Herrera Environmental Consultants, Inc.

Final Memorandum

To	Kimberly Swan, Clackamas River Water Providers
From	Jennifer Schmidt, Herrera Environmental Consultants
Date	May 20, 2012
Subject	GIS Vunerable Soils Risk Analysis Results

Introduction

The Clackamas River is a source of drinking water for more than 300,000 people in Clackamas County and is an important resource for helping to meet future water demand in the region. The Clackamas River Water Providers (CRWP) represents five municipal surface water intakes on the Clackamas River: City of Estacada, Clackamas River Water, North Clackamas County Water Commission, South Fork Water Board, and City of Lake Oswego. In 2010, the CRWP developed a Drinking Water Protection Plan that outlined a series of strategies and programs to address potential threats to source water quality in the Clackamas River watershed. Herrera Environmental Consultants (Herrera) was hired to complete a series of geographic information system (GIS) analyses in order to help to identify potential pathways for pollutant export from the Clackamas River Watershed. The following major high-risk activity categories were identified in the Drinking Water Protection Plan (Clackamas River Water Providers 2010):

- Septic Systems
- Agricultural Activities
- Forestry Activities
- Vulnerable Soils
- Urban Development
- Point-Source Pollutants

The goal of these GIS analyses was to map risk factors known to have a strong negative correlation with drinking water quality in the Clackamas River watershed. Mapped risk "hot spots" for each category will provide a spatial context for both the geography and intensity of risk by activity that can be used by the CRWP to help prioritize mitigation efforts. This memorandum focuses specifically on the results of the GIS Vulnerable Soils Risk Assessment portion of the Drinking Water Protection Plan.

Potential Threats from Vulnerable Soils

The Clackamas River Water Providers (CRWP) have identified vulnerable soils as a contributing factor to source water quality impacts from multiple high-risk activities in the Clackamas River watershed, including (Clackamas River Water Providers 2010):

1. Increased septic system failure risk from effluent exceeding the absorbent capacity of soils, resulting in the release of partially treated effluent onto the ground surface.

2. Soil erosion and increased rates of sediment, pesticide, and fertilizer runoff from agricultural land after crops have been harvested.

3. Potential leaking of contaminants into groundwater from sewer lines that are located in highly permeable soils adjacent to streams.

4. Runoff and erosion from bare soil areas created by roads, landings, and skid trails constructed to support forestry activities (Neary et.al. 2008)

Soil composition, including depth, texture, structure, consistency, and the presence of restricture layers, exerts an important influence on water quality. Soil erosion, increased sedimentation, rapid or very slow soil permeability, the presence of hardpans or shallow depth to bedrock, landslide areas, and steep slopes are all factors that can increase the overall cost of drinking water treatment when improperly managed (Cook 1996).

GIS Vulnerable Soils Risk Analysis

Herrera completed a GIS analysis identifying and mapping vulnerable soils in the Clackamas River watershed that could have a negative impact on source water quality. The contribution of soil characteristics to the 5 primary high-risk activities of concern to the CRWP (septic systems; agricultural activities; forestry activities; urban development; and point-source pollutants) are addressed in the associated risk analysis results memorandums. The purpose of this memorandum is to summarize existing GIS data and soil survey reports to provide an overview of the general extent and severity of the following soil characteristics in the Clackamas River watershed:

- Permeability
- Erodibility
- Slope
- Restrictive horizons
- Landslides

The following sections provide more detailed information on each soil characteristic, including data sources used to map the soil properties and limitations. Detailed information on soil characteristics by subbasin in the Clackamas River watershed can be found in the 2005

Clackamas Basin Summary Watershed Overview report prepared for the Clackamas River Basin Council (WPN 2005).

