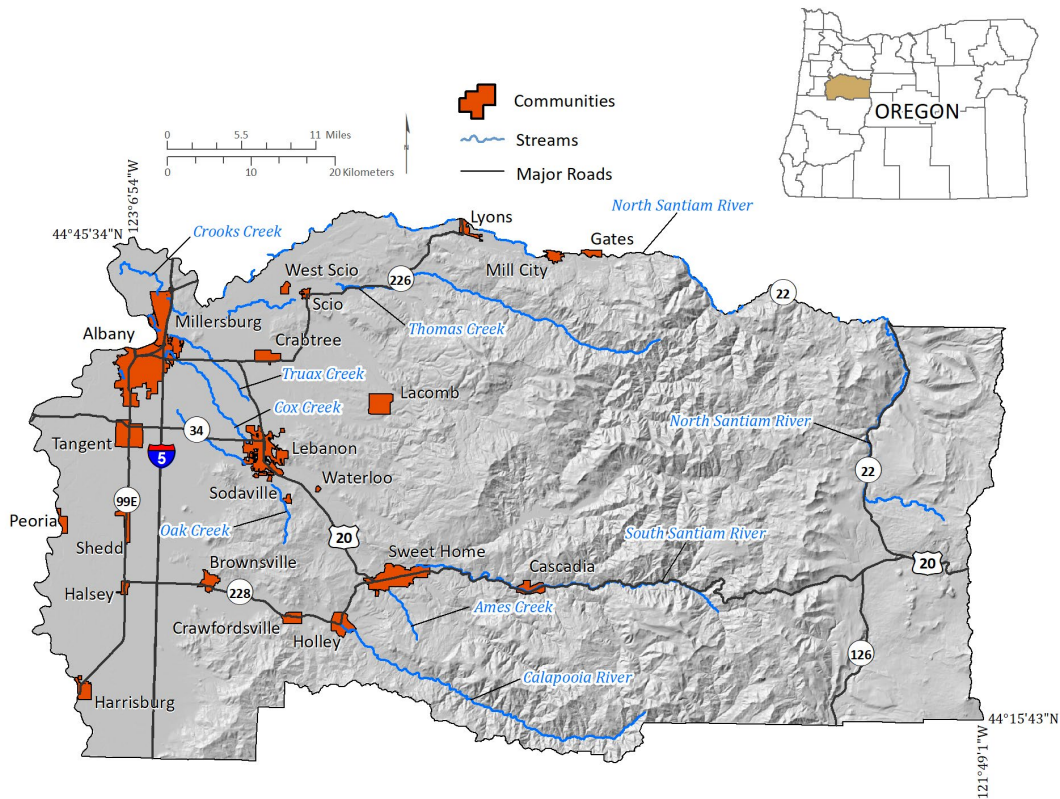


OPEN-FILE REPORT O-24-15

MULTI-HAZARD RISK REPORT FOR LINN COUNTY, OREGON

INCLUDING THE CITIES OF ALBANY, BROWNSVILLE, GATES, HALSEY, HARRISBURG, IDANHA, LEBANON, LYONS, MILL CITY, MILLERSBURG, SCIO, SODAVILLE, SWEET HOME, TANGENT, AND WATERLOO



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2024

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DISCLAIMER

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

WHAT'S IN THIS REPORT?

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



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GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

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

Linn_County_Risk_Report_Data.gdb

Feature dataset: Asset_Data

- feature classes:
- Building_footprints (polygons)
- Communities (polygons)
- UDF_points (points)

Linn_County_Depth_Grids.gdb:

- FL_Depth_10
- FL_Depth_50
- FL_Depth_100
- FL_Depth_500

Metadata in .xml file format:

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

EXECUTIVE SUMMARY

This report was prepared for communities in Linn County, Oregon, with funding provided by the Oregon Department of Land Conservation and Development (DLCD). 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 Linn County (herein referred to as the study area). The purpose of this project is to provide communities with detailed risk assessment information to enable them to understand and compare hazards on a community-by-community basis and act to reduce their risk. The risk assessment results quantify the consequences of natural hazards to each community by estimating the number of people and buildings at risk and support the decision-making process in planning for disaster.

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

- In the first task, we created a comprehensive asset database for Linn County by synthesizing assessor data, U.S. Census information, Federal Emergency Management Agency (FEMA) Hazus®-MH general building stock information, and building footprint data. This work resulted in a single dataset of building points and their associated characteristics (e.g., construction materials, number of floors, usage, 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 Linn County include: flooding, earthquakes, landslides, channel migration, wildfires, and volcanic lahars. 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, channel migration, 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 Linn County. A Cascadia Subduction Zone (CSZ) earthquake magnitude 9.0 (Mw 9.0) is expected to cause extensive damage and losses throughout the county, with many of the critical facilities at High risk. A modeled Mw 6.6 earthquake focused on the Turner and Mill Creek Fault is expected to cause localized high damages for areas in the northwestern portion of Linn County. We demonstrate the potential for reduction in earthquake damages and losses through seismic retrofits using the building code simulations in the Hazus earthquake model. We also find that the highest potential for population displacement is associated with earthquake, wildfire, and landslide hazards. Flooding is

identified as a High-risk hazard event for some communities in the county (Brownsville, Crawfordsville, Scio, and Shedd) and we quantify the number of elevated structures that are less vulnerable to flood hazard. Our analysis shows that areas with moderate to steep slopes or at the base of steep hillsides are at the greatest risk from landslide hazards; such areas are present throughout the central and eastern portions of the county. More than 400 buildings along the North Santiam River and Santiam River are exposed to channel migration hazard. Wildfire exposure analysis shows a higher risk for buildings within the wildland-urban interface (WUI) in the eastern and central parts of the county. Volcanic lahar hazard that originates from Mount Jefferson could affect many buildings along the North Santiam River, especially in Gates.

Results were broken out for the following geographic areas:

- Unincorporated Linn County (rural)
- Community of Crabtree
- Community of Holley
- Community of Peoria
- Community of West Scio
- City of Brownsville
- City of Halsey
- City of Lebanon
- City of Mill City*
- City of Scio
- City of Sweet Home
- City of Waterloo
- Community of Cascadia
- Community of Crawfordsville
- Community of Lacombe
- Community of Shedd
- City of Albany*
- City of Gates**
- City of Harrisburg
- City of Lyons
- City of Millersburg
- City of Sodaville
- City of Tangent

*Only the portions of the cities of Albany and Mill City that are within Linn County are included in this report. The entirety of Mill City is included in O-22-05 (Marion County Multi-Hazard Risk Assessment) (Williams and Madin, 2022). The entirety of the City of Albany is included in O-23-06 (Benton County Multi-Hazard Risk Assessment) (Williams and Calhoun, 2023).

**The entirety of the City of Gates, which is in Linn and Marion Counties, is included in this report.

Selected countywide results	
Total buildings: 94,241	
Total estimated building value: \$27 billion	
Cascadia Subduction Zone Magnitude 9.0 Earthquake Scenario Red-tagged buildings ^a : 2,612 Yellow-tagged buildings ^b : 11,488 Loss estimate: \$2.6 billion	Turner and Mill Creek Fault Magnitude 6.6 Earthquake Scenario Red-tagged buildings ^a : 2,749 Yellow-tagged buildings ^b : 8,942 Loss estimate: \$2.4 billion
100-year Flood Scenario Number of buildings damaged: 1,973 Loss estimate: \$99 million	Landslide Exposure (High and Very High-Susceptibility) Number of buildings exposed: 6,713 Exposed building value: \$1.5 billion
Channel Migration Zone* (Erosion Hazard Area – 30-year) Number of buildings exposed: 420 Exposed building value: \$110 million	Wildfire Exposure (High and Moderate Risk) Number of buildings exposed: 3,855 Exposed building value: \$807 million
Lahar (1,000 to 15,000-year Scenario) Number of buildings exposed: 1,059 Exposed building value: \$560 million	
^a Red-tagged buildings are considered uninhabitable due to complete damage ^b Yellow-tagged buildings are considered limited habitability due to extensive damage *Results are limited to the study area of Appleby and others (2021), which covers the North Santiam River and Santiam River.	

The information presented in this report is designed to increase awareness of natural hazard risk, to support public outreach efforts, and to aid local decision-makers in developing comprehensive plans and natural hazard mitigation plans. This study can help emergency managers identify vulnerable critical facilities and develop contingencies in their response plans. The results of this study 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 Linn 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 Linn County communities.

Linn County is located in the northwestern part of Oregon with the western half in the Willamette Valley and the eastern half in the Cascade Range. It is subject to a variety of natural hazards, including: earthquakes, riverine flooding, landslides, channel migration, wildfire, and volcanic lahars. This region of Oregon ranges from sparsely to heavily developed, including dense urban areas transitioning to suburban development in unincorporated parts of the study. There are also large uninhabited areas where the county jurisdiction extends into the Cascade Range.

1.1 Purpose

The purpose of this publication is to help communities in Linn County to better understand their natural hazards and risk, and increase resilience to earthquakes (including ground shaking, liquefaction and coseismic landslides), riverine flooding, landslides, channel migration, wildfire, and volcanic lahars. 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 publication 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 (Hazus 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** contains results of vulnerability assessments for bridges, lifelines, and high hazard dams. **Appendix D** provides additional explanation of the Hazus methodology. **Appendix E** contains acronyms and definitions used throughout the report. **Appendix F** contains tabloid-size maps showing the spatial extent of the hazards, assets, and population across Linn County. These appendices can be helpful in clarifying the summarized results in each hazard section.

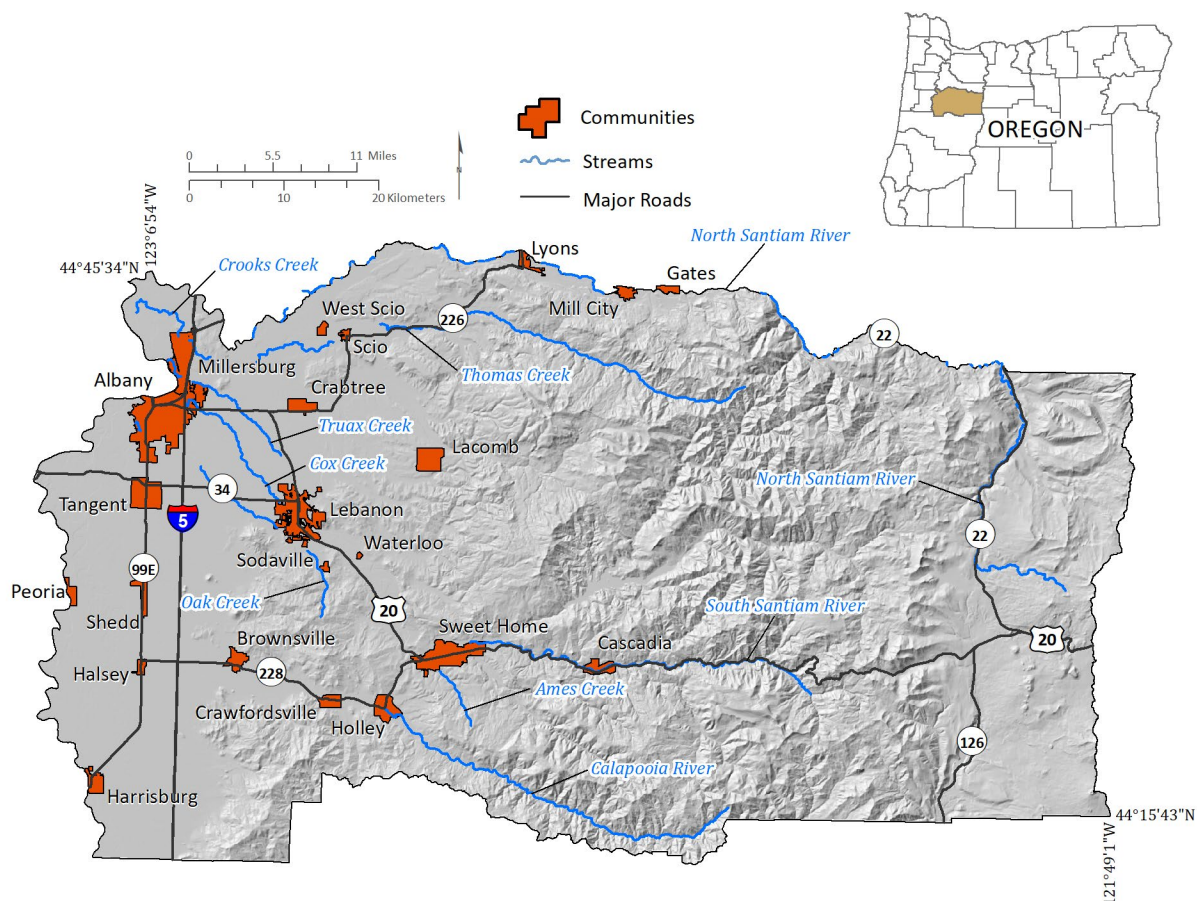
1.2 Study Area

The study area for this project includes the entirety of Linn County, Oregon (**Figure 1-1**). Linn County is located in the northwestern portion of the state; the county is bordered by Marion County to the north, Jefferson County and Deschutes County to the east, Lane County to the south, and Benton County and a small portion of Polk County to the west. The entire western boundary of Linn County with Benton County (and a small portion of Polk County) is defined by the north-flowing Willamette River. The total area of Linn County is 214 square miles (554 square kilometers).

The geography of eastern Linn County consists of the heavily forested Cascade Range. Mount Jefferson, a stratovolcano in the Cascade Range, is located at the northeastern corner of Linn County. Much of the land management for the county's eastern half is administered by the Willamette National Forest. The western half of the county transitions from the heavily forested mountains to gently rolling farmland and then onto the agricultural and intermixed urbanized broad flat bottom of the Willamette Valley.

The population of Linn County is approximately 132,000 people based on an estimated population for each community in 2023 from the Portland State University (PSU) Population Research Center <https://www.pdx.edu/population-research/population-estimate-reports>. Most people reside in the western half of the county. The City of Albany, which is largest in the county and the county seat, has a population of approximately 49,000. Other incorporated communities in the study area are Brownsville, Gates, Halsey, Harrisburg, Lebanon, Lyons, Mill City, Millersburg, Scio, Sodaville, Sweet Home, Tangent, and Waterloo (**Figure 1-1**). The unincorporated communities examined in this study are Cascadia, Crabtree, Crawfordsville, Holley, Lacombe, Peoria, Shedd, and West Scio. Portions of Albany in Benton County and Mill City in Marion County are not included in this study but are included in totality within their respective previously published countywide risk assessments (Williams and others, 2022; Williams and others, 2023). The portion of Gates that is within Marion County is included in this publication. The buildings in the Linn County portion of Idanha were included in this publication but were grouped into the unincorporated Linn County jurisdiction.

Figure 1-1. Study area: Linn 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 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 flood and earthquake. 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 Linn County tax assessor database (acquired 2023). The other key component is datasets representing the best available science for a variety of natural hazards. The geologic hazard scenarios were selected by DOGAMI staff based on their expert knowledge of the area and the available hazard data; 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 CSZ earthquake magnitude Mw 9.0 scenario. This includes earthquake induced or “coseismic” liquefaction, soil amplification, and landslides.
 - Hazus loss estimation from a Turner and Mill Creek Fault Mw 6.6 scenario. This includes coseismic liquefaction, soil amplification, and landslides.
- 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 Zones and landslide deposit mapping
- Channel Migration Risk Assessment
 - Exposure based on the erosion hazard area—30-year (exposed, not exposed)
- Wildfire Risk Assessment
 - Exposure based on Overall Wildfire Risk (Low to High)
- Volcanic Lahar Risk Assessment
 - Exposure based on size and frequency (Small, Medium, Large Probability zones)

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

Hazard	Scenario or Classes	Spatial Extent	Data Source
Earthquake	CSZ Mw 9.0	Regional (Pacific Northwest)	DOGAMI (Madin and others, 2021)
	Turner and Mill Creek Fault Mw 6.6	Regional (Pacific Northwest)	USGS (Personius, 2002) accessed via Hazus fault database
-Coseismic landslide	Susceptibility – wet (3-10 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	DOGAMI, derived from FEMA (2016) data included in GIS data for this report.
Landslide	Susceptibility (Low, Moderate, High, Very High)	Statewide	DOGAMI (Burns and others, 2016)
Channel Migration	Susceptibility (Not Exposed, Exposed)	North Santiam Rivers and tributaries	DOGAMI (Appleby and others, 2021)
Wildfire	Overall Wildfire Risk (Low, Moderate, High)	Regional (Pacific Northwest, US)	ODF (Gilbertson-Day and others, 2018)
Lahar	Size and frequency: Small (100 to 1,000-year) Medium (1,000 to 15,000-year) Large (>15,000-year)	Mount Jefferson and North Santiam River watershed	USGS (Walder and others, 1999)

1.4 Previous Studies

We are aware of one previous risk assessment that has been conducted for Linn County. Wang (1998) used Hazus to estimate the impact from a Mw 8.5 CSZ earthquake scenario on the state of Oregon. The results of the Wang (1998) study were arranged into individual counties. Linn County was estimated to experience a 5.12% loss ratio in the Mw 8.5 CSZ scenario due to its proximity to the earthquake source. Wang (1998) utilized a much lower level of detailed building information and site-specific earthquake hazard inputs. Because of these differences, comparative analysis was not beneficial to the scope of this project.

Burns and others (2008) developed earthquake and landslide hazard maps and used Hazus to estimate future earthquake damage for the mid-Southern Willamette Valley, including Linn County. Their Hazus analysis used a Mw 6.7 Mill Creek Fault earthquake and a Mw 8.5 CSZ earthquake. Both scenarios aggregated results at the census tract level using the default Hazus general building stock database. Estimated loss ratios for Linn County were 34% for the Mill Creek Fault and 29% for the CSZ scenario. 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. 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.”

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.

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.

Figure 2-1. 100-year flood zone and building loss estimates example in rural Linn County, Oregon.

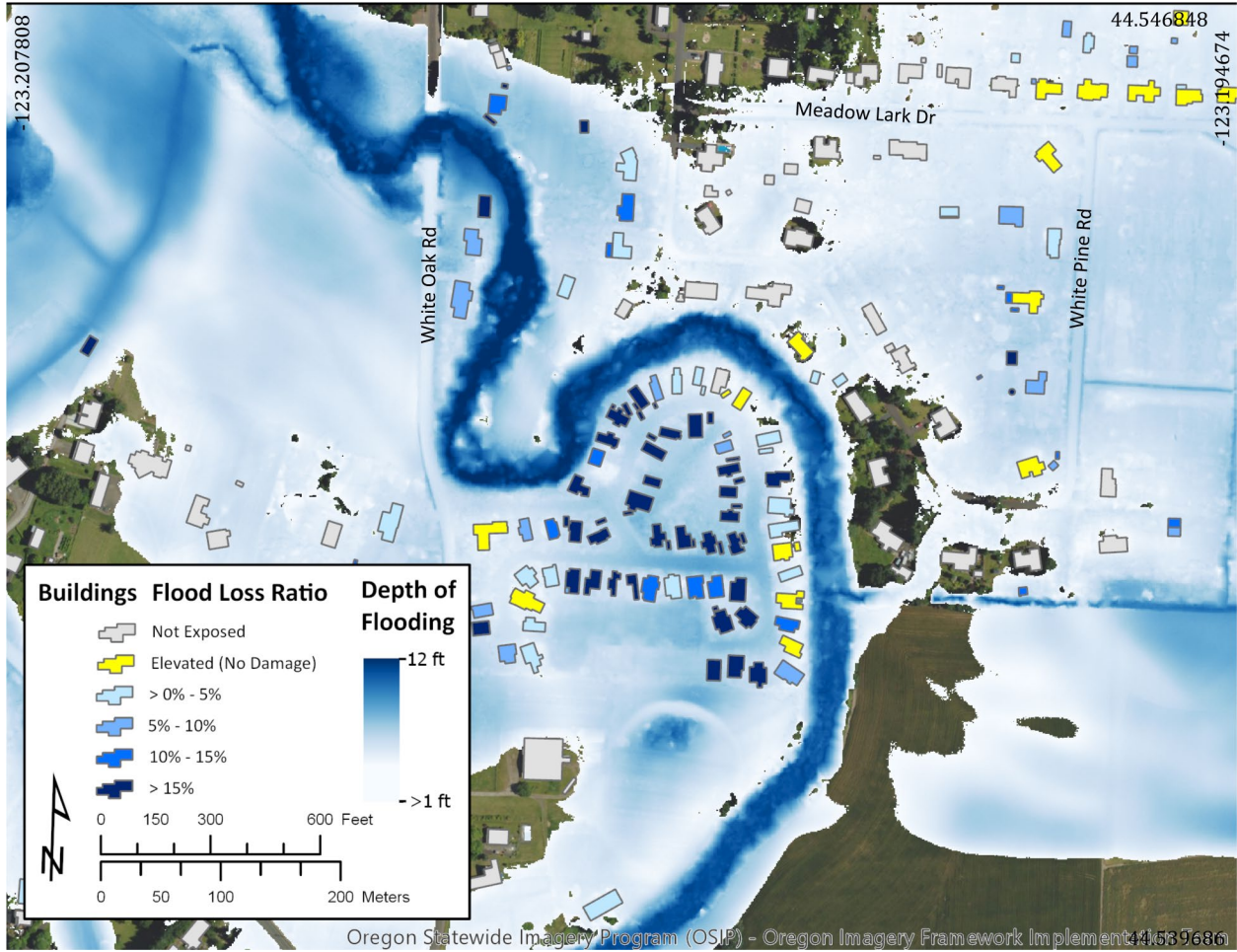


Image source: Oregon Statewide Imagery Program, 2018

Depth grid: Derived from the effective FEMA Flood Insurance Rate Map data for Linn County, 2016

2.2 Exposure

Since loss estimation using Hazus is not available for all types of natural hazards, we used exposure analysis to assess landslide, channel migration, wildfire, and volcanic lahar 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 like 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, channel migration, wildfire, and volcanic lahar 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 Sweet Home, Oregon.

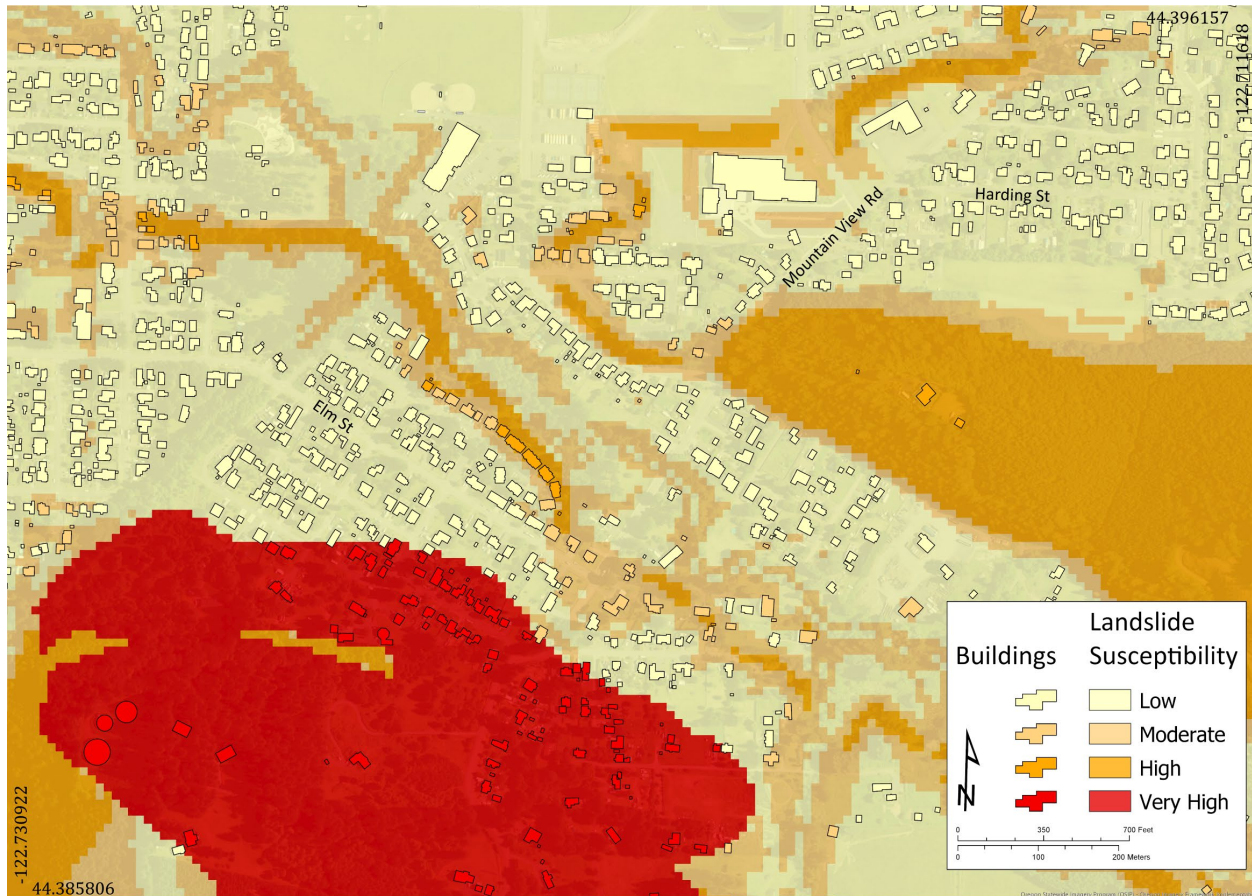


Image source: Oregon Statewide Imagery Program, 2018

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

2.3 Building Inventory

A key piece of the risk assessment is the countywide building inventory. This inventory consists of all buildings larger than 9.3 square meters (100 square feet), 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 5.1 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, City of Albany, Oregon.



The number of buildings and total building value per community varies significantly in Linn County, with 136 buildings and \$26 million for Peoria to 20,286 buildings and \$7 billion for Albany (**Table 2-1**). A table detailing the occupancy class distribution by community is included in **Appendix B: Detailed Risk Assessment Tables**.

Table 2-1. Linn County building inventory.

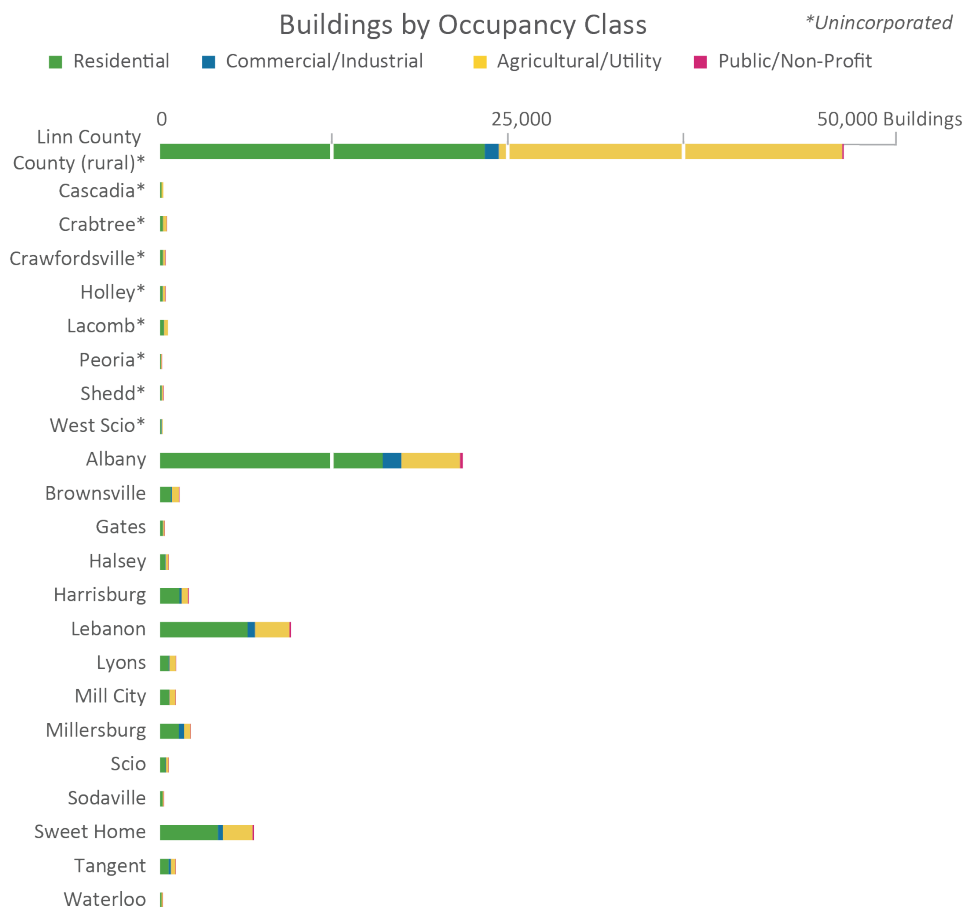
Community	Total Number of Buildings	Percentage of Total Buildings	Estimated Total Building Value (\$)	Percentage of Total Building Value
Unincorp. Linn Co (rural)	45,792	49%	12,020,435,000	45%
Cascadia	231	0.2%	27,896,000	0.1%
Crabtree	459	0.5%	97,309,000	0.4%
Crawfordsville	374	0.4%	80,383,000	0.3%
Holley	380	0.4%	79,188,000	0.3%
Lacomb	535	0.6%	126,968,000	0.5%
Peoria	136	0.1%	25,591,000	0.1%
Shedd	248	0.3%	107,103,000	0.4%
West Scio	198	0.2%	52,104,000	0.2%
Total Unincorporated County	48,351	51%	12,616,823,000	47%
Albany	20,286	22%	7,004,487,000	26%
Brownsville	1,326	1.4%	284,607,000	1.1%
Gates	326	0.3%	70,923,000	0.3%
Halsey	602	0.6%	182,922,000	0.7%
Harrisburg	1,924	2.0%	544,762,000	2.0%
Lebanon	8,789	9.3%	2,688,032,000	10.0%
Lyons	1,074	1.1%	223,889,000	0.8%
Mill City	1,060	1.1%	237,466,000	0.9%
Millersburg	2,049	2.2%	878,299,000	3.3%
Scio	601	0.6%	156,690,000	0.6%
Sodaville	271	0.3%	48,953,000	0.2%
Sweet Home	6,313	6.7%	1,466,569,000	5.5%
Tangent	1,064	1.1%	407,086,000	1.5%
Waterloo	203	0.2%	32,851,000	0.1%
Total Study Area	94,241	100%	26,844,514,000	100%

The building inventory was developed from the Statewide Building Footprints for Oregon, release 1 (SBFO-1) (Williams, 2021). The SBFO-1 data of Linn County was modified from a building footprints dataset maintained by Linn County, obtained June 2020. The building footprints provide a location and 2D outline of each structure. There are a total of 93,964 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 Linn County Assessment Office supplied assessor data and we formatted it for use in this study. The assessor data contains an array of information about each improvement (e.g., building). Tax lot data, which contains property boundaries and other information regarding the property, was obtained from the county assessor and was used to link the buildings with assessor data. The linkage between the two datasets resulted in a database of UDF points that contain attributes for each building. These points are used in the risk assessment for both loss estimation and analyses. Albany and Lebanon are the

communities 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 Linn 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 through coordination with Linn County officials. Communities that have critical facilities that can function during and immediately after a natural disaster are more resilient than those with critical facilities that are inoperable after a disaster. Critical facilities are present throughout the county with most in Albany and Lebanon (**Table 2-2**). Critical facilities are listed for each community in **Appendix A**.

Table 2-2. Linn County critical facilities inventory.

