STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Landslide Inventory Map of the Southwest Quarter of the Beaverton Quadrangle, Washington County, Oregon

2008

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

by William J. Burns

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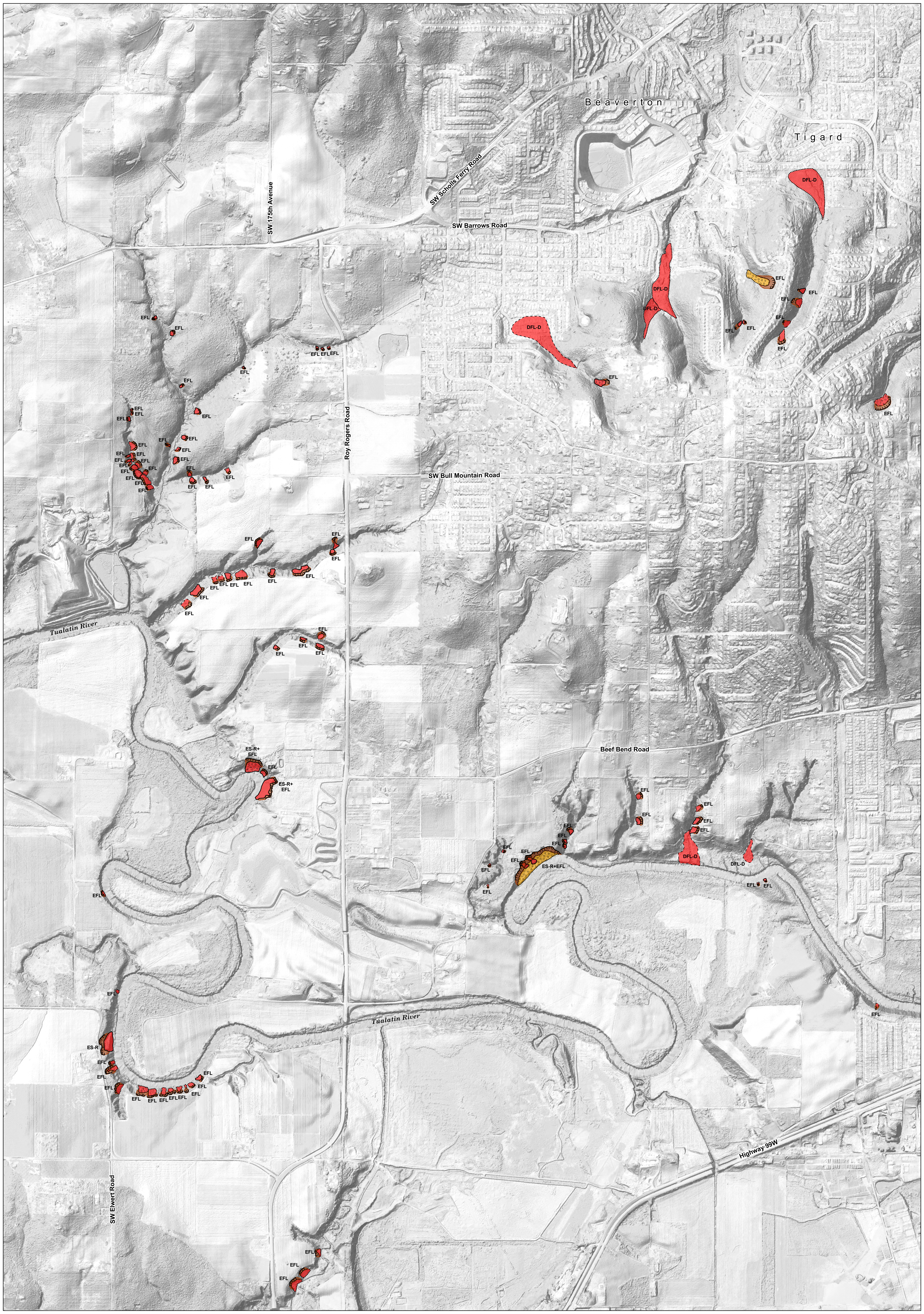
PLATE 1



EXPLANATION

This map is an inventory of existing landslides in this area. The landslide inventory is one of the essential data layers used to delineate regional landslide susceptibility. This landslide inventory is not regulatory; revisions can happen when new information regarding landslides is found or new landslides occur. Therefore, it is possible that landslides within the map area were not identified or occurred after the map was prepared.

