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Deep-Landslide Susceptibility Map of the Northeast Quarter of the Canby Quadrangle, Clackamas County, Oregon

2013

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Landslide Hazard and Risk Study of Northwestern Clackamas County, Oregon

by William J. Burns, Katherine A. Mickelson, Cullen B. Jones, Sean G. Pickner, and Kaleena L. B. Hughes
Oregon Department of Geology and Mineral Industries, Portland, Oregon
Rachel Sleeter
U.S. Geological Survey, Menlo Park, California

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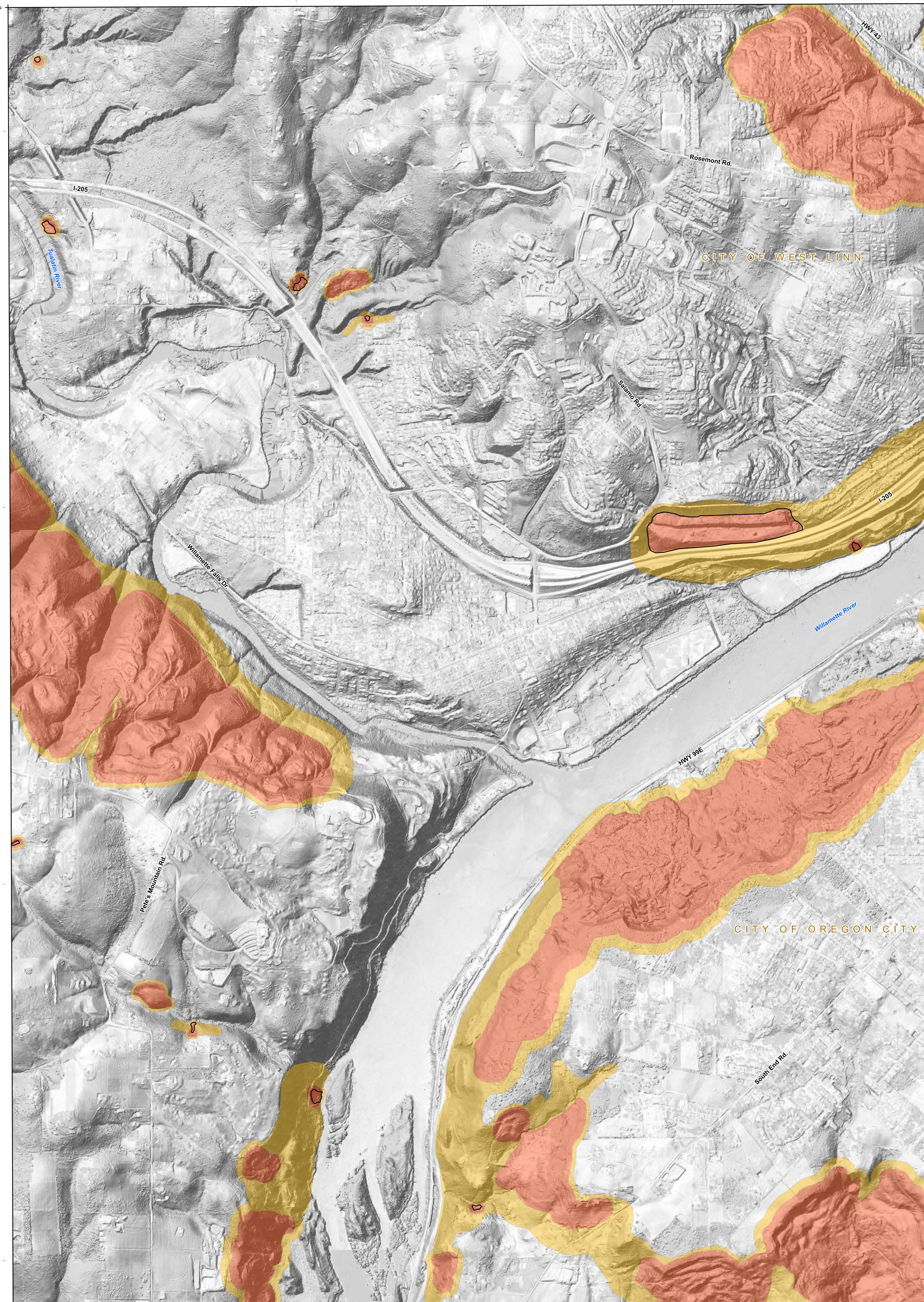
PLATE 46



EXPLANATION

This map depicts susceptibility to deep landslides in this area. For the purpose of this map, deep landslides are defined as those with a depth to the failure plane of greater than 15 ft (4.5 m) (Burns and Madin, 2009).