Community	Hospital & Clinic		School		Police/Fire		Emergency Services		Military		Other*		Total	
	Count	Value (\$)	Count	Value (\$)	Count	Value (\$)	Count	Value (\$)	Count	Value (\$)	Count	Value (\$)	Count	Value (\$)
<i>(all dollar amounts in thousands)</i>														
Unincorp. Linn Co (rural)	1	681	10	42,723	7	5,329	0	0	0	0	8	1,403	26	50,136
Cascadia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crabtree	0	0	0	0	1	1,116	0	0	0	0	0	0	1	1,116
Crawfordsville	0	0	1	5,910	1	273	0	0	0	0	0	0	2	6,183
Holley	0	0	1	5,142	0	0	0	0	0	0	0	0	1	5,142
Lacomb	0	0	1	5,679	1	318	0	0	0	0	0	0	2	5,998
Peoria	0	0	0	0	1	380	0	0	0	0	0	0	1	380
Shedd	0	0	0	0	1	1,216	0	0	0	0	0	0	1	1,216
West Scio	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Unincorporated County	1	681	13	59,454	12	8,633	0	0	0	0	8	1,403	34	70,171
Albany	10	39,833	21	185,607	4	9,129	0	0	0	0	6	68,552	41	303,121
Brownsville	0	0	0	0	1	1,811	0	0	0	0	1	565	2	2,376
Gates	0	0	0	0	1	1,227	0	0	0	0	1	574	2	1,800
Halsey	0	0	1	14,568	1	3,261	0	0	0	0	3	1,592	5	19,421
Harrisburg	0	0	2	31,101	2	1,979	0	0	0	0	0	0	4	33,080
Lebanon	10	76,229	7	111,759	4	11,507	0	0	2	4,677	8	16,722	31	220,893
Lyons	0	0	1	4,478	1	1,592	0	0	0	0	3	537	5	6,607
Mill City	0	0	2	24,237	2	1,971	0	0	0	0	0	0	4	26,208
Millersburg	0	0	0	0	2	3,186	0	0	0	0	1	1,255	3	4,441
Scio	0	0	3	16,491	1	2,423	0	0	0	0	1	1,094	5	20,008
Sodaville	0	0	1	2,343	0	0	0	0	0	0	2	223	3	2,566
Sweet Home	0	0	5	84,987	4	5,427	0	0	0	0	1	2,728	10	93,142
Tangent	0	0	2	7,781	1	2,373	0	0	0	0	1	432	4	10,586
Waterloo	0	0	0	0	0	0	0	0	0	0	1	75	1	75
Total Study Area	21	116,743	58	542,805	36	54,518	0	0	2	4,677	37	95,753	154	814,496

Note: Facilities with multiple buildings were consolidated into one building.

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

2.4 Community Lifelines

Lifelines are important structures that, when functioning during or immediately after an emergency, can enable a community to meet the health, safety, and economic needs of its residents. Lifelines provide fundamental services that can minimize direct and indirect consequences from a natural disaster and expediate the recovery process. These services meet a community's day-to-day needs and, when not functioning, are highly disruptive and can exacerbate the negative consequences of a natural disaster. In this report, lifelines include bridges, communication infrastructure, fuel supply, food centers, financial institutions, and high-occupancy buildings. We obtained data regarding lifelines from information provided by Linn County officials and the Oregon Department of Transportation (ODOT) (ODOT, 2023). Other lifeline categories that are not examined in this report include power distribution, highways, hazardous storage, and some aspects of water infrastructure.

Bridges are considered a highly important infrastructure lifeline and are vital to public safety. During a natural disaster, bridges are crucial for emergency response, evacuation, and recovery. Bridges that are

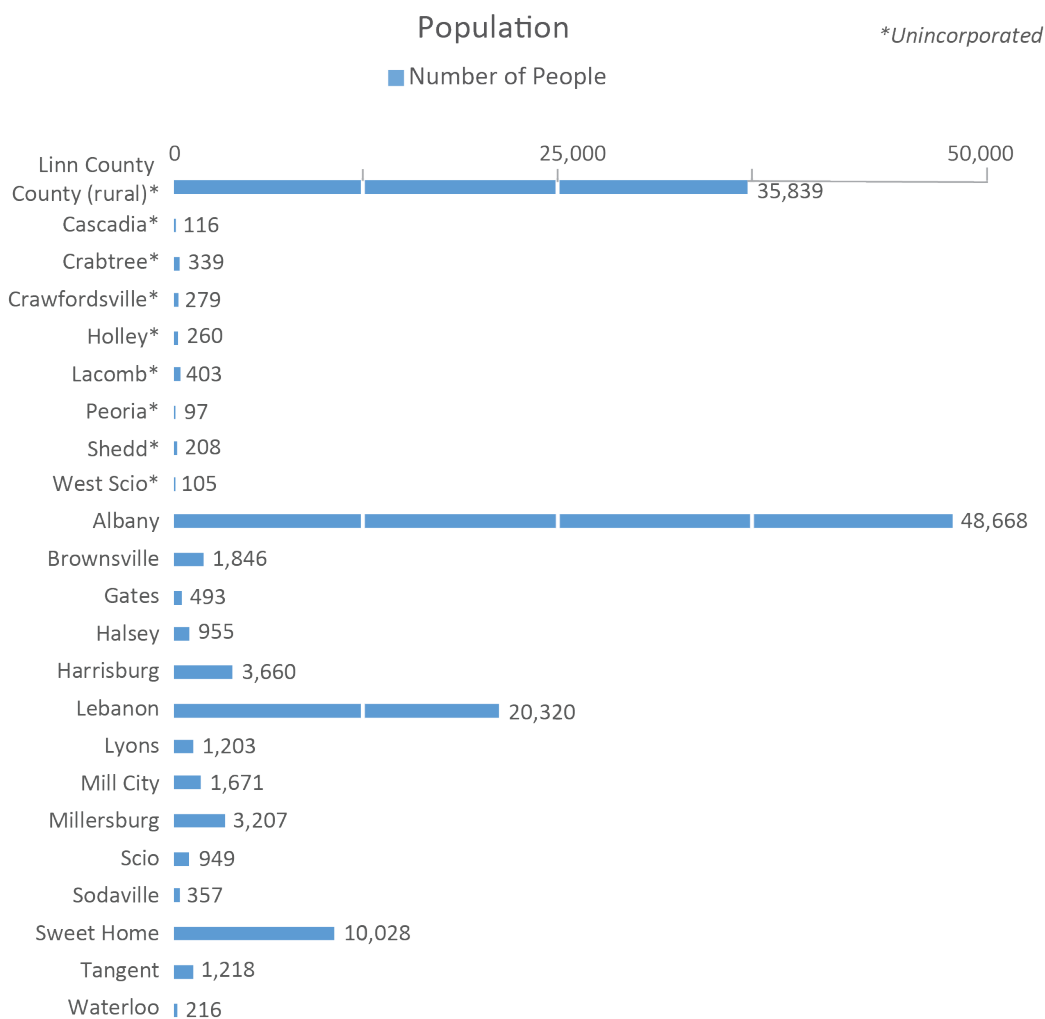
functioning after a disaster increase a community's ability to recover by facilitating the transportation of goods and services for relief. We identified bridges that could be at risk from hazards addressed in this report. A list of all bridges that are greater than 500 ft in length within Linn County are included in **Appendix C: Vulnerability Assessment of Lifelines**.

Some of the communities of Linn County provided a list of fuel supply, food distribution, and high-occupancy buildings. DOGAMI derived a list of financial institutions based on the county assessor dataset. We conducted a risk assessment for each structure identified in the list. These facilities were anonymized at the community level to address privacy concerns; however, individual structures can be identified in the GIS database included with this report. The results of this analysis are included in **Appendix C: Vulnerability Assessment of Lifelines**.

2.5 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 was 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 and census databases, 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 131,984 residents within the study area. For each natural hazard, except for the earthquake scenarios, a simple exposure analysis was used to find the number of potentially displaced residents within a hazard zone. For the earthquake scenarios the number of potentially displaced residents was based on residents in buildings estimated to be significantly damaged by the earthquake.

Figure 2-5. Population by Linn County community.

3.0 ASSESSMENT OVERVIEW AND RESULTS

In this risk assessment, we considered six natural hazards (earthquake, flood, landslide, channel migration, wildfire, and volcanic lahar) that pose a risk to Linn 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 the entirety of Linn 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).

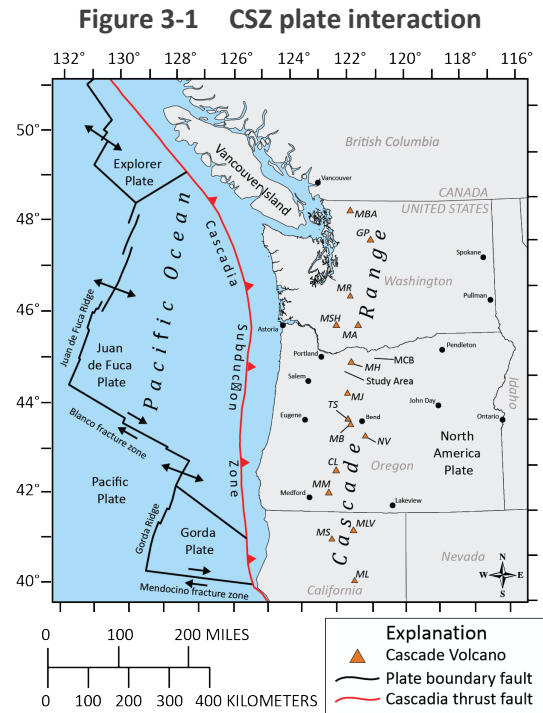
Two earthquake-induced hazards are liquefaction and landslides. Liquefaction occurs when saturated soils substantially lose bearing capacity due to ground shaking, causing the soil to behave like a liquid; this action can be a source of tremendous damage (Kramer, 1996). Coseismic landslides are mass movement of rock, debris, or soil induced by ground shaking. Both 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.

This area of northwest Oregon is seismically active, with several historic damaging earthquakes. For example, the Mount Angel Fault is an active fault located near the cities of Mount Angel, Woodburn, and Silverton. On March 25, 1993, a Mw 5.7 earthquake occurred with an epicenter approximately 5 km (3 mi) east of the City of Scotts Mills. Many buildings were damaged from the event, including the Capitol building in Salem. Many unreinforced masonry buildings in the area (e.g., large Catholic cathedrals in Mount Angel and Gervais) were significantly damaged due to intense shaking. The preliminary damage estimate was \$28.4 million (\$50 million adjusted to 2022 dollars) (Black, 1996).

3.1.1 Scenarios: CSZ and Turner and Mill Creek Fault

Offshore of Oregon's coastline, the Juan de Fuca tectonic plate slides under the North America plate. Oregon (along with the rest of the Pacific Northwest and the nation) sits on the North America plate. This area of interaction between the two plates is known as the CSZ. The pressure and friction created by this convergent motion builds potential energy at the plate boundary until the overriding plate (North America) suddenly slips, releasing energy that manifests as strong shaking spread over a wide area (**Figure 3-1**). Earthquakes as large as Mw 8–Mw 9 occur along the CSZ on average every 230 years–540 years and scientists estimate a 16%–22% chance of one happening in the next 50 years (Goldfinger and others, 2012, 2017).

The other scenario examined for this report is an earthquake focused on the Quaternary Turner and Mill Creek Fault (**Figure 3-2**). This east-west-oriented crustal fault is located approximately 10 mi (16 km) northeast of Albany and is mapped for 11 mi (18 km) between Interstate 5 (mile marker 244) and Highway 22 at Aumsville. It has an estimated slip rate less than 0.2mm/yr (0.008in/yr) (Personius, 2002 and citations therein). Unlike the CSZ, which is a very large and deep fault between two tectonics plates, the Turner and Mill Creek Fault is a crustal fault. Such planar fractures occur in the Earth's crust where rocks are displaced relative to one another. Despite their comparatively small size, crustal earthquakes can cause significant damage due to their proximity to the surface and the built environment.



The estimated maximum fault displacement for the Turner and Mill Creek Fault could produce relatively large (Mw 6.6) earthquakes, enough to pose a significant hazard (Personius, 2002). The current understanding of this fault and various aspects of its frequency and magnitude are limited.

We examined earthquake shaking and ground failure hazards produced from both earthquake scenarios in Hazus to encapsulate the range of damages from two very different kinds of earthquakes: a nearby crustal earthquake focused on the Turner and Mill Creek Fault and a more distant and very large-magnitude earthquake focused on the CSZ.

According to the National Seismic Hazard Map (Frankel and others, 2000), 75% of earthquake risk is due to a CSZ-related earthquake; in comparison, a crustal earthquake makes up 4% of the earthquake risk. The remaining risk is from an earthquake with focal mechanisms in the subducting slab of the CSZ. The effects from either earthquake scenario present a challenge for planners preparing for hazard impacts.

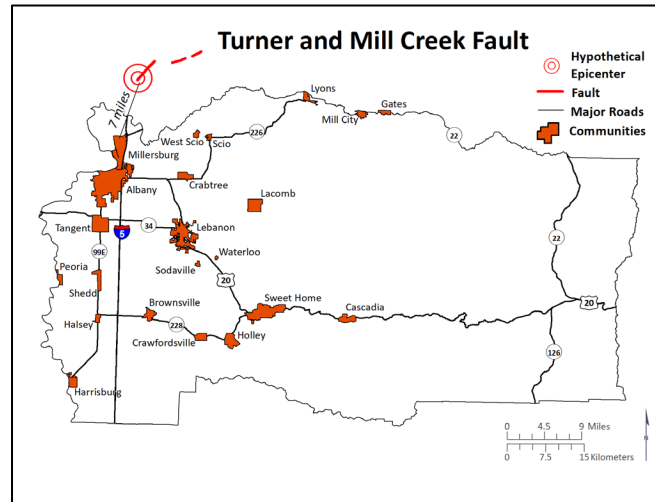
3.1.2 Data sources: CSZ

Most of the hazard data inputs for our Hazus earthquake analysis were originally created for the Oregon Seismic Hazard Database, release 1.0 (OSHD-1), which included ground shaking and site-specific data (coseismic landslide, liquefaction, and soil amplification) for a CSZ Mw 9.0 event (Madin and others, 2021). Wirth and others (2021) ran 30 CSZ Mw 9.0 simulations that represented the variability of shaking using ground shaking datasets developed by Madin and others (2021) for OSHD-1. At the time of writing, these are the most up to date earthquake simulations and site-specific data.

Hazus offers two methods for estimating loss from earthquake: probabilistic and deterministic (FEMA, 2012b). A probabilistic scenario uses USGS National Seismic Hazard Maps, which are derived from seismic hazard curves calculated on a grid of sites across the United States that describe the annual frequency of exceeding a set of ground motions as a result of all possible earthquake sources (USGS, 2017). A deterministic scenario is based on a specific seismic event, which in this case is the CSZ Mw 9.0 event. We selected the deterministic scenario method because the CSZ event is the most likely large earthquake to impact this area (Goldfinger and others, 2012, 2017). We used the deterministic method along with the UDF database so that loss estimates could be calculated on a building-by-building basis.

The following hazard layers used for the loss estimation analysis are derived from work conducted by Madin and others (2021): National Earthquake Hazard Reduction Program (NEHRP) soil classification, peak ground acceleration (PGA), peak ground velocity (PGV), spectral acceleration at 1.0 second period and 0.3 second period (SA10 and SA03), liquefaction susceptibility, and landslide susceptibility. The liquefaction and landslide susceptibility layers together with PGA were used by the Hazus tool to calculate the probability and magnitude of permanent ground deformation.

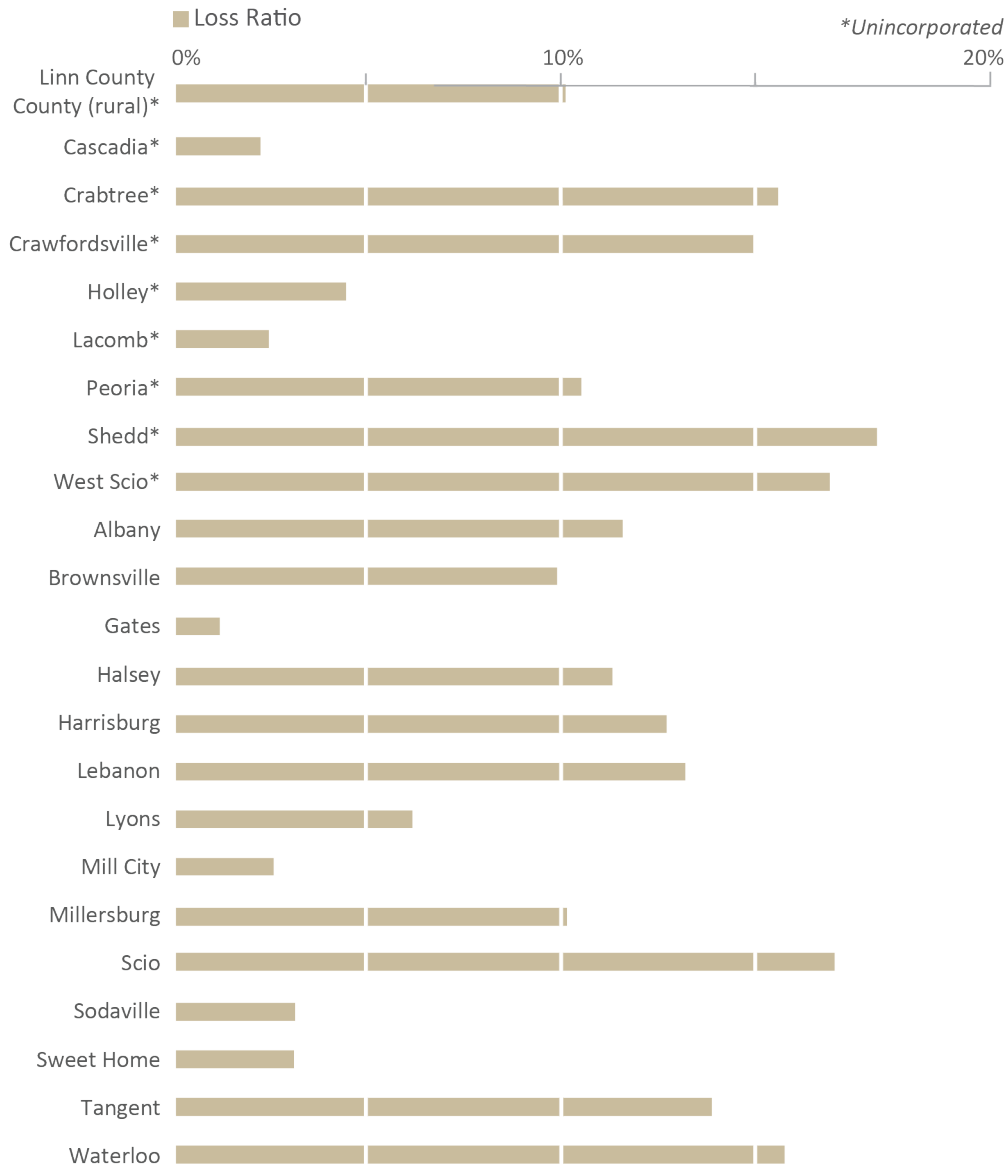
Figure 3-2. Turner and Mill Creek Fault location



3.1.3 Countywide results: CSZ

Because an earthquake can affect a wide area, every building in Linn County will be shaken by a CSZ Mw 9.0 earthquake. Hazus loss estimates (see [Table B-2](#)) for each building are based on a formula where coefficients are multiplied by each of the five damage state percentages (i.e., none, slight, 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 estimates from the CSZ earthquake scenario are presented in [Figure 3-3](#).

Figure 3-3. CSZ Mw 9.0 earthquake loss ratio by Linn County community.



In keeping with earthquake-damage reporting conventions, we used the Applied Technology Council (ATC-20) post-earthquake building safety evaluation color-tagging system to represent damage states (Applied Technology Council, 2015). Red-tagged buildings correspond to a Hazus damage state of “complete,” which means the building is uninhabitable. Yellow-tagged buildings are in the “extensive”

damage state, indicating limited habitability. The number of red or yellow-tagged buildings 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 they are of higher importance after a disaster, we chose to report the results of these buildings individually.

The number of potentially displaced residents from our CSZ Mw 9.0 earthquake scenario was based on the formula (FEMA, 2022b): $[(\text{Number of Occupants}) * (\text{Probability of Complete Damage})] + (0.9 * (\text{Number of Occupants}) * (\text{Probability of Extensive Damage}))$.

The results indicate that Linn County could incur moderate to significant losses (10%) due to a CSZ Mw 9.0 earthquake. Most of the communities in Linn County can expect approximately 10% to 16% of damage from a CSZ event. Much of the anticipated damage is due to liquefaction and soils that amplify seismic shaking. The Willamette River and Santiam River floodplains are composed of liquefiable soils where the majority of the buildings in Linn County are located. Since these unconsolidated sediments and soils amplify ground shaking, the probability of earthquake damage is greater for structures built in these areas.

Linn County CSZ Mw 9.0 earthquake results:

- Number of red-tagged buildings: 2,612
- Number of yellow-tagged buildings: 11,488
- Loss estimate: \$2,637,395,000
- Loss ratio: 10%
- Non-functioning critical facilities: 33 of 154
- Potentially displaced population: 5,263

Although damage caused by coseismic landslides was not specifically looked at in this report, it likely contributes to the estimated damage from earthquake hazard in Linn County. Landslide exposure (not to be confused with coseismic landslide analysis) results show that 5.5% of buildings in Linn County are within a Very High or High susceptibility zone. We infer that a similar percentage of the total earthquake losses estimated in this study may be due to coseismic landslide activity.

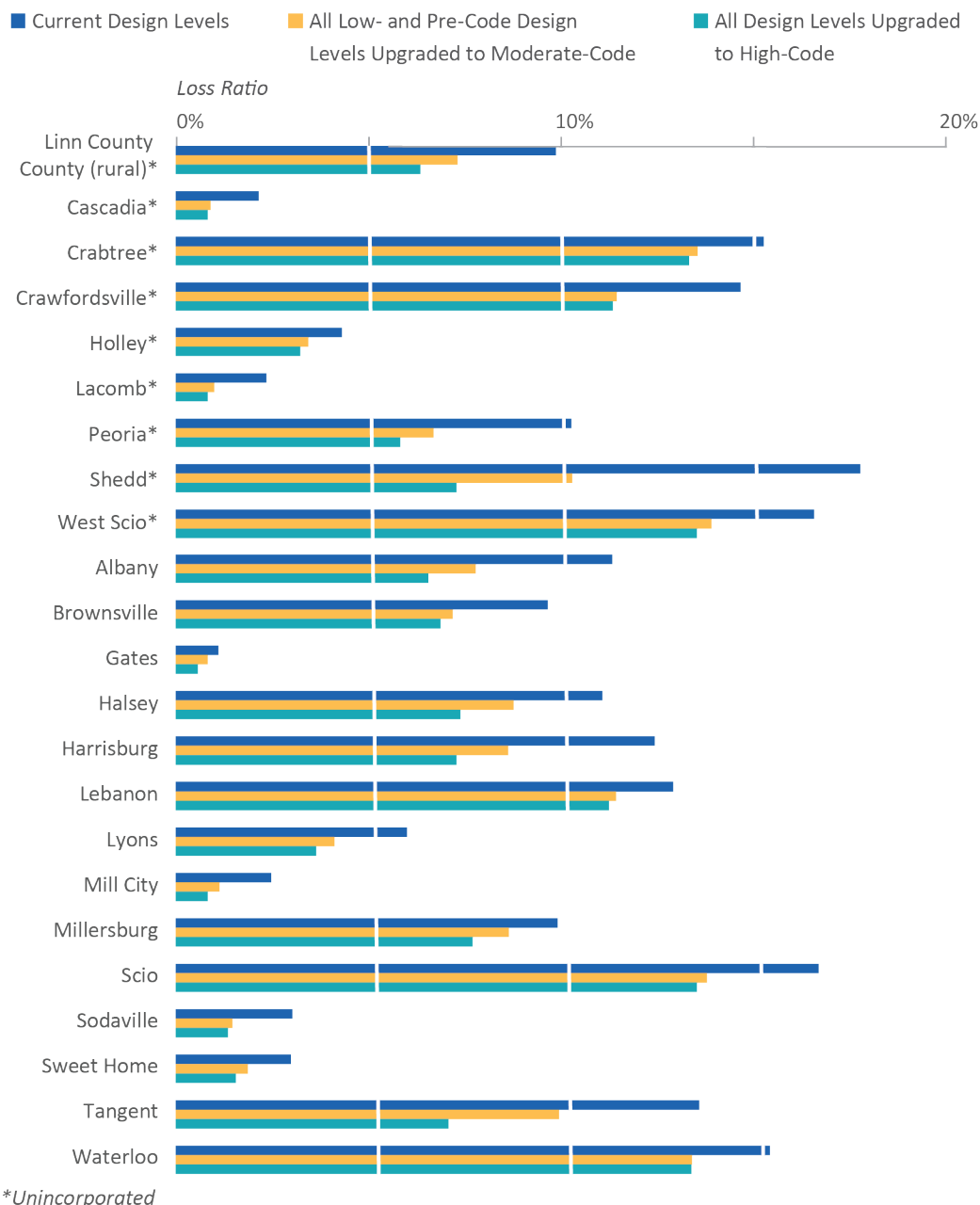
Aging building stock and certain occupancy types are also contributing factors in loss estimates. The first seismic building codes were implemented in Oregon in the 1970s (Judson, 2012) and by the 1990s modern seismic building codes were being enforced. Nearly 45% of Linn County's buildings were built before the 1990s. In Hazus, manufactured homes are one occupancy type that performs 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 earthquake than communities with fewer of these vulnerabilities.

If Pre-code 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 10% to 7%, when all Pre-code and Low-code buildings are upgraded to at least Moderate-code level. While retrofits can decrease earthquake vulnerability, for areas of High landslide or liquefaction susceptibility, additional geotechnical mitigation may be necessary to have a significant effect on losses. Two Hazus simulations of a CSZ Mw 9.0 earthquake where all Pre-code and Low-code buildings are upgraded to Moderate-code and High-code standards show significant reductions in losses ([Figure 3-4](#)).

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 3-4. CSZ Mw 9.0 earthquake loss ratio in Linn County, with simulated seismic building code upgrades.



3.1.4 Data sources: Turner and Mill Creek Fault scenario

The Turner and Mill Creek Fault deterministic Mw 6.6 earthquake scenario was selected as the most appropriate for communicating the crustal earthquake risk for Linn County because of the indication of late Quaternary activity and the fact that its location is moderately constrained (Personius, 2002). The default Hazus earthquake scenario database contained the location and geometry of the fault and

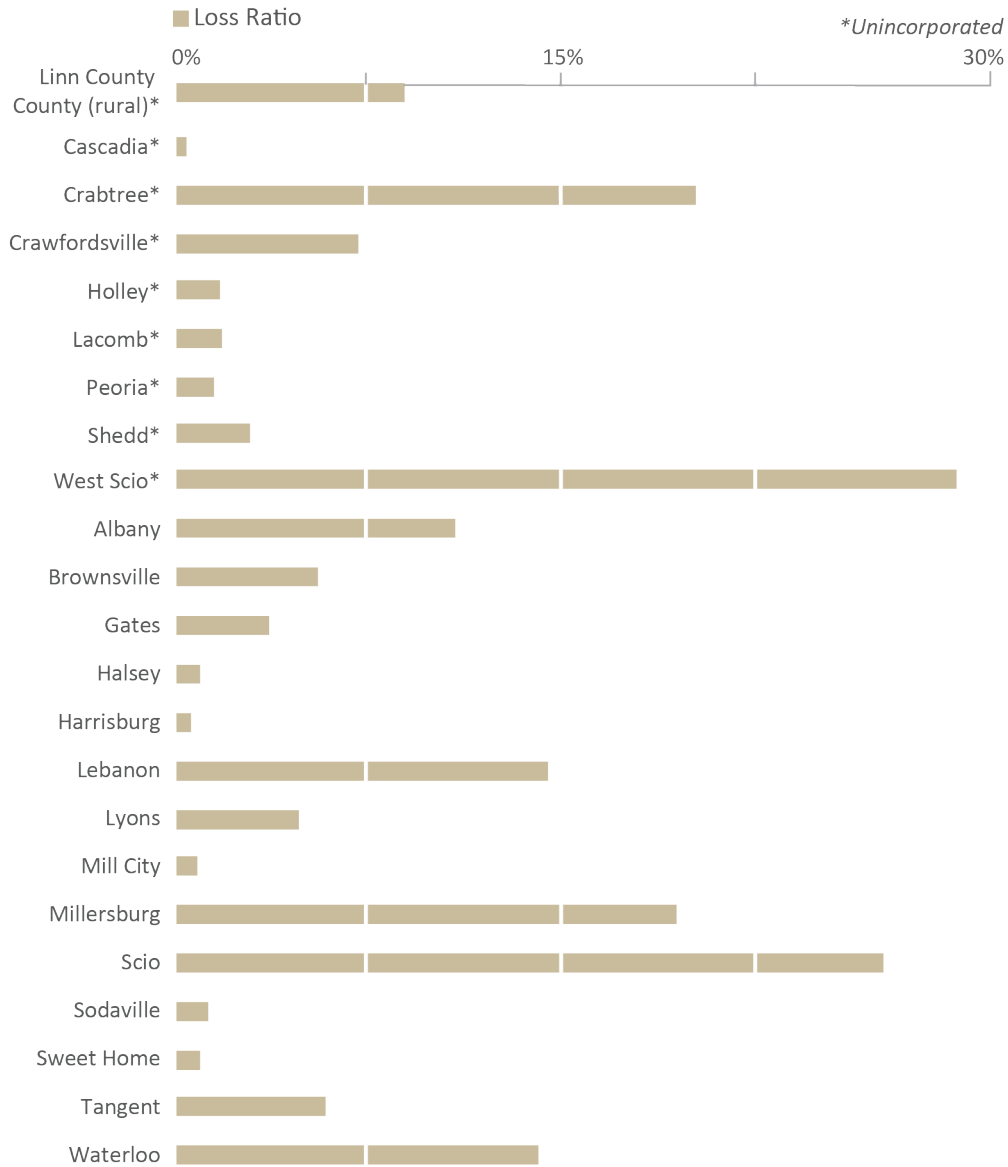
recommends a maximum magnitude for a potential event. The hypothetical epicenter was manually selected and was located at the closest proximity to buildings within the study area.

The following hazard layers used for our loss estimation were 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 by 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 used Hazus defaults, including a Mw 6.6 scenario as the characteristic event.

3.1.5 Countywide results: Turner and Mill Creek Fault scenario

While a CSZ event will cause substantial widespread damage throughout the entire study area, our results indicate a Turner and Mill Creek Fault Mw 6.6 earthquake will cause significant damage (15%–30% in losses) to primarily areas in the northwest portion of the county. Because an earthquake can affect a wide area, it will also cause damage in the other communities in Linn County, but to a lesser degree. Ground deformation (coseismic liquefaction and landslides) are also determining factors in damage results for this earthquake scenario. **Figure 3-5** shows loss ratios from this earthquake scenario for the communities of Linn County.

Figure 3-5. Earthquake loss ratio from Turner and Mill Creek Fault Mw 6.6 by Linn County community.



