



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

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Landslide Hazard and Risk Study of  
Northwestern Clackamas County, Oregon

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PLATE 45

### EXPLANATION

This shallow-landslide susceptibility map identifies landslide-prone areas that are defined following the protocol of Burns and Madin (2009).

On the basis of several factors and past studies (described in detail by Burns and Madin (2009)), a depth of 15 ft (4.5 m) is used to divide shallow from deep landslides. This susceptibility map was prepared by combining three factors: 1) calculated factor of safety (FOS), 2) landslide inventory data, and 3) buffers applied to the previous two factors. The FOS was calculated using measured values such as having a water table at the ground surface. The landslide inventory data were taken from the corresponding inventory map. The combination of these factors comprise the relative susceptibility hazard zones, high, moderate, and low as shown by the Susceptibility Hazard Zone Matrix below. The 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 and others (2012).

### SHALLOW-LANDSLIDE SUSCEPTIBILITY CLASSIFICATION

Each landslide susceptibility hazard zone shown on this map has been developed according to a number of specific factors. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries (Burns and others, 2012). The symbology used to display these hazard zones is explained below.

Shallow-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).

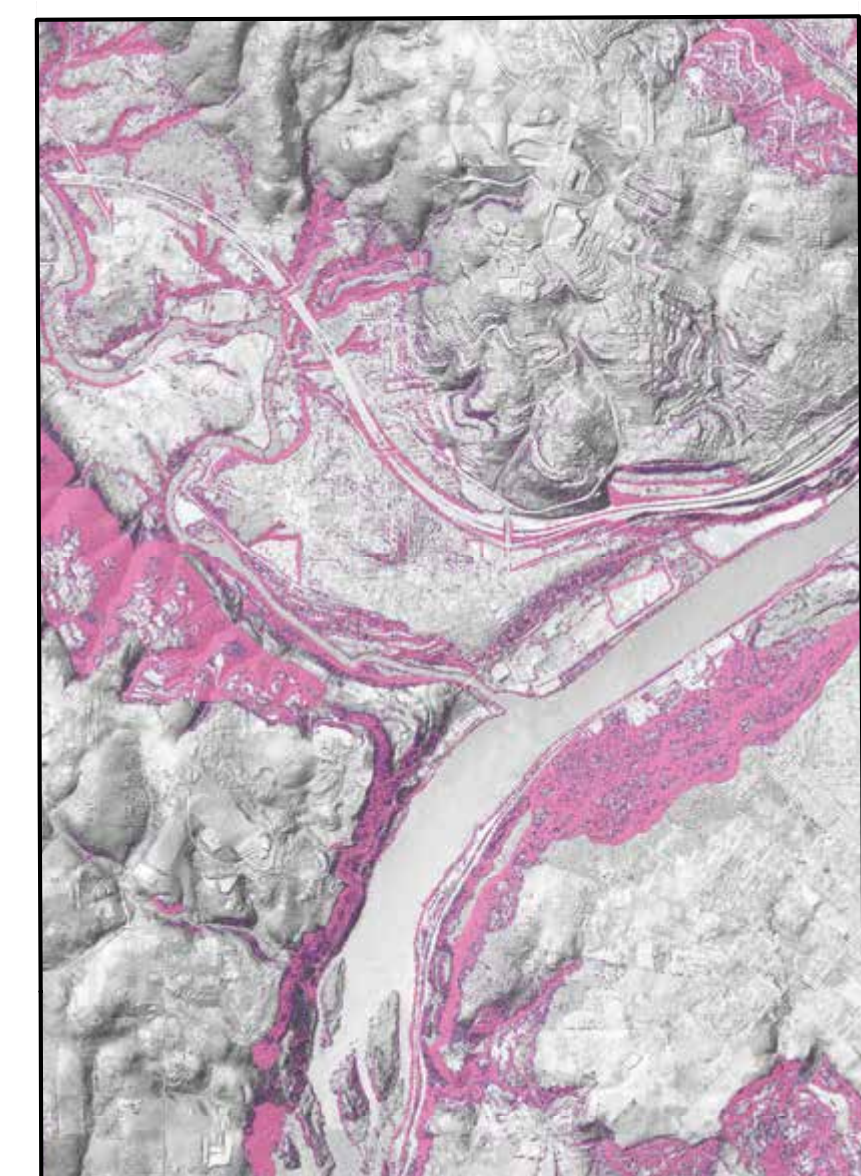
- HIGH: High susceptibility to shallow landslides.
- MODERATE: Moderate susceptibility to shallow landslides.
- LOW: Low susceptibility to shallow landslides.

