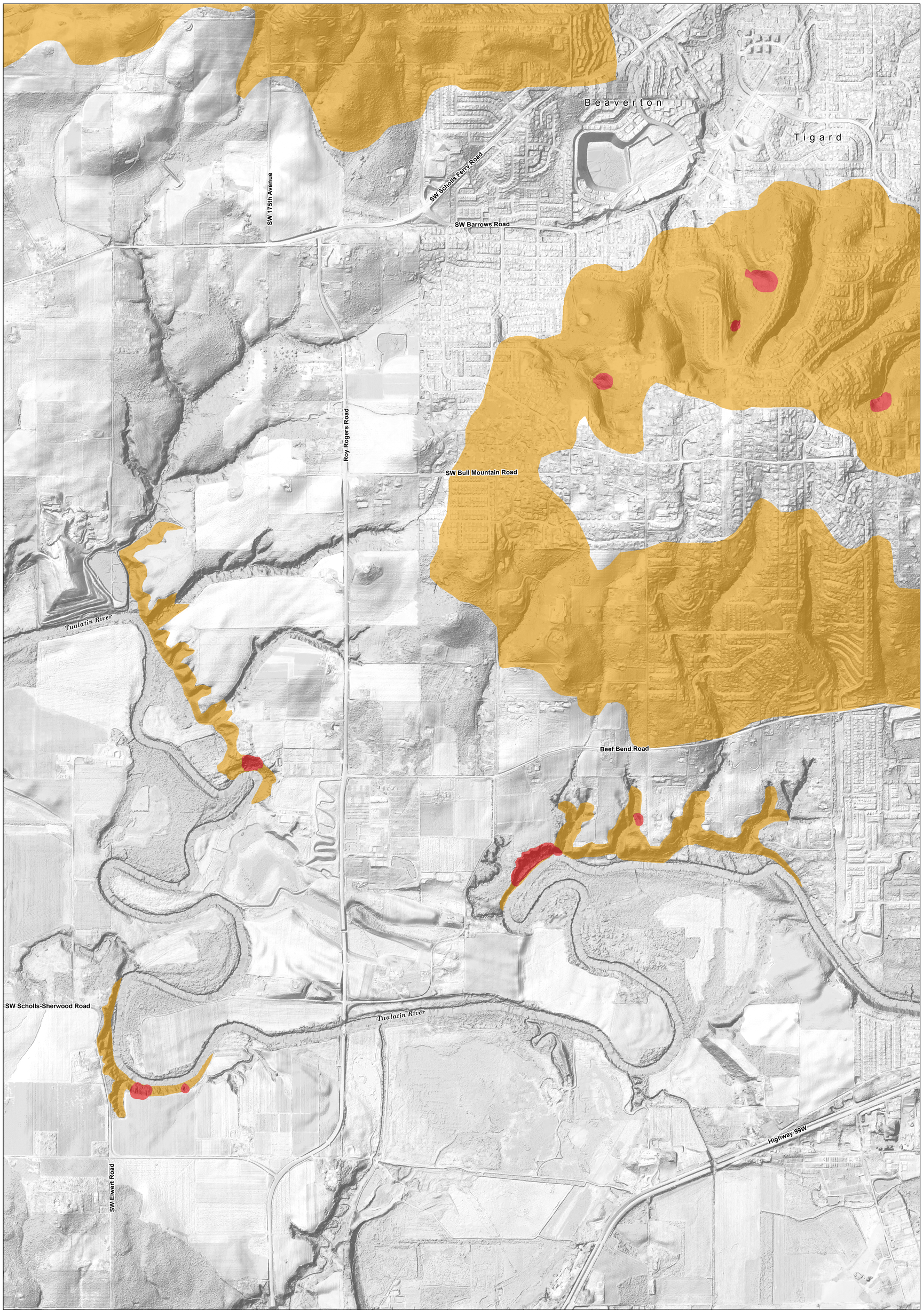
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
VICKI S. McCONNELL, STATE GEOLOGIST

# Deep-Seated Landslide Susceptibility Map of the Southwest Quarter of the Beaverton Quadrangle, Washington County, Oregon

**2008**




Base Map:

Elevation data from Oregon Lidar Consotrium, 2007. Digital elevation model (DEM) consists of a 3-foot by 3-foot elevation grid with hillshade sunangle 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\O-08-09\Plate_3.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, Oregon Department of Geology and Mineral Industries

Outside agency review by Paul Schaefer, Washington County

**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.

## OPEN-FILE REPORT O-08-09

**Regional Landslide Hazard Maps of the Southwest Quarter of the Beaverton Quadrangle, West Bull Mountain Planning Area, Washington County, Oregon**

by William J. Burns

Partial funding provided by Washington County (Project 100075, PO 141319)

**PLATE 3**

### EXPLANATION

The map depicts susceptibility to deep-seated landslides for this area. For the purpose of this map, deep-seated landslides are defined as those with a depth to the failure plane of greater than 4.5 m (15 ft) (Burns, 2008). This susceptibility map is not regulatory. When new information regarding factors that affect landslide susceptibility becomes available or when new landslides occur, the map may be updated. Therefore, it is possible that susceptible areas within the map area were not identified and that landslides occurred after the map was prepared.

This deep-seated susceptibility map was prepared by combining three factors: 1) landslide inventory data (shown on Plate 1), 2), head scarp buffers, and 3) geologic units and slope angles. The combinations of these factors comprise the relative susceptibility hazard zones: high, moderate, and low. The deep-seated landslide susceptibility data are displayed on top of a base map that consists of an orthorectified aerial photograph overlain on a lidar data derived digital elevation model. For additional detail on how this map was developed, see Burns (2008) or the accompanying text report.