The results indicate that Linn County could incur losses near \$2.4 billion (8.8% of their total building assets) from a Turner and Mill Creek Fault Mw 6.6 earthquake. These results are strongly influenced by the proximity of buildings to the epicenter of the simulated earthquake. Communities in the northwestern portion of the county are not only close to the epicenter, but also are in areas of highly liquefiable soils. In addition to proximity, liquefaction exacerbates the level of risk from this earthquake scenario for the communities in this part of the county. We reviewed the risk assessment results in ArcMap™ and observed that residential buildings in Albany and commercial buildings in Millersburg in the area where Truax Creek flows into the Willamette River have a high risk of damage from this earthquake due to liquefaction hazard. Other areas that are at risk from this earthquake are along the South Santiam River, which includes the communities of Crabtree and Lebanon. Communities along Thomas Creek, including the communities of Scio and West Scio, are at much greater risk from this earthquake than other communities in Linn County. Keep in mind that these results are based on a hypothetical epicenter location. A Mill

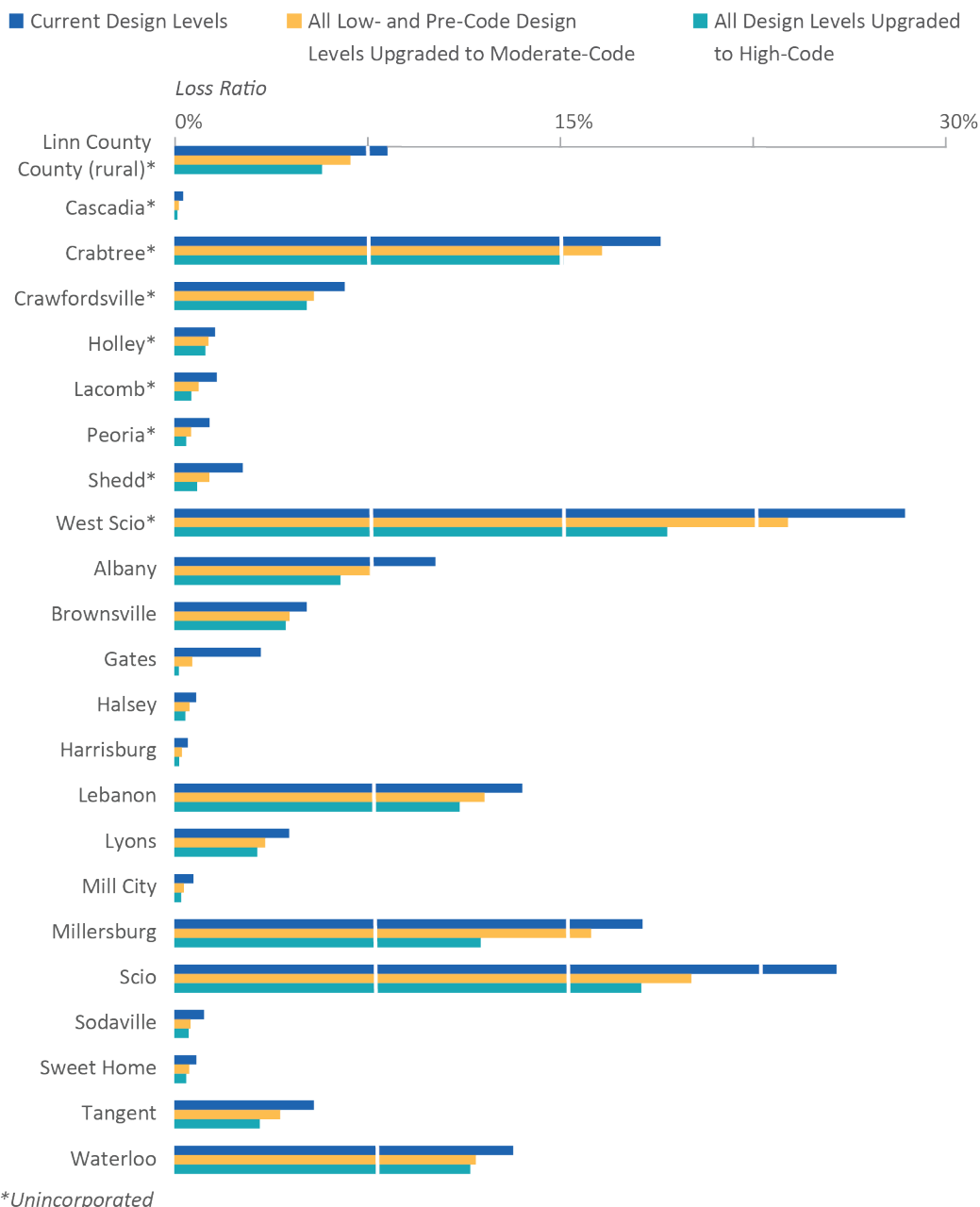
Creek and Turner Fault earthquake with a different rupture location will cause different levels of damage in the communities of northwest Linn County.

Linn County Turner and Mill Creek Fault Mw 6.6 earthquake results:

- Number of red-tagged buildings: 2,749
- Number of yellow-tagged buildings: 8,942
- Loss estimate: \$2,369,796,000
- Loss ratio: 8.8%
- Nonfunctioning critical facilities: 34 of 154
- Potentially displaced population: 5,286

As with the CSZ earthquake hazard, if buildings could be seismically retrofitted to Moderate-code or High-code standards, the impact of this event would be greatly reduced. In a simulation by DOGAMI, a Hazus earthquake analysis shows that loss estimates drop from 8.8% to 7.2% when all buildings are brought up to at least Moderate-code level. Although these upgrades can decrease earthquake vulnerability, the benefits are minimized in landslide and liquefaction areas, where buildings would need additional geotechnical mitigation to have a significant effect on losses. **Figure 3-6** illustrates the reduction in loss estimates from a Turner and Mill Creek Fault Mw 6.6 earthquake through two simulations where all buildings are upgraded to at least Moderate-code standards and then to High-code standards.

Figure 3-6. Turner and Mill Creek Fault Mw 6.6 earthquake loss ratio in Linn County, with simulated seismic building code upgrades



3.1.6 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to earthquake hazard:

- A large High liquefaction zone east of Albany that includes the community of Crabtree and parts of Lebanon will increase the likelihood of damage in that area from an earthquake produced from the CSZ or the Turner and Mill Creek Fault.
- High liquefaction areas on the Willamette River and Mill Creek floodplains will increase the likelihood of damage from an earthquake.

- Unreinforced masonry buildings in the older downtown portions of Albany, Millersburg, Lebanon, and Sweet Home are more vulnerable to substantial damage during an earthquake, compared to other nearby structures built to modern standards.
- 35 of the 154 critical facilities in the study area are estimated to be nonfunctioning following a CSZ earthquake like the one simulated in this study and 34 are estimated to be nonfunctioning due to a Turner and Mill Creek Fault earthquake.

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 Linn 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, post-wildfire floods, and inundation due to a dam breach were not examined in this report.

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

The major rivers and creeks within the county are the Calapooia, North Santiam, South Santiam, and Willamette rivers and Ames, Cox, Crooks, Oak, Truax, and Thomas creeks. In addition, there are several tributaries to these major streams that have mapped flood zones. All the mapped streams are subject to flooding and can cause damage to buildings in the floodplain.

Within the last 60 years there have been several major floods of note for Linn County, two of these floods affected large areas and many communities. In December 1964 heavy rainfall on snow occurred that caused historic flooding on the Calapooia, North Santiam, Santiam, and Willamette rivers and Thomas and Ames creeks. This flooding caused damage to the communities of Albany, Jefferson, Scio, Sweet Home, and Cascadia. Flooding would have been much worse were it not for flood reduction measures, primarily upstream of Linn County communities, such as flood storage areas along the Willamette River and the Detroit Dam. Other notable floods occurred in 1966 and 1974 along Ames Creek, which caused damage in the City of Sweet Home and surrounding areas (FEMA, 2016).

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

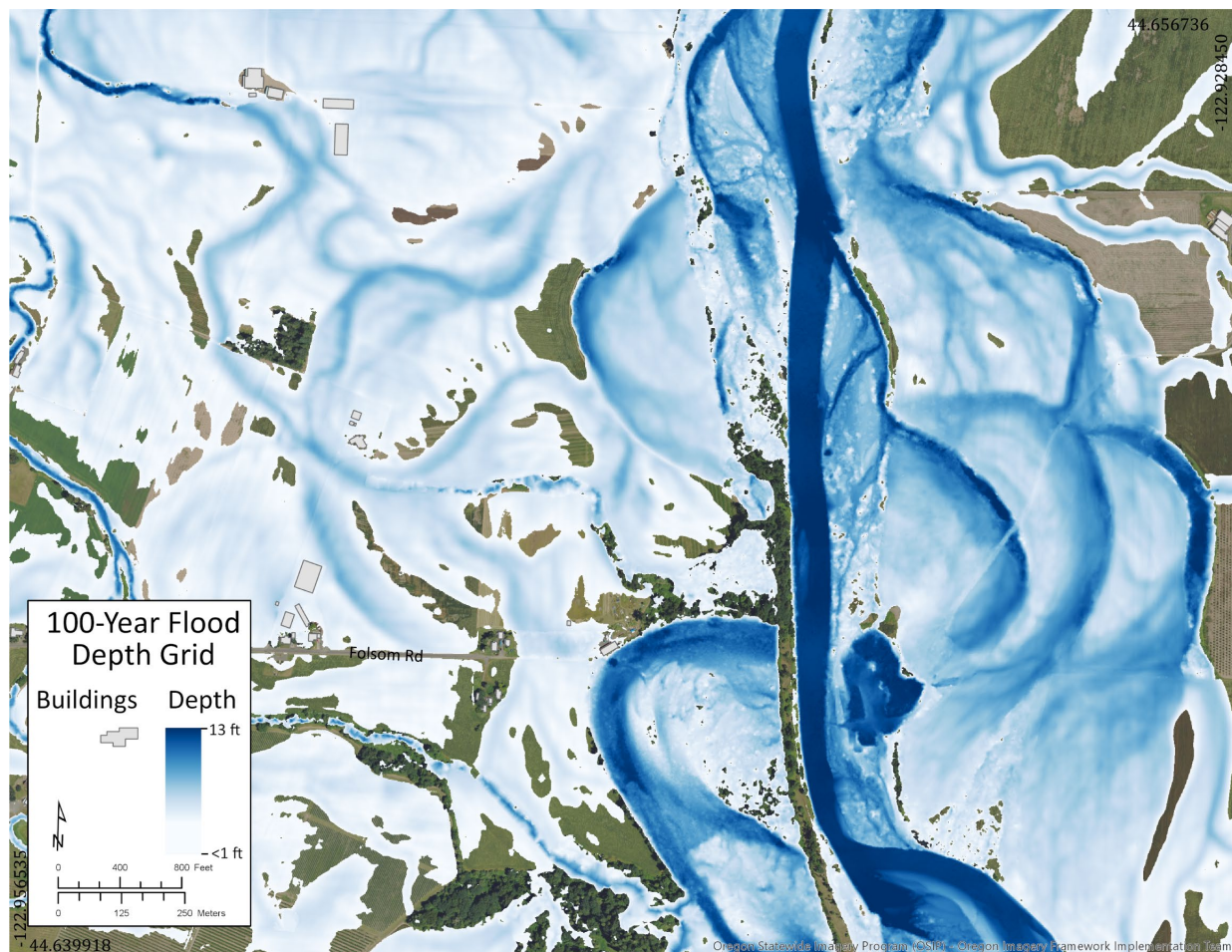
expected level of flooding, removing structures through FEMA's property acquisition (buyout) program, or land use planning that considers risk from flooding.

3.2.1 Data sources

The Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) for Linn County were updated in 2016 (FEMA, 2016); this was the primary data source for this flood risk assessment. This data source was adopted in 2016 by Linn County to regulate flood zones. Further information regarding the National Flood Insurance Program (NFIP) is on the FEMA website: <https://nfpiservices.floodsmart.gov/reports-flood-insurance-data>. While no place is completely risk-free from flood hazard, this was the only flood data source that was available for this analysis.

DOGAMI developed depth grids for four riverine flooding scenarios (10, 50, 100, and 500 year) from detailed stream information and high-resolution lidar collected in 2009 and 2012 (Willamette Valley 2009 project and Central Coast 2012 project - Oregon Lidar Consortium; see <http://www.oregongeology.org/lidar/collectinglidar.htm>). Depth grids are raster GIS datasets in which each digital pixel value represents the depth of flooding at that location (Figure 3-7). They were used in this risk assessment to determine the level to which buildings could be impacted by flooding through loss estimation and exposure analyses.

Figure 3-7. Flood depth grid example along the Willamette River in rural Linn County, Oregon.



Note: The deepest depths (dark-blue) indicate the current position of the Willamette River.

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 Linn 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 in this manner. 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. 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 [Table B-4](#) for multi-scenario cumulative results.

Linn Countywide 100-year flood loss:

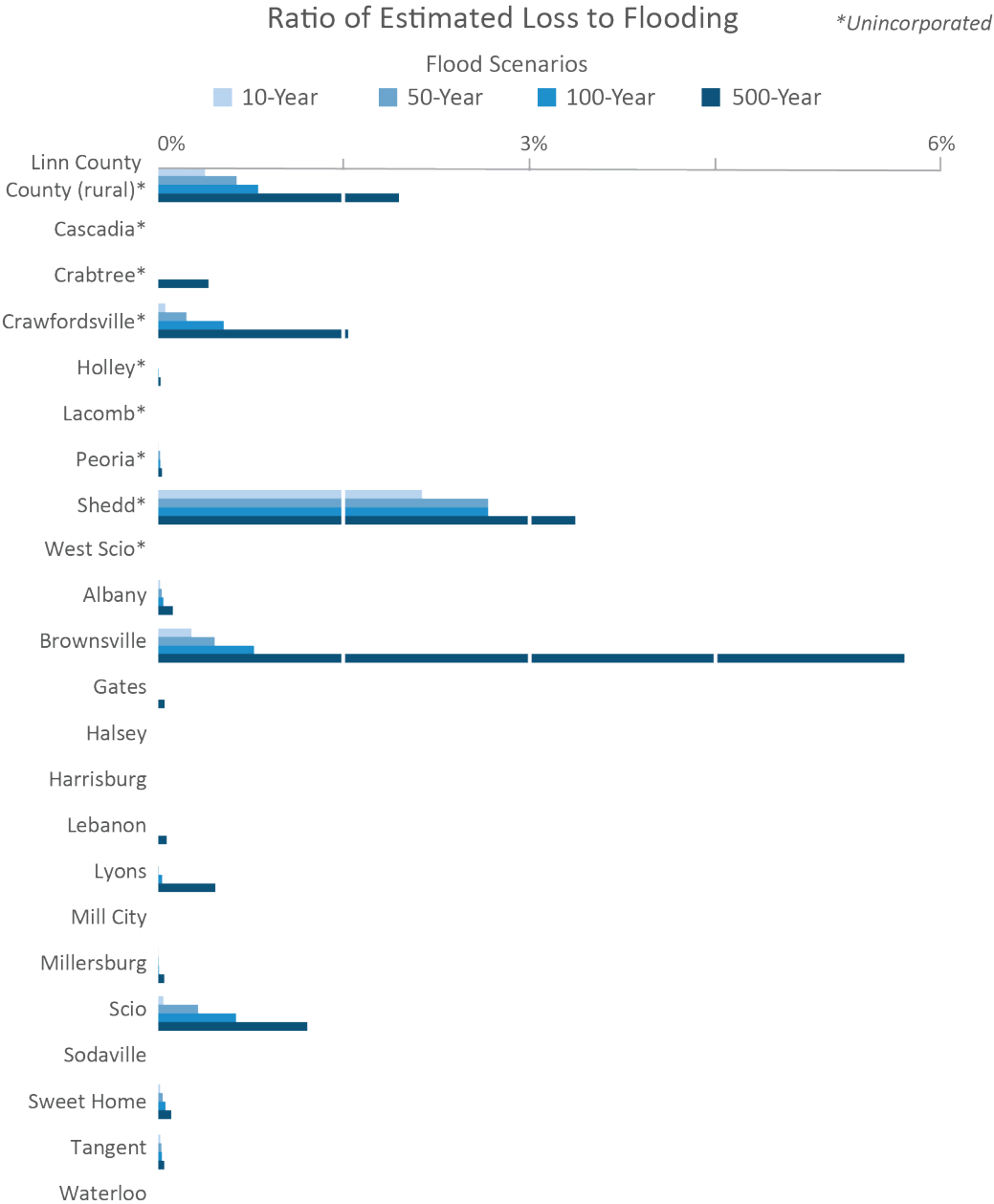
- Number of buildings damaged: 1,973
- Loss estimate: \$99,287,000
- Loss ratio: 0.4%
- Damaged critical facilities: 3 of 154
- Potentially displaced population: 1,917

3.2.3 Hazus analysis

The countywide loss estimate for the 100-year flood scenario is nearly \$100 million. While the loss ratio of flood damage for the entirety of Linn County is 0.4%, the impact to developed areas near flood-prone streams is significant, specifically Brownsville and Shedd ([Figure 3-8](#)). 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 mitigation activities will provide the greatest resilience to flooding.

The main flooding problems within Linn County are primarily in the areas of Brownsville, Scio, Crawfordsville, and Shedd. The unincorporated county also has a high level of estimated damage from the major streams and their tributaries that flow through the county ([Figure 3-8](#)). There are few specific areas in Linn County where a cluster of buildings are all at risk from flood. The small amount of damage that is estimated is scattered across the county at various places along the mapped streams.

Figure 3-8. Ratio of flood loss estimates by Linn County community.



3.2.4 Exposure analysis

For comparison purposes, 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 calculate the number of buildings that are elevated above the level of flooding and estimate the number of displaced residents. This was done by comparing the number of nondamaged buildings from Hazus with the number of exposed buildings in the flood zone. A small proportion (2.4%) of Linn County’s buildings were found to be within designated flood zones. Of those 2,246 buildings, we estimate that 273 are above the height of the 100-year flood. This evaluation also estimates that 1,917 residents might have mobility or access

issues due to being surrounded by rising floodwaters. See [Appendix B: Table B-5](#) for community-based results of flood exposure.

3.2.5 Dam safety

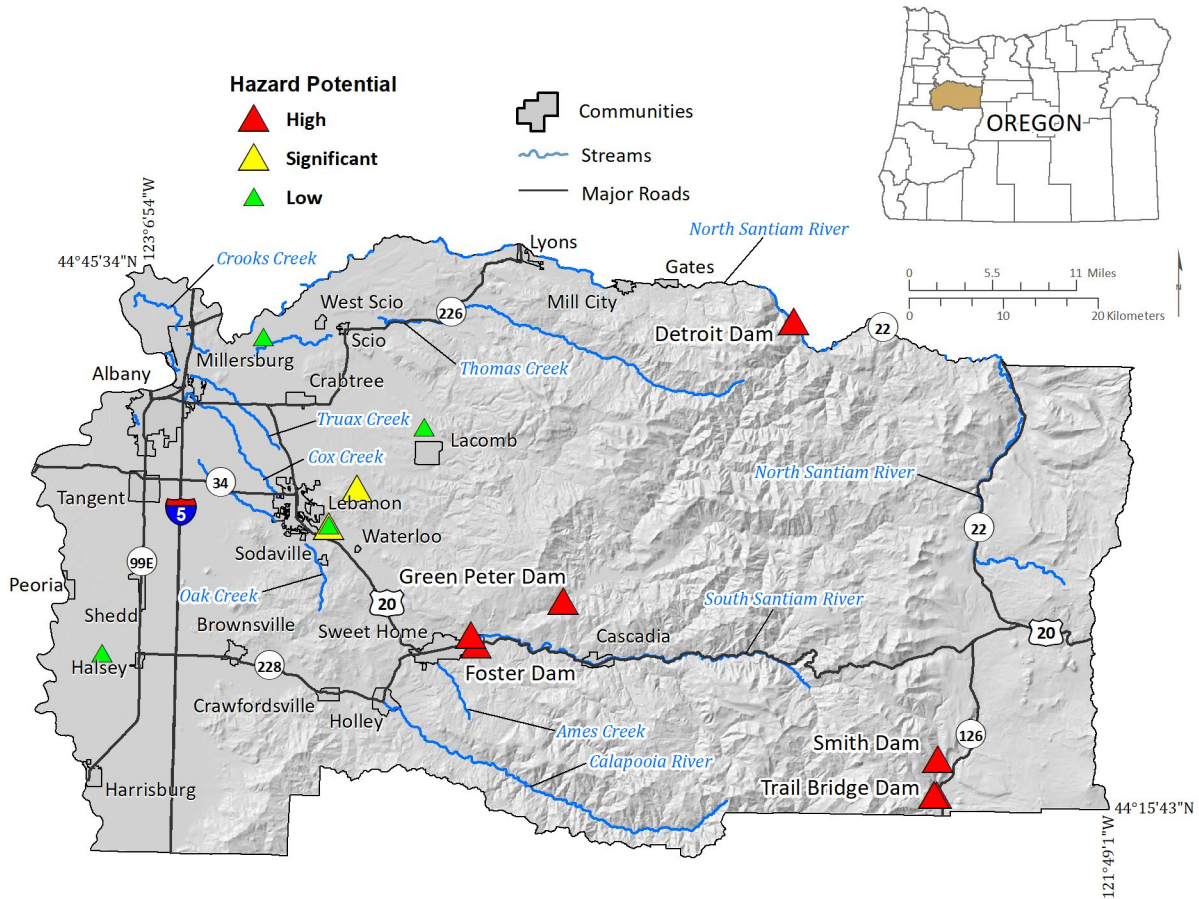
Dam safety is highly important when considering flood hazards. Dams are crucial structures designed to store and control water flow, but their failure can lead to catastrophic consequences during periods of heavy rainfall and flooding. Ensuring the safety of dams involves rigorous monitoring, regular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

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

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

DOGAMI used the USACE dam inventory to identify specific dams that were considered to be at a potentially High, Significant, or Low risk from a natural hazard impact perspective. Meaning, in the event of a dam failure or breach, there would be a potential for loss of life or other significant damage. There are 14 dams in Linn County that serve several functions, including agricultural, hydroelectric, water supply, and flood reduction ([Appendix Table B-6](#)). Seven of those dams are considered high hazard, including the largest three dams that are operated by the USACE: Green Peter Lake, Detroit, and Foster dams ([Figure 3-9](#)). These dams were primarily built as flood control structures. Green Peter Dam is on the Middle Santiam River and forms the Green Peter Reservoir, which is located 9.7 km (6 mi) northeast of Sweet Home. Detroit Dam forms Detroit Lake, which is used for numerous recreational activities; it is located along the North Santiam River and is 12.9 km (8 mi) upstream of the City of Gates. The third high hazard dam operated by the USACE is Foster Dam, which is located in the City of Sweet Home. Foster Dam is built on the confluence of the South Santiam River and Middle Santiam River and forms the Foster Reservoir.

Figure 3-9. Dams in Linn County.



3.2.6 Future conditions: flood hazard

Climate change has had a significant impact on flood hazards around the world, exacerbating the frequency, intensity, and magnitude of flooding events (OCCRI, 2023). The interplay between climate change and flood hazards is a complex phenomenon influenced by various factors such as rising temperatures, changing precipitation patterns, and altered hydrological cycles caused by warmer air holding more water vapor. These changes have a wide range of consequences for human populations, ecosystems, and infrastructure (OCCRI, 2023).

According to the report examining climate projections by OCCRI (2023), climate change will influence changes to flood hazard in Linn County. Predictive models indicate an increase in winter runoff levels and lower runoff during the summer and fall months. Winter flooding is projected to increase due to rain-on-snow occurrences as average winter temperatures increase. Warmer average temperatures, more extreme storms, including atmospheric rivers, and an increase in the proportion of precipitation falling as rain instead of snow all will contribute to an increase of flood risk in Linn County.

3.2.7 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk of flood hazard:

- Many farms and residential structures south of Stayton (Marion County) are built within the floodplain of the Santiam River.
- Many buildings are at risk from flooding along Thomas Creek in the City of Scio.
- Flood risk is present in areas along the Willamette River, Mill Creek, and the South Santiam River.

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 Clackamas 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 preexisting landslides.

This study represents our current understanding of landslide susceptibility to measure the risk in Linn 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 the 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.

The most recent landslide mapping in SLIDO for Linn County was published in 2010 (western half of Linn County) (McCloughry and others, 2010) and 2002 (eastern half of Linn County) (compiled in Franczyk and others, 2021). The lack of lidar-based landslide mapping means the statewide landslide

susceptibility layer in Linn County relies more heavily on modeled slope and generalized geology. The scale of mapping in much of Linn County is considered the "least detail[ed]", meaning smaller than 1:62,500 map scale. The portion within the Willamette Valley, however, is considered to be more detailed, with scales between 1:8,000 to 1:62,500.

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 found that areas along Route 22 along the North Santiam River have a high level of exposure to landslide hazard. Generally, communities in the central and eastern portion of Linn County that are in terrain with moderate to steep slopes or at the base of steep hillsides are more likely to be exposed to landslides. The percentage of building value exposed to Very High and High landslide susceptibility is approximately 5.5%, which equates to more than 6,700 buildings, with a value approaching \$1.5 billion.

We combined High and Very High susceptibility areas as the primary scenarios to provide a general sense of community risk for planning purposes (see [Appendix E: Plate 8](#)). 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.

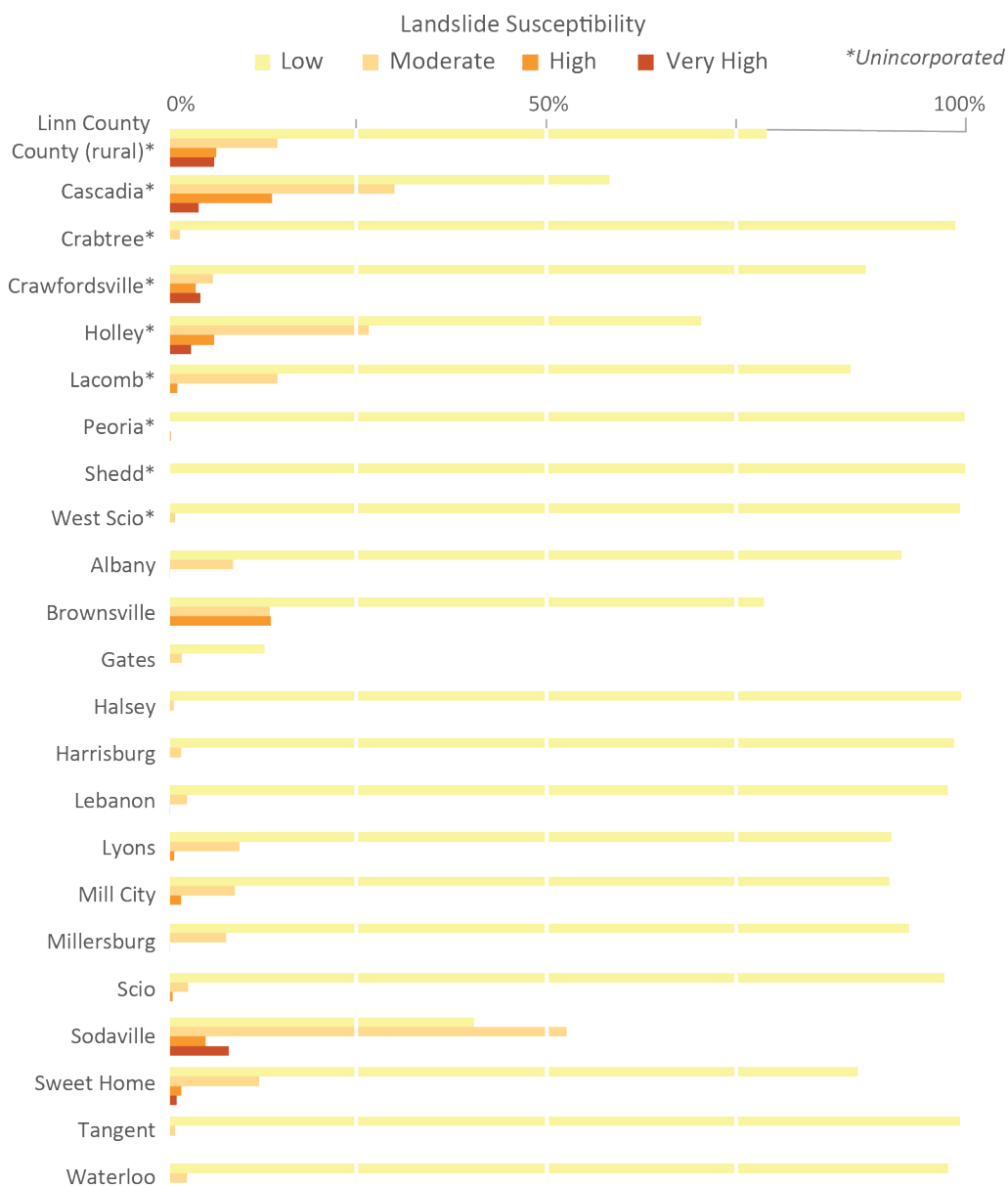
For this risk assessment, we compared building locations to geographic extents of the landslide susceptibility zones ([Figure 3-10](#)). See [Appendix B: Detailed Risk Assessment Tables](#) for exposure analysis results of all susceptibility categories.

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

- Number of buildings: 6,759
- Value of exposed buildings: \$1,484,804,000
- Percentage of total county value exposed: 5.5%
- Critical facilities exposed: 1 of 154
- Potentially displaced population: 6,047

Most of the developed land in Linn County is located on the low-relief terrain found in the Willamette Valley, which is predominantly classified as having a Low landslide susceptibility. However, there are developed areas in the central part of Linn County where Highway 20 intersects Route 228, in the vicinity of Brownsville, Sodaville, Crawfordsville, and Holley, that are highly susceptible to landslide hazard. Landslide hazard is also ubiquitous in the eastern portion of Linn County, which may present challenges for planning and mitigation efforts. Awareness of nearby areas of landslide hazard is beneficial to reducing risk for every community and rural area of Linn County.

Figure 3-10. Landslide susceptibility exposure by Linn County community.



3.3.3 Future conditions: landslide hazard

Climate change will influence landslide hazards in some landslide-prone areas where an increase in precipitation occurs (OCCRI, 2023). The frequency and magnitude of precipitation events can influence the probability of landslides occurring by saturating soils and prolonging the period in which soils remain saturated. Saturated soil increases landslide risk because saturated soils are heavier, and the presence of water reduces friction in the potential landslide material. In addition, areas that have recently burned are far more susceptible to landslides after heavy rainfall (OCCRI, 2023). Since climate change is also expected to increase the likelihood of wildfire, post-wildfire debris flows are also at a higher chance of occurring.

According to the report examining climate projections by OCCRI (2023), the annual number of days where soil saturation exceeds the threshold for landslide risk is expected to remain the same (31 days) as observed risk days measured from 2010-2022. The projection for landslide risk in Linn County is expected to not increase or decrease due to precipitation rates remaining near the average. However, precipitation is only one factor of several that influence landslide risk and this analysis does not account for all aspects of landslide hazard.

3.3.4 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to landslide hazard:

- Nearly all of Linn County's exposure to landslide hazard occurs east of Brownsville and Lebanon.
- A very large number of buildings are exposed to Very High landslide hazard between Lebanon and Sweet Home due to steep slopes in the South Santiam River valley.

3.4 Channel Migration

Channel migration is a dynamic process by which a stream's location changes over time. This process includes channel bed and bank erosion, sediment deposition, and channel avulsion, a process in which the stream abruptly moves to a new location on the floodplain. Many factors influence channel movement, including the local geology, size, and quantity of sediment within the river, discharge of water, vegetation, channel shape, and slope. Human changes to the channel, such as the construction of dams and levees, also have a major impact on how a channel changes its course. In combination, these factors affect how a river's energy and erosive power is dispersed. Straight, steep streams have highly concentrated erosive power; by contrast, curving channels that flow across wide and flat floodplains allow a river to dissipate its energy and deposit sediment over a wider area (Rapp and Abbe, 2003).

The area in which a stream channel moves laterally over a given time is known as a channel migration zone (CMZ). In places where development has occurred within the CMZ, structures are at risk for severe damage to foundations and infrastructure through erosion and flooding. The CMZ typically extends beyond the limits of the regulatory floodplain, but little consideration is given to this potential hazard. This factor contributes greatly to the level of risk that exists for many developed areas along streams (Rapp and Abbe, 2003).

The frequency and severity of channel migration may change over time due to changes in climate and precipitation patterns, land use, and how we manage our waterways. This study represents our current understanding of channel migration hazards and risk, but we recognize that channel migration mapping and risk assessments will need to be updated with time and changing conditions.

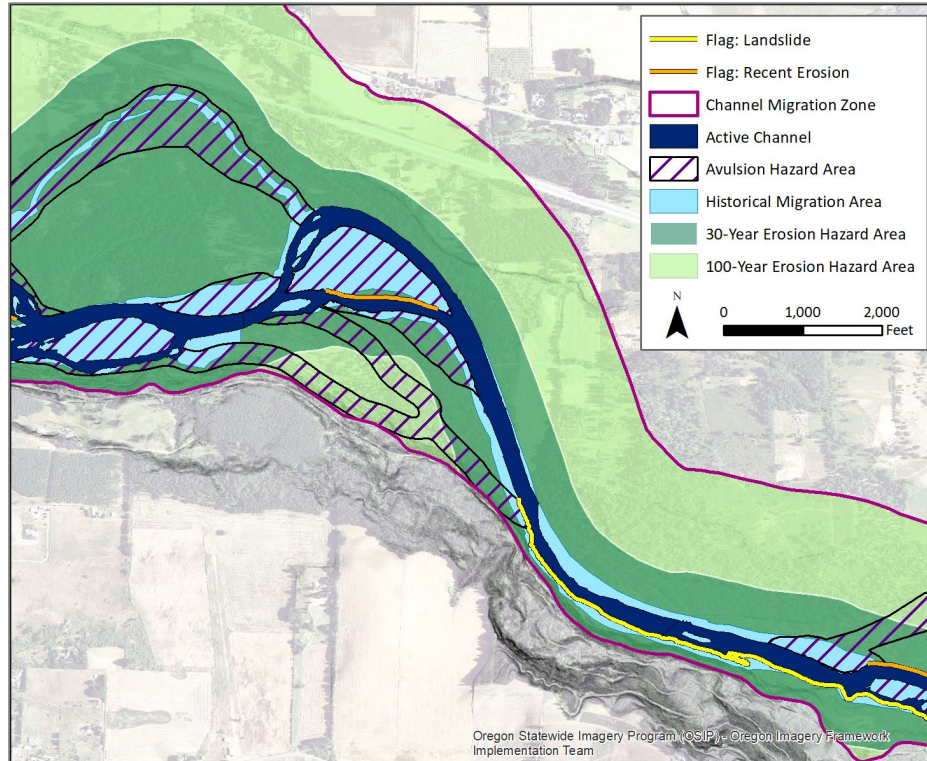
3.4.1 Data sources

The channel migration zones used for this report were developed by Appleby and others (2021) for the Santiam and North Santiam Rivers. DOGAMI's CMZ mapping considers areas of historical channel migration, potential erosion, and channel avulsion; these areas are mapped based on geology, historical aerial imagery, lidar topography, limited field work, and measured rates of historical channel migration. The methodology for developing the related zones and how they are combined are described in Appleby and others (2021). The CMZ is subdivided into seven subcomponents: the active channel, historical migration area, 30-year and 100-year erosion hazard areas, the avulsion hazard area, and flagged streambanks that are actively eroding or adjacent to landslides (**Figure 3-11**). The methodology for calculating each component and how they are combined are described in Appleby and others (2021).