### Shallow-Landslide Susceptibility Hazard Zone Matrix

Contributing Factors *	Final Hazard Zone		
	High	Moderate	Low
1 Factor of Safety (FOS)	less than 1.25	1.25 - 1.5	greater than 1.5
2 Landslide Deposits & Head Scarps (Shallow)	Included	—	—
3 Buffers	2H1V (head scarps)	2H1V (FOS less than 1.5)	—

\*See explanation of corresponding contributing factors below.

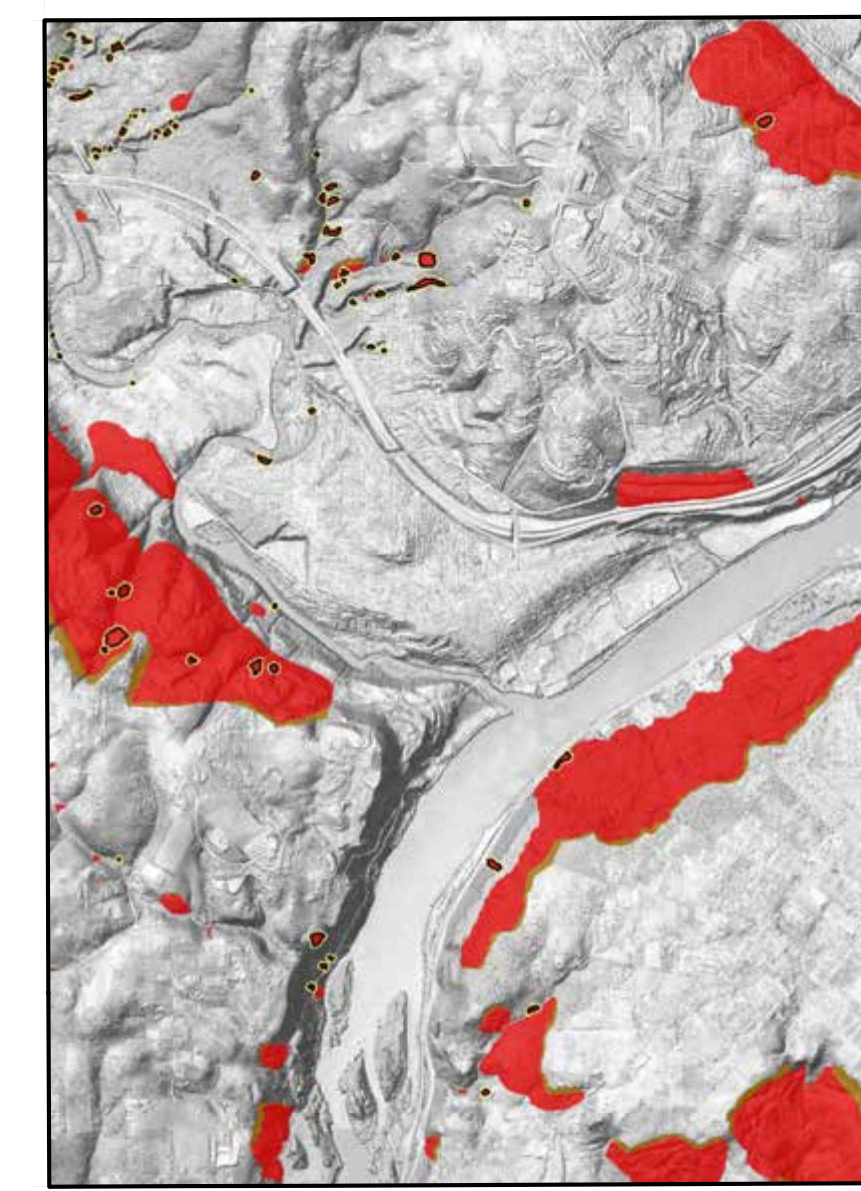
### 1 Factor of Safety



**EXPLANATION**

- FOS less than or equal to 1.25
- FOS between 1.25 and 1.5
- FOS greater than or equal to 1.5

