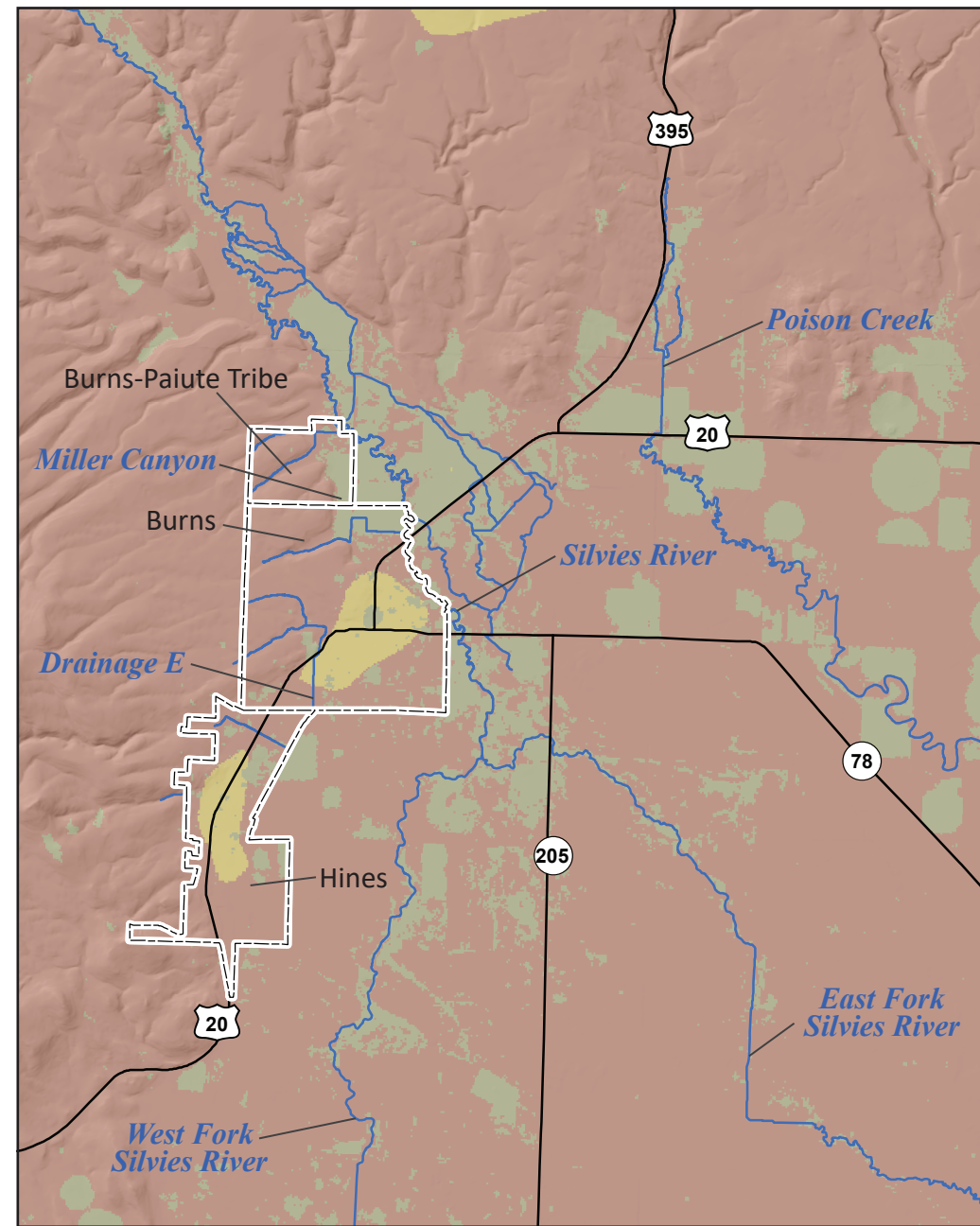
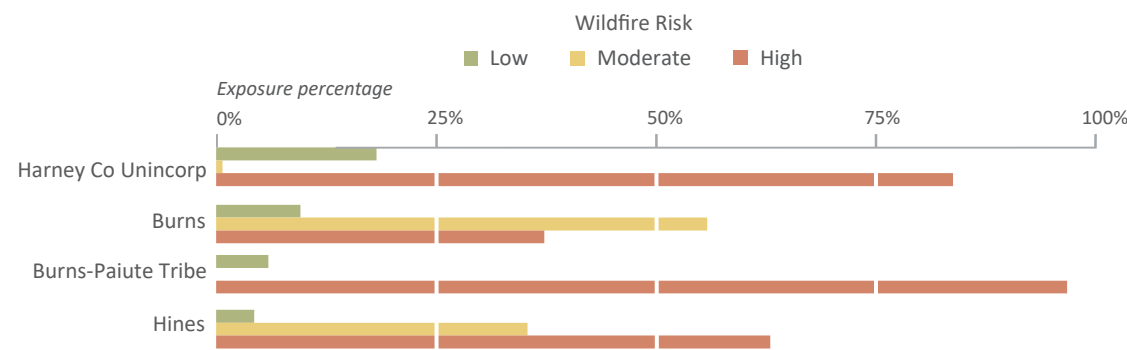
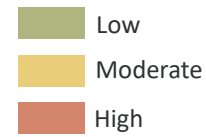




Wildfire Risk Map of Harney County, Oregon

The Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results (PNRA; Pyrologix LCC, 2023) is a comprehensive report that includes a database developed by the U.S. Forest Service for the states of Oregon and Washington. The PNRA produced the Burn Probability dataset that we used to calculate risk. The Burn Probability dataset was categorized 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.

Wildfire Risk



Data Sources:
 Wildfire risk data: Oregon Department of Forestry, Pyrologix, LCC. (2023)
 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® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2025

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

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.