It is important to note that this study only examines channel migration hazard along the Santiam and North Santiam Rivers due to data availability. There are other waterways in Linn County that could present additional channel migration hazard, including the Calapooia River. Structures built in proximity to these non-CMZ-mapped waterways are also potentially at risk to channel migration hazard.

To assess the exposure within each community, we overlaid buildings and critical facilities onto the CMZ. The following section presents the estimated total dollar value of exposed buildings and the number of people potentially displaced from the CMZ. Land value losses due to CMZ were not examined for this report.

Figure 3-11. Example diagram of the components of a CMZ map in Oregon, including the active channel (AC) in dark blue, historical migration area (HMA) in light blue, avulsion hazard area (AHA) with hatched lines, 30-year and 100-year erosion hazard areas (EHA) in dark and light green, flagged streambanks with yellow and orange lines, and channel migration zone (CMZ) boundary outlined in magenta (from Appleby and others, 2021).



3.4.2 Countywide results

Mapped channel migration areas along the Santiam and North Santiam rivers show a very high level of risk from this hazard for many communities along either watercourse. To quantify risk, the exposure analysis was conducted by determining which buildings were within or outside of the CMZ. Due to the frequency of shifting channel patterns in streams, channel migration can be a serious hazard in areas close to a stream regardless of hazard mapping or not.

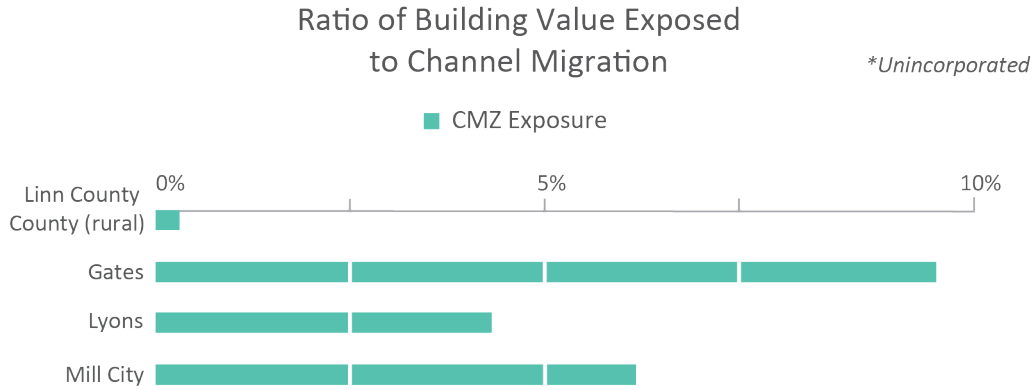
Linn County channel migration exposure (30-year erosion hazard area):

- Number of buildings: 420
- Value of exposed buildings: \$109,629,000
- Percentage of total county value exposed: 0.4%
- Critical facilities exposed: 0 of 154
- Potentially displaced population: 508

A significant number of buildings in the unincorporated county and cities along the Santiam and North Santiam rivers are within areas where channel migration is likely to occur. Nearly 10% of the buildings in Gates are within the 30-year erosion hazard zone. **Figure 3-12** presents the estimated total building value

at risk from channel migration for the communities of Gates, Lyons, and Mill City. See [Appendix B: Detailed Risk Assessment Tables](#) for complete analysis results.

Figure 3-12. 30-year erosion hazard exposure by Linn County community within the study area of Appleby and others (2021).



Note: Communities in figure limited to communities within the study area of Appleby and others (2021).

3.4.3 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to channel migration hazard:

- The North Santiam and Santiam rivers are highly susceptible to stream channel migration. Structures near and within these floodplains are at very high risk from channel migration hazard.

3.5 Volcanic Hazard – Lahar

A lahar is a water-saturated mixture of muddy debris and rock fragments that originates from a volcano and flows down channels at a rapid speed (exceeding 200 km/hr [120 mi/hr]). Lahars can occur on the flanks of a volcano with or without a volcanic eruption; non-eruption-related lahars can be initiated during heavy rains or by a sudden outburst of glacial melt where a volcano is covered with heavy loads of snow and ice. When this sudden large volume of water mixes with volcanic sediments and moves downslope, a damage-causing lahar can be produced.

Distal volcanic hazards, as opposed to proximal, are hazard types that affect outer areas away from the center of volcanic activity. A lahar is considered a distal volcanic hazard because they can travel large distances, causing damage to anything in their path. Because lahars have high drag and buoyancy forces resulting from the high sediment content of the flow, they have the capability to move large objects such as trees and vehicles and destroy infrastructure such as houses and bridges. They also can influence water quality, depending on the water sources used by affected communities.

For additional detailed information on volcanic hazards and potential impacts, the interested reader should review Walder and others (1999), "Volcano Hazards in the Mount Jefferson Region". This report discusses the risk from lahars to the Detroit Dam and Detroit Lake. If lahars entered this lake, they could cause large waves that could overtop the dam and possibly cause dam failure, with catastrophic effects downstream. Such events have very low probabilities but great potential consequences (Walder and others, 1999).

The eruptive history of Mount Jefferson is not well known. The last major eruption occurred somewhere between 35,000 and 100,000 years ago (Walder and others, 1999). Tephra that was sourced from this eruption has been found in southeast Idaho. Extensive pyroclastic flows during this same time period moved down the flanks of Mount Jefferson, along the Whitewater River on the east and Whitewater Creek on the west. Since data for this specific event was not available, exposure analysis to this eruption was not conducted.

3.5.1 Data sources

The lahar zones used in this report were created by Walder and others (1999) and were based on previous volcanic eruptions to estimate the extent of potential lahars on Mount Jefferson. Three nested lahar zones were computed based on an estimated volume of debris that could suddenly flow from Mount Jefferson. The largest and least likely scenario (>15,000-year annual recurrence) is designed at a volume of 500 million cubic meters (650 million cubic yards) and would correspond to volcanic activity or a low-probability landslide event involving large flank failures not caused by magmatic intrusion (Walder and others, 1999). The intermediate and small lahar scenarios are based on more likely events ranging from small eruptions, stream explosion, or rain-on-snow events. Such events are estimated to produce volumes of debris smaller than the largest scenario. The intermediate scenario, categorized in this report as "Medium," has an estimated volume of 100 million cubic meters (130 million cubic yards) with an annual recurrence of 1,000 to 15,000 years. The smallest scenario, categorized as "Small," has an estimated volume of 20 million cubic meters (25 million cubic yards) with an annual recurrence of 100 to 1,000 years.

For this risk assessment, we compared the locations of buildings and critical facilities to the geographic extent of the lahar inundation zones to assess the exposure for each community ([Appendix B: Table B](#)). The exposure results shown below are for only the Medium scenario.

The following section presents the estimated total dollar value of exposed buildings and the number of people potentially displaced from the Medium lahar hazard zone. Land value losses were not examined for this report. Refer to **Figure 3-13** to view the cumulative multi-scenario analysis results.

3.5.2 Countywide results

It is important to understand that volcanic hazards differ from earthquake or flood hazards on a timing basis. Earthquakes and floods tend to happen in relatively short windows, from minutes to hours, and recovery can usually begin within days or weeks after the event. By contrast, volcanic hazards can last days to decades, delaying a region's ability to recover. The aftermath of a volcanic event can lead to periods of localized channel transport of lahar material, precipitation patterns for the region can also lead to increased debris flows due to increased discharge in the riverine environment. Results of this study examine a single volcanic event, not the cumulative effects of all hazards from a volcanic eruption (Walder and others, 1999).

Most of the 132,000 residents in the study area are not exposed to lahar hazard, but the hazard poses significant concerns for those closer to Mount Jefferson and within riverine valleys. The total dollar value of exposed buildings was summed for the study area and is shown in **Figure 3-13**. The communities most threatened from a lahar event are Gates, Lyons, and Mill City.

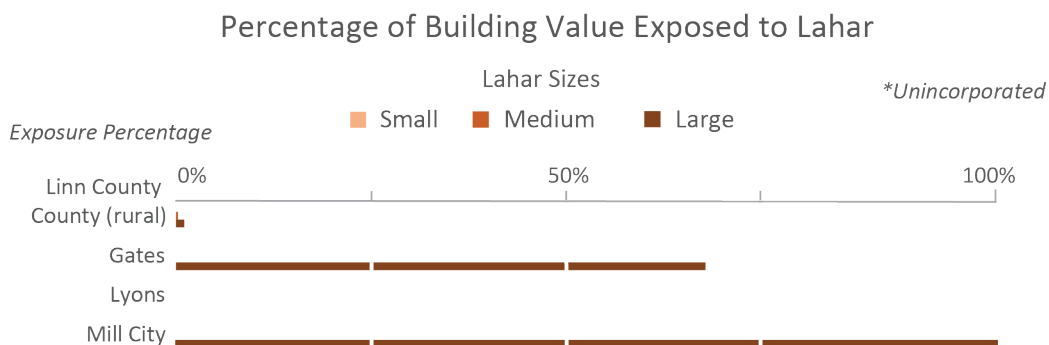
For this risk assessment, the results of the exposure analysis were limited to the communities included in the report by Walder and others (1999) that fall within the study area, which are those communities along the North Santiam River and the unincorporated county.

Linn County study area volcanic lahar exposure (Medium scenario):

- Number of buildings: 2,313
- Value of exposed buildings: \$559,662,000
- Percentage of total county value exposed: 2.1%
- Critical facilities exposed: 6 of 154
- Potentially displaced population: 2,778

Lahar hazard is not a concern for the vast majority of residents in Linn County. However, developed areas along Route 22 (North Santiam Highway) on the western slope of Mount Jefferson have a high exposure to volcanic lahar hazard. Buildings that are located outside of the riverine valleys of Mount Jefferson are at much lower to zero risk from lahar hazard. The communities with the highest risk from a lahar event are Gates and Mill City.

Figure 3-13. Lahar risk exposure by Linn County community.



Note: Communities in figure are limited to communities within the study area of Burns and others (2011).

3.5.3 Areas of concern

- Lahar risk is confined to river valley channels and is a higher risk for communities and infrastructure closer to Mount Jefferson.
- Lahar risk is present for all buildings near the North Santiam River along state Highway 22.

3.6 Wildfire

Wildfires are a natural part of the ecosystem in Oregon. However, wildfires can present a substantial hazard to life and property in communities, especially those experiencing rapid growth. The most common wildfire conditions include hot, dry, and windy weather; 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 flood, debris flows, and landslides. These post-wildfire hazards were not evaluated in this project.

The 2024 Linn County Community Wildfire Protection Plan (LCCWPP) recommended that the county develop policies addressing fire restriction enforcement, wildland urban interface standards, and building code enforcement related to emergency access. Forests cover large portions of the study area and play an important role in the local economy, but also surround homes and businesses (LCCWPP, 2024). Contact the Linn County Planning Department for specific requirements related to the county's comprehensive plan.

Linn County was impacted by the 2020 Labor Day Fires, specifically the Beachie Creek and Lionshead Wildfires. These fires are termed "megafires" because they were greater than 100,000 acres in size. The Beachie Creek wildfire burned nearly 194,000 acres and the Lionshead wildfire burned 205,000 acres (Northwest Interagency Coordination Center website, accessed 2/25/2022). The fires resulted in severe impacts to the built and natural environment in Linn and Marion counties and directly demonstrate the significant wildfire risk in Linn County. The Oregon Department of Emergency Management estimates that more than 1,500 structures, including 700 homes, were destroyed from these wildfires with an estimated \$600 million in losses.

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.

3.6.1 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 Linn County.

Using guidance from ODF, we categorized the Overall Wildfire Risk dataset into Low, Moderate, and High hazard zones for the wildfire exposure analysis. Overall Wildfire Risk was developed as a combination of burn probability and the presence of infrastructure and assets. The range of values in the dataset describe the level of potential impact and are characterized by negative values that indicate very high risk to zero, which indicates Low risk. The risk dataset also includes positive values that represent uninhabited areas that benefit from wildfire, but these were combined into the Low risk category (Gilbertson-Day and others, 2018).

Overall Wildfire Risk values were grouped into three hazard categories:

- Low wildfire hazard (-0.000011 to 0.005)
- Moderate wildfire hazard (-0.000119 to -0.000011)
- High wildfire hazard (-0.203 to -0.000119)

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 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.

3.6.2 Countywide results

This study focuses on the High and Moderate hazard because they represent areas that have the highest potential for losses. Moderate wildfire risk is included with High risk in the assessment of exposure, because under certain conditions Moderate risk zones can be very susceptible to burn. In combining the High and Moderate risk categories within Linn County, we can emphasize areas where lives and property are most at risk.

Linn Countywide wildfire exposure (High or Moderate risk):

- Number of buildings: 3,871
- Value of exposed buildings: \$811,012,000
- Percentage of total county value exposed: 3.1%
- Critical facilities exposed: 6 of 154
- Potentially displaced population: 4,419

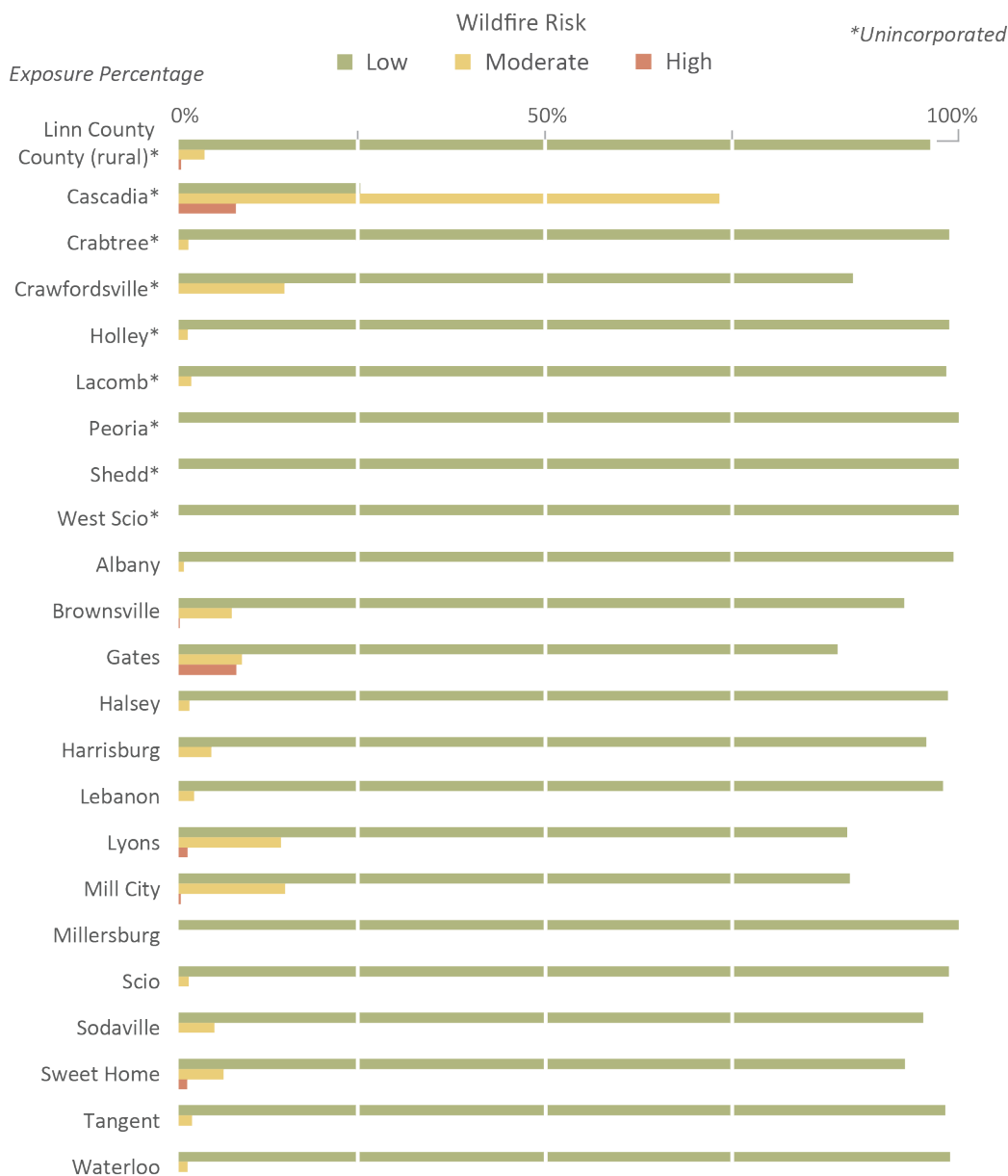
For this risk assessment, the building locations were compared to the geographic extent of the wildfire risk categories. More than 3,800 buildings in the heavily forested parts of central and eastern Linn County are exposed to High or Moderate wildfire hazard. Wildfires significantly impact the communities of Cascadia, Crawfordsville, Gates, Lyons, Mill City, and Sweet Home. [Figure 3-14](#) illustrates the level of risk from wildfire for the different communities of Linn County. See [Appendix B: Detailed Risk Assessment Tables](#) for multi-scenario analysis results.

3.6.3 Future conditions: wildfire hazard

Climate change has been recognized as a significant factor contributing to the increased frequency and severity of wildfires in various parts of the world. The effects of climate change on wildfire hazards are multifaceted and pose significant challenges to ecosystems, communities, and economies. Climate change increases the likelihood of wildfires through increased temperatures, drought conditions, reduced snowpack, altered precipitation patterns, and changes in vegetation (OCCRI, 2023).

The frequency, intensity, and size of wildfires are expected to continue to increase for the Pacific Northwest. The number of High fire danger days per year in Linn County are projected to increase an average of 12 days (range -6 to 31) by the 2050s, from the current average per year of 36.5. In addition, the number of days where vapor pressure deficit is extreme (another factor that impacts wildfire hazard) is expected to increase by 28 days (range 10 to 43) in the next 30 years from the current average per year of 24.5.

Figure 3-14. Wildfire risk exposure by Linn County community



3.6.4 Areas of significant risk

We identified locations within the study area that are comparatively at greater risk to wildfire hazard:

- Portions of Linn County that are at greatest risk from wildfires are primarily along the North Santiam River, which includes the communities of Lyons, Gates, and Mill City (and Idanha). These communities were also severely affected by the 2020 wildfires.

- The entire heavily forested eastern half of Linn County (the Cascades) is at Moderate to High risk from wildfire. Very little development is present in these areas, with the exception of the community of Cascadia.

4.0 CONCLUSIONS

The purpose of this study is to provide a better understanding of the 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:

- **Significant damage and losses for most areas in Linn County can occur from earthquake hazard**—Based on the results of the CSZ Mw 9.0 earthquake analysis, many communities in Linn County will experience building losses ranging from 10% to 17%. Generally, buildings in the western portion of Linn County will experience more damage from a CSZ Mw 9.0 earthquake than the eastern half. Based on the results of a Turner and Mill Creek Fault Mw 6.6 earthquake analysis, some communities in Linn County will experience at least some impact and disruption from such an event. Results show that this earthquake could cause building value losses of approximately 20% in Millersburg, Scio, Crawfordsville, and West Scio, primarily due to their proximity to the hypothetical earthquake epicenter. Buildings in the floodplains of the Santiam River, South Santiam River, Truax Creek, and Willamette River are at higher damage risk from either earthquake scenario due to significantly higher liquefaction susceptibility. Building age, proximity to a potential earthquake source, and liquefiable soils all contribute to the estimated levels of losses expected in Linn County.
- **Retrofitting buildings to modern seismic building codes can reduce damages and losses from earthquake shaking**—Our study shows that seismic building codes have a major influence on earthquake shaking damage. 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 10% to 7% for a CSZ Mw 9.0 event and 9% to 7% for a Turner and Mill Creek Fault Mw 6.6. Communities with older buildings that were constructed below the Moderate-code standards are both the most vulnerable and have the greatest potential for risk reduction. For example, the community of Shedd could reduce losses from 17% to 10% for a CSZ Mw 9.0 event by retrofitting all buildings to at least Moderate code. While seismic retrofits are an effective strategy for reducing earthquake shaking damage, it should be noted that earthquake-induced liquefaction hazards will also be present in areas along some of the major streams in the county; these hazards require additional study and different geotechnical mitigation strategies.
- **Some communities in the study area are at moderate risk from flooding**—Many buildings within the floodplain are vulnerable to significant damage from flooding. At first glance, Hazus flood loss estimates may give a false impression of lower risk because they show lower damages within individual communities relative to other hazards we examined. This is likely due to the difference between the type of results from loss estimation and exposure analysis, as well as the limited area impacted by flooding. Flooding is one of the most frequently occurring natural hazards and thus, commonly has repetitive losses that occur with recurrence intervals of tens to hundreds of years, versus earthquake hazards, with recurrence intervals of hundreds to

thousands of years. We estimate that an average of 18% building value loss exists for buildings within the 100-year flood zone. The buildings most vulnerable to flood hazard within the study lie along the Willamette River, Mill Creek, Thomas Creek, South Santiam River, and North Santiam River.

- **Elevating structures in the flood zone reduces vulnerability**—We used an exposure analysis in addition to Hazus loss estimation to identify buildings that were not damaged but were within the area expected to experience a 100-year flood. By using both analyses in this way, the number of elevated structures within the flood zone could be quantified. This showed possible mitigation needs in flood loss prevention and the effectiveness of past activities. For example, in the City of Scio an estimated 50 buildings exposed to flooding are elevated above the base flood elevation (BFE). Based on the number of buildings exposed to flooding throughout the county, many would benefit from elevating above the level of flooding.
- **Landslide risk is significant for steeper areas in the county**—The recent landslide mapping used in this study was created using lidar and modern mapping methods to develop very accurate landslide hazard maps. We used an exposure analysis to assess the threat from landslide hazards. The developed areas in the central part of Linn County where Highway 20 intersects Route 228, in the vicinity of Brownsville, Sodaville, Crawfordsville, and Holley, are highly susceptible to landslide hazards. Nearly 12% of the buildings in Brownsville and Sodaville are exposed to Very High or High landslide hazard.
- **Channel migration is a hazard for buildings in the riverine valleys of the study area**—Exposure analysis shows that channel migration hazard is a threat to communities and buildings along the North Santiam and Santiam rivers, specifically the community of Gates which has approximately 10% of its buildings exposed to the hazard. Buildings along the Willamette and Calapooia rivers were not evaluated for CMZ in this report.
- **Wildfire risk is higher in the WUI portions of the county**—Exposure analysis shows that buildings in rural central and eastern portions of the county are at higher risk from wildfire than other areas in the county. The communities of Cascadia, Crawfordsville, Gates, Lyons, Mill City, and Sweet Home have the highest risk from wildfire.
- **Most of the study area's critical facilities are at greatest risk from a CSZ Mw 9.0 earthquake hazard, relative to other hazards**—Because of their importance during and after a natural disaster, we identified and examined the risk to critical facilities for each hazard. We estimate that 23% (35 of 154) of Linn County's critical facilities will be nonfunctioning after a CSZ Mw 9.0 earthquake and 22% (34 of 154) will be nonfunctioning after a Turner and Mill Creek Fault Mw 6.6 earthquake. We also found that six critical facilities are exposed to wildfire hazard.
- **People are most likely to be displaced from their homes due to earthquake, wildfire, and landslide hazards**—We estimated that 4% of the permanent residents in the county could be displaced from a CSZ Mw 9.0 or a Turner and Mill Creek Fault Mw 6.6 earthquake. Permanent residents are vulnerable to displacement at a rate of 3.4% due to wildfire hazard and 4.6% due to landslide hazard. A small percentage of residents are vulnerable to displacement from flood, channel migration, and lahar hazards.
- **These results allow communities to compare risk across hazards and prioritize their needs**—The impact of multiple natural hazards was assessed for each community in Linn County. This allows for comparison of risk for a specific hazard between communities. It also allows for a comparison between different hazards, though care must be taken to distinguish loss estimates

and exposure results. The loss estimates and exposure analyses can assist in developing plans that address the concerns of those individual communities.

5.0 LIMITATIONS

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, channel migration, 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 un-reinforced 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 Linn County have vacation homes and rentals, which are more often occupied during the summer. Our estimates of potentially displaced people rely on permanent populations based on PSU Population Research Center data. 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 were 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 Linn 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 impact the frequency and intensity of floods, wildfires, and landslides, but quantifying this impact was beyond the scope of this study.

6.0 RECOMMENDATIONS

The following actions are needed to better understand hazards and reduce risk to natural 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 Landslides (https://www.oregongeology.org/Landslide/ger_homeowners_guide_landslides.pdf) provides a variety of risk reduction options for homeowners who live in high landslide susceptibility areas. This guide is one of many existing resources. Agencies partnering with local officials in the development of additional effective resources could help reach a broader community and user groups.

6.2 Planning

This report can help local decision-makers develop 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 natural hazard mitigation plan (NHMP) process. NHMP plans focus on characterizing natural hazard risk and identifying actions to reduce risk. Additionally, the information presented here can be a resource when updating the mitigation actions and inform 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 non-building 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 re-evaluate 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 funds

(https://www.oregon.gov/OEM/Documents/Oregon_Hazard_Mitigation_Grant_Program_Handbook.pdf).

At the time of writing this report, FEMA has five programs that assist with mitigation funding for natural hazards: Hazard Mitigation Grant Program (HMGP), HMGP Post-Fire Assistance, Pre-Disaster Mitigation (PDM) Grant Program, Building Resilient Infrastructure and Communities (BRIC) grant program, and Flood Mitigation Assistance (FMA) (<https://www.fema.gov/grants/mitigation>). 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 73% of critical facilities (**Appendix A: Community Risk Profiles**) will be damaged by a 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 are 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 Channel migration

- Future development in areas with the largest CMZs, particularly North Santiam and Santiam rivers, could incorporate CMZ mitigation strategies into plans and designs.
- Evaluate the losses in land value or productivity due to channel migration.
- Evaluate risks to transportation networks and bridges due to channel migration.
- Identify areas suitable for conservation corridors along rivers that are at risk from channel migration. These can be multi-purpose including areas that provide or improve flood water storage, riparian and aquatic habitat restoration, climate change resilience, and water quality.

6.5.5 Volcanic hazard — lahar

- Awareness campaign focusing on the risk and evacuation protocols for areas with elevated exposure, conduct exercises to test protocols.
- Maintain appropriate setbacks in riverine valleys susceptible to lahar. The additional benefit would be a reduction of impacts from flooding and channel migration.

6.5.6 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

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9.0 APPENDICES

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APPENDIX A. COMMUNITY RISK PROFILES

This appendix contains community specific data to provide an overview and a better understanding about the relative levels of risk from each natural hazard analyzed for the purpose of fostering risk reduction efforts. 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.

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A.1 Unincorporated Linn County (Rural)

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

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Unincorporated Linn County (rural)	35,839	45,792	26	12,020,435,000			
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	1,275	3.6%	1,574	1	89,881,000	0.7%
Earthquake	CSZ Mw-9.0 Deterministic	894	2.5%	6,111	6	1,139,942,855	9.5%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	947	2.6%	5,305	4	988,024,312	8.2%
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	5,287	15%	6,213	1	1,372,345,000	11%
Channel Migration	Channel Migration Zone	290	0.8%	324	0	79,728,000	0.7%
Wildfire	High and Moderate Risk	1,669	4.7%	2,251	0	439,756,000	3.3%
Volcanic Lahar	1% Annual Chance	789	2.2%	2,251	0	273,507,000	2.3%

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

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

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

	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Volcanic Lahar - 1% Annual Chance
Critical Facilities by Community	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed	Exposed	Exposed
Brownsville Rural Fire Dist - Station 61	-	-	-	-	-	-	-
Brownsville STP	-	-	-	-	-	-	-
Central Linn High School*	-	-	-	-	-	-	-
Clover Ridge Elementary School	-	X	X	-	-	-	-
East Linn Christian Academy	-	X	-	-	-	-	-
Electric Distribution	-	-	-	-	-	-	-
Halsey STP	-	-	-	-	-	-	-
Halsey-Shedd RFPD - Station 54	-	-	-	-	-	-	-
Hamilton Creek School	-	-	-	-	-	-	-
Harris Private School	-	X	-	-	-	-	-
Harrisburg Water Facilities	-	-	-	-	-	-	-
Lake Creek Mennonite School	-	X	-	-	-	-	-
Lebanon Fire District - Station 33	-	-	-	-	-	-	-
Lebanon Fire District Station 35	-	-	-	X	-	-	-
Lebanon Water Intake Facility	-	-	-	-	-	-	-
Little Promises Children's Program	-	-	-	-	-	-	-
Lourdes Public Charter School	-	-	-	-	-	-	-
Lyons RFPD - Station 570	-	-	-	-	-	-	-
Samaritan Lebanon Community Hospital	-	-	-	-	-	-	-
Scio STP	-	-	-	-	-	-	-
Scio Public Works shops	X	-	-	-	-	-	-
Scio RFPD - Station 93	-	-	-	-	-	-	-
Skyline Christian Academy	-	-	-	-	-	-	-
Sweet Home Charter School	-	-	-	-	-	-	-
Sweet Home Fire and Ambulance	-	-	-	-	-	-	-
Cascadia Substation	-	-	-	-	-	-	-
Tangent STP	-	-	-	-	-	-	-

*Seismic upgrades have occurred for some or all of the buildings associated with this critical facility.

A.2 Unincorporated Community of Cascadia

Table A-3. Unincorporated Community of Cascadia hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Cascadia		116	231	0	27,896,000		
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	0	0.3%	9	0	575,960	2.1%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	0	0%	0	0	97,390	0.3%
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	15	13%	41	0	4,592,000	17%
Wildfire	High and Moderate Risk	92	79%	171	0	21,393,000	76%

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

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

A.3 Unincorporated Community of Crabtree

Table A-4. Unincorporated Community of Crabtree hazard profile.

Community Overview							
Community Name	Population	Number of Buildings		Critical Facilities ¹	Total Building Value (\$)		
Crabtree	339	459		1	97,309,000		
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	21	6.1%	133	1	14,269,464	15%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	29	8.6%	147	1	18,234,476	19%
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%
Wildfire	High and Moderate Risk	7	2%	12	0	1,198,000	1%

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

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

Table A-5. Unincorporated Community of Crabtree critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Scio RFPD – Station 92	-	X	X	-	-

A.4 Unincorporated Community of Crawfordsville

Table A-6. Unincorporated Community of Crawfordsville hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Crawfordsville	279	374	2	80,383,000			
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	27	9.5%	30	0	394,000	0.5%
Earthquake	CSZ Mw-9.0 Deterministic	14	5.0%	103	0	11,322,373	14%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	6	2.0%	41	0	5,279,500	6.6%
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	9	3.1%	19	0	5,706,000	7.1%
Wildfire	High and Moderate Risk	40	14%	67	1	10,906	14%

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

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

Table A-7. Unincorporated Community of Crawfordsville critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Crawfordsville Elementary School	-	-	-	-	-
Sweet Home Fire and Ambulance	-	-	-	-	X

A.5 Unincorporated Community of Holley

Table A-8. Unincorporated Community of Holley hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Holley	260	380	1	79,188,000			
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	0	0%	1	0	3,000	0.0%
Earthquake	CSZ Mw-9.0 Deterministic	3	1.0%	23	0	3,280,394	4.1%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	1	0.4%	9	0	1,250,036	1.6%
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	26	10%	32	0	6,498,000	8.2%
Wildfire	High and Moderate Risk	2	0.8%	8	0	955,000	1%

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

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

Table A-9. Unincorporated Community of Holley critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Holley Elementary School	-	-	-	-	-

A.6 Unincorporated Community of Lacombe

Table A-10. Unincorporated Community of Lacombe hazard profile.