This susceptibility map was prepared by combining four factors: 1) landslide inventory data taken from the corresponding inventory map, 2) head scarp buffers, 3) moderate zone buffer, and 4) geologic factors (susceptible geologic units and contacts, slope angles, and preferred direction of movement). The combinations of these factors comprise the relative susceptibility hazard zones: high, moderate, and low as shown in the Hazard Zone Matrix below. The deep-landslide susceptibility data are displayed on top of a base map that consists of an aerial photograph (orthorectified) overlain on the lidar-derived digital elevation model. For additional detail on how this map was developed see Burns (2008).

DEEP-LANDSLIDE SUSCEPTIBILITY CLASSIFICATION

Each landslide susceptibility hazard zone shown on this map has been developed according to a classification scheme using a number of specific factors. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries; see accompanying text report. The symbology used to display these hazard zones is explained below.

Deep-Landslide Susceptibility Zones: This map uses color to show the relative degree of hazard. Each zone is a combination of several factors (see Hazard Zone Matrix, below).

HIGH: High susceptibility to deep landslides. Deposits mapped as historical and/or active are outlined in black.

MODERATE: Moderate susceptibility to deep landslides.

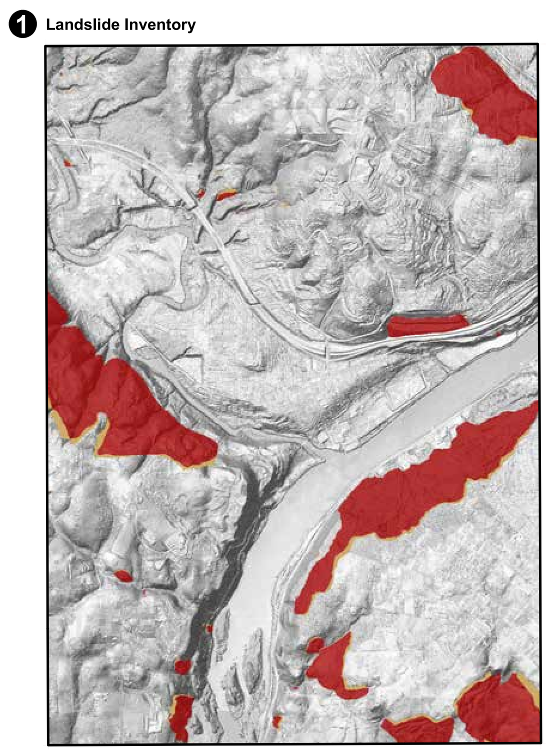
LOW: Low susceptibility to deep landslides.

Deep-Landslide Susceptibility Hazard Zone Matrix

Contributing Factors*	Final Hazard Zone		
	High	Moderate	Low
1 Landslides, Head Scarp-Flanks, Buffers	included	—	—
2 Geologic Factors, High Zone Buffer	—	included	—
3 Minimal Geologic Factors	—	—	included

*See explanation of corresponding contributing factors below.

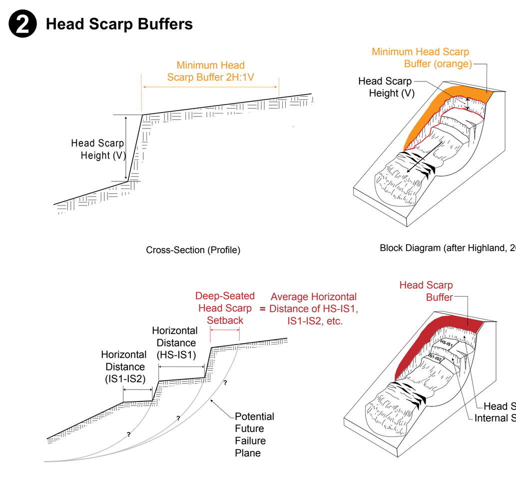
1 Landslide Inventory



Landslide Inventory: This map is an inventory of existing deep-landslide deposits and head scarps in this area. This inventory map was prepared by compiling all previously mapped landslides from published and unpublished geologic and landslide mapping, lidar-based geomorphic analysis, and review of aerial photographs. Each landslide was also attributed with classifications for activity, depth of failure, movement type, and confidence of interpretation using the protocol developed by Burns and Madin (2009). This map uses color to show different landslide features as explained below.