This inventory map was prepared by compiling all previously mapped landslides (published geologic and landslide mapping), analyzing lidar-based geomorphology, and reviewing aerial photographs. Landslides identified by these methods were digitally compiled into a GIS database at a scale of 1:1,500. The recommended map scale for these data is 1:8,000, as displayed on this map. Each landslide was also attributed with classifications for activity, landslide features, depth of failure, confidence of interpretation, and movement type. The landslide data are displayed on top of a base map that consists of an orthorectified aerial photograph overlain on the lidar-derived digital elevation model.

This landslide inventory map is intended to provide users with basic information regarding landslides within the area. The geologic, terrain and climatic conditions that led to slope failures in the past may provide clues to locations and conditions of future slope failures, and it is intended that this map will provide useful information to develop regional landslide susceptibility maps, to guide site-specific investigations for future developments, to assist in regional planning, and to mitigate existing landslides.

LANDSLIDE CLASSIFICATION

Each landslide shown on this map has been classified according to a number of specific characteristics identified at the time recorded in the GIS database. The classification scheme was developed by the Oregon Department of Geology and Mineral Industries (DOGAMI) (Burns and Madin, 2008). Several significant landslide characteristics recorded in the database are portrayed with symbols on this map. The specific characteristics shown for each landslide are the activity of landsliding, landslide features, deep or shallow failure, type of landslide movement, and confidence of landslide interpretation. These landslide characteristics are determined primarily on the basis of geomorphic features, or landforms, observed for each landslide. The symbology used to display these characteristics is explained below.

LANDSLIDE ACTIVITY: Each landslide has been classified according to the relative age of last movement. This map uses color to show the activity.

ACTIVE or HISTORIC (movement < 100 years): The landslide appears to be currently moving or to have moved within historic time.

DORMANT – YOUNG (movement 100-10,000 years – Holocene): Landslide features are fresh to slightly eroded, but there is no evidence of historic movement.

DORMANT – MATURE (movement > 10,000 – Pleistocene and earlier): The observed landforms related to the landslide have been greatly eroded or covered with Pleistocene or earlier alluvial deposits that result in smoothed and subdued morphology.

LANDSLIDE FEATURES: Because of the high resolution of the lidar-derived topographic data, some additional landslide features were identified. These include:

HEAD SCARP: The uppermost scarp, which in most cases exposes the primary surface of rupture.

HEAD AND INTERNAL SCARPS: Scarps within the body of the landslide.

DEPTH OF FAILURE: The depth of landslide failure was estimated from scarp height. Failures less than 4.5 m (15 ft) deep are classified as shallow-seated, and failures greater than 4.5 m (15 ft) deep are classified as deep-seated.

SHALLOW-SEATED LANDSLIDE: Estimated failure plane depth is less than 4.5 m (15 ft).

DEEP-SEATED LANDSLIDE: Estimated failure plane depth is greater than 4.5 m (15 ft).

CONFIDENCE OF INTERPRETATION: Each mapped landslide is classified according to a "confidence" that the mapper assigns to it, and can be regarded as a measure of the likelihood that the landslide actually exists. Landslides are mapped on the basis of characteristic landforms, and the confidence of interpretation is based on the presence or absence of those landforms. As a landslide ages after its last movement, erosion removes or covers the landforms that formed by landsliding. With time, these distinctive landforms become so subtle that they resemble landforms produced by geologic processes and conditions unrelated to landsliding.