Community Overview							
Community Name	Population	Number of Buildings		Critical Facilities ¹	Total Building Value (\$)		
Lacombe	403	535		2	126,968,000		
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	0	0%	4	0	2,871,810	2.3%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	0	0%	4	0	2,083,269	1.6%
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	8	1.9%	7	0	1,157,000	0.9%
Wildfire	High and Moderate Risk	13	3.2%	10	0	2,039,000	2%

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

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

Table A-11. Unincorporated Community of Lacombe critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Lacombe School	-	-	-	-	-
Lebanon Fire District - Station 32	-	-	-	-	-

A.7 Unincorporated Community of Peoria

Table A-12. Unincorporated Community of Peoria hazard profile.

Community Overview							
Community Name	Population	Number of Buildings		Critical Facilities ¹	Total Building Value (\$)		
Peoria	97	136		1	25,591,000		
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	0	0%	1	0	4,000	0%
Earthquake	CSZ Mw-9.0 Deterministic	4	3.7%	28	1	2,524,238	9.9%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	0	0.1%	2	0	347,664	1.4%
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%	1	0	29,000	0.1%
Wildfire	High and Moderate Risk	0	0%	0	0	0	0%

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

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

Table A-13. Unincorporated Community of Peoria critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Halsey-Shedd RFPD - Station 53	-	X	-	-	-

A.8 Unincorporated Community of Shedd

Table A-14. Unincorporated Community of Shedd hazard profile.

Community Overview							
Community Name	Population	Number of Buildings		Critical Facilities ¹	Total Building Value (\$)		
Shedd	208	248		1	107,103,000		
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	38	18%	44	0	2,397,000	2.2%
Earthquake	CSZ Mw-9.0 Deterministic	5	2.3%	42	0	18,285,600	17%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	0	0.1%	4	0	2,833,576	2.6%
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%
Wildfire	High and Moderate Risk	0	0%	0	0	0	0%

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

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

Table A-15. Unincorporated Community of Shedd critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Halsey-Shedd RFPD - Station 52	-	-	-	-	-

Table A-16. Unincorporated Community of West Scio hazard profile.

Community Overview							
Community Name		Population	Number of Buildings		Critical Facilities ¹	Total Building Value (\$)	
West Scio		105	198		0	52,104,000	
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	9	8.7%	75	0	8,294,827	16%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	28	27%	95	0	14,667,365	28%
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%
Wildfire	High and Moderate Risk	0	0%	0	0	0	0%

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

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

A.9 City of Albany

Table A-17. City of Albany hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Albany		48,668	20,286	33	7,004,487,000		
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	108	0.2%	58	0	2,611,000	0%
Earthquake	CSZ Mw-9.0 Deterministic	2,307	4.7%	3,399	16	761,814,128	11%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	2,446	5.0%	3,067	19	704,757,418	10%
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	33	0.1%	17	0	3,518,000	0.1%
Wildfire	High and Moderate Risk	275	0.6%	73	1	46,900,000	1%

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

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

Table A-18. City of Albany critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Albany Christian School	-	-	-	-	-
Albany Fire Department Station 11	-	-	-	-	-
Albany Fire Department Station 12	-	-	-	-	-
Albany Fire Department Station 13	-	-	-	-	-
Albany Options School	-	-	-	-	-
Albany Police Department	-	-	-	-	-
Albany Public Works	-	-	X	-	-
Albany-Millersburg WRF	-	-	X	-	-
Calapooia Middle School	-	-	-	-	-
Central Elementary School	-	X	X	-	-
Circle of Friends Learning Center	-	-	-	-	-
First United Methodist Early Learning Center	-	-	-	-	-
Good Shepherd Lutheran School	-	X	X	-	-
Lafayette Elementary School	-	-	-	-	-
Liberty Elementary School	-	X	X	-	-
Linn County Courthouse	-	X	X	-	-
Linn County Fairgrounds	-	-	X	-	-
Linn County Road Department	-	X	X	-	-
Linn County Sheriff's Office / Linn County Jail	-	X	X	-	-
Memorial Middle School	-	-	-	-	-
Oak Elementary School	-	X	X	-	-
Periwinkle Elementary School	-	-	-	-	-
Samaritan Albany General Hospital	-	-	-	-	-
Samaritan Geary Street Urgent Care Clinic	-	-	-	-	-
South Albany High School	-	X	-	-	X
South Shore Elementary School	-	-	-	-	-
Standard Christian School	-	X	-	-	-
Sundborn Children's House Montessori	-	-	-	-	-
Sunrise Elementary School	-	-	-	-	-
Takena Elementary	-	-	-	-	-
Timber Ridge School	-	-	-	-	-
Waverly Elementary School	-	X	-	-	-
West Albany High School	-	-	-	-	-

A.10 City of Brownsville

Table A-19. City of Brownsville hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Brownsville	1,846	1,326	2	284,607,000			
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	180	9.7%	119	1	2,042,000	0.7%
Earthquake	CSZ Mw-9.0 Deterministic	70	3.8%	230	0	26,402,644	9.3%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	33	1.8%	124	0	14,539,754	5.1%
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	237	13%	137	0	36,203,000	13%
Wildfire	High and Moderate Risk	162	8.8%	70	0	19,850,000	7.1%

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

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

Table A-20. City of Brownsville critical facilities.

	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
Critical Facilities by Community	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Brownsville Public Works	X	-	-	-	-
Linn County Sheriff's Office and Brownsville Rural Fire District – Station 62	-	-	-	-	-

A.11 City of Gates

Table A-21. City of Gates hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Gates	493	326	3	70,923,000			
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	3	0.5%	6	0	756,492	1.1%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	0	0%	4	0	2,366,249	3.3%
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%
Channel Migration	Channel Migration Zone	33	6.6%	27	0	6,929,000	9.8%
Wildfire	High and Moderate Risk	56	11%	46	0	11,012,000	15%
Volcanic Lahar	1% Annual Chance	323	65%	216	1	49,139,000	69%

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

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

Table A-22. City of Gates critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Volcanic Lahar - 1% Annual Chance
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed	Exposed	Exposed
Gates City Hall	-	-	-	-	-	-	-
Gates Public Works Shop	-	-	-	-	-	-	X
Gates RFPD	-	-	-	-	-	-	-

A.12 City of Halsey

Table A-23. City of Halsey hazard profile.

Community Overview							
Community Name	Population	Number of Buildings		Critical Facilities ¹	Total Building Value (\$)		
Halsey	955	602		5	182,922,000		
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	26	2.7%	79	1	19,448,832	11%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	0	0%	2	0	1,553,929	0.8%
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%
Wildfire	High and Moderate Risk	21	2.2%	15	0	2,534,000	1.4%

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

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

Table A-24. City of Halsey critical facilities.

	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
Critical Facilities by Community	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Central Linn Elementary School*	-	-	-	-	-
Halsey City Hall and Community Center	-	X	-	-	-
Halsey Public Library	-	-	-	-	-
Halsey Public Works	-	-	-	-	-
Halsey-Shedd RFPD - Station 51*	-	-	-	-	-

*Seismic upgrades have occurred for some or all of the buildings associated with this critical facility.

A.13 City of Harrisburg

Table A-25. City of Harrisburg hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Harrisburg		3,660	1,924	5	544,762,000		
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	162	4.4%	403	0	65,086,627	12%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	1	0%	5	0	2,878,941	0.5%
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%
Wildfire	High and Moderate Risk	228	6.2%	76	0	22,789,000	4.2%

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

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

Table A-26. City of Harrisburg critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Harrisburg City Hall	-	-	-	-	-
Harrisburg Fire and Rescue - Station 41	-	-	-	-	-
Harrisburg High School*	-	-	-	-	-
Harrisburg Middle School/Elementary School*	-	-	-	-	-
Linn County Sheriff's Office – Harrisburg Substation	-	-	-	-	-

*Seismic upgrades have occurred for some or all of the buildings associated with this critical facility.

A.15 City of Lebanon

Table A-27. City of Lebanon hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Lebanon		20,320	8,789	29	2,688,032,000		
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	0	0%	0	0	0	0%
Earthquake	CSZ Mw-9.0 Deterministic	1,425	7.0%	2,092	3	333,797,893	12%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	1,422	7.0%	1,895	6	360,458,752	13%
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	6	0%	7	0	826,000	0%
Wildfire	High and Moderate Risk	523	2.6%	153	1	54,052,000	2.0%

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

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

Table A-28. City of Lebanon critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Cascades School	-	X	X	-	-
Green Acres School	-	-	-	-	-
LBCC Advanced Transportation Technology Center	-	-	X	-	-
LBCC Lebanon Center	-	-	-	-	-
Lebanon City Hall	-	-	-	-	-
Lebanon City Storage	-	-	-	-	-
Lebanon Fire District - Station 31	-	-	-	-	-
Lebanon Fire District Station 34	-	-	-	-	-
Lebanon High School*	-	-	-	-	-
Lebanon Maintenance Training Bay	-	-	-	-	-
Lebanon Police Department	-	-	-	-	-
Lebanon State Airport	-	-	-	-	-
Lebanon Waterwater Treatment	-	-	X	-	-
Linn County Sheriff's Office – Lebanon Substation	-	-	-	-	-
Montessa Pump Station	-	-	-	-	-
Oregon Army National Guard	-	-	-	-	-
Park Drive Pump Station	-	-	-	-	-
Pioneer School	-	-	-	-	-
Riverview Elementary School	-	-	-	-	X
Samaritan Lebanon Community Hospital - East Linn Health Clinic	-	-	-	-	-
Samaritan Lebanon Community Hospital	-	-	-	-	-
Sand Ridge Charter – South Main Campus	-	-	-	-	-
Seven Oak Middle School	-	-	-	-	-
Water Treatment Plant	-	-	-	-	-
Western University COMP Northwest	-	-	X	-	-
Western University Health Sciences University	-	X	X	-	-

*Seismic upgrades have occurred for some or all of the buildings associated with this critical facility.

A.16 City of Lyons

Table A-29. City of Lyons hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Lyons		1,203	1,074	5	223,889,000		
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	11	0.9%	6	0	70,000	0%
Earthquake	CSZ Mw-9.0 Deterministic	23	1.9%	126	1	12,905,823	5.8%
Earthquake	Turner and Mill Creek Fault Mw-6.6 Deterministic	20	1.7%	75	1	9,900,919	4.4%
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	8	0.6%	6	0	1,185,000	0.5%
Channel Migration	Channel Migration Zone	22	4.7%	22	0	8,509,000	3.8%
Wildfire	High and Moderate Risk	188	16%	194	0	31,971,000	14%
Volcanic Lahar	1% Annual Chance	0	0%	0	0	0	0%

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

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

Table A-30. City of Lyons critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Volcanic Lahar - 1% Annual Chance
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed	Exposed	Exposed
City of Lyons Shop	-	-	-	-	-	-	-
Lyons City Hall	-	-	-	-	-	-	-
Lyons RFPD - Station 550	-	-	-	-	-	-	-
Lyons-Mehama Water District Shop	-	-	-	-	-	-	-
Mari-Linn Elementary School	-	X	-	-	-	-	-

A.17 City of Mill City

Table A-31. City of Mill City hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Mill City		1,671	1,060	4	237,466,000		
Hazus Analysis Summary							
		%			Damaged Critical Facilities	Loss Estimate (\$)	Loss Ratio
Hazard	Scenario	Potentially Displaced Residents	Potentially Displaced Residents	Damaged Buildings	Damaged Critical Facilities	Loss Estimate (\$)	Loss Ratio
Flood ²	1% Annual Chance	0	0%	0	0	0	0%
Earthquake*	CSZ Mw-9.0 Deterministic	5	0.3%	34	1	5,647,141	2.4%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	1	0.1%	5	0	1,770,598	0.7%
Exposure Analysis Summary							
		%			Exposed Critical Facilities	Building Value (\$)	Exposure Ratio
Hazard	Scenario	Potentially Displaced Residents	Potentially Displaced Residents	Exposed Buildings	Exposed Critical Facilities	Building Value (\$)	Exposure Ratio
Landslide	High and Very High Susceptibility	21	1.2%	25	0	3,349,000	1.4%
Channel Migration	Channel Migration Zone	128	7.7%	47	0	14,463,000	6.1%
Wildfire	High and Moderate Risk	252	15%	153	2	33,177,000	14%
Volcanic Lahar	1% Annual Chance	1,667	99%	1059	4	237,016,000	99%

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

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

Table A-32. City of Mill City critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Volcanic Lahar - 1% Annual Chance
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed	Exposed	Exposed
Linn County Sheriff’s Office – Mill City Substation	-	-	-	-	-	-	X
Mill City Fire Department	-	-	-	-	-	X	X
Mill City Middle School	-	X	-	-	-	X	X
Santiam High School	-	-	-	-	-	-	X

A.18 City of Millersburg

Table A-33. City of Millersburg hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Millersburg		3,207	2,049	3	878,299,000		
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	9	0.3%	5	0	61,000	0%
Earthquake*	CSZ Mw-9.0 Deterministic	65	2.0%	279	2	83,644,164	9.5%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	143	4.4%	447	2	158,515,773	18%
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	1	0%	3	0	291,000	0%
Wildfire	High and Moderate Risk	0	0%	0	0	0	0%

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

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

Table A-34. City of Millersburg critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Albany Fire Department - Millersburg Station 15	-	-	-	-	-
Jefferson RFPD - Millersburg	-	X	X	-	-
Millersburg City Hall	-	X	X	-	-

A.19 City Scio

Table A-35. City of Scio hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Scio		949	601	5	156,690,000		
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	210	22%	87	1	914,000	0.6%
Earthquake*	CSZ Mw-9.0 Deterministic	73	7.7%	196	0	25,128,291	16%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	163	17%	243	2	39,965,839	26%
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	4	0.4%	1	0	529,000	0.3%
Wildfire	High and Moderate Risk	11	1.2%	7	0	1,996,000	1.3%

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

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

Table A-36. City of Scio critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Centennial Elementary School	-	-	X	-	-
Scio City Hall Library and Senior Center	-	-	-	-	-
Scio High School*	X	-	-	-	-
Scio Middle School*	-	-	-	-	-
Scio RFPD - Main Station	-	-	X	-	-

*Seismic upgrades have occurred for some or all of the buildings associated with this critical facility.

A.20 City of Sodaville

Table A-37. City of Sodaville hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Sodaville		357	271	4	48,953,000		
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	0	0%	0	0	0	0%
Earthquake*	CSZ Mw-9.0 Deterministic	1	0.2%	12	0	1,421,274	2.9%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	1	0.2%	5	0	560,484	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	49	14%	34	0	5,831,000	12%
Wildfire	High and Moderate Risk	13	3.6%	15	0	2,238,000	4.6%

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

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

Table A-38. City of Sodaville critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Sand Ridge Charter School – Sodaville Campus	-	-	-	-	-
Sodaville City Hall	-	-	-	-	-
Sodaville General Store	-	-	-	X	-
Sodaville water system building	-	-	-	-	-

A.21 City of Sweet Home

Table A-39. City of Sweet Home hazard profile.

Community Overview							
Community Name		Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)		
Sweet Home		10,028	6,313	10	1,466,569,000		
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	55	0.5%	39	0	796,000	0.1%
Earthquake*	CSZ Mw-9.0 Deterministic	64	0.6%	334	0	42,142,096	2.9%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	14	0.1%	53	0	12,507,581	0.9%
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	276	2.7%	170	0	33,736,000	2.3%
Wildfire	High and Moderate Risk	833	8.3%	516	1	100,826,000	6.9%

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

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

Table A-40. City of Sweet Home critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Lahar
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed	Exposed	Exposed
Foster Elementary School	-	-	-	-	-	-	-
Hawthorne Elementary School	-	-	-	-	-	-	-
Oak Heights Elementary School	-	-	-	-	-	-	-
Sweet Home Fire and Ambulance No.21	-	-	-	-	-	-	-
Sweet Home Fire and Ambulance Station 22	-	-	-	-	-	-	-
Sweet Home High School	-	-	-	-	-	-	-
Sweet Home Junior High School	-	-	-	-	-	X	-
Sweet Home Police Department	-	-	-	-	-	-	-
City of Sweet Home	-	-	-	-	-	-	-
Willamette National Forest – Sweet Home Ranger District	-	-	-	-	-	-	-

A.22 City of Tangent

Table A-41. City of Tangent hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Tangent	1,218	1,064	4	407,086,000			
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	4	0.3%	9	0	113,000	0%
Earthquake*	CSZ Mw-9.0 Deterministic	78	6.4%	316	1	53,119,121	13%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	19	1.5%	102	0	21,919,532	5.4%
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%
Wildfire	High and Moderate Risk	31	2.5%	32	0	7,049,000	1.7%

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

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

Table A-42. City of Tangent critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Central Valley Christian School	-	-	-	-	-
Tangent City Hall	-	-	-	-	-
Tangent Elementary School	-	X	-	-	-
Tangent RFPD*	-	-	-	-	-

*Seismic upgrades have occurred for some or all of the buildings associated with this critical facility.

A.23 City of Waterloo

Table A-43. City of Waterloo hazard profile.

Community Overview							
Community Name	Population	Number of Buildings	Critical Facilities ¹	Total Building Value (\$)			
Waterloo	216	203	1	32,851,000			
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	0	0%	0	0	0	0%
Earthquake*	CSZ Mw-9.0 Deterministic	13	5.8%	63	0	4,867,488	15%
Earthquake*	Turner and Mill Creek Fault Mw-6.6 Deterministic	11	5.3%	50	1	4,291,330	13%
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%
Wildfire	High and Moderate Risk	2	0.9%	2	0	7,049,000	1.1%

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

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

Table A-44. City of Waterloo critical facilities.

Critical Facilities by Community	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Turner and Mill Creek 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
	Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Waterloo City Hall	-	-	-	-	-

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Table B-1. Linn County building inventory.

Community	<i>(all dollar amounts in thousands)</i>															
	Residential			Commercial and Industrial			Agricultural			Public and Non-Profit			All Buildings			
	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	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. Linn Co	21,754	6,284,412	52%	937	795,203	6.6%	22,986	4,815,610	40%	115	125,210	1.0%	45,792	49%	12,020,435	45%
Cascadia	104	19,843	71%	0	0	0%	127	8,053	29%	0	0	0%	231	0.2%	27,896	0.1%
Crabtree	214	58,629	60%	6	2,580	2.7%	237	34,153	35%	2	1,948	2.0%	459	0.5%	97,309	0.4%
Crawfordsville	199	48,077	60%	5	1,139	1.4%	164	24,990	31%	6	6,177	7.7%	374	0.4%	80,383	0.3%
Holley	181	45,801	58%	3	748	1%	188	25,814	33%	8	6,826	8.6%	380	0.4%	79,188	0.3%
Lacomb	263	66,472	52%	8	9,064	7.1%	264	51,433	41%	0	0	0.0%	535	1%	126,968	0%
Peoria	75	17,211	67%	0	0	0%	59	7,581	30%	2	800	3%	136	0.1%	25,591	0.1%
Shedd	109	38,163	36%	24	24,925	23%	104	33,869	32%	11	10,147	9%	248	0.3%	107,103	0.4%
West Scio	91	15,174	29%	31	27,991	54%	76	8,939	17%	0	0	0%	198	0.2%	52,104	0.2%
Total Unincorp. County	22,990	6,593,782	52%	1,012	861,494	7%	24,205	5,010,441	40%	144	151,107	1%	48,351	51%	12,616,823	47%
Albany	14,930	4,636,894	66%	1,241	1,737,236	25%	3,917	232,468	3%	198	397,888	5.7%	20,286	22%	7,004,487	26%
Brownsville	746	193,845	68%	53	29,851	10%	504	40,770	14%	23	20,141	7%	1,326	1%	284,607	1%
Gates	200	46,518	66%	6	3,639	5%	116	18,222	26%	4	2,544	3.6%	326	0%	70,923	0%
Halsey	358	102,732	56%	29	34,096	19%	197	16,785	9%	18	29,310	16%	602	1%	182,922	1%
Harrisburg	1,323	344,311	63%	129	126,567	23%	436	26,628	5%	36	47,256	9%	1,924	2%	544,762	2%
Lebanon	5,888	1,638,905	61%	474	710,451	4%	2,321	130,414	5%	106	208,262	8%	8,789	9%	2,688,032	10%
Lyons	597	156,943	70%	54	27,487	12%	413	33,622	15%	10	5,837	3%	1,074	1%	223,889	1%
Mill City	619	173,300	73%	20	7,952	3%	404	25,460	11%	17	30,754	13%	1,060	1%	237,466	1%
Millersburg	1,286	429,295	49%	333	361,323	41%	425	82,468	9%	5	5,213	1%	2,049	2%	878,299	3%
Scio	383	107,495	69%	26	16,197	10%	182	20,337	13%	10	12,661	8%	601	1%	156,690	1%
Sodaville	192	34,236	70%	1	59	0%	70	6,451	13%	8	8,207	17%	271	0%	48,953	0%
Sweet Home	3,897	955,074	65%	334	215,248	15%	1,982	154,626	11%	100	141,621	10%	6,313	7%	1,466,569	5%
Tangent	597	126,291	31%	155	210,726	52%	299	55,031	14%	13	15,037	4%	1,064	1%	407,086	2%
Waterloo	117	24,954	76%	1	306	1%	82	6,365	19%	3	1,225	4%	203	0%	32,851	0%
Total	54,123	15,564,575	58%	3,870	4,342,787	16%	35,553	5,860,089	22%	695	1,077,063	4%	94,241	100%	26,844,514	100%

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

(all dollar amounts in thousands)

	Total Number of Buildings	Total Estimated Building Value (\$)	Total Earthquake Damage							
			Buildings Damaged				All Buildings Changed to At Least Moderate Code			
			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. Linn Co	45,792	12,020,435	4942	1169	1139943	9.5%	3535	818	844982	7.0%
Cascadia	231	27,896	9	1	576	2.1%	1	0	242	0.9%
Crabtree	459	97,309	107	26	14269	15%	90	22	12665	13%
Crawfordsville	374	80,383	84	19	11322	14%	61	15	8841	11%
Holley	380	79,188	19	4	3280	4.1%	16	4	2617	3.3%
Lacomb	535	126,968	4	0	2872	2.3%	0	0	1216	1.0%
Peoria	136	25,591	21	7	2524	9.9%	13	2	1646	6.4%
Shedd	248	107,103	34	9	18286	17%	22	4	10587	9.9%
West Scio	198	52,104	61	15	8295	16%	40	10	6962	13%
Total Unincorp. County	48,351	12,616,823	5280	1249	1201367	9.5%	3778	875	889757	7.1%
Albany	20,286	7,004,487	2770	629	761814	11%	1707	361	523660	7.5%
Brownsville	1,326	284,607	185	45	26403	9.3%	128	31	19658	6.9%
Gates	326	70,923	0	0	90	0.1%	0	0	76	0.1%
Halsey	602	182,922	65	14	19449	11%	46	10	15402	8.4%
Harrisburg	1,924	544,762	331	72	65087	12%	193	38	45143	8.3%
Lebanon	8,789	2,688,032	1703	389	333389	12%	1364	326	295221	11%
Lyons	1,074	223,889	111	16	12906	5.8%	45	9	8854	4.0%
Mill City	1,060	237,466	32	2	5647	2.4%	5	0	2583	1.1%
Millersburg	2,049	878,299	225	54	83644	9.5%	169	40	72963	8.3%
Scio	601	156,690	158	38	25128	16%	120	30	20757	13%
Sodaville	271	48,953	12	0	1421	2.9%	2	0	692	1.4%
Sweet Home	6,313	1,466,569	302	31	42142	3%	98	18	26290	2%
Tangent	1,064	407,086	256	60	53119	13%	122	18	38906	10%
Waterloo	203	32,851	52	11	4867	15%	39	10	4230	13%
Total	94,241	26,844,514	11483	2611	2636474	10%	7816	1765	1964193	7%

Table B-3. Turner and Mill Creek Fault Mw-6.6 Earthquake loss estimates.

	<i>(all dollar amounts in thousands)</i>									
	Total Earthquake Damage									
	Total Number of Buildings	Total Estimated Building Value (\$)	Buildings Damaged				All Buildings Changed to At Least Moderate Code			
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. Linn Co (rural)	45,792	12,020,435	4,062	1243	988,024	8.2%	3,519	888	816,282	6.8%
Cascadia	231	27,896	0	0	97	0.3%	0	0	48	0.2%
Crabtree	459	97,309	112	35	18,234	19%	105	26	16,036	17%
Crawfordsville	374	80,383	33	7	5,280	6.6%	27	7	4,328	5.4%
Holley	380	79,188	7	2	1,250	1.6%	6	1	1,049	1.3%
Lacomb	535	126,968	4	0	2,083	1.6%	2	0	1,198	0.9%
Peoria	136	25,591	2	0	348	1.4%	0	0	166	0.6%
Shedd	248	107,103	4	0	2,834	2.6%	1	0	1,445	1.3%
West Scio	198	52,104	56	39	14,667	28%	60	20	12,317	24%
Total Unincorp. County	48,351	12,616,823	4280	1,327	1,032,817	8.2%	3,721	942	852,869	6.8%
Albany	20,286	7,004,487	2316	751	704,757	10%	1,809	446	527,340	7.5%
Brownsville	1,326	284,607	100	24	14,540	5.1%	85	20	12,659	4.4%
Gates	326	70,923	4	0	2,366	3.3%	0	0	25	0.0%
Halsey	602	182,922	2	0	1,554	0.8%	1	0	1,071	0.6%
Harrisburg	1,924	544,762	5	0	2,879	0.5%	2	0	1,625	0.3%
Lebanon	8,789	2,688,032	1514	381	360,459	13%	1,367	334	321,375	12%
Lyons	1,074	223,889	61	14	9,901	4.4%	42	9	7,848	3.5%
Mill City	1,060	237,466	4	0	1,771	0.7%	1	0	895	0.4%
Millersburg	2,049	878,299	312	135	158,516	18%	301	86	141,041	16%
Scio	601	156,690	161	82	39,966	26%	155	45	31,226	20%
Sodaville	271	48,953	4	1	560	1.1%	2	0	309	0.6%
Sweet Home	6,313	1,466,569	46	7	12,508	1%	30	6	8,511	1%
Tangent	1,064	407,086	86	16	21,920	5%	45	7	16,634	4%
Waterloo	203	32,851	40	10	4,291	13%	34	8	3,815	12%
Total Study Area	94,241	26,844,514	8,937	2,748	2,368,805	9%	7,595	1,904	1,927,244	7%

Table B-4. 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. Linn Co	45,792	12,020,435	520	42,212	0.4%	1,243	70,483	0.6%	1,574	89,881	0.7%	3,566	216,505	1.8%
Cascadia	231	27,896	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Crabtree	459	97,309	0	0	0%	0	0	0%	0	0	0%	23	366	0.4%
Crawfordsville	374	80,383	2	42	0.1%	14	170	0.2%	30	394	0.5%	40	1,144	1.4%
Holley	380	79,188	0	0	0%	0	0	0%	1	3	0%	2	14	0%
Lacomb	535	126,968	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Peoria	136	25,591	1	0	0%	1	3	0%	1	4	0%	1	7	0%
Shedd	248	107,103	44	2,115	2.0%	44	2,647	2.5%	44	2,397	2.2%	47	3,346	3.1%
West Scio	198	52,104	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total Unincorp. County	48,351	12,616,823	567	44,370	0.4%	1,302	73,303	0.6%	1,650	92,679	0.7%	3,679	221,383	1.8%
Albany	20,286	7,004,487	32	945	0%	48	1,912	0%	58	2,611	0.04%	121	7,647	0.1%
Brownsville	1,326	284,607	60	709	0.2%	96	1,204	0.4%	119	2,042	0.7%	574	15,907	5.6%
Gates	326	70,923	0	0	0%	0	0	0%	0	0	0%	1	35	0%
Halsey	602	182,922	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Harrisburg	1,924	544,762	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Lebanon	8,789	2,688,032	0	0	0%	0	0	0%	0	0	0%	19	1,699	0.1%
Lyons	1,074	223,889	0	0	0%	3	8	0%	6	70	0%	24	959	0.4%
Mill City	1,060	237,466	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Millersburg	2,049	878,299	1	11	0%	2	37	0%	5	61	0%	24	390	0%
Scio	601	156,690	22	60	0%	62	468	0.3%	87	914	0.6%	151	1,749	1.1%
Sodaville	271	48,953	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Sweet Home	6,313	1,466,569	14	211	0%	27	513	0%	39	796	0.1%	63	1,435	0.1%
Tangent	1,064	407,086	2	69	0%	5	96	0%	9	113	0%	14	180	0%
Waterloo	203	32,851	0	0	0%	0	0	0%	0	0	0%	0	0	0%
Total	94,241	26,844,514	698	46,374	0.2%	1,545	77,541	0.3%	1,973	99,287	0.4%	4,670	251,384	0.9%

Table B-5. 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. Linn Co	45,792	35,839	1,275	3.6%	1,735	3.8%	161
Cascadia	231	116	0	0%	0	0%	0
Crabtree	459	339	0	0%	0	0%	0
Crawfordsville	374	279	27	9.5%	35	9.4%	5
Holley	380	260	0	0%	1	0.3%	0
Lacomb	535	403	0	0%	0	0%	0
Peoria	136	97	0	0%	1	0.7%	0
Shedd	248	208	38	18%	44	18%	0
West Scio	198	105	0	0%	0	0%	0
Total Unincorp. County	48,351	37,644	1,340	3.6%	1,816	3.8%	166
Albany	20,286	48,668	108	0.2%	62	0.3%	4
Brownsville	1,326	1,846	180	9.7%	156	12%	37
Gates	326	493	0	0%	0	0%	0
Halsey	602	955	0	0%	0	0%	0
Harrisburg	1,924	3,660	0	0%	0	0%	0
Lebanon	8,789	20,320	0	0%	0	0%	0
Lyons	1,074	1,203	11	0.9%	8	0.7%	2
Mill City	1,060	1,671	0	0%	0	0%	0
Millersburg	2,049	3,207	9	0.3%	8	0.4%	3
Scio	601	949	210	22%	137	23%	50
Sodaville	271	357	0	0%	0	0%	0
Sweet Home	6,313	10,028	55	1%	46	1%	7
Tangent	1,064	1,218	4	0%	13	1%	4
Waterloo	203	216	0	0%	0	0%	0
Total	94,241	132,435	1,917	1%	2,246	2%	273

Table B-6. 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. Linn Co	45,792	12,020,435	3,096	671,204	5.6%	3,117	701,140	5.8%	7,806	1,624,967	14%
Cascadia	231	27,896	8	1,008	3.6%	33	3,584	13%	61	7,877	28%
Crabtree	459	97,309	0	0	0%	0	0	0%	7	1,243	1%
Crawfordsville	374	80,383	3	3,088	3.8%	16	2,618	3.3%	26	4,359	5%
Holley	380	79,188	11	2,104	2.7%	21	4,394	5.5%	109	19,787	25%
Lacomb	535	126,968	0	0	0%	7	1,157	0.9%	88	17,180	14%
Peoria	136	25,591	0	0	0%	1	29	0.1%	0	0	0%
Shedd	248	107,103	0	0	0%	0	0	0%	0	0	0%
West Scio	198	52,104	0	0	0%	0	0	0%	4	332	1%
Total Unincorp. County	48,351	12,616,823	3,118	677,404	5%	3,193	712,768	5.6%	8,101	1,675,746	13%
Albany	20,286	7,004,487	0	0	0%	17	3,518	0.1%	1,894	556,987	8%
Brownsville	1,326	284,607	0	0	0%	137	36,203	13%	176	35,725	13%
Gates	326	70,923	0	0	0%	0	0	0%	5	1,070	2%
Halsey	602	182,922	0	0	0%	0	0	0%	4	865	0.5%
Harrisburg	1,924	544,762	0	0	0%	0	0	0%	26	7,797	1.4%
Lebanon	8,789	2,688,032	0	0	0%	7	826	0%	231	57,292	2.1%
Lyons	1,074	223,889	0	0	0%	6	1,185	0.5%	105	19,639	8.8%
Mill City	1,060	237,466	0	0	0%	25	3,349	1.4%	101	19,374	8.2%
Millersburg	2,049	878,299	0	0	0%	3	291	0%	265	62,011	7.1%
Scio	601	156,690	0	0	0%	1	529	0.3%	15	3,637	2.3%
Sodaville	271	48,953	21	3,624	7.4%	13	2,207	4.5%	147	24,404	50%
Sweet Home	6,313	1,466,569	70	12,479	0.9%	100	21,256	1.4%	757	164,376	11%
Tangent	1,064	407,086	0	0	0%	0	0	0%	8	2,625	0.6%
Waterloo	203	32,851	0	0	0%	0	0	0%	7	702	2.1%
Total	94,241	26,844,514	3,209	693,507	2.6%	3,504	782,288	2.9%	11,842	2,632,249	9.8%

Table B-7. Channel migration exposure*(all dollar amounts in thousands)*

Community*	Total Number of Buildings	Total Population	Total Estimated Building Value (\$)	Channel Migration Hazard				
				Potentially Displaced Residents from channel migration Exposure	% Potentially Displaced Residents from channel migration Exposure	Number of Buildings Exposed	Building Value (\$)	Ratio of Exposure Value
Unincorp. Linn Co (rural)	45,792	35,839	12,020,435	290	0.8%	324	79,728	0.7%
Gates	326	493	70,923	33	6.6%	27	6,929	9.8%
Lyons	1,074	1,203	223,889	57	4.7%	22	8,509	3.8%
Mill City	1,060	1,671	237,466	128	7.7%	47	14,463	6.1%
Total Study Area	48,252	39,206	12,552,713	508	1.3%	420	109,629	0.9%

*Communities in table limited to communities within the study area of Appleby and others (2021).

