

STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES  
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# Deep-Landslide Susceptibility Map of the Central-Western Quarter of the Cathlamet Bay Quadrangle, Clatsop County, Oregon

2013

OPEN-FILE REPORT O-13-05

Landslide Inventory, Susceptibility Maps, and Risk Analysis  
for the City of Astoria, Clatsop County, Oregon

by William J. Burns and Katherine A. Mickelson

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and the City of Astoria (IA No. 41570-03202008)

PLATE 9

## EXPLANATION

This map depicts susceptibility to deep-landslides in this area of the the quadrangle. The value (depth) of 15 ft (4.5 m) is used to divide shallow from deep-landslide. 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 is not regulatory, and revisions can happen when new information regarding factors that affect landslide susceptibility are found or when new landslide occur. Therefore, it is possible that susceptible areas within the map area were not identified or actual landslides occurred after the map was prepared.

This susceptibility map was prepared by combining three factors: 1) landslide inventory data, 2) head scarp buffers, and 3) susceptible geologic units and slope angles. 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 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 (hereinafter referred to as the lidar-derived digital elevation model). For additional detail on how this map was developed see Burns (2009).

This susceptibility map is intended to provide users with relative hazard information regarding deep landslide susceptibility within the quadrangle. The map is not intended to replace site-specific engineering, geologic, and geotechnical investigations. It is intended that this map will provide useful information to guide regional and site-specific investigations for future developments, to assist in regional planning, and to reduce risk in areas where moderate and high hazards intersect vulnerable population.

## DEEP-LANDSLIDE SUSCEPTIBILITY CLASSIFICATION

Each landslide susceptibility hazard zone shown on this map was developed according to a classification scheme that uses a number of specific factors. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries (DOGAMI) (Burns, 2009). The symbology used to display these hazard zones is explained below.

**Landslide Susceptibility Zones:** This map uses color to show the relative degree of hazard. Each zone is a combination of several factors.

- HIGH:** High susceptibility to deep-seated landslides.
- MODERATE:** Moderate susceptibility to deep-seated landslides.
- LOW:** Low susceptibility to deep-seated landslides.

## Hazard Zone Matrix

Contributing Factors*	Final Hazard Zone		
	High	Moderate	Low
1 Landslide Inventory	Included	—	—
2 Head Scarp Buffers	Included	—	—
3 Geologic Units and Slope Angles	—	Included	Included

\*See explanation of corresponding contributing factors below.