Soil Permeability

Permeability refers to the ability of soil to absorb and transmit water, and is determined primarily by soil structure and texture. Water quality problems can occur when these soil properties cause water to be absorbed either very slowly or very rapidly. For example, water moves through dense, impermeable soil (primarily fine-textured and clayey or sandy soils) more slowly than it is applied to the soil surface as precipitation, causing these soil horizons to become saturated with water. Alternatively, water moves through thin, rapidly-draining soils (primarily coarse-textured and sandy or gravelley soils like those found near large rivers) faster than the soil can treat it, placing groundwater supplies at risk (Lee et. al. 2004; Coche 1986).

Herrera mapped soil permeability in the Clackamas River watershed based on GIS soil survey data and reports from the U.S. Department of Agriculture (USDA) National Resource Conservation Service (NRCS) and the U.S Environmental Protection Agency (EPA). Data mapped at a scale of 1:24,000 was used for the portion of the Clackamas River watershed north of Mt. Hood National Forest; data mapped at a scale of 1:250,000 was used for the remainder of the watershed, including the Warm Springs Indian Reservation. The difference in resolution between these datasets is important to consider when interpreting permeability patterns; accuracy may vary considerably between the survey areas.

Figure 1 shows soil permeability rates within the Clackamas River watershed; approximate acreages by permability class are summarized in Table 1.

Table 1. Soil permeability in the Clackamas River watershed.

Permeability	Area (acres)	Percent of Watershed
Very slow	2,950	< 1%
Slow	17,105	3%
Moderately slow	78,830	14%
Moderate	344,425	57%
Moderately rapid	155,380	26%
Very rapid	440	< 1%
Waterbodies	4,110	< 1%
Total	**603,240**	

Sources: NRCS (1985); U.S.EPA (1994)

Herrera analyzed soil permeability as a contributing factor to water quality risk from septic system failure in the Clackamas River watershed; detailed information on this analysis is documented in the GIS Septic Systems Risk Analysis Results final memorandum.

Soil Erodibility

Water quality is significantly impacted by soil erosion. Increased levels of nitrogren and phosphorous and higher sediment loads are the primary contributors to water quality problems from eroding soils (Al-Kaisi et.al. 2003). Soil erodibility refers to the ability of soil to resist erosion based on physical characteristics like permeability, organic content, and soil texture. Generally, soils with the highest occurences of erodibility have slow infiltration rates, low levels of organic content, and are silty, very fine sandy, or clayey textured. Surface runoff that occurs when the infiltration capacity of soils is exceeded can contribute to significant soil erosion. In addition, soils that have experienced past erosion are more likely to erode again in the future (Wall et. al. 2003).

Herrera mapped soil erodibility in the Clackamas River watershed using four GIS data sources: 1) soil survey data and reports from NRCS mapped at a scale of 1:24,000 covering the portion of the watershed north of Mt. Hood National Forest; 2) spatial data depicting soil erosion potential prepared by the Oregon Department of Environmental Quality (DEQ) mapped at a scale of 1:250,000; 3) spatial data depicting highly erodible land mapped by Oregon DEQ at a scale of 1:24,000; and 4) soil survey data and reports from EPA mapped at a scale of 1:250,0000 for the portion of the watershed in Marion County. The difference in resolution between these datasets is important to consider when interpreting erodibility patterns; accuracy may vary considerably between the survey areas.

Figure 2 shows soil erosion risk within the Clackamas River watershed; acreages by risk category are summarized in Table 2.

Table 2. Soil erodibility in the Clackamas River watershed.

Erosion Risk	Area (acres)	Percent of Watershed
Low	411,330	68%
Moderate	73,495	12%
High	17,170	3%
Severe	97,135	16%
Waterbodies	4,110	1%
Total	**603,240**	**100%**

Sources: NRCS (1985); U.S.EPA (1994); Oregon DEQ (2010)

Herrera analyzed soil erodibility as a contributing factor to water quality risk from agricultural and forestry activities in the Clackamas River watershed; detailed information on these analyses is documented in the GIS Forestry and Agricultural Risk Analyses Results final memorandums.