Table B-8. 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. Linn Co	45,792	12,020,435	175	39,650	0%	2,076	400,106	3%	43,541	11,580,679	96%
Cascadia	231	27,896	21	2,051	7%	150	19,342	69%	60	6,503	23%
Crabtree	459	97,309	0	0	0%	12	1,198	1%	447	96,111	99%
Crawfordsville	374	80,383	0	0	0%	67	10,906	14%	307	69,477	86%
Holley	380	79,188	0	0	0%	8	956	1%	372	78,232	99%
Lacomb	535	126,968	0	0	0%	10	2,040	2%	525	124,928	98%
Peoria	136	25,591	0	0	0%	0	0	0%	136	25,591	100%
Shedd	248	107,103	0	0	0%	0	0	0%	248	107,103	100%
West Scio	198	52,104	0	0	0%	0	0	0%	198	52,104	100%
Total Unincorp. County	48,351	12,616,823	196	41,701	0%	2,323	434,548	3%	45,832	12,140,575	96%
Albany	20,286	7,004,487	0	0	0%	73	46,900	1%	20,213	6,957,587	99%
Brownsville	1,326	284,607	1	377	0.1%	69	19,474	7%	1,256	264,757	93%
Gates	326	70,923	22	5,249	7%	24	5,763	8%	280	59,911	84%
Halsey	602	182,922	0	0	0%	15	2,534	1.4%	587	180,389	99%
Harrisburg	1,924	544,762	0	0	0%	76	22,789	4.2%	1,848	521,973	96%
Lebanon	8,789	2,688,032	0	0	0%	153	54,052	2.0%	8,636	2,633,980	98%
Lyons	1,074	223,889	17	2,553	1.1%	177	29,417	13%	880	191,918	86%
Mill City	1,060	237,466	3	732	0.3%	150	32,445	14%	907	204,289	86%
Millersburg	2,049	878,299	0	0	0%	0	0	0%	2,049	878,299	100%
Scio	601	156,690	0	0	0%	7	1,996	1.3%	594	154,695	99%
Sodaville	271	48,953	0	0	0%	15	2,238	4.6%	256	46,715	95%
Sweet Home	6,313	1,466,569	84	16,365	1.1%	432	84,461	5.8%	5,797	1,365,743	93%
Tangent	1,064	407,086	0	0	0%	32	7,049	1.7%	1,032	400,036	98%
Waterloo	203	32,851	0	0	0%	2	370	1.1%	201	32,481	99%
Total	94,241	26,844,514	323	66,977	0.2%	3,548	744,035	2.8%	90,370	26,033,502	97%

Table B-9. Volcanic lahar hazard exposure.

Community	Total Number of Buildings	Total Estimated Building Value (\$)	Small: (100 to 1,000-yr)			Medium: (1,000 to 15,000-yr)			Large: (>15,000-yr)		
			Number of Buildings	Loss Estimate	Percent of Building Value Exposed	Number of Buildings	Loss Estimate	Percent of Building Value Exposed	Number of Buildings	Loss Estimate	Percent of Building Value Exposed
Unincorp. Linn Co (rural)	45,792	12,020,435	67	11,771	0.1%	69	12,207	0.1%	1038	273,507	2.3%
Gates	326	70,923	0	0	0%	0	0	0%	216	49139	69%
Lyons	1,074	223,889	0	0	0%	0	0	0%	0	0	0%
Mill City	1,060	237,466	0	0	0%	0	0	0%	1059	237016	99%
Total	48,252	12,552,713	67	11,771	0.1%	69	12,207	0.1%	2313	559,662	4.5%

*Communities in table limited to communities within the study area of Walder and others (1999).

APPENDIX C. VULNERABILITY ASSESSMENT OF LIFELINES**Table C-1. Inventory of Linn County high hazard potential dams.**

Dam name	NID ID	Hazard	Owner/Operator	State	Purpose
		Potential		Regulated	
Sullivan Pond 3	OR04077	Significant	Private	Yes	Irrigation
Helms Reservoir	OR00455	Low	Private	Yes	Irrigation
Macedo Dairy Lagoon	OR03060	Low	Private	Yes	Other
American Can Dams (Lagoon)	OR00752	Low	Private	Yes	Other
Foster Log Pond	OR00159	High	Private	Yes	Other
Canal Intake	OR04067	Significant	Local Government	No	Water Supply
Trail Bridge Saddle Dike	OR00540	High	Public Utility	No	Hydroelectric
Smith Dam	OR00541	High	Public Utility	No	Hydroelectric
Lebanon Dam	OR04067	Low	Local Government	No	Water Supply
Trail Bridge	OR00540	High	Public Utility	No	Hydroelectric
Carmen Diversion	OR00539	Low	Public Utility	No	Hydroelectric
Green Peter Dam	OR00010	High	Federal	No	Flood Risk Reduction
Detroit Dam	OR00004	High	Federal	No	Flood Risk Reduction
Foster Dam	OR00012	High	Federal	No	Flood Risk Reduction

Table C-2. Inventory of Linn County Bridges

Bridge Name	Stream Name	Scour Risk from Flooding	Liquefaction High and Very High Susceptibility	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Volcanic Lahar - 1% Annual Chance
		Exposed	Exposed	Exposed	Exposed	Exposed	Exposed
Santiam River Oflow, Hwy 164 at MP 6.98	Santiam River Oflow	-	X	-	-	-	-
Santiam River Oflow, Hwy 164 at MP 7.12	Santiam River Oflow #4	X	X	-	-	-	-
North Santiam River, Hwy 211 (Mehama)	North Santiam River	X	X	-	X	-	-
Calapooia Bottoms, Hwy 58 at MP 11.19	Calapooia Bottom No. 2	-	X	-	-	-	-
Calapooia Bottoms, Hwy 58 at MP 13.96	Calapooia Bottoms No. 7	-	X	-	-	-	-
Willamette River, Hwy 31 EB (Ellsworth St)	Willamette River	X	X	-	-	-	-
Wiley Creek, Hwy 16	Wiley Creek	-	-	X	-	-	-
South Santiam River. McDowell Creek Rd	SOUTH SANTIAM RIVER	-	X	-	-	-	-
Santiam River, Hwy 164	Santiam River	-	X	-	X	-	-
South Santiam River, Hwy 211	South Santiam River	X	X	-	-	-	-
Sheep Creek, Hwy 16	Sheep Creek	-	-	X	-	-	-
Santiam River, Hwy 162 Conn Rt	North Santiam River	-	-	-	X	-	-
South Santiam River, County Rd 721	SOUTH SANTIAM RIVER	X	X	-	-	-	-
Calapooia River, Hwy 58	Calapooia River	X	X	-	-	-	-
Calapooia River, Main St	CALAPOOIA RIVER	X	X	-	-	-	-

Multi-Hazard Risk Report for Linn County, Oregon: Appendix C—Vulnerability Assessment of Lifelines

Bridge Name	Stream Name	Scour Risk from Flooding	Liquefaction High and Very High Susceptibility	Landslide High and Very High Susceptibility	Channel Migration Zone	Wildfire High or Moderate Risk	Volcanic Lahar - 1% Annual Chance
		Exposed	Exposed	Exposed	Exposed	Exposed	Exposed
Hwy 58 over City Street & UPRR	City Street & UPRR	-	-	-	-	-	-
North Santiam River, Sorbin Ave	NORTH SANTIAM RIVER	-	-	X	X	-	X
Willamette River, Hwy 210 EB (Van Buren Ave)	Willamette River	X	X	-	-	-	-
North Fork Santiam River, Jefferson Scio Dr	N FORK SANTIAM RIVER	-	X	-	X	-	-
South Santiam River, Berlin Rd	SOUTH SANTIAM RIVER	-	X	-	-	-	-
Santiam River, Hwy 1 SB	Santiam River	-	X	-	X	-	-
Dever-Conner Road over Hwy 1	I-5 (Hwy 1)	-	X	-	-	-	-
Viewcrest Rd over Hwy 1	I-5 (HWY 1)	-	-	-	-	-	-
Hwy 16 over Hwy 1 & Conns	I-5 (Hwy 1)	-	-	-	-	-	-
Grand Prairie Drive over Hwy 1	I-5 (HWY 1)	-	-	-	-	-	-
Seven Mile Lane over Hwy 1	I-5 (HWY 1)	-	-	-	-	-	-
Hwy 210 over Hwy 1	I-5 (Hwy 1)	X	-	-	-	-	-
Willamette River, Hwy 210 WB (Harrison Blvd)	Willamette River	X	X	-	-	-	-
Willamette River, Hwy 31 WB (Lyon St)	Willamette River	X	X	-	-	-	-
Calapooia River, Hwy 210	Calapooia River	X	X	-	-	-	-
Muddy Creek, Oakville Rd	MUDDY CREEK	X	X	-	-	-	-
Little Muddy Creek, Rowland Rd	LITTLE MUDDY CREEK	X	X	-	-	-	-
Calapooia River, Calapooia River Rd	CALAPOOIA RIVER	X	-	-	-	-	-
Green Peter Reservoir, Quartzville Dr	GREEN PETER RESERVOIR	X	-	-	-	-	-
Muddy Creek, Fayetteville Dr	MUDDY CREEK	X	X	-	-	-	-
Overflow, Boston Mill Rd at MP 5.57	OVERFLOW	X	X	-	-	-	-
Santiam River, Hwy 1 NB	Santiam River	-	X	-	X	-	-
Hwy 1 NB over UPRR & Hwy 164	UPRR & Hwy 164	-	X	-	-	-	-
Santiam Oflow No 6, Hwy 1 NB at MP 239.85	Santiam Overflow No. 6	-	X	-	-	-	-
Whitewater Creek, Hwy 162	Whitewater Creek	-	-	-	-	-	X
Santiam Oflow No 6, Hwy 1 SB at MP 239.85	Santiam Overflow No. 6	-	X	-	-	-	-
Hwy 1 SB over UPRR & Hwy 164	UPRR & Hwy 164	-	X	-	-	-	-
South Santiam River, Grant St	SOUTH SANTIAM RIVER	-	X	-	-	-	-
Sodom Ditch, Hwy 1 NB	Sodom Ditch	-	X	-	-	-	-
Sodom Ditch, Hwy 1 SB	Sodom Ditch	-	X	-	-	-	-
Middle Fork Santiam River, Quartzville Dr	MIDDLE FORK SANTIAM R.	X	-	-	-	-	-
South Santiam River, Quartzville Rd	SOUTH SANTIAM RIVER	-	X	-	-	-	-

Table C-3. Lifeline Risk by Polk County Community

Lifeline by Community	UDF ID	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Mill Creek and Turner Fault Mw 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
		Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
UNINCORPORATED COUNTY						
High-occupancy building	113768					
Fuel Supply	175658					
Fuel Supply	179149		X			
Communication	143044					
Communication	147709			X		
Communication	121952					
Communication	169548					X
Communication	115026					
Communication	182231					
Communication	162089					X
Communication	161255					
Communication	176338					X
Communication	186154					X
Communication	186004					
Communication	173615					
Communication	174433	X				
Communication	291165				X	
Communication	176188					
ALBANY						
Elder Care	134986					
Financial Institution	146001			X		
Financial Institution	131712		X			
Financial Institution	133483					
Financial Institution	140100					
Financial Institution	140342		X	X		
Financial Institution	140186		X	X		
Financial Institution	140052					
Elder Care	126506		X			
Elder Care	130864					
Elder Care	136609					
Elder Care	137389					
Financial Institution	140026					
Financial Institution	139877		X	X		
Financial Institution	146156		X			
Elder Care	125871		X			
Elder Care	139223					
Elder Care	180205		X			
Elder Care	136719					

Multi-Hazard Risk Report for Linn County, Oregon: Appendix C—Vulnerability Assessment of Lifelines

Lifeline by Community	UDF ID	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Mill Creek and Turner Fault Mw 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
		Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Elder Care	132354		X	X		
Elder Care	189553			X		
Financial Institution	137586		X	X		
Financial Institution	137655		X			
Elder Care	132793					
CRAWFORDSVILLE						
Financial Institution	166695					
HALSEY						
Church	171597					
Fuel Supply	171711					
HARRISBURG						
Church	170032					
Financial Institution	170157					
LEBANON						
Elder Care	138068					
Community Center	104687					
Elder Care	113518					
Elder Care	106548					
Elder Care	112905					
Financial Institution	108433		X	X		
Financial Institution	108525					
Financial Institution	104476			X		
Elder Care	106562			X		
Financial Institution	108022					
Financial Institution	190602					
Food Distribution	110190		X	X		
Communications	191165					
Elder Care	110615					
Communications	105661					
Financial Institution	109254			X		
Financial Institution	113623					
Financial Institution	180113					
Elder Care	107961					
Elder Care	190379					
Financial Institution	108105			X		
Financial Institution	104835			X		
Financial Institution	113984		X	X		
LYONS						
High-occupancy Building	114515		X			X
US Post Office	114583					
Church	114822					

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Lifeline by Community	UDF ID	Flood 1% Annual Chance	CSZ 9.0 Earthquake Moderate to Complete Damage	Mill Creek and Turner Fault Mw 6.6 Moderate to Complete Damage	Landslide High and Very High Susceptibility	Wildfire High or Moderate Risk
		Exposed	>50% Prob.	>50% Prob.	Exposed	Exposed
Church	114833					
High-occupancy Building	114947					
MILLERSBURG						
Communications	146586			X		
SODAVILLE						
Church	153367					
Church	166090					
SWEET HOME						
Elder Care	158115					
Elder Care	160042				X	
Financial Institution	157358					
Financial Institution	157710					
Financial Institution	157923					
Financial Institution	158240					
Financial Institution	158317					
TANGENT						
High-occupancy Building	149484					
WATERLOO						
Food Distribution	152997		X	X		
Church	154516					

APPENDIX D. HAZUS METHODOLOGY

D.1 Software

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

D.2 User-Defined Facilities (UDF) Database

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

D.2.1 Locating buildings points

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

D.2.2 Attributing building points

Populating the required attributes for Hazus was achieved through a variety of approaches. The Linn County assessor database was used whenever possible, but in many cases that database did not provide the necessary information. The following is 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 Linn 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 Linn County assessor database. When not available, the year of “1900” was applied.
- **Square feet** – The size of the UDF is used to pro-rate the total improvement value for 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 within a census block. The value was obtained from DOGAMI’s building footprints; where (RES) footprints were not available, we used the Linn County assessor database.
- **Number of stories** – The number of stories for an individual UDF, along with Occupancy Class, determines the applied damage function for flood analysis. The value was obtained from the Linn 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 Linn 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 Linn 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 (Linn County Assessor) and state/regional Seismic Building Code benchmark years.
- **Number of people** – The estimated number of permanent residents living within an individual residential structure. It is used in the post-analysis phase to determine the amount of people affected by a given hazard. This attribute is derived from default Hazus database (United States Census Bureau, 2020a) of population per census block and distributed across residential UDFs and adjusted based on population growth estimates from PSU Population Research Center.
- **Community** – The community that a UDF is within. These areas are used in the post-analysis for reporting results. The communities were based on incorporated area boundaries; unincorporated community areas were based on building density.

D.2.3 Seismic building codes

Oregon initially adopted seismic building codes in the mid-1970s (Judson, 2012). The established benchmark years of code enforcement are used in determining a “design level” for individual buildings. The design level attributes (pre code, low code, moderate code, and high code) are used in the Hazus earthquake model to determine what damage functions are applied to a given building (FEMA, 2022b). The year built or the year of the most recent seismic retrofit are the main considerations for an individual design level attribute. Seismic retrofiting information for structures would be ideal for this analysis but was not available for Linn County. **Table D-1** outlines the benchmark years that apply to buildings within Linn County.

Table D-1. Linn County seismic design level benchmark years.

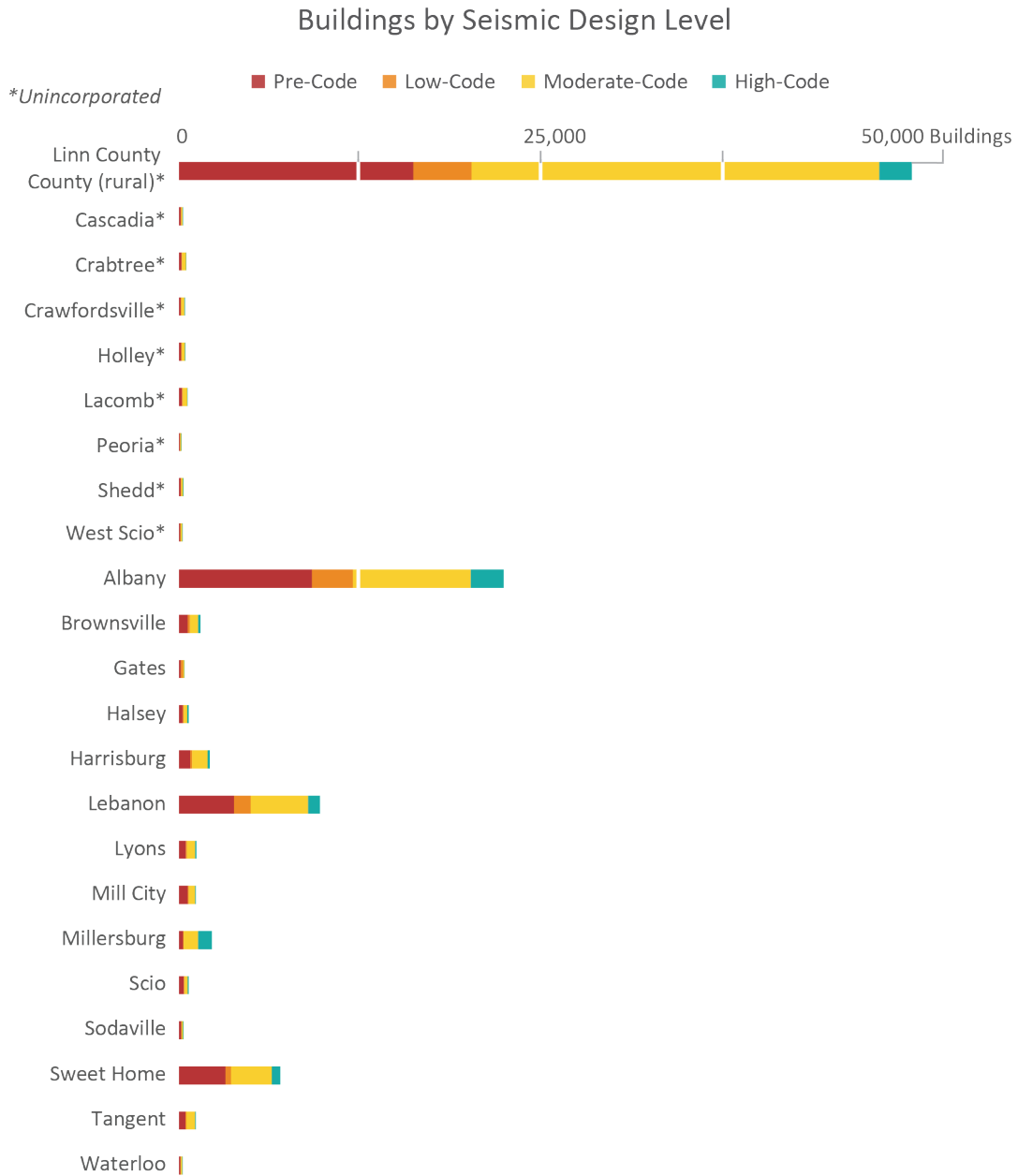
Building Type	Year Built	Design Level	Basis
Single-Family Dwelling (includes Duplexes)	prior to 1976	Pre Code	Interpretation of Judson (Judson, 2012)
	1976–1991	Low Code	
	1992–2003	Moderate Code	
	2004–2016	High Code	
Manufactured Housing	prior to 2003	Pre Code	Interpretation of OR BCD 2002 Manufactured 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	prior to 1976	Pre Code	Business Oregon 2024 Oregon Benefit-Cost Analysis Tool, p. 24 (Business Oregon, 2024)
	1976–1990	Low Code	
	1991–2016	Moderate Code	

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

Table D-2. Seismic design level in Linn 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. Linn Co	45,792	14,624	32%	3,653	8.0%	25,471	55.6%	2,044	4.5%
Cascadia	231	109	47%	21	9.1%	96	41.6%	5	2.2%
Crabtree	459	148	32%	25	5.4%	274	59.7%	12	2.6%
Crawfordsville	374	115	31%	14	3.7%	226	60.4%	19	5.1%
Holley	380	126	33%	30	7.9%	202	53.2%	22	5.8%
Lacomb	535	180	34%	50	9.3%	277	51.8%	28	5.2%
Peoria	136	63	46%	9	6.6%	57	41.9%	7	5.1%
Shedd	248	120	48%	6	2.4%	115	46.4%	7	2.8%
West Scio	198	75	38%	2	1.0%	119	60.1%	2	1.0%
Total Unincorp. County	48,351	15,560	32%	3,810	7.9%	26,835	55.5%	2,146	4.4%
Albany	20,286	8,305	41%	2,554	12.6%	7,365	36.3%	2,062	10.2%
Brownsville	1,326	539	41%	132	10.0%	530	40.0%	125	9.4%
Gates	326	104	32%	144	44.2%	74	22.7%	4	1.2%
Halsey	602	225	37%	63	10.5%	232	38.5%	82	13.6%
Harrisburg	1,924	693	36%	128	6.7%	966	50.2%	137	7.1%
Lebanon	8,789	3,440	39%	1,048	11.9%	3,588	40.8%	713	8.1%
Lyons	1,074	417	39%	60	5.6%	527	49.1%	70	6.5%
Mill City	1,060	532	50%	84	7.9%	389	36.7%	55	5.2%
Millersburg	2,049	247	12%	58	2.8%	880	42.9%	864	42.2%
Scio	601	297	49%	55	9.2%	173	28.8%	76	12.6%
Sodaville	271	149	55%	14	5%	97	35.8%	11	4.1%
Sweet Home	6,313	2,885	46%	376	6%	2,531	40%	521	8%
Tangent	1,064	395	37%	73	7%	534	50%	62	6%
Waterloo	203	93	46%	4	2%	96	47%	10	5%
Total	94,241	33,881	36%	8,603	9%	44,819	48%	6,938	7%

Figure D-1. Seismic design level by Linn County community.



D.3 Flood Hazard Data

Depth grids for “Zone A” designated flood zones, or approximate 100-year flood zones, were developed by the Strategic Alliance for Risk Reduction (STARR) in 2015 to revise the Linn County FIRMs (FEMA, 2016). DOGAMI developed depth grids from detailed stream model information within the study area. Both sets of 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.

D.4 Earthquake Hazard Data

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

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

D.5 Post-Analysis Quality Control

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

Identifying, verifying, and correcting (if needed) the outliers in the results is the most efficient way to improve the UDF database. This 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 E. ACRONYMS AND DEFINITIONS

E.1 Acronyms

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

E.2 Definitions

1% annual chance flood – The flood elevation that has a 1-percent chance of being equaled or exceeded each year. Sometimes referred to as the 100-year flood.

0.2% annual chance flood – The flood elevation that has a 0.2-percent chance of being equaled or exceeded each year. Sometimes referred to as the 500-year flood.

Base flood elevation (BFE) – Elevation of the 1-percent-annual-chance flood. This elevation is the basis of the insurance and floodplain management requirements of the NFIP.

Critical facilities – Facilities that, if damaged, would present an immediate threat to life, public health, and safety. As categorized in HAZUS, critical facilities include hospitals, emergency operations centers, police stations, fire stations and schools.

Exposure – Determination of whether a building is within or outside of a hazard zone. No loss estimation is modeled.

Flood Insurance Rate Map (FIRM) – An official map of a community, on which FEMA has delineated both the SFHAs and the risk premium zones applicable to the community.

Flood Insurance Study (FIS) – Contains an examination, evaluation, and determination of the flood hazards of a community and, if appropriate, the corresponding water-surface elevations.

Hazus – A GIS-based risk assessment methodology and software application created by FEMA and the National Institute of Building Sciences for analyzing potential losses from floods, hurricane winds, and earthquakes.

Lidar – A remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light. Lidar is popularly used as a technology to make high-resolution maps.

Liquefaction – Describes a phenomenon whereby a saturated soil substantially loses strength and stiffness in response to an applied stress, usually an earthquake, causing it to behave like liquid.

Loss Ratio – The expression of loss as a fraction of the value of the local inventory (total value/loss).

Magnitude – A scale used by seismologists to measure the size of earthquakes in terms of energy released.

Risk – Probability multiplied by consequence; the degree of probability that a loss or injury may occur 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.

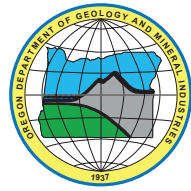
Susceptibility – Degree of proneness to natural hazards that is determined based on physical characteristics that are present.

Vulnerability – Characteristics that make people or assets more susceptible to a natural hazard.

APPENDIX F. MAP PLATES

See appendix folder for individual map PDFs.

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Population Density Map of Linn County, Oregon

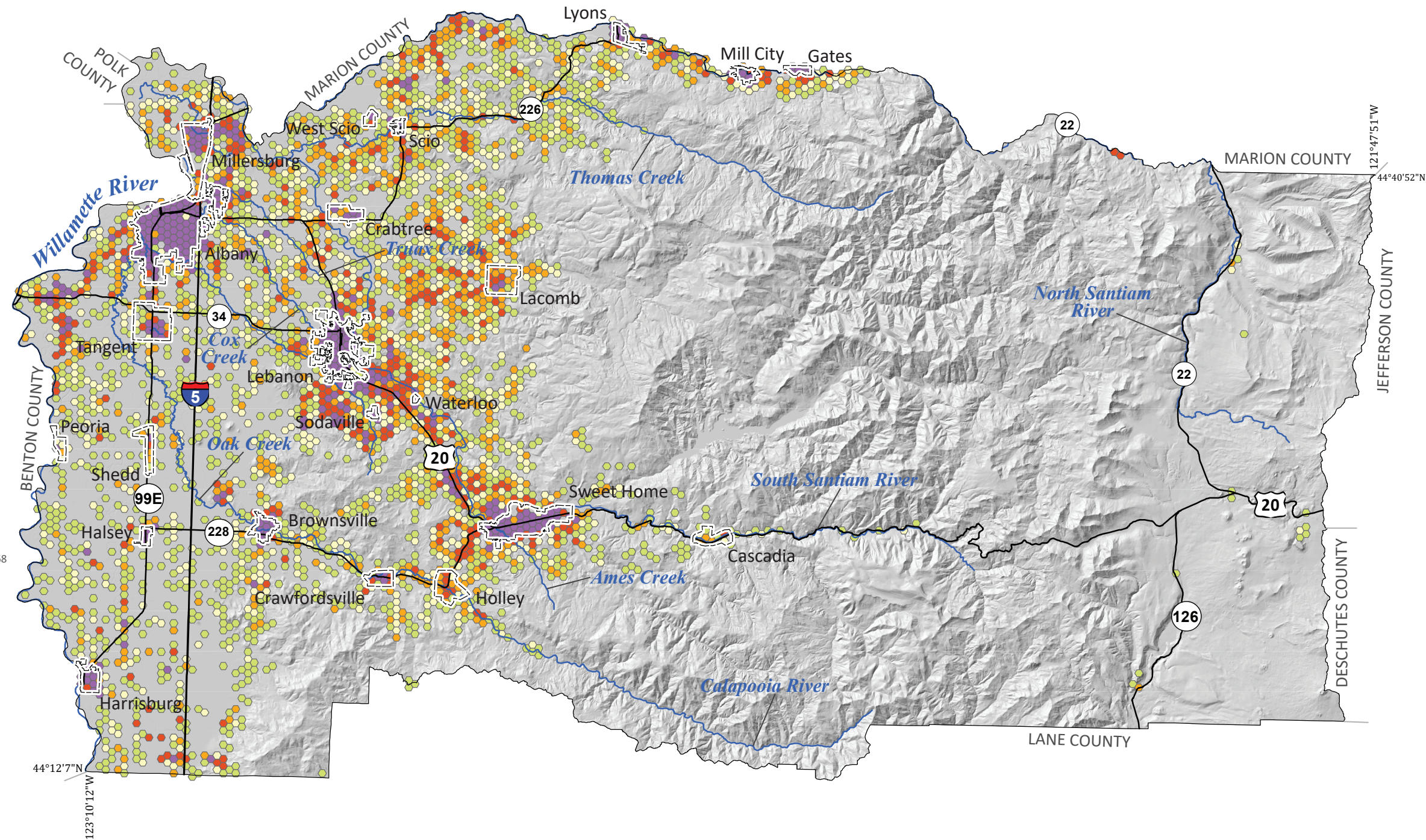
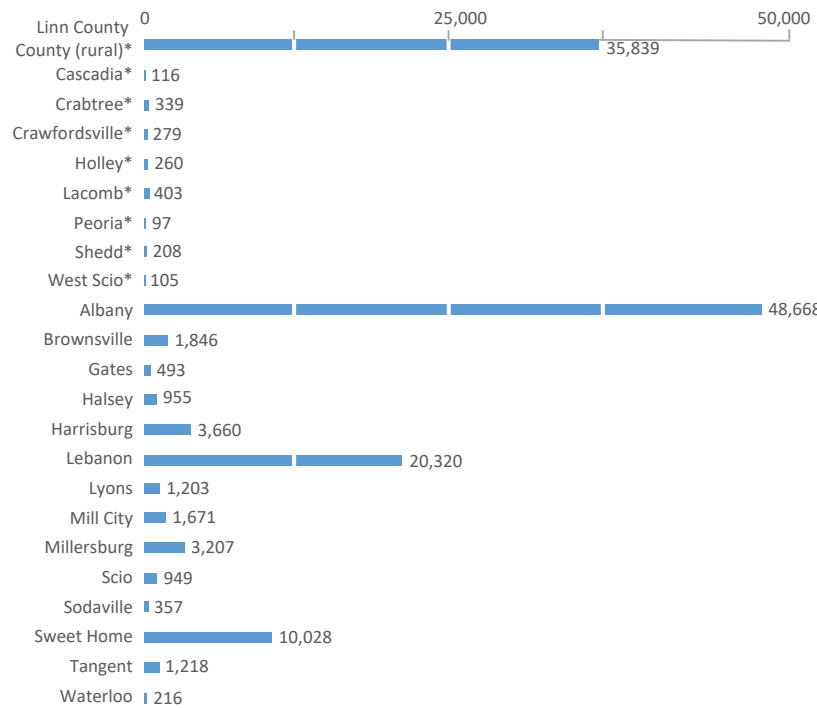
People per 50 acres