This susceptibility map is intended to provide users with relative hazard information regarding deep-seated landslide susceptibility within this area. The map cannot 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-SEATED 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, 2008). 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.

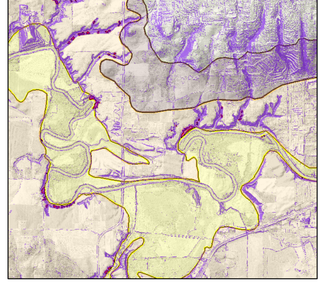
**LOW:** Low susceptibility to deep-seated landslides.

**Hazard Zone Matrix Table**

| 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.

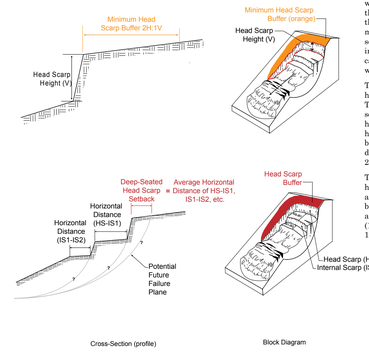
**1 Landslide Inventory**



**Landslide Inventory:** This map displays a subset of the landslide inventory containing only the deep-seated landslide deposits and head scarps in this area (see accompanying landslide inventory map, Plate 1). This inventory map was prepared by compiling previously mapped landslides from published geologic and landslide mapping, analyzing lidar-based geomorphology, and examining aerial photographs. Each landslide was also attributed with classifications for activity, landslide features, confidence of interpretation depth of failure, and movement type (Burns and Madin, 2008). The map uses color to show different landslide features across the map as explained below.

EXPLANATION
- Deep-Seated Landslide Deposits
- Landslide Head Scarps

**2 Head Scarp Buffers**




**Buffer for Head Scarps:** This buffer was applied to all head scarps from the landslide inventory. In most cases the first buffer results in the minimum buffer distance and the second buffer (described below) results in the maximum buffer distance. In all cases the greater of the two values was used.

The first 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 2 m (6.5 ft) has a 2H:1V buffer equal to 4 m (13 ft) (Block diagram modified after Highland, 2004)..

The second buffer 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 50 m (150 ft) has a 2H:1V buffer equal to 100 m (300 ft).

**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 slopes across the map.

Using educated judgment, the author combined three subfactors 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.

EXPLANATION

Landslide Deposits (from landslide inventory)
- Landslide deposit

Geologic Units (from best available geologic map)
- Qal - Recent alluvium
- Ql - Loess
- Qff - Quaternary alluvium
- Tcr - Columbia River Basalt

Slope Angle (degrees) (derived from lidar DEM)
- Greater than 10

### LIMITATIONS

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

1) Although it is possible to check for errors in the GIS and tabular database, it is not feasible to completely verify all original input data.
2) As discussed above, the protocol to develop deep-seated landslide susceptibility maps is based on three primary factors: a) landslide inventory, b) head scarp buffers, and c) additional factors. These factors can affect the level of detail and accuracy of the final susceptibility map. Because the maps are based on a subjective combination of factors, all of which have inherent uncertainty, the resultant hazard zones also have uncertainty. For example:
   a) The landslide inventory data have limitations that are discussed in the lidar-based landslide inventory mapping protocol (Burns and Madin, 2008).
   b) Calculation of head scarp buffers is limited based on 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-seated landslides have the potential to fail retrogressively upslope; however, this is not always the case.
   c) Using educated judgment, the author combined three subfactors: susceptible geologic units, slope angles greater than 10 degrees, and relative proximity to identified deep-seated landslides to create the third hazard zone matrix factor. Because this estimate is based on visual overlap of these subfactors, the accuracy and resolution of the output data can be substantially overestimated or underestimated.
3) The GIS database is a "snapshot" view of current data; new information regarding landslides may be found and new landslides may occur.
4) Because the lidar-based digital elevation model (DEM) is only a model of elevation, it does not distinguish elevation changes that may be due to the construction of structures like retaining walls. Because it would require extensive field work to locate all of these existing structures and determine the stability of each individual structure, these potential structures have been assumed to be slopes as a conservative approach and therefore must be examined on a site-specific basis.
5) Some landslides and slopes have been mitigated. Because it is not feasible to collect detailed site-specific information on every landslide or slope (for example, if it has been mitigated and what level of mitigation was implemented), mitigation has been omitted.

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 point for future 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.

*Acknowledgments:* Funding for this project was provided through a grant by Washington County Land Use and Transportation, Planning Division, with additional funds from the State of Oregon. We thank DOGAMI staff who helped work on this project through technical assistance, review, and general aid.

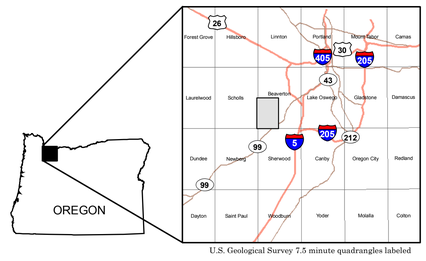
### REFERENCES

Burns, W. J., and Madin, I. P., 2008 manuscript in preparation, Lidar-based landslide inventory mapping protocol, Oregon Department of Geology and Mineral Industries.

Burns, W.J., 2008 manuscript in preparation, Lidar-based deep-seated landslide susceptibility mapping protocol, Oregon Department of Geology and Mineral Industries.

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 labeled

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