Slope

As slope increase, soil erosion rates also increase as a result of greater accumulations of surface runoff (Wall et.al. 2003). Steep slopes also pose significant development constraints for certain land uses that are prevalant in the Clackamas River watershed, including urban development, constructing on-site septic systems, and timber harvesting.

Herrera mapped steep slopes in the Clackamas River watershed using elevation data obtained from the United States Geological Survey (USGS) with a 10-meter pixel resolution. Figure 3 shows percent slope within the Clackamas River watershed; acreages by slope categories are summarized in Table 3.

Table 3. Percent slope in the Clackamas River watershed.

Percent Slope	Area (acres)	Percent of Watershed
< 10%	164,265	26%
10 to 25%	184,135	31%
25 to 40%	111,900	19%
> 40%	142,940	24%
Total	**603,240**	**100%**

Source: USGS (1999)

Herrera analyzed steep slopes as a contributing factor to water quality risk from septic systems, urban development, and forestry activities in the Clackamas River watershed; detailed information on these analyses is documented in the GIS Forestry and Agricultural Risk Analyses Results final memorandums.

Restrictive Horizons

Soil layers that restrict the vertical movement of water resulting in perched ground water are referred to as restrictive horizons. These soils tend to be dense, strongly compacted, and largely impervious to water (Mokma et. al. 2005). The two primary categories of restrictive horizons mapped by Herrera in the Clackamas River watershed are 1) soil hardpans and 2) shallow depth to bedrock.

Herrera mapped restrictive horizons in the Clackamas River watershed based on GIS data and soil survey reports from NRCS and EPA. Data mapped at a scale of 1:24,000 was used for the portion of the Clackamas River watershed north of Mt. Hood National Forest; data mapped at a scale of 1:250,000 was used for the remainder of the watershed, including the Warm Springs Indian Reservation. Based on this data, approximately 186,530 acres (30%) of the watershed contains soils with restrictive horizons that are largely impervious to water; the distribution of these areas is shown in Figure 4. The difference in resolution between the source datasets used is important to consider when interpreting restrictive horizon patterns; accuracy may vary considerably between the survey areas, and restrictive horizons mapped using data at a scale of 1:250,000 are likely overestimated.

Herrera analyzed restrictive horizons as a contributing factor to water quality risk from septic systems; detailed information on this analysis is documented in the GIS Septic Systems Risk Analysis Results final memorandum.

Landslide Areas

Landslides generate large quantities of sediment, posing a significant risk to water quality as the sediment moves downhill and into rivers and streams. Herrera mapped landslide areas in the Clackamas River watershed using the Statewide Landslide Information Database for Oregon (SLIDO-2) from the Oregon Department of Geology and Mineral Industries (DOGAMI), which is a database of landslides and landslide related features compiled from more than 300 published and unpublished geologic hazard studies. Approximately 1,250 landslide deposits and landslide-related features and 605 historic landslide point locations were mapped by DOGAMI in the Clackamas River watershed; these features are shown in Figure 5.

Herrera analyzed landslides and landslide-related features as a contributing factor to water quality risk from forestry activities; detailed information on this analysis is documented in the GIS Forestry Activities Risk Analysis Results final memorandum.