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

Population

■ Number of People

*Unincorporated



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, 2024

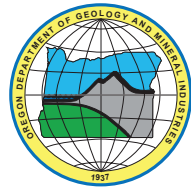


Study Location Map



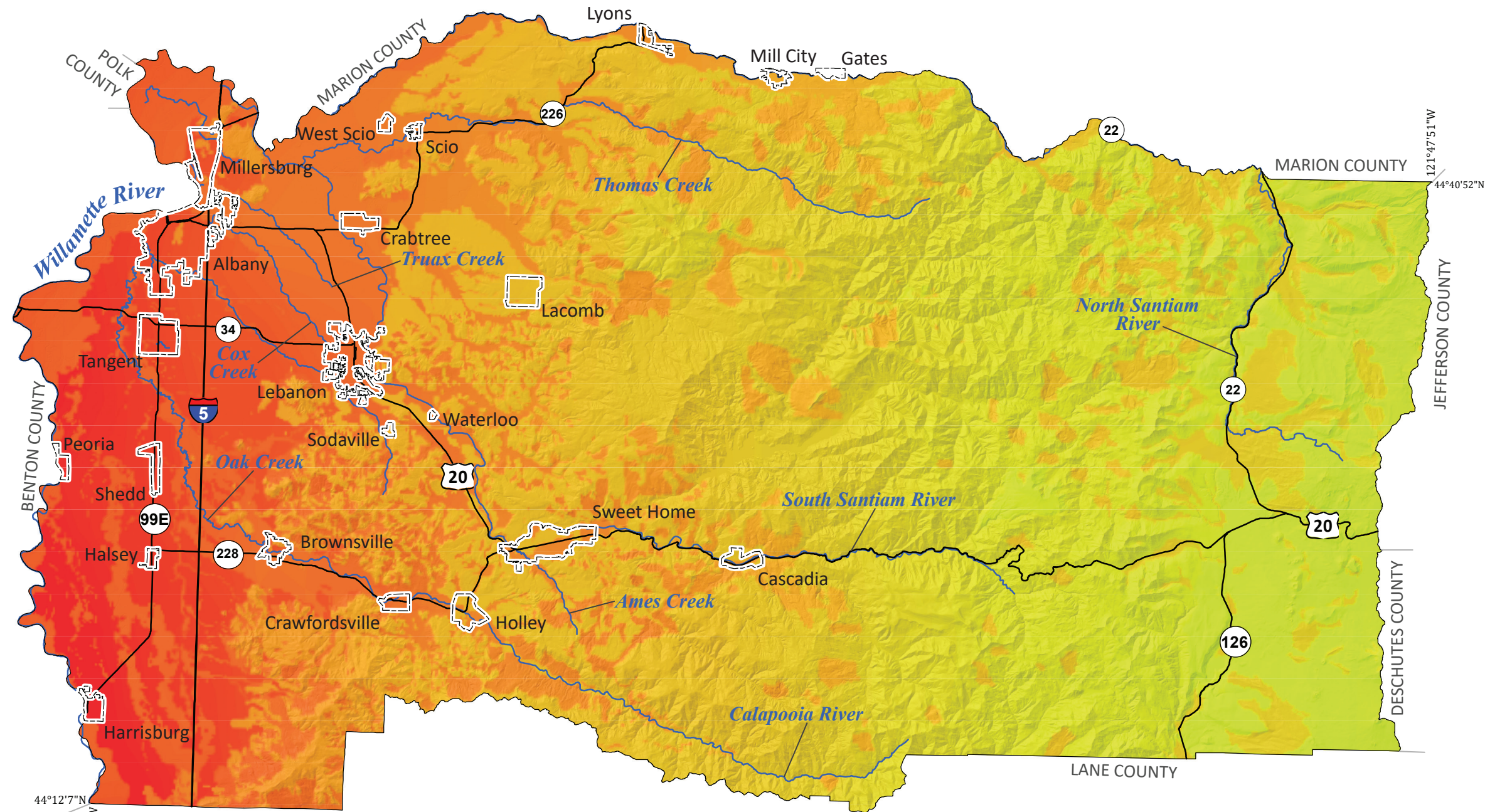
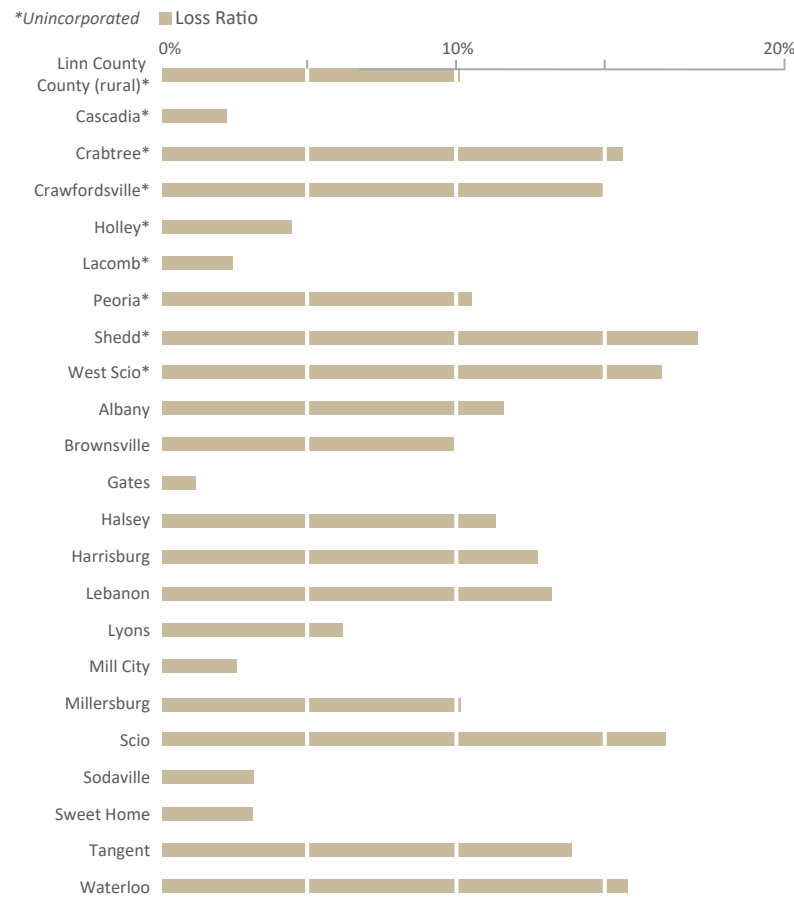
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CSZ Magnitude-9.0 Earthquake Shaking Map of Linn County, Oregon

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.



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



Study Location Map

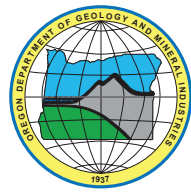


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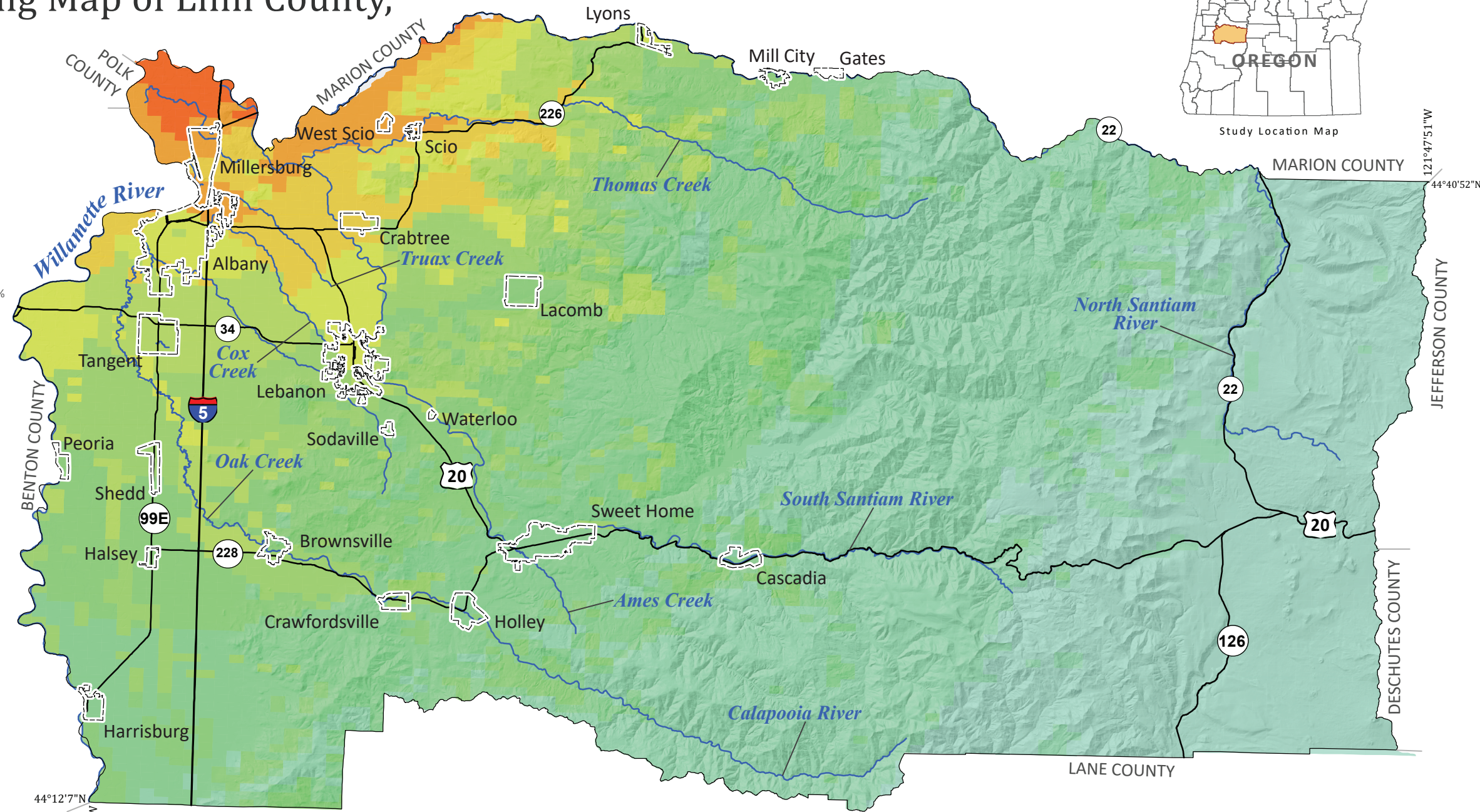
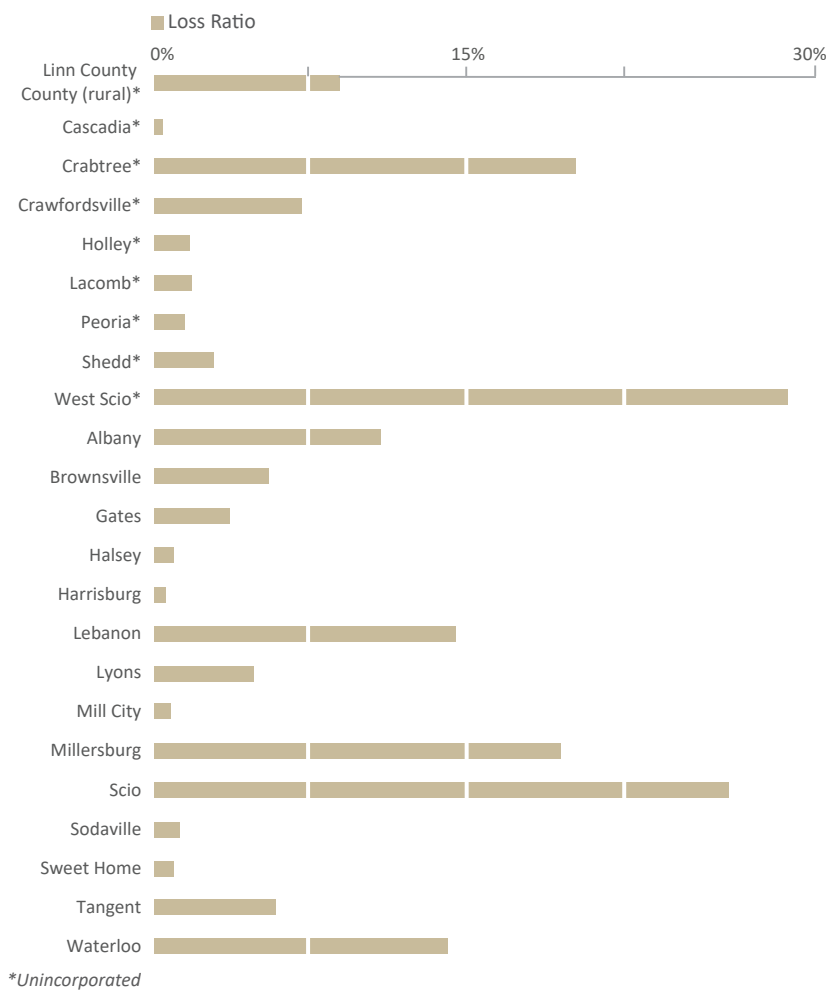
Data Sources:
 Earthquake peak ground acceleration: Madin and others (2021)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar 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, 2023

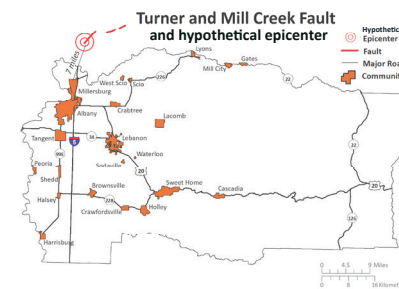


Turner and Mill Creek Fault Magnitude-6.6 Earthquake Shaking Map of Linn County, Oregon

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.

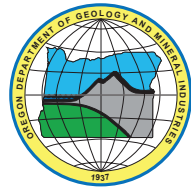


Modified Mercalli	Perceived Shaking	Potential Damage	Peak Ground Acceleration (g)
I	Not felt	None	< 0.000464
II	Weak	None	0.000464 - 0.00297
III	Weak	None	0.000464 - 0.00297
IV	Light	None	0.00297 - 0.0276
V	Moderate	Very Light	0.0276 - 0.115
VI	Strong	Light	0.115 - 0.215
VII	Very Strong	Moderate	0.215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



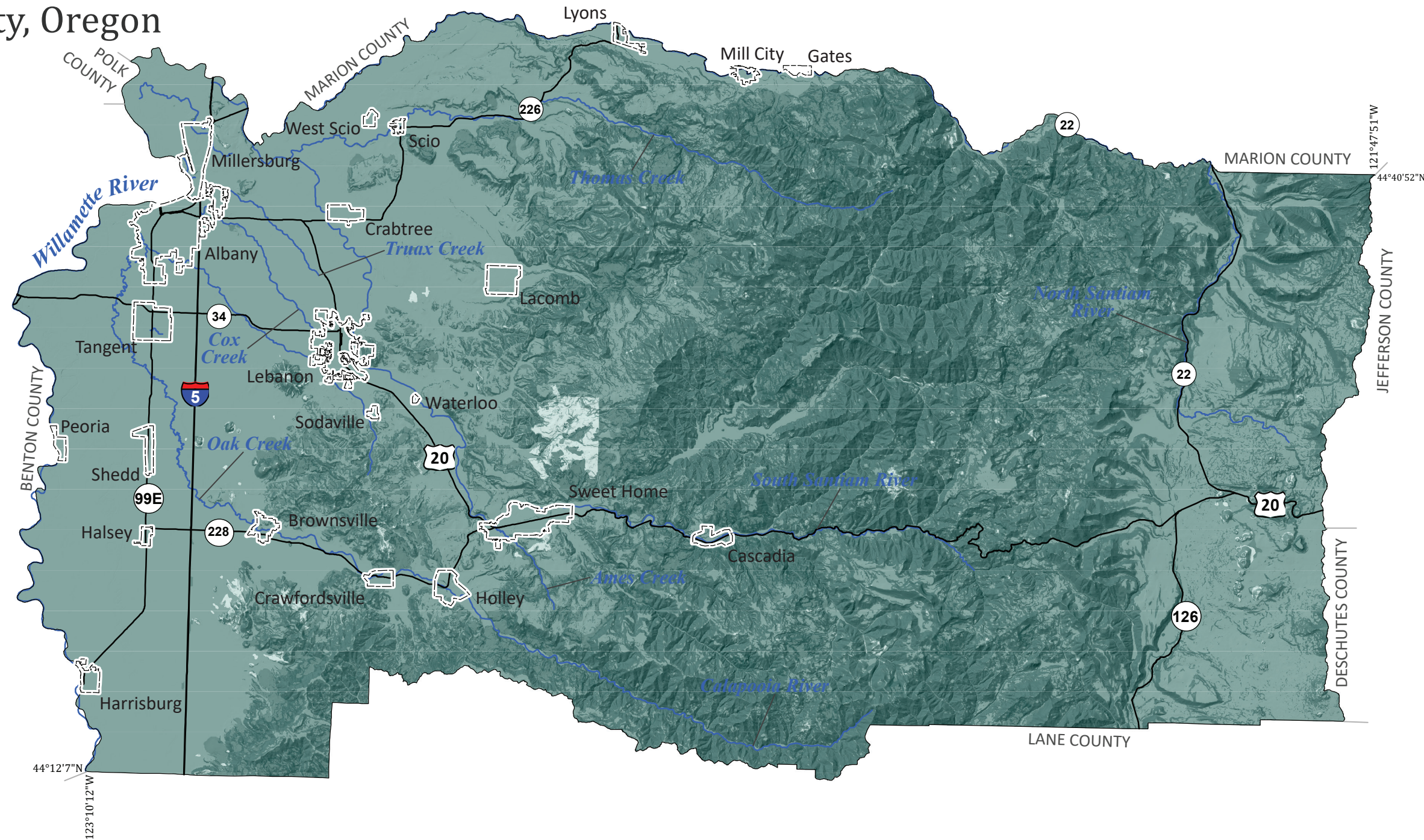
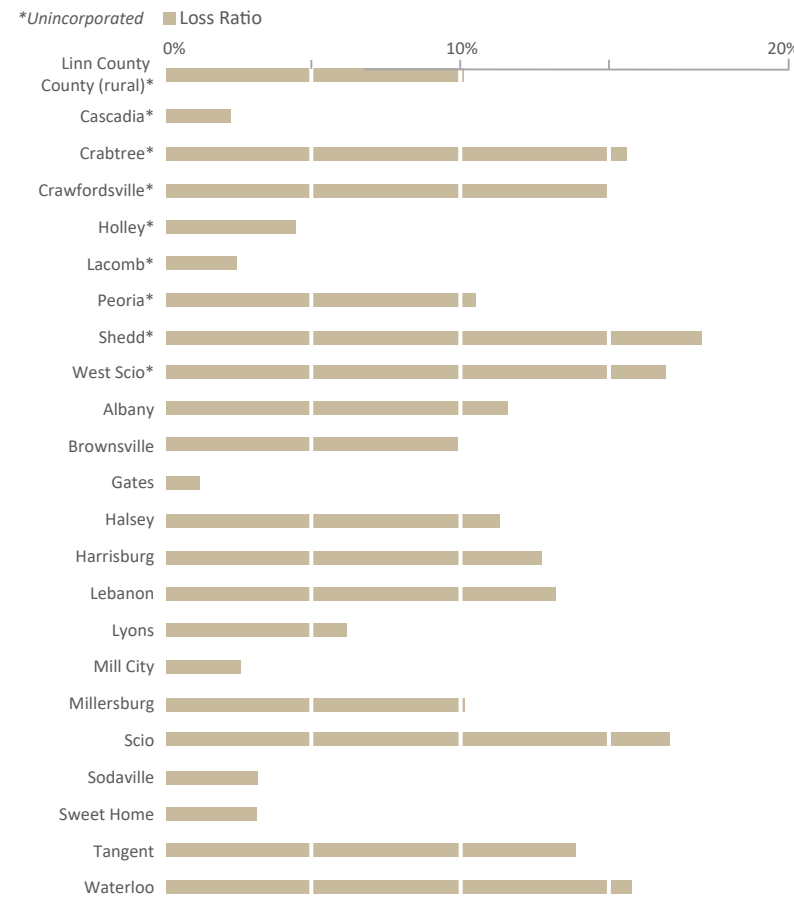
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Coseismic Landslide Susceptibility (Wet) Map of Linn County, Oregon

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.



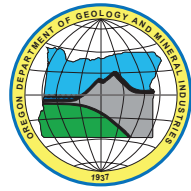
Data Sources:
 Coseismic Landslide (wet): Madin and others (2021)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (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, 2023



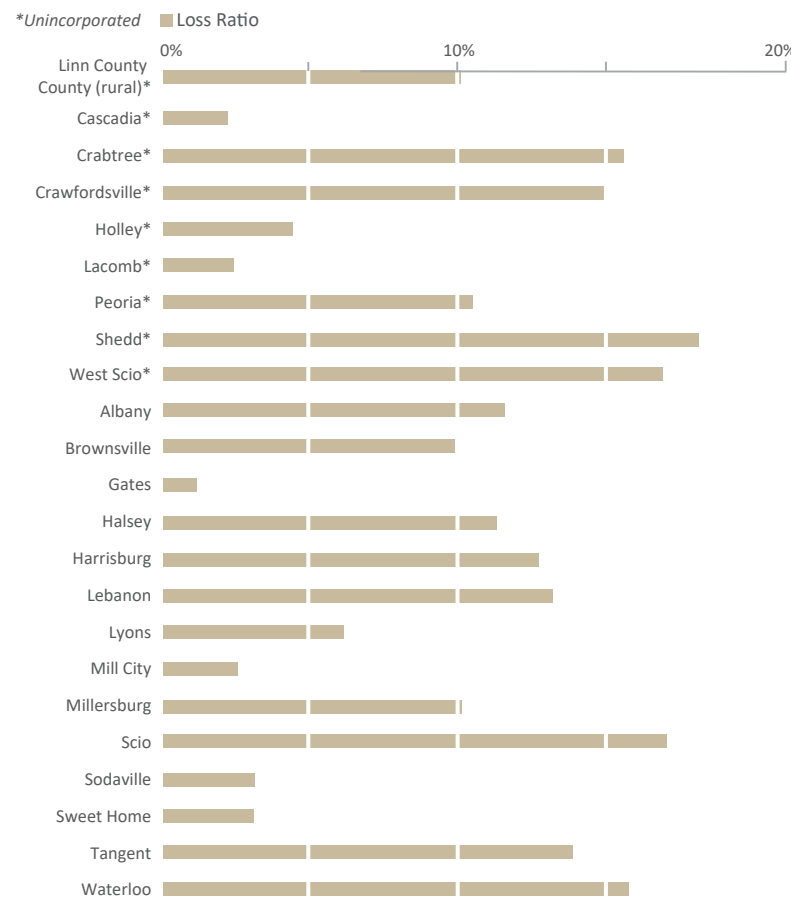
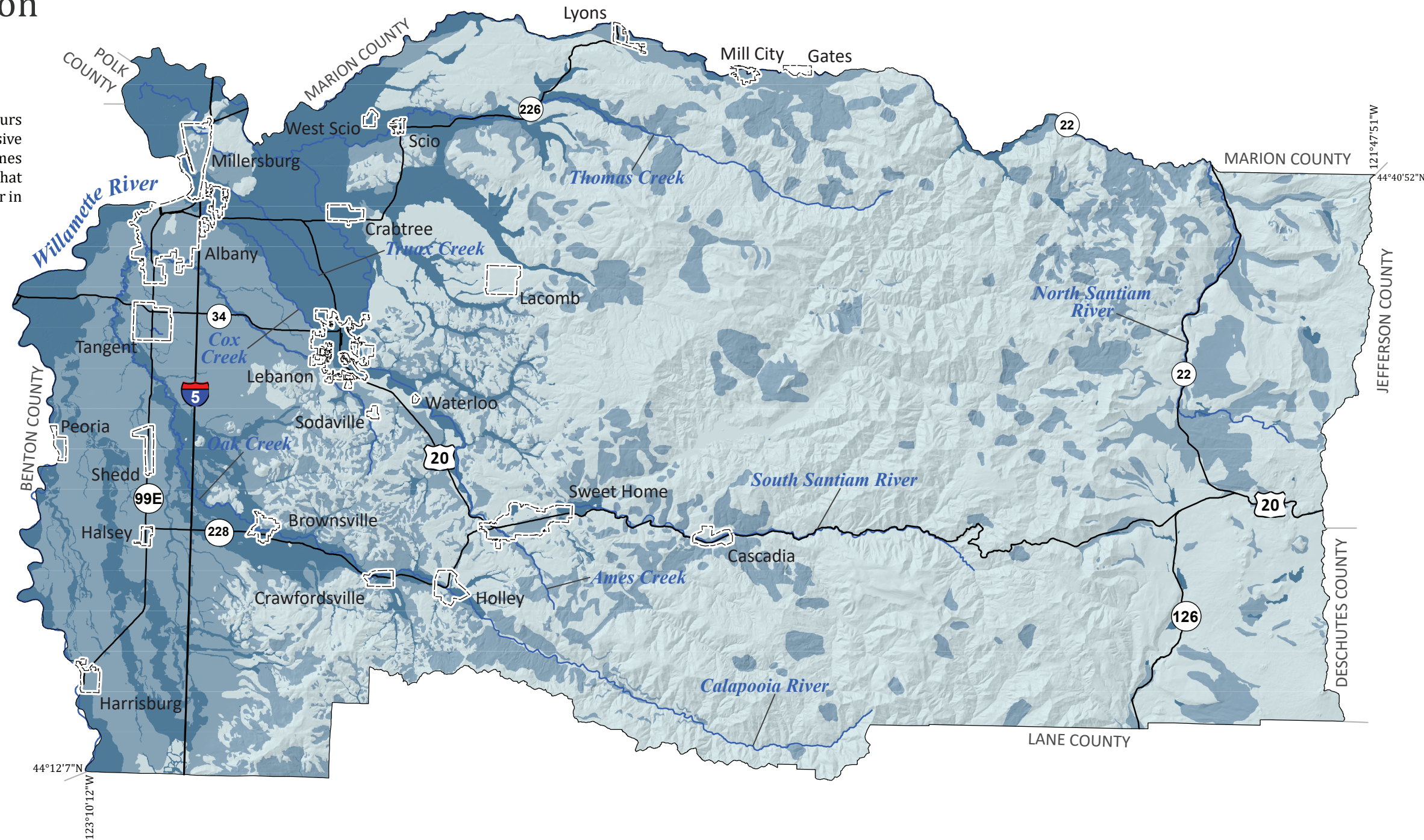
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Liquefaction Susceptibility Map of Linn County, Oregon

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.



Data Sources:

- Liquefaction susceptibility: Madin and others (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, 2023

Liquefaction Susceptibility

- Low or None
- Moderate
- High
- Very High

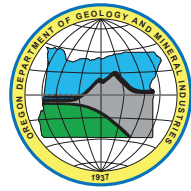


Study Location Map



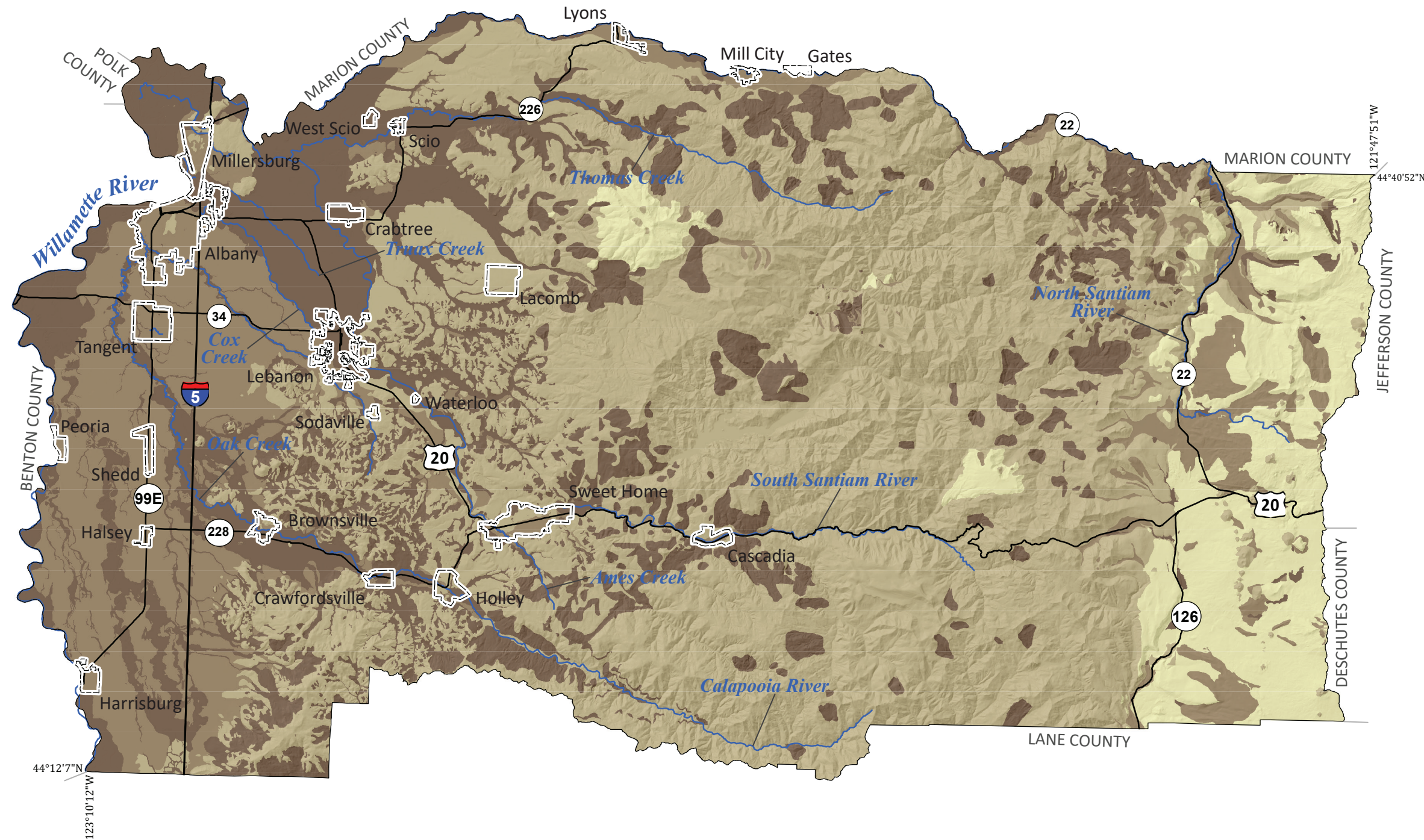
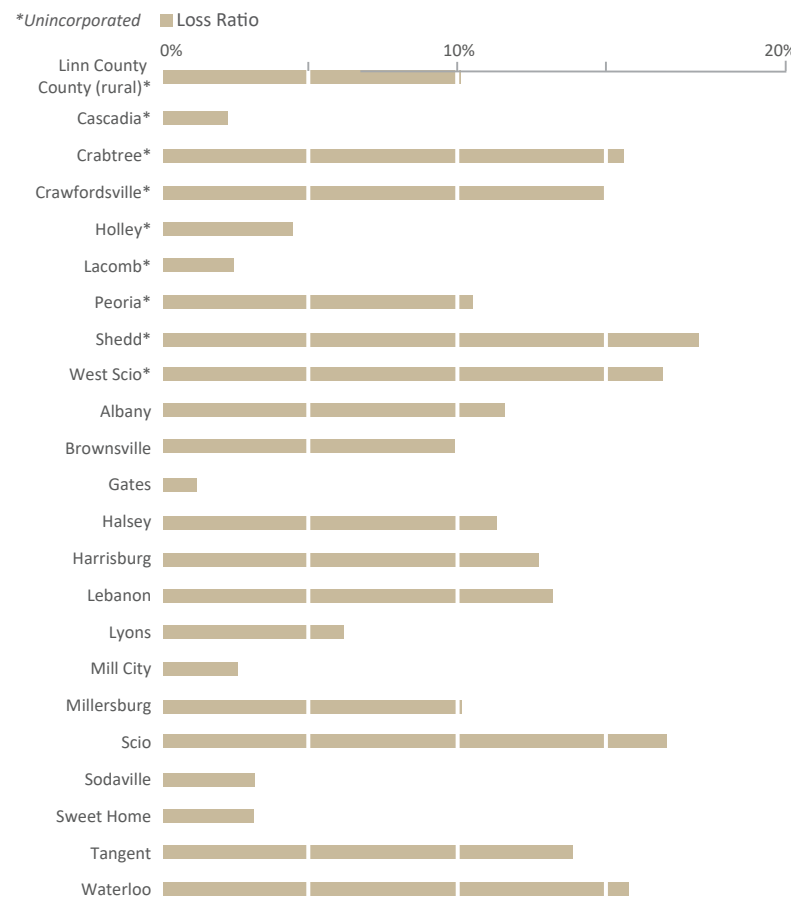
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Site Amplification Map of Linn County, Oregon