## 1 Landslide Inventory

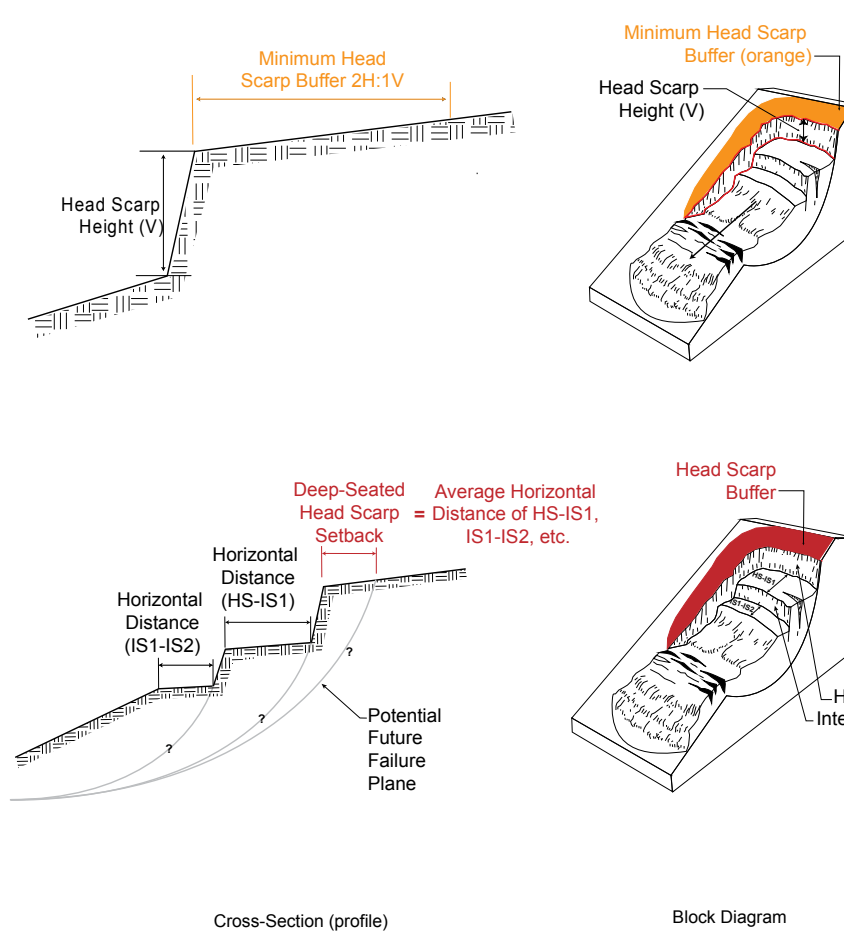


**Landslide Inventory:** This map is an inventory of existing deep-landslide deposits and head scarps in this area. This inventory map was prepared by compiling all previously mapped landslides from published and unpublished geologic and landslide mapping, lidar-based geomorphic analysis, and review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