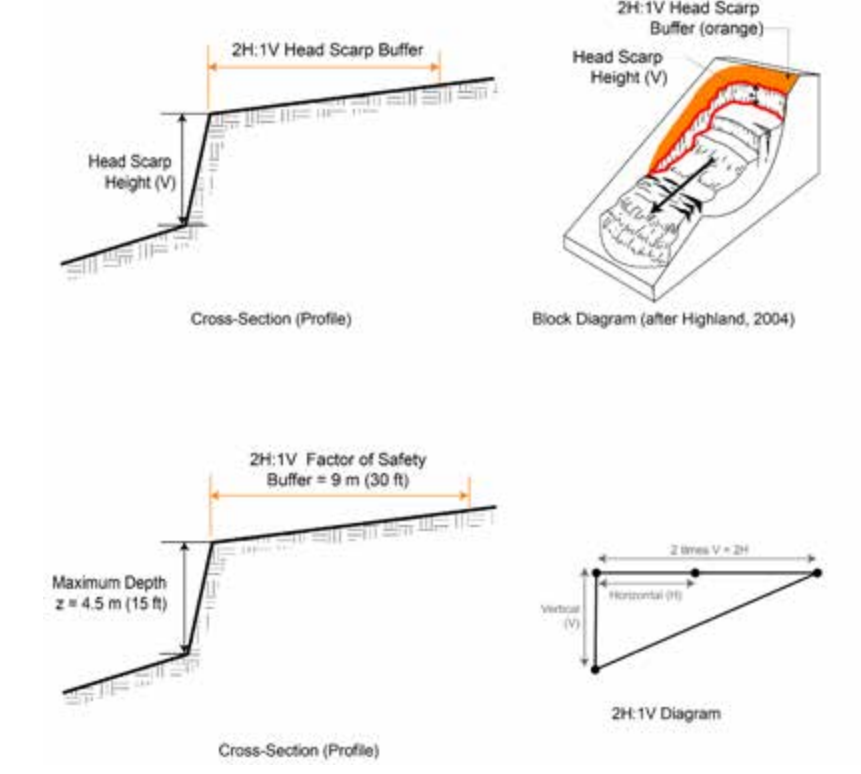
### 2 Landslide Deposits and Head Scarps



**EXPLANATION**

- Shallow-Landslide Deposits
- Landslide Deposits
- Head Scarps

### 3 Buffers for Head Scarps and Factor of Safety Less Than 1.5



**Buffer for Head Scarps:** This buffer was applied to all head scarps from the landslide inventory. The buffer 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 ft (1.8 m) has a 2H:1V buffer equal to 12 ft (3.7 m).

**Buffer for Factor of Safety Less Than 1.5:** This buffer was applied to all areas with a calculated FOS less than 1.5. The buffer consists of a 2:1 horizontal to vertical distance (2H:1V). For example, if the maximum depth for shallow landslides is 15 ft (4.5 m), then the 2H:1V buffer would equal 30 ft (9.1 m).

### LIMITATIONS

Several limitations are worth noting and 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) The shallow-landslide susceptibility maps are based on three primary sources: a) calculated factor of safety, b) landslide inventory, and c) buffers. Factors that can affect the level of detail and accuracy of the final susceptibility map include the following:
  - a) Factor of safety calculations are strongly influenced by the accuracy and resolution of the input data for material properties, depth to failure surface, depth to groundwater, and slope angle. The first three of these inputs are usually estimated (material properties or conservative limiting cases (depth to failure surface and groundwater), and local conditions may vary substantially from the estimated values used to make these maps.
  - b) Limitations of the landslide inventory, which are discussed by Burns and Madin (2009).
  - c) Infinite slope factor of safety calculations are done on one grid cell at a time without regard for the adjacent grids. The results sometimes underestimate or overestimate the level of stability for a certain area. We developed buffers for areas with low factors of safety to try to counter the tendency to underestimate susceptibility. We developed the local relief method to try to reduce the problem of overestimation of susceptibility due to steep slopes with low relief. However, the overestimation and underestimation of susceptible areas is still likely in some isolated areas.
- 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., 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, 20 p.