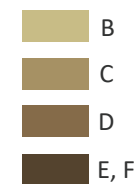
Site Amplification is the degree to which soil types attenuate (weaken) or amplify (strengthen) seismic waves produced from an earthquake. The National Earthquake Hazards Reduction Program (NEHRP) classifies these geologic units into soft rock (B), dense soil or soft rock (C), stiff soil (D), and soft 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



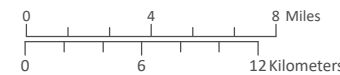
Data Sources:
 Soil amplification: Madin and others (2021)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (2014)
 Basemap: Oregon Lidar Consortium (2014)
 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, 2023

NEHRP Class

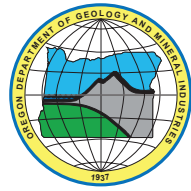


Study Location Map



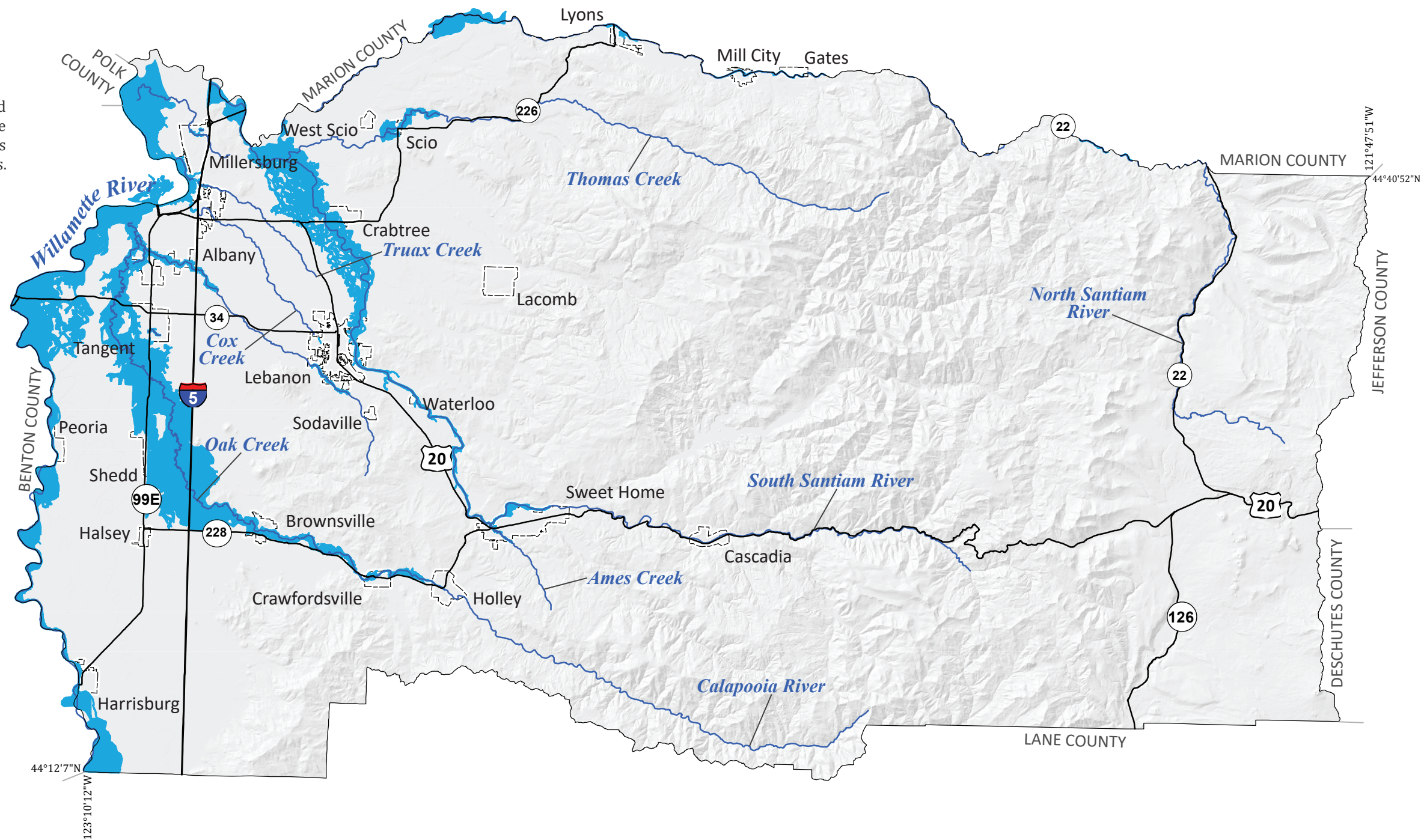
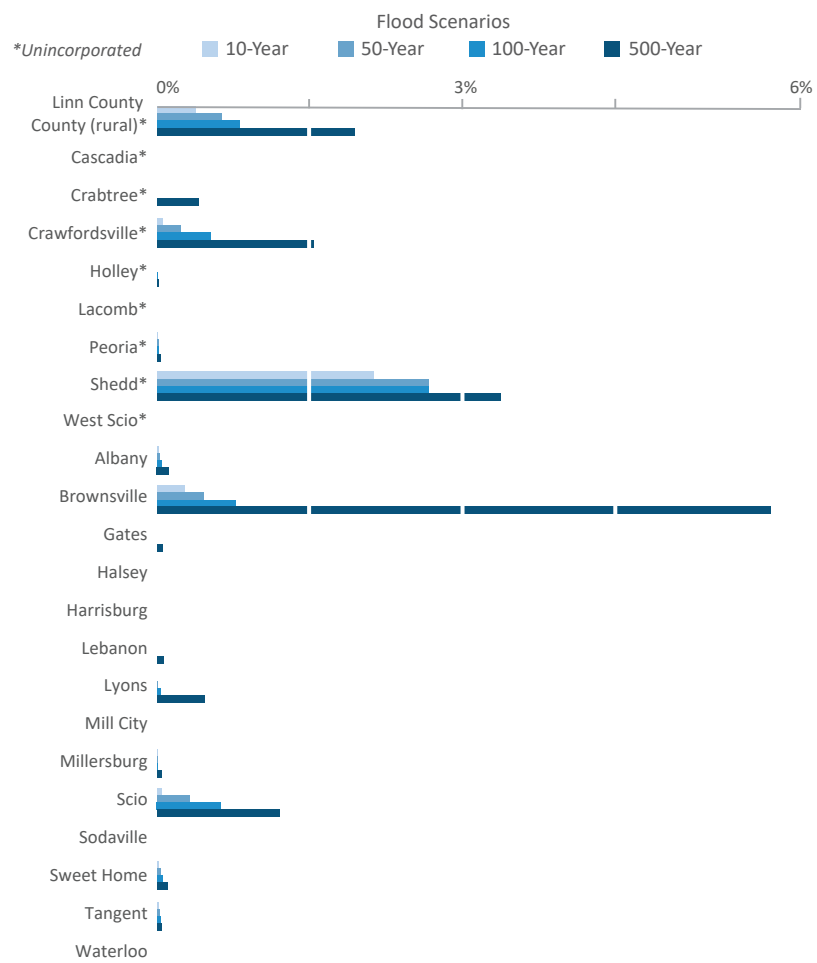
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Flood Hazard Map of Linn County, Oregon

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 Linn County's Digital Flood Insurance Rate Maps.



Data Sources:
 Flood hazard zone (100-year): Linn County Flood Insurance Rate Map (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, 2024

Flood Hazard Zone

100-Year Flood
 (1% annual chance)*

*Only 100-year scenario shown on map. Graph included shows 10-, 50-, 100-, 500-year results

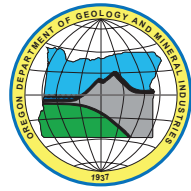


Study Location Map



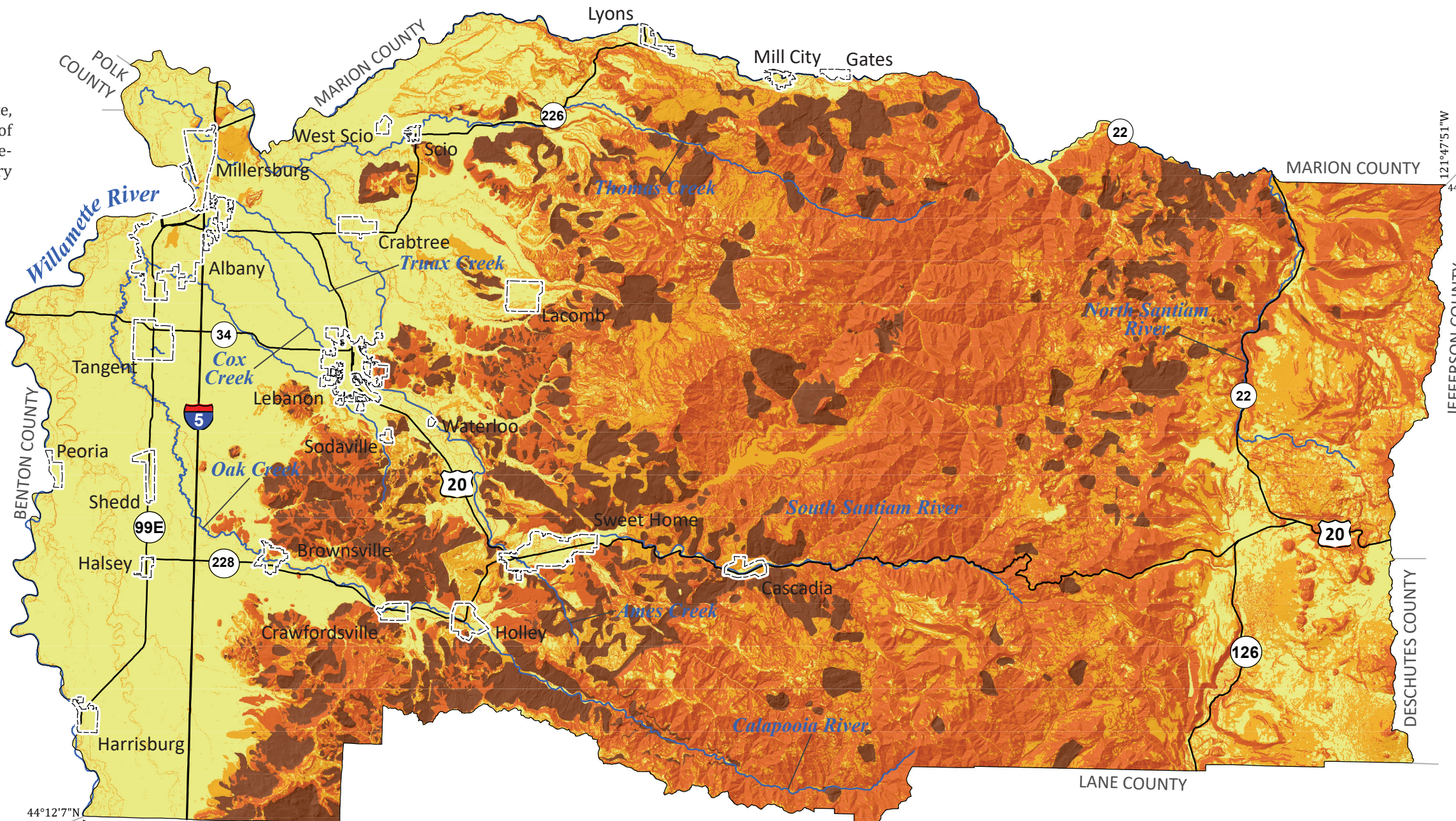
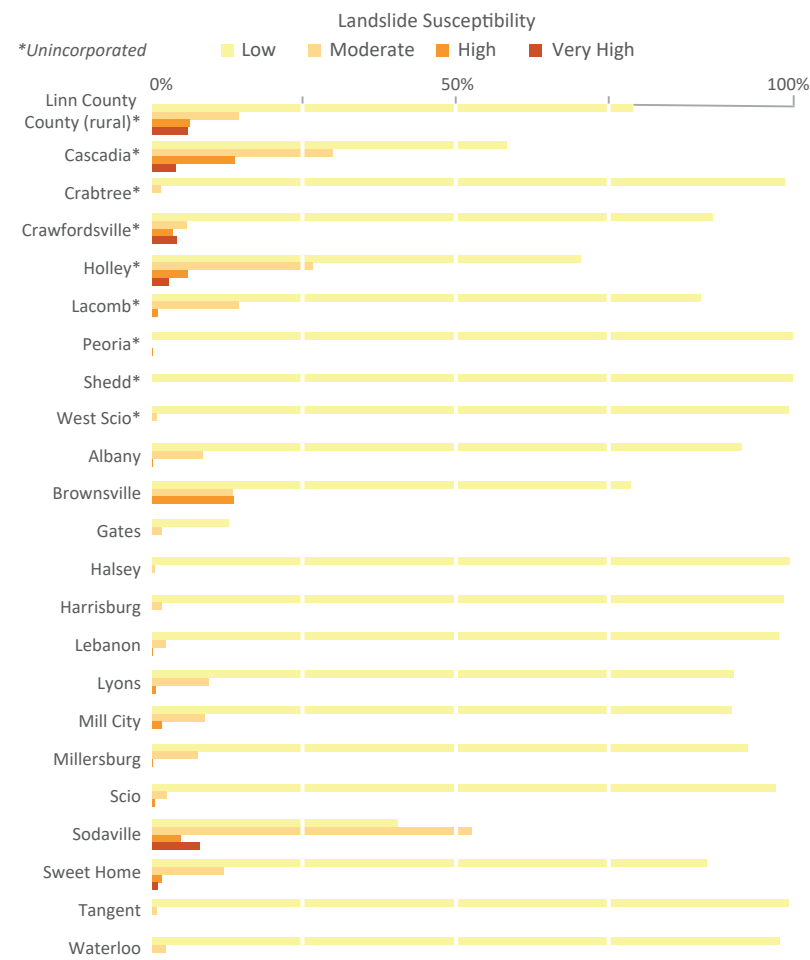
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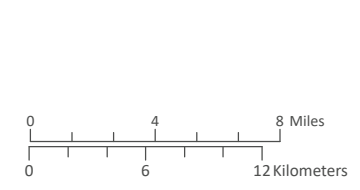
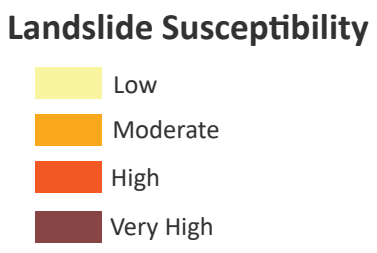
Landslide Susceptibility Map of Linn County, Oregon

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.



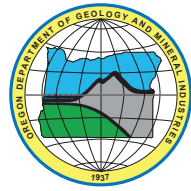
Data Sources:
 Landslide susceptibility: Oregon Department of Geology and Mineral Industries, Burns and others (2016)
 Roads: Oregon Department of Transportation Signed Routes (2013)
 Place names: U.S. Geological Survey Geographic Names Information System (2015)
 City limits: Oregon Department of Transportation (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, 2023



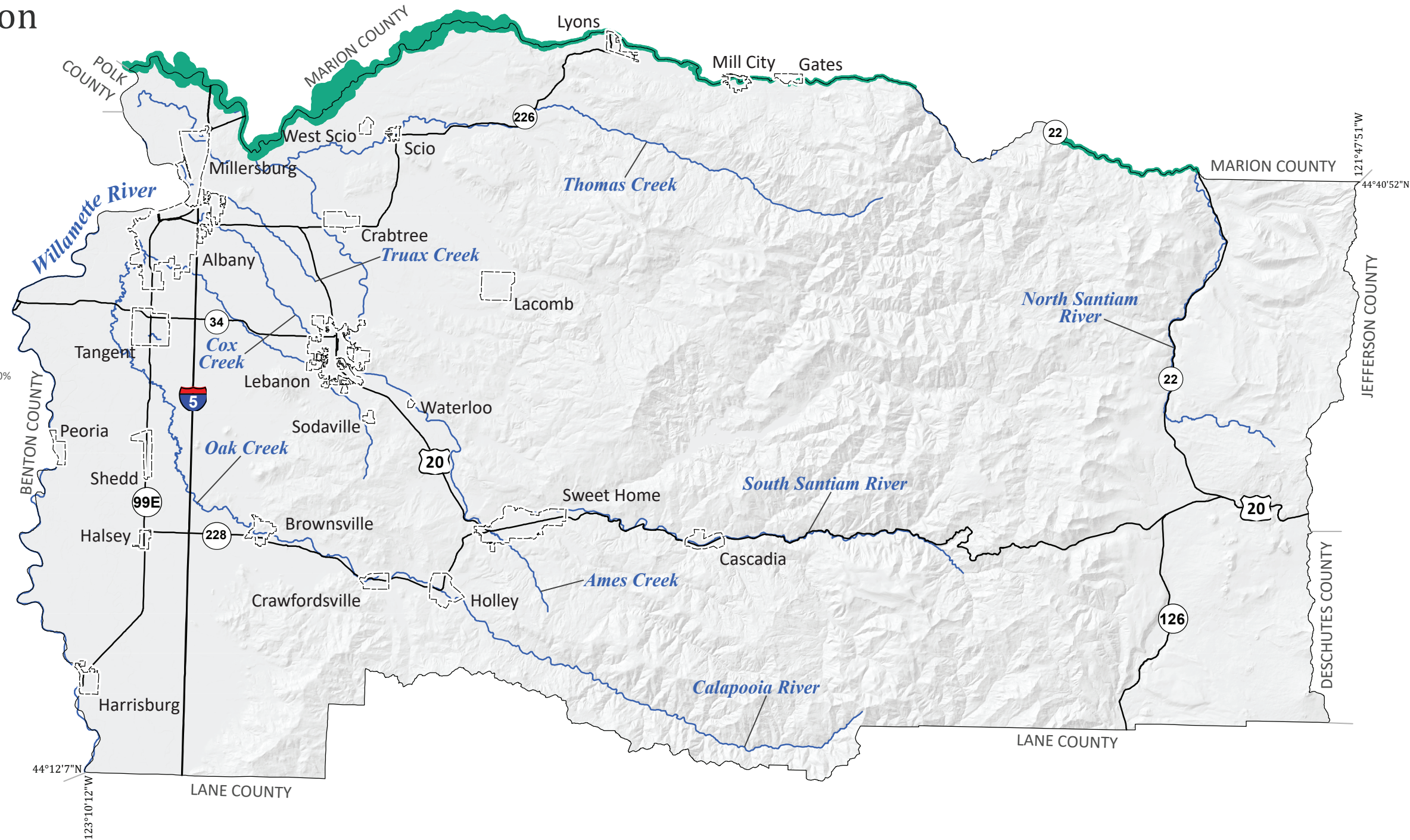
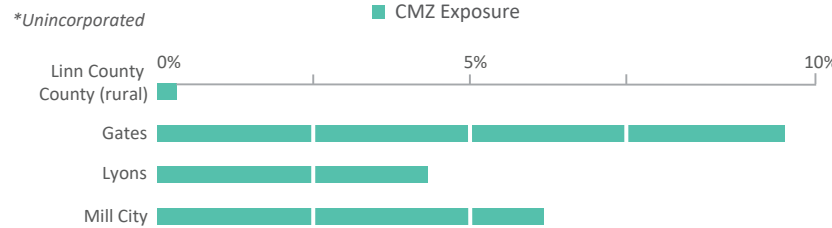
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Channel Migration Hazard Map of Linn County, Oregon

Channel migration is a process by which a stream's course changes over time due to bank erosion and stream deposition. The channel migration zone is defined by the 30-year Erosion Hazard Area (EHA). Shown are the 30-year EHA in Linn County. Buildings within these areas are at greater risk to channel migration hazard than other areas.



Data Sources:
 Channel migration zone (30-year): DOGAMI (Appleby and others, 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 UTM Zone 10N
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2024

Channel Migration Hazard Zone

30-Year Erosion

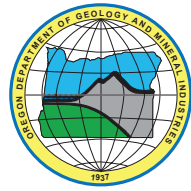


Study Location Map



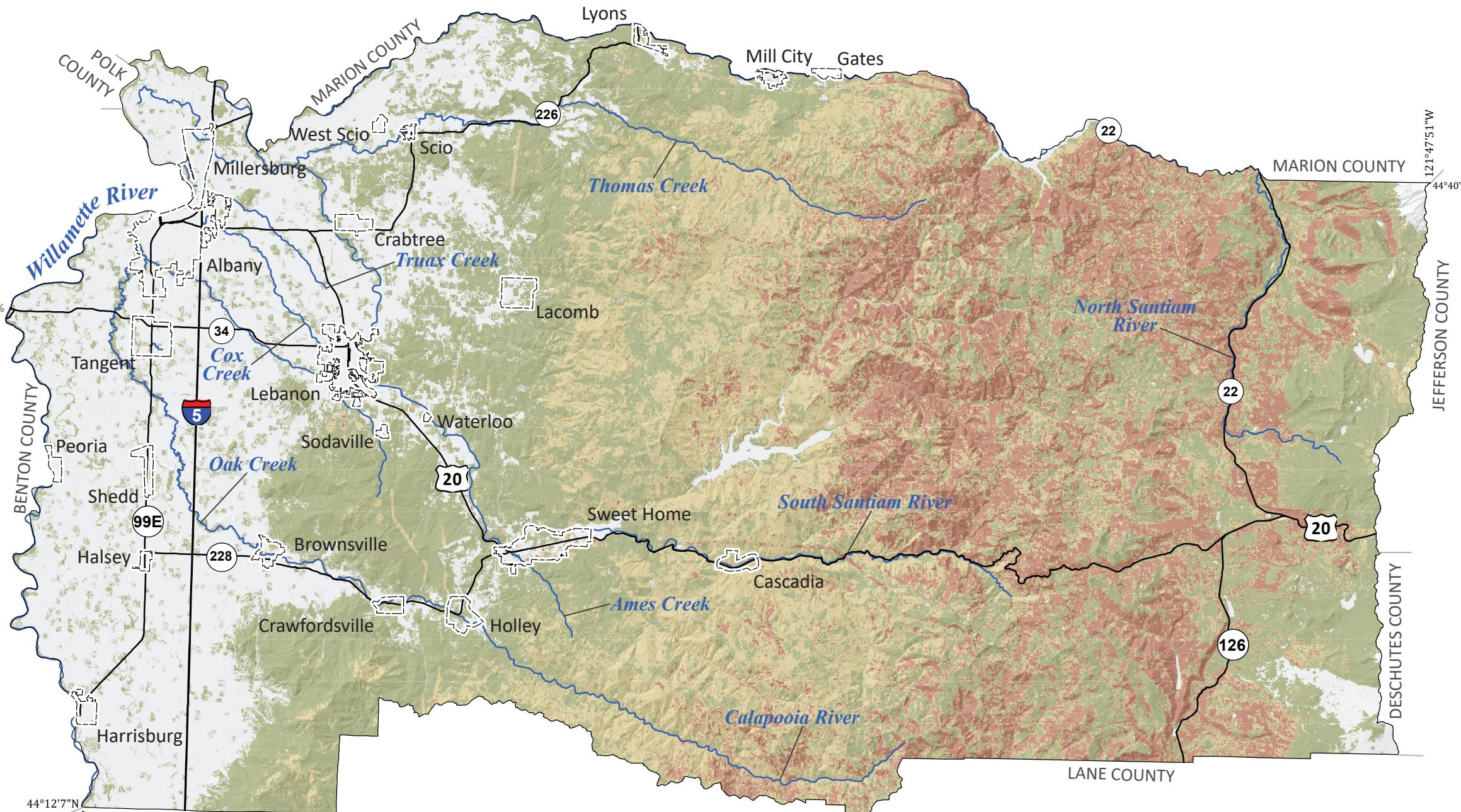
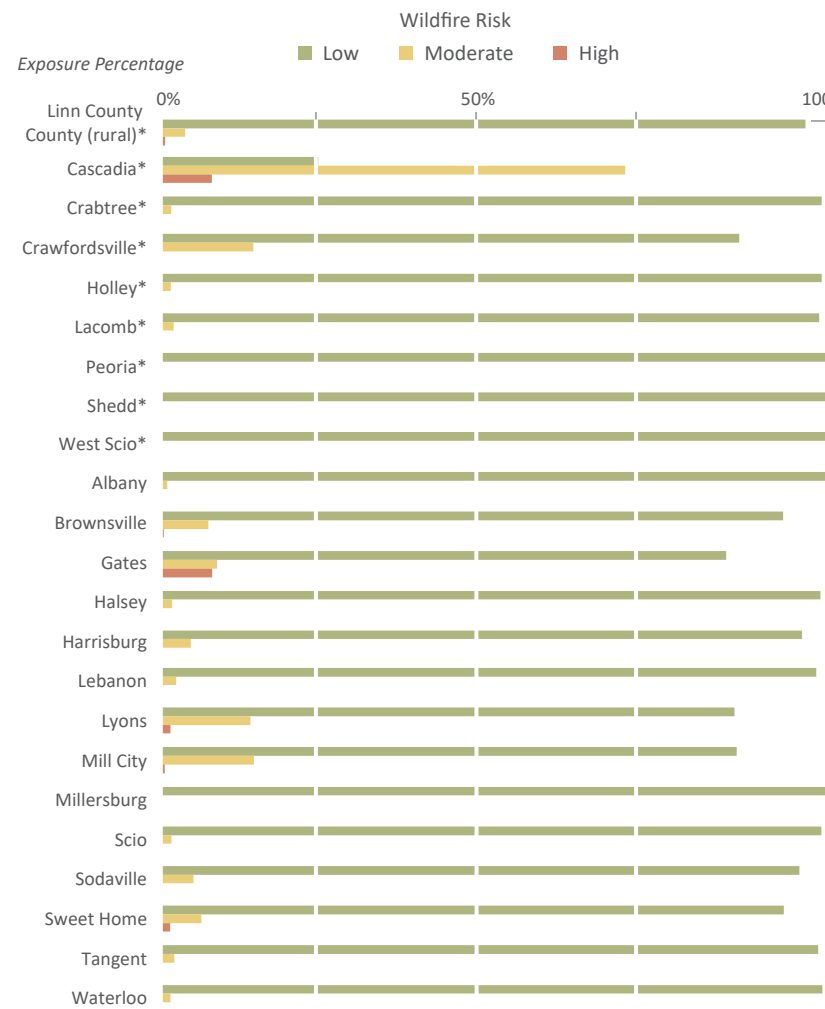
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Wildfire Risk Map of Linn County, Oregon

Wildfire Risk is categorized as Low, Moderate, and High and indicates the level of risk a location has to wildfire hazard. The Wildfire Risk data layer is derived from a combination of the burn probability (fire history and behavior) and conditional flame length data.



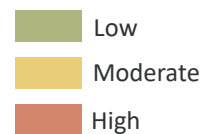
*Unincorporated

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

Projection: NAD 1983 HARN Oregon Statewide Lambert
 Software: Esri® ArcMap 10, Adobe® Illustrator CC

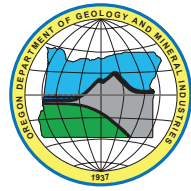
Cartography by: Matt C. Williams, 2024

Wildfire Risk



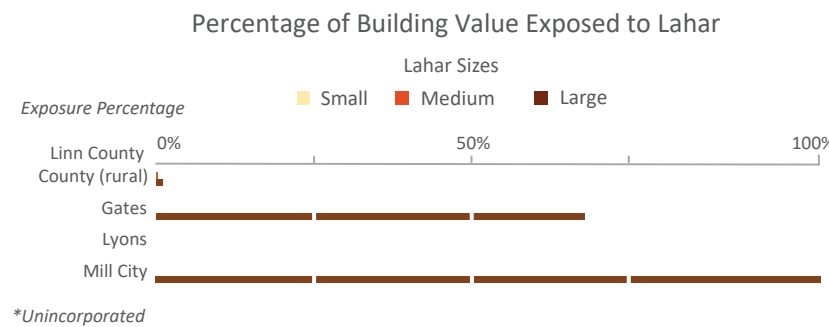
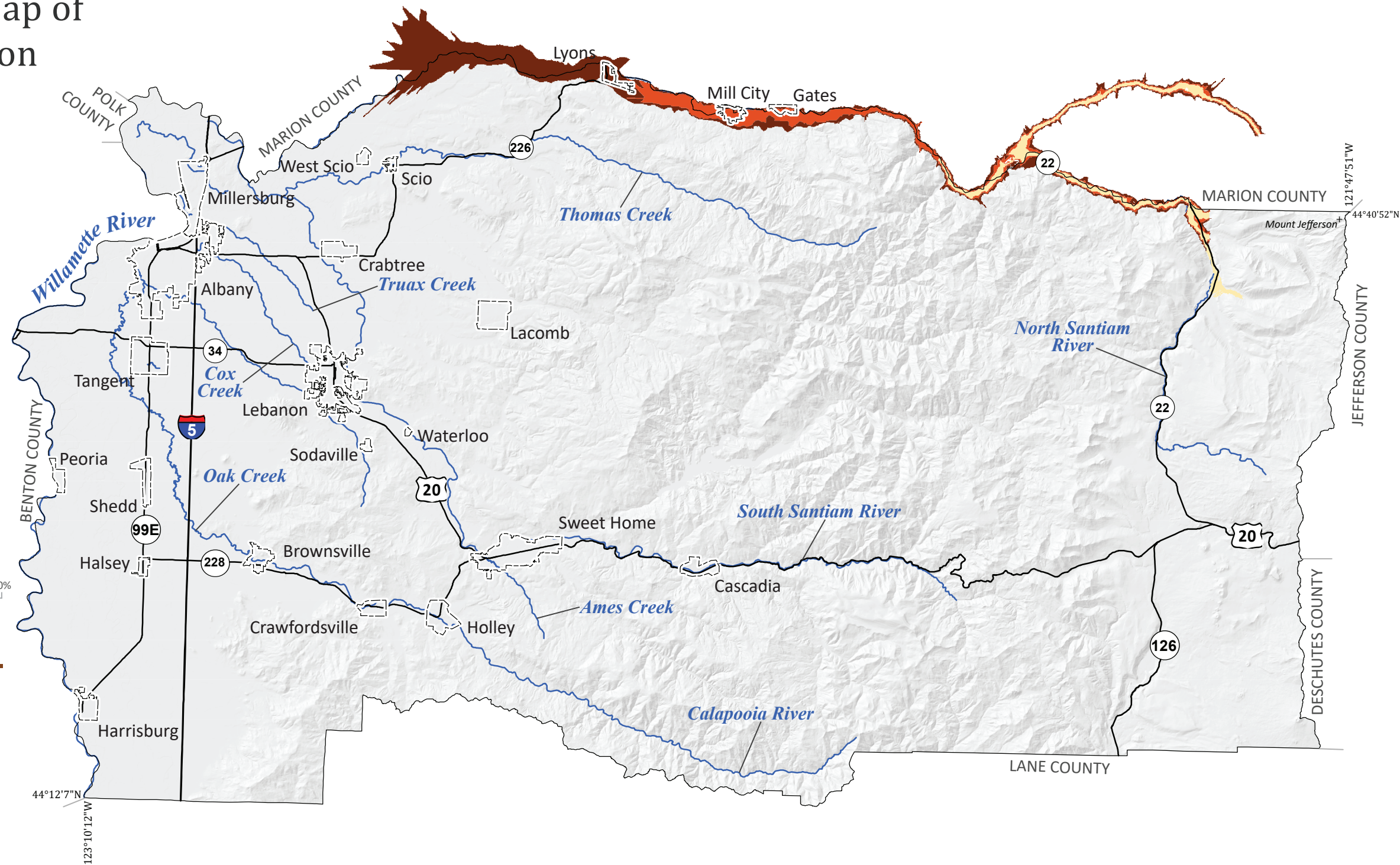
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Lahar Exposure Map of Linn County, Oregon

The lahar hazard data show areas of expected exposure from several local lahar scenarios produced from a volcanic event on Mt. Jefferson. The scenarios were categorized based on three sizes, ranging from Small to Large.



Lahar Hazard Zone

- Small
- Medium
- Large



Study Location Map



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

Data Sources:
 Mount Jefferson lahar zones: USGS (Walder and others, 1999)
 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 UTM Zone 10N
 Software: Esri® ArcMap 10, Adobe® Illustrator CC
 Cartography by: Matt C. Williams, 2024