Because most landslides, with the exception of channelized debris flow transport zones and deposit zones, rock falls, and topples, have several different types of geomorphic features associated with them, a good way to define certainty is through a simple point system associated with these features. For example, if the head scarp and toe of a landslide are only features identifiable during mapping, the mapper applies 30 points for the head scarp and 30 points for the toe, equaling 60 points, which is associated with a good certainty of identification.

The visual display of this confidence of interpretation is through the use of different line styles as shown below.

EXCELLENT (> 80% confidence, ≥ 90 points)

GOOD (60%–80% confidence, 60–89 points)

MODERATE (40%–60% confidence, 30–59 points)

FAIR (20%–40% confidence, 11–29 points)

POOR (< 20% confidence, ≤ 10 points)

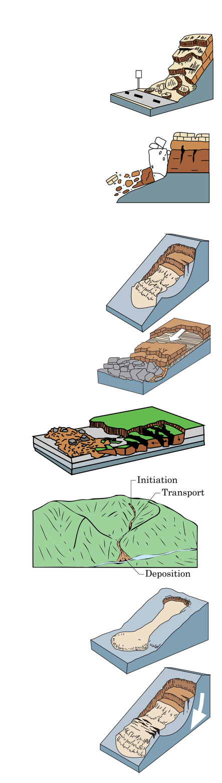
Landslide Feature	Points
Head scarp	30
Flanks	30
Toe	30
Internal scarps, sag ponds, compression ridges, etc.	10*

*Applied only once so that total points do not total more than 100

CLASSIFICATION OF MOVEMENT: Each landslide was classified with the type of landslide movement. There are five types of landslide movement: slide, flow, fall, topple, and spread. These movement types are combined with material type to form the landslide classification. Not all combinations are common in nature, and not all are present in this area.

Example: EFL — **EFL - Earth Flow** – Abbreviation for class of slope movement. Table below displays all types. Generalized diagrams displaying types of movements are shown below table (some modified from Highland, 2004).

Type of Movement	Type of Material		
	Rock	Coarse Soils	Fine Soils
Fall	RF rock fall	DF debris fall	EF earth fall
Topple	RP rock topple	DT debris topple	ET earth topple
Slide-rotational	RS-R rock slide-rotational	DS-R debris slide-rotational	ES-R earth slide-rotational
Slide-translational	RS-T rock slide-translational	DS-T debris slide-translational	ES-T earth slide-translational
Lateral spread	RSP rock spread	DSP debris spread	ESP earth spread
Flow	RFL rock flow	DFL-I debris flow-initiation DFL-T debris flow-transport DFL-D debris flow-deposition	EFL earth flow
Complex	C complex or combinations of two or more types (for example, ES-R + EFL)		



Falls are near-vertical, rapid movements of masses of materials, such as rocks or boulders. The rock debris sometimes accumulates as talus at the base of a cliff.

Topples are distinguished by forward rotation about some pivotal point, below or low in the mass.

Slides are downslope movement of soil or rock on a surface of rupture (failure plane or shear-zone).

- Rotational slides move along a surface of rupture that is curved and concave.
- Translational slides displace along a planar or undulating surface of rupture, sliding out over the original ground surface.

Spreads are commonly triggered by earthquakes, which can cause liquefaction of an underlying layer and extension and subsidence of commonly cohesive materials overlying liquefied layers.

Channelized Debris Flows commonly start on a steep, concave slope as a small slide or earthflow into a channel. As this mixture of landslide debris and water flows down the channel, it picks up more debris and water, as well as speed, and deposits material in a fan at the outlet of the channel.

Earth Flows commonly have a characteristic “hourglass” shape. The slope material liquefies and runs out, forming a bowl or depression at the head.

Complex Landslides are combinations of two or more types. A common complex landslide is a slump-earth flow, which usually exhibits slump features in the upper region and earth flow features near the toe.