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FIGURES

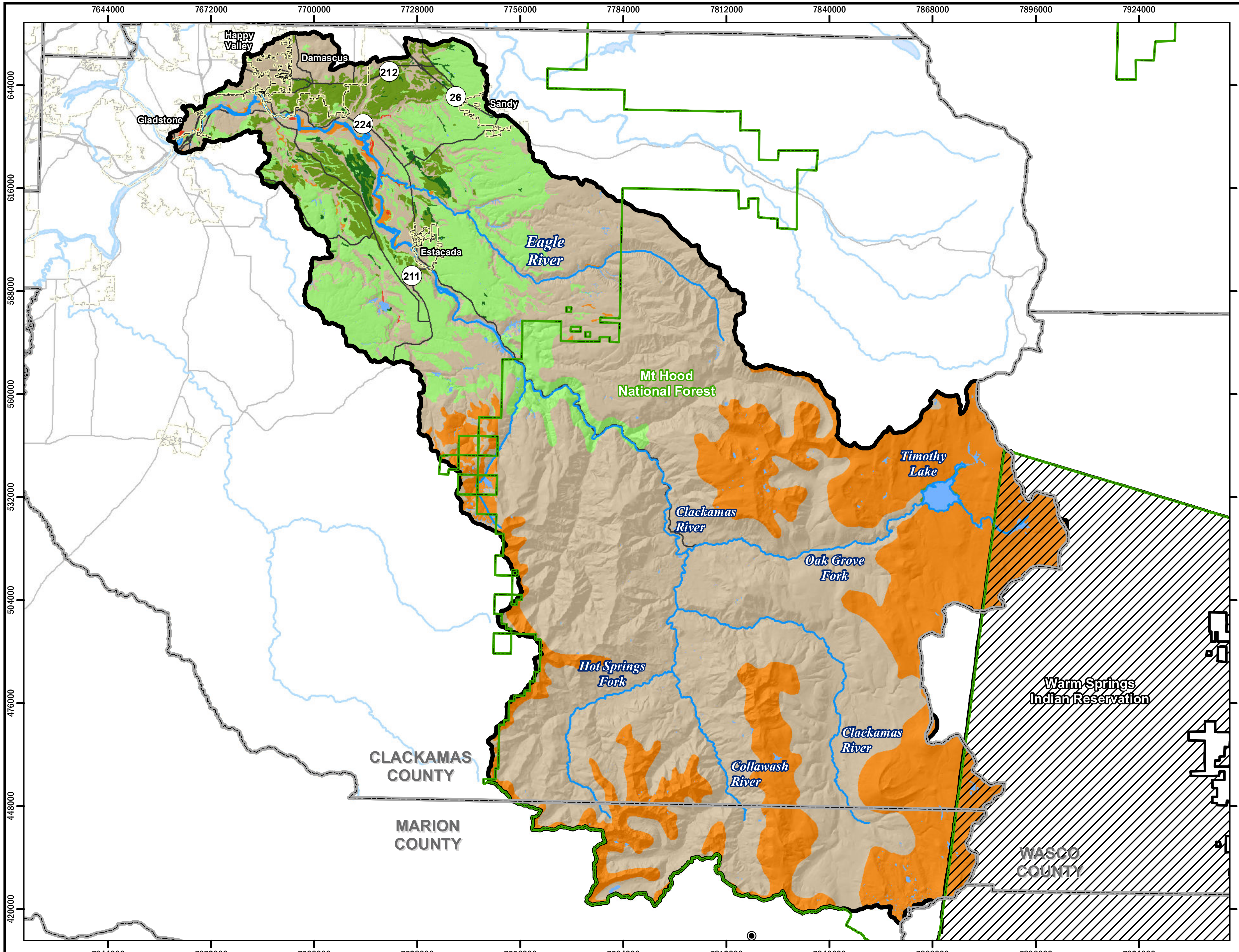

Figure 1.
Soil permeability in the Clackamas River watershed.

Legend

Soil permeability

- Very slow
- Slow
- Moderately slow
- Moderate
- Moderately rapid
- Very rapid
- County boundary
- National Forest boundary
- Clackamas River Watershed boundary
- Warm Springs Indian Reservation
- City limits

N

0 14,000 28,000 56,000
feet

Clackamas River Water Providers
Working together to protect and conserve our drinking water.