EXPLANATION
- Landslide Head Scarps
- Deep-Landslide Deposits

2 Head Scarp Buffers

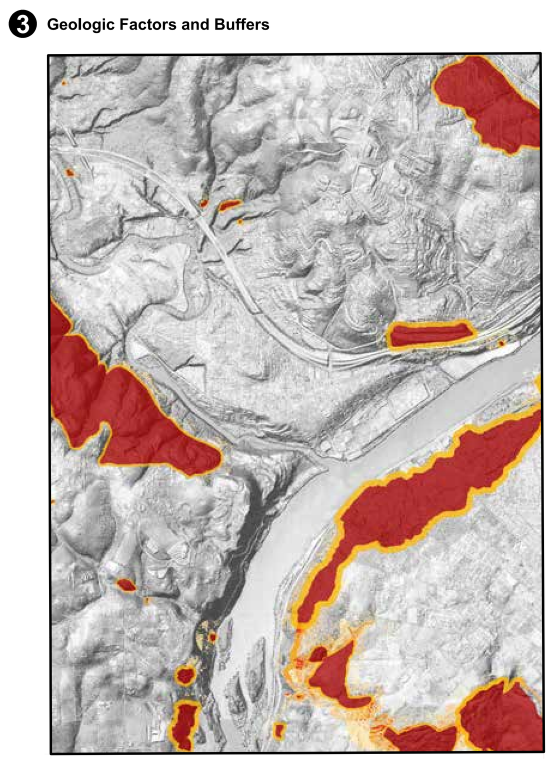


Head Scarp Buffers: Buffers were applied to all head scarps from the landslide inventory. In most cases the first buffer results in a minimum buffer distance and the second buffer (described below) results in the maximum buffer distance. In all cases the greater of the two was used.

The first buffer (orange on diagram) consists of a 2:1 horizontal to vertical distance (2H:1V). This buffer is different for each head scarp and is dependent on head scarp height. For example, a head scarp height of 6.5 ft (2 m) has a 2H:1V buffer equal to 13 ft (4 m).

The second buffer (red on diagram) is different for each head scarp and is dependent on the average of the horizontal distance between internal scarps. For example, an average horizontal distance of 150 ft (50 m) has a 2H:1V buffer equal to 300 ft (100 m).

3 Geologic Factors and Buffers



Moderate Susceptibility Zone: This map displays the scores of the relative geologic susceptibility zone factors, a moderate zone buffer applied around the high susceptibility zone, and the mapped deep-landslide deposits in this area.

A moderate zone buffer was applied around the high-susceptibility zone of each landslide deposit. This buffer is different for each landslide deposit and is dependent on head scarp height.

Each geologic zone factor was given a score of 0, 1, or 2. Thus, if all factors have the highest score at some particular location, the final factor score is 8. A minimal combined factor score threshold between 3 and 5 along with educated judgment was used to delineate the boundary between the low and moderate zones. The geologic zone factors are:

1) Susceptible geologic units
2) Susceptible geologic contacts
3) Susceptible slope angles for each engineering geology unit polygon
4) Susceptible direction of movement for each engineering geology unit polygon

The geologic susceptibility zone factors and the moderate zone buffer data sets along with professional judgment were used to create the boundary between the moderate and low deep-landslide susceptibility zones.

EXPLANATION
- Deep-Landslide Deposits
- Moderate Zone Buffer

Geologic Susceptibility Zone Factors Score
- 1 (low)
- 2
- 3
- 4
- 5
- 6
- 7
- 8 (high)

LIMITATIONS

The deep-landslide susceptibility map was developed following an established protocol (Burns, 2008) that incorporates several types of data. Several limitations are worth noting and underscore that any regional hazard map can be useful for regional applications but should not be used as an alternative to site-specific studies in critical areas. Limitations include the following.

1) Every effort has been made to ensure the accuracy of the GIS and tabular database, but it is not feasible to completely verify all of the original input data.

2) As discussed in the Explanation section, the protocol to develop deep-landslide susceptibility maps is based on four factors: 1) landslide inventory data taken from the corresponding inventory map, 2) head scarp buffers, 3) moderate zone buffer, and 4) geologic factors (susceptible geologic units and contacts, slope angles, and preferred direction of movement). All of these parameters can affect the level of detail and accuracy of the final susceptibility map. Because the maps are based on a combination of factors, all of which

a. Limitations of the landslide inventory, which are discussed by Burns and Madin (2009).

b. Calculation of head scarp buffers is limited based on the head scarp height (first buffer) and an average of the horizontal widths of previous or downslope blocks (second buffer). It is assumed that most large deep landslides have the potential to fail retrogressively upslope; however, this is not always the case.

c. The additional factors used to delineate the moderate susceptibility zone include susceptible geologic units, susceptible geologic contacts, susceptible slope angles for each engineering geology unit polygon, and susceptible direction of movement for each engineering geology unit polygon. These factors are combined and a final score is produced, but the delineation of the final moderate zone is based on visual overlap of these four factors; therefore, the accuracy and resolution of the output data can be overestimated or underestimated.