LIMITATIONS

The landslide inventory mapping protocol was developed with input from many sources and people, along with expertise gained from years of experience. Several limitations are worth noting and underscore that any 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 verify all original input data.
2. As discussed above, the protocol to develop landslide inventories is based on four primary tasks: 1) interpretation of lidar-derived topographic data, 2) compilation and review of previously mapped landslides, 3) review of historic air photos, and 4) limited field check. These tasks can affect the level of detail and accuracy of the landslide inventory. We expect lidar data quality will improve in the future, which will likely result in identification of more landslides with greater accuracy and confidence. Because of time limitations some previously mapped landslides have likely been missed. For some locations, historic air photos may not be available. Because field work is time consuming and therefore expensive, field checking may be extensive in some locations and very limited in some remote locations.
3. The GIS database is a “snapshot” view of the current data; new information regarding landslides may be found and new landslides may occur.
4. Because of the resolution of the lidar data and air photos, landslides that are smaller than 100 square meters (1,075 square feet) may not be identified. Small landslides were included if they are provided by a local governmental agency, a site- or area-specific study report, or a local area landslide expert, and are found to be accurately located.
5. It can be expected that the geological interpreter will not recognize some landslides as a result of lidar data and air photo quality, scale, vegetation, or other characteristics. A mapper’s experience level and experience with landslides in the immediate area also affect the quality of the inventory map. To limit these problems, this map was developed following the lidar-based landslide inventory mapping protocol developed by Burns and Madin (2008) and has undergone peer review.
6. Earthwork related to development on hillsides can remove the geomorphic expressions of past landsliding. This can result in landslides being missed in the inventory. Earthwork on hillsides can also create geomorphic expressions that mimic past landsliding. For example, a cut and fill can look like a landslide scarp and toe. This limitation can sometimes be addressed by viewing aerial photographs that predate development in the area being mapped. Therefore, to ensure that past landslides have been adequately identified, if a landslide was identified on the predevelopment air photos, it was included in the landslide inventory, whether or not surface expression was located on the lidar-based map.
7. Some landslides have been mitigated. Because it is not feasible to collect detailed site-specific information on every landslide, 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.

Acknowledgements: 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 Indutries

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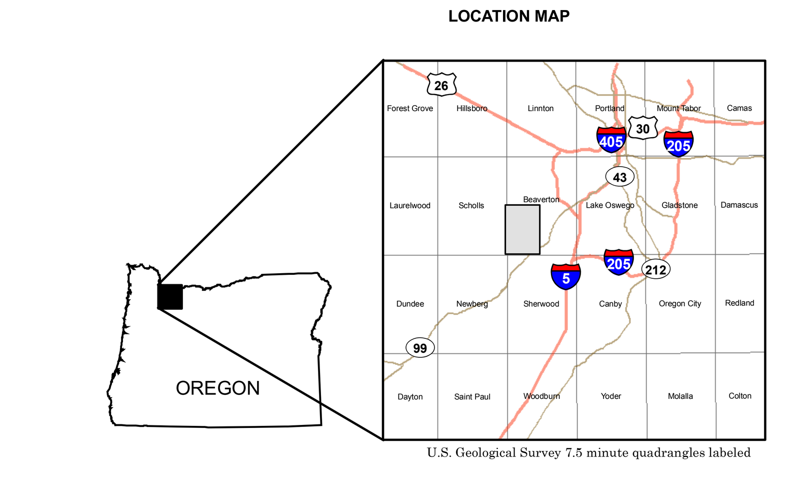
Wiegers, M, O., 2006, Landslide inventory map of the Morgan Hill quadrangle, Santa Clara County, California: California Geological Survey, Landslide inventory map series.

LOCATION MAP



U.S. Geological Survey 7.5 minute quadrangles labeled

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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_1.mxd

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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 existing landslides on the basis of limited data. The hazard zones were created following the protocol defined by Burns and Madin (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.