HERRERA

Coordinates: Oregon State Plane North
HARN NAD83 (feet)
Soils Data: NRCS 1985; U.S. EPA 1994; ODEQ 2010

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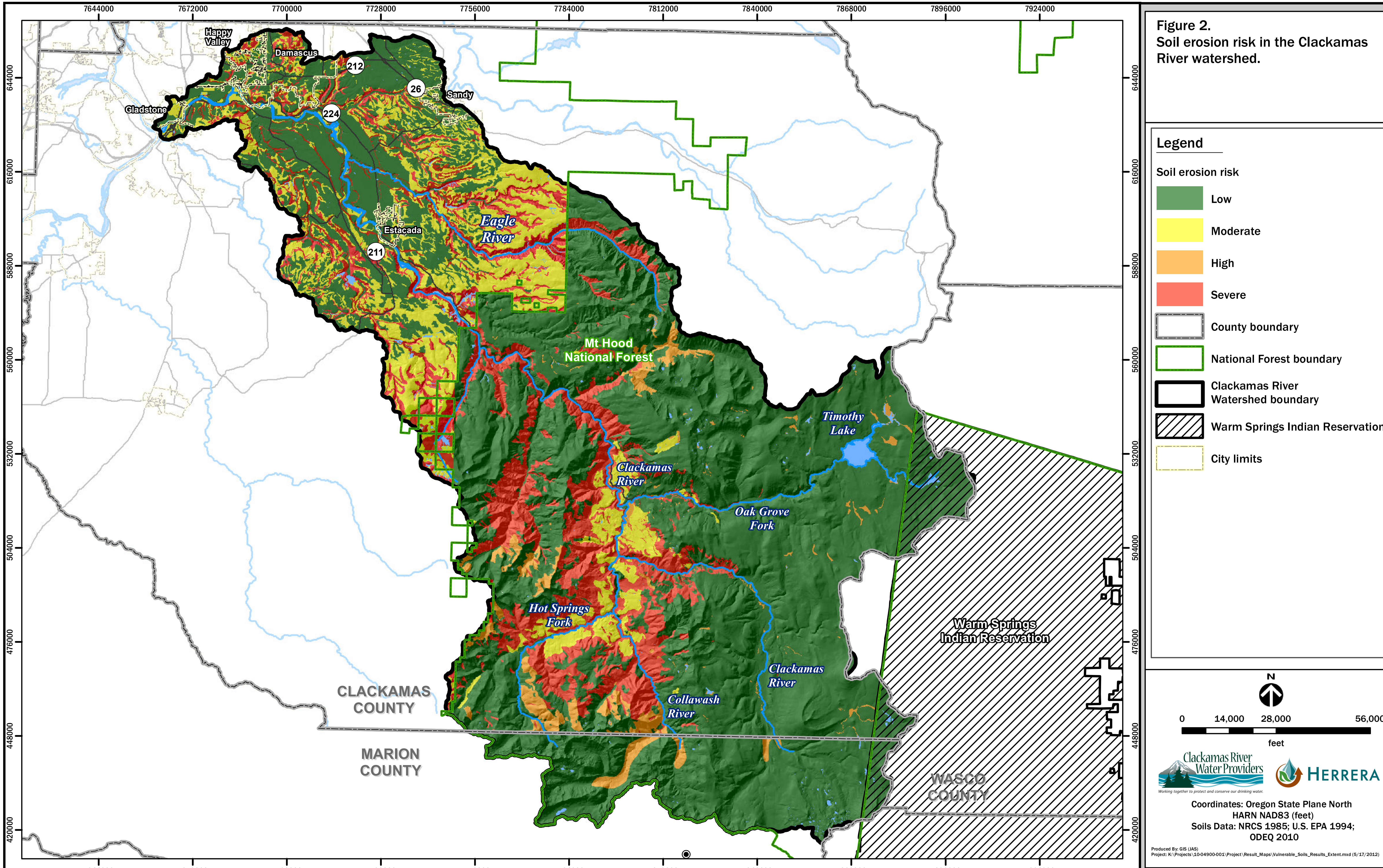
Figure 2.
Soil erosion risk in the Clackamas River watershed.