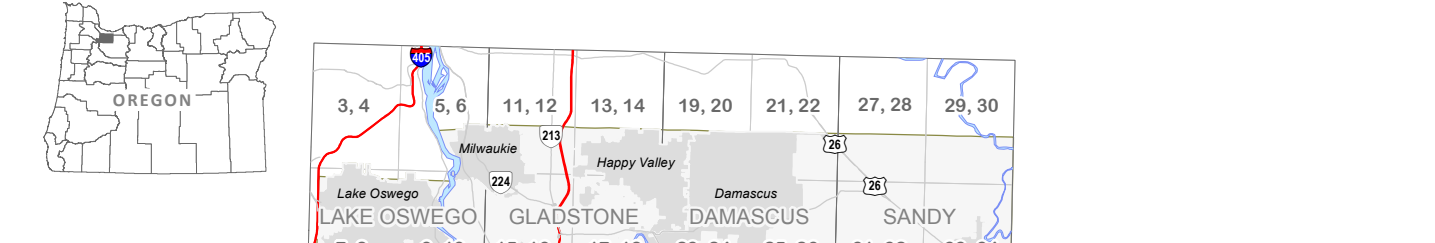
Burns, W.J., Madin, I.P., and Mickelson, K.A., 2012. Protocol for shallow-landslide susceptibility mapping. Oregon Department of Geology and Mineral Industries Special Paper 45, 32 p.

Cornforth, D.H., 2005. Landslides in practice: Investigation, analysis, and remedial/preventative options in soils. Hoboken, New Jersey, John Wiley and Sons, Inc., 506 p.

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

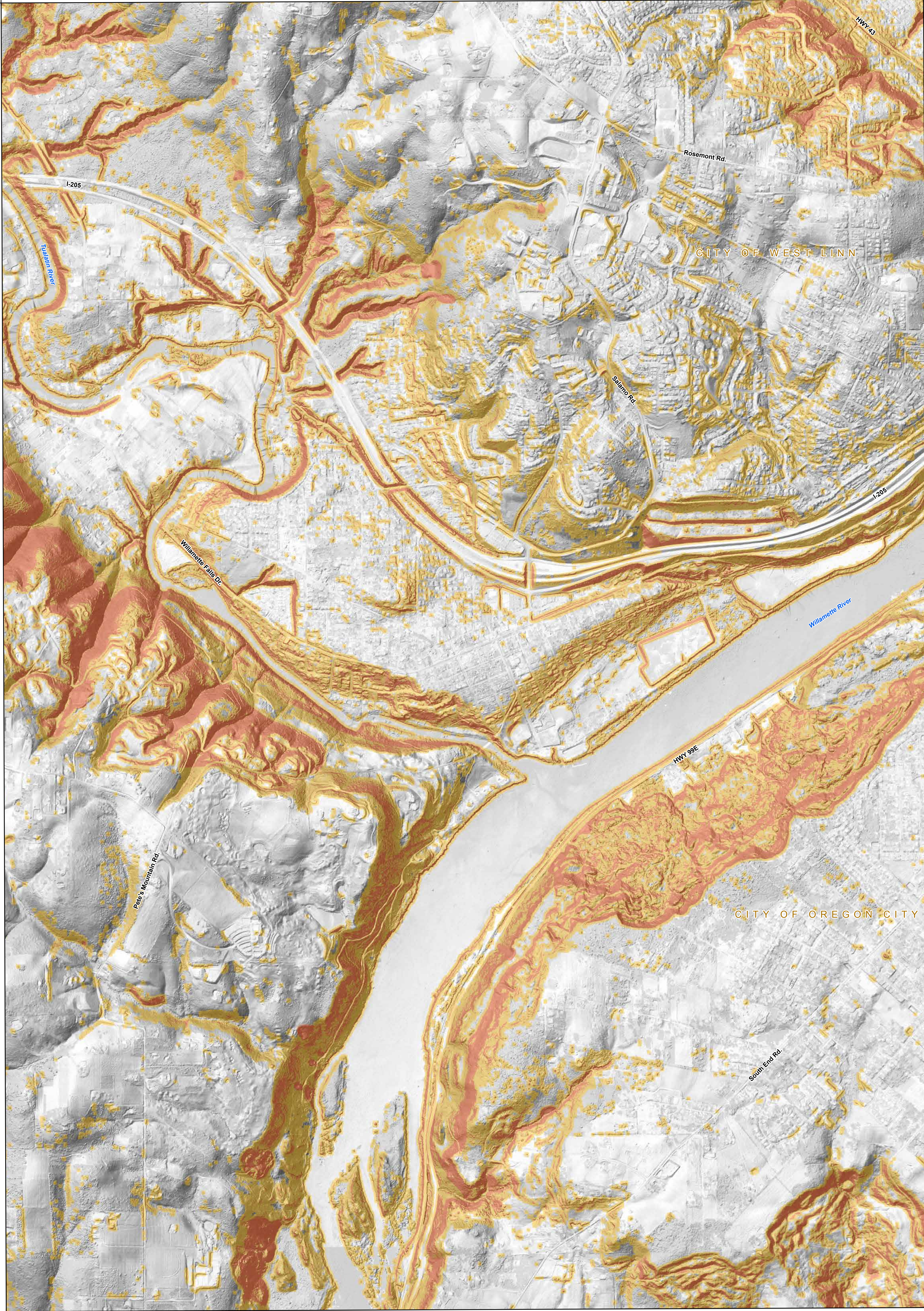
Turner, A.K., and Schuster, R.L., eds., 1986. Landslides: Investigation and mitigation. Transportation Research Board, National Research Council, Special Report 217, 673 p.