## EXPLANATION

- Landslide Head Scarps
- Deep-Landslide Deposits

## 2 Head Scarp Buffers

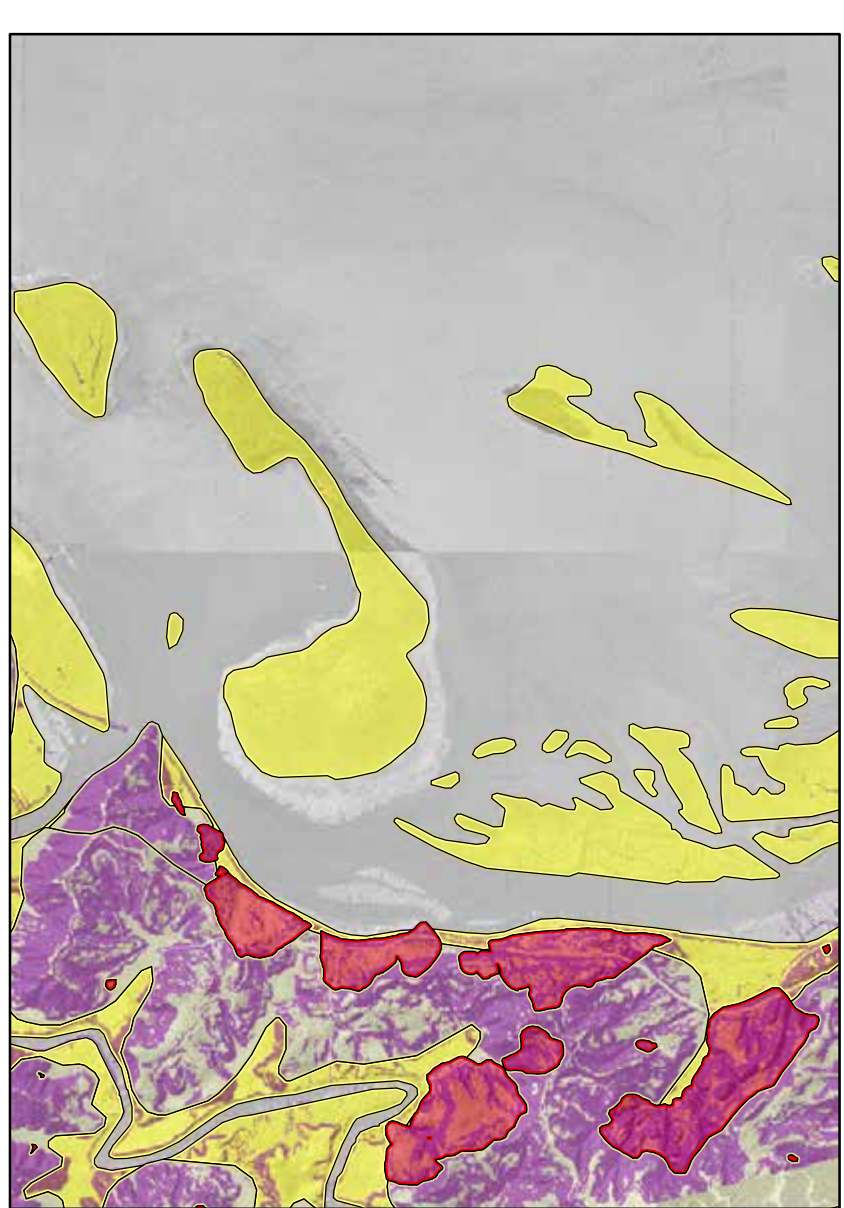


**Head Scarp Buffers:** Buffers were applied to all head scarps from the landslide inventory. In most cases the first buffer results in a minimum buffer distance, and the second buffer (described below) results in the maximum buffer distance. In all cases the greater of the two was used.

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 100 ft (30 m) has a 2H:1V buffer equal to 300 ft (100 m) (Block diagrams modified after Highland, 2004).

## 3 Geologic Units and Slope Angles



**Geologic Units and Slope Angles:** This map is a generalized geologic map that also shows areas where slope is greater than 10 degrees. This map uses color to show different geologic units and slope angles across the map.

Using educated judgment, the author combined three subjective to create this hazard zone contributing factor:

- 1) Susceptible geologic units or units that contain deep-seated landslides in the inventory.
- 2) Relative proximity to identified deep-seated landslides from the inventory.
- 3) Slope angles greater than 10 degrees.

The results of this third contributing factor were used to create the boundary between moderate and low hazard zones for deep-seated landslide susceptibility.

- Landslide Deposits (from landslide inventory)
- Landslide deposit
- Geologic Units (from best available geologic map)
- Recent alluvium
- Mudstone
- Gravel
- Sand
- Slope Angle (degrees) (derived from lidar DEM)
- Greater than 10

## 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:

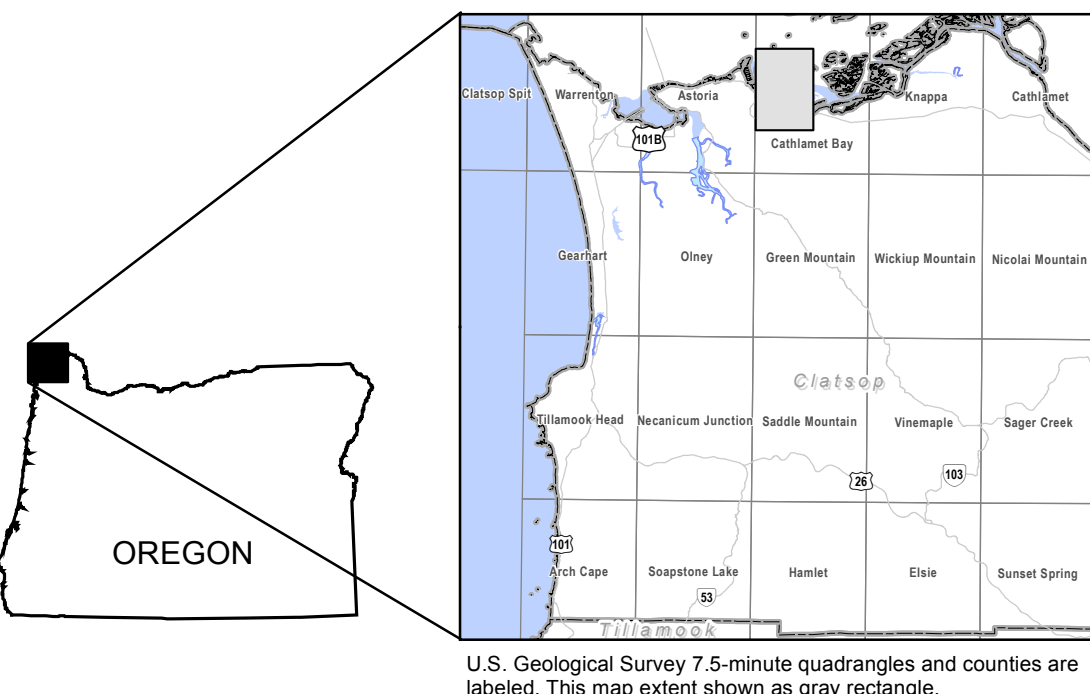
- 1) Every effort has been made to ensure the accuracy of the GIS and tabular database, but it is not feasible to completely verify all of the original input data.
- 2) As discussed in the explanation section, the protocol to develop deep-landslide susceptibility maps is based on three primary factors: a) landslide inventory; b) head scarp buffers; and c) additional factors. All of these contributors 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 have inherent uncertainty, the resultant hazard zones also have uncertainty.
  - a. Limitations of the landslide inventory, which are discussed in the Special Paper 42 (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 drainage 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 geologic unit polygon, and movement direction of movement for each engineering geologic 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 and/or underestimated.
- 3) The GIS database is a "snapshot" view of current data; new information regarding landslides may be found or future (new) landslides may occur.
- 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 retaining structures and remove them or adjust the material properties in the model, these 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.

Because of these limitations this map is intended for regional purposes only and cannot replace site-specific investigations. However, the map can serve as a useful tool for estimating the regional landslide hazard and as a starting place for detailed site-specific maps. Please contact DOGAMI if errors and/or omissions are found so that they can be corrected in future versions of this map.

## 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-08-00, 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.

## LOCATION MAP



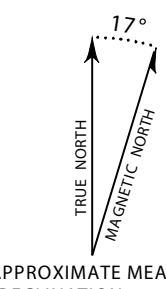
U.S. Geological Survey 7.5-minute quadrangles and counties are labeled. This map extent shown as gray rectangle.



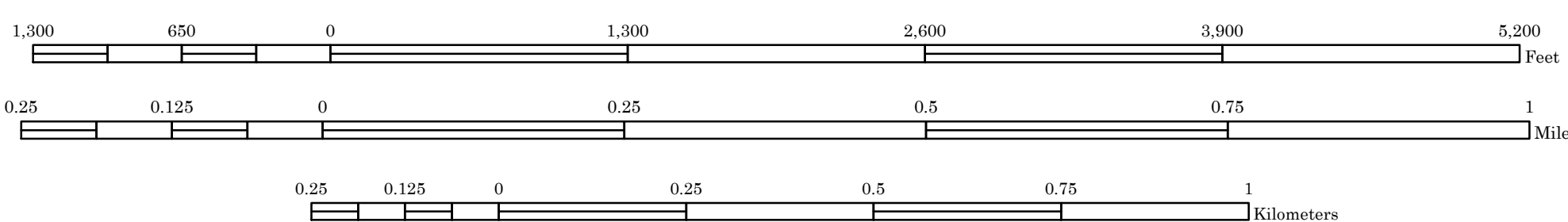
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Base Map:  
Elevation data from Puget Sound Lidar Consortium, 2003. Digital elevation model (DEM) consists of a 3-foot by 3-foot elevation grid with hillshade sun angle at 315 degrees at a 45 degree angle from horizontal. Orthophoto is from Oregon Geospatial Enterprise Office, 2005, and consists of 2005 orthophoto draped over DEM with transparency.

Projection: North American Datum 1983, UTM zone 10 north.  
Software: MapInfo Professional 8.0, Esri ArcMap 9.2, Adobe Illustrator CS2.  
Source File: Rocks\Publications\Astoria.mxd.



SCALE 1:8,000



Cartography by William J. Burns, Oregon Department of Geology and Mineral Industries  
Outside agency review by Ken Cook, Public Works Director, City of Astoria

## IMPORTANT NOTICE

This map depicts landslide susceptibility zones developed on the basis of limited data. The susceptibility zones were created following the protocol defined by Burns (2008). This map cannot serve as a substitute for site-specific investigations by qualified practitioners. Site-specific data may give results that differ from those shown on this map.