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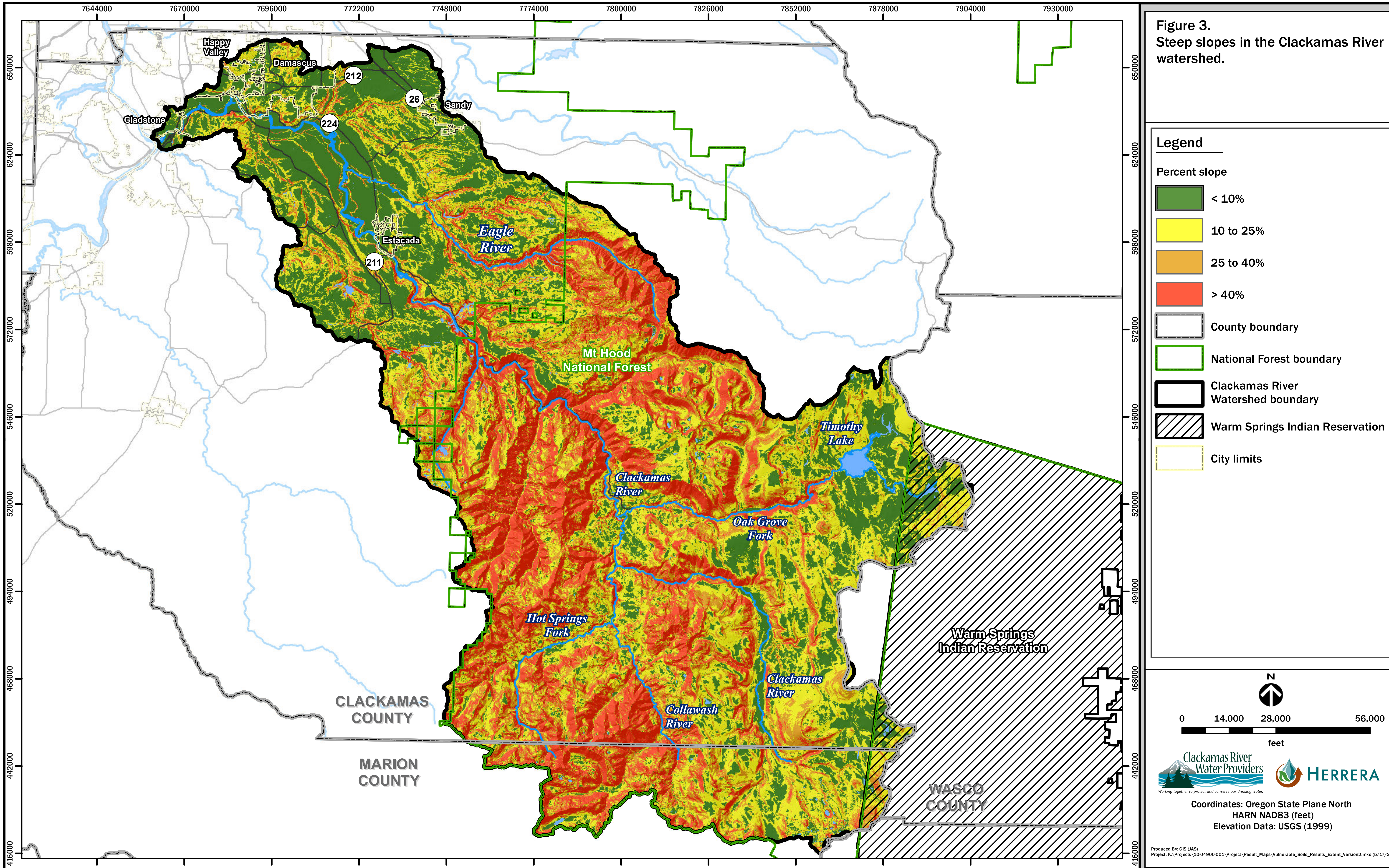