### PLATE INDEX AND LOCATION MAP

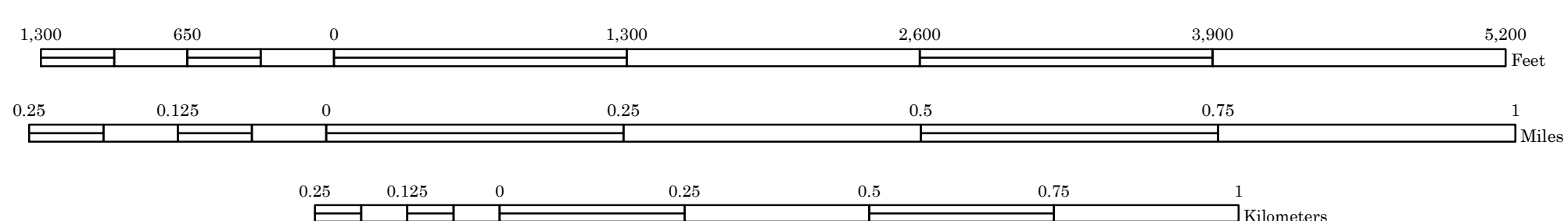


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U.S. Geological Survey 7.5-minute quadrangle maps are divided into quarter quadrangles. Each quarter quadrangle has plate numbers; the first plate number indicates the shallow-landslide susceptibility map, and the second plate number indicates the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



SCALE 1:8,000



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Base map for plates in this publication:  
Lidar data from DOGAMI Lidar Data Quadrangle LIDQ 2009-45122C3-Estacada, LIDQ 2009-45122C4-Bellvue, LIDQ 2009-45122C5-Oregon City, LIDQ 2009-45122C6-Canby, LIDQ 2009-45122C7-Sherwood, LIDQ 2009-45122C8-Scenic, LIDQ 2009-45122D1-Rosemont, LIDQ 2009-45122D3-Clatskanie, LIDQ 2009-45122D6-Lake Oswego  
Digital elevation model (DEM) consists of a 3-foot square elevation grid that was converted into a hillshade image with an angle of 315 degrees at a 60-degree angle from horizontal. The DEM was multiplied by 5 vertical exaggeration to enhance slope areas.  
2008 orthophoto imagery 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

APPROXIMATE MEAN DECLINATION, 2012