3) The susceptibility maps are based on the topographic and landslide inventory data available as of the date of publication. Future new landslides may render this map locally inaccurate.

4) The lidar-based digital elevation model does not distinguish elevation changes that may be due to the construction of structures like retaining walls. Because it would require extensive GIS and field work to locate all of these existing structures and remove them or adjust the material properties in the model, such features have been included as a conservative approach and therefore must be examined on a site-specific basis.

5) Some landslides in the inventory may have been mitigated, thereby reducing their level of susceptibility. Because it is not feasible to collect detailed site-specific information on every landslide, potential mitigation has been ignored.

REFERENCES

Burns, W.J., 2008, Regional landslide hazard maps of the southwest quarter of the Beaverton quadrangle, West Bull Mountain Planning Area, Washington County, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report O-08-09, 17 p., scale 1:8,000.

Burns, W.J., and Madin, I.P., 2009, Protocol for inventory mapping of landslide deposits from light detection and ranging (lidar) imagery: Oregon Department of Geology and Mineral Industries Special Paper 42, 30 p.

Highland, L., compiler, 2004, Landslide types and processes: U.S. Geological Survey Fact Sheet 2004-3072 (ver. 1.1), 4 p.

Base map for plates in this publication:

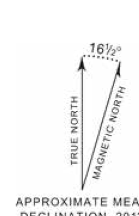
Lidar data from DOGAMI Lidar Data Quadrangle LDQ-2009-45122C3-Estacada, LDQ-2009-45122C4-Redland, LDQ-2009-45122C5-Oregon City, LDQ-2009-45122C6-Canby, LDQ-2009-45122C7-Sherwood, LDQ-2009-45122D3-Sandy, LDQ-2009-45122D4-Damascus, LDQ-2009-45122D5-Gladstone, LDQ-2009-45122D6-Lake Oswego.
Digital elevation model (DEM) consists of a 3-foot-square elevation grid that was converted into a hillshade image with sun angle at 315 degrees at a 60-degree angle from horizontal. The DEM was multiplied by 5 (vertical exaggeration) to enhance slope areas.

2005 orthophoto imagery is from Oregon Geospatial Enterprise Office and is draped over the hillshade image with transparency.

Projection: North American Datum 1983, UTM zone 10 North.

Software: Esri ArcMap 10, Adobe Illustrator CS2.

Source File: Project\Clackamas Landslide\ClackamasStudy.mxd



SCALE 1:8,000

1,300 650 0 1,300 2,600 3,900 5,200 Feet

0.25 0.125 0 0.25 0.5 0.75 1 Miles

0.25 0.125 0 0.25 0.5 0.75 1 Kilometers

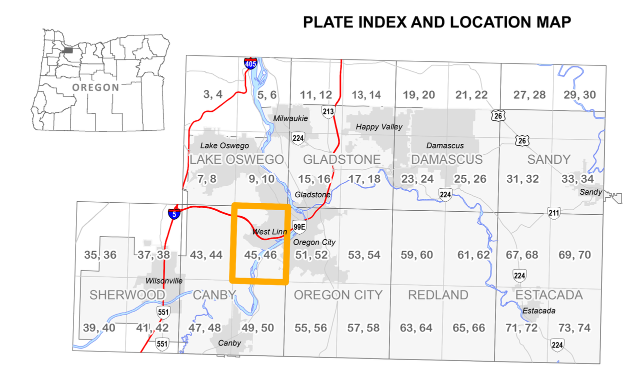
Cartography by William J. Burns and Katherine A. Mickelson, Oregon Department of Geology and Mineral Industries.

This map also benefited from internal review and comments by Ian Madin, DOGAMI Chief Scientist.

IMPORTANT NOTICE

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.

PLATE INDEX AND LOCATION MAP



U.S. Geological Survey 7.5-minute quadrangle maps are divided into quarter quadrangles. Each quarter quadrangle has two plate numbers; the first plate number indicates the shallow-landslide susceptibility map, and the second plate number indicates the corresponding deep-landslide susceptibility map. Plates 1 and 2 (not shown here) are overview maps for this publication.

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Nature of the Northwest Information Center
800 NE Oregon Street, #28, Ste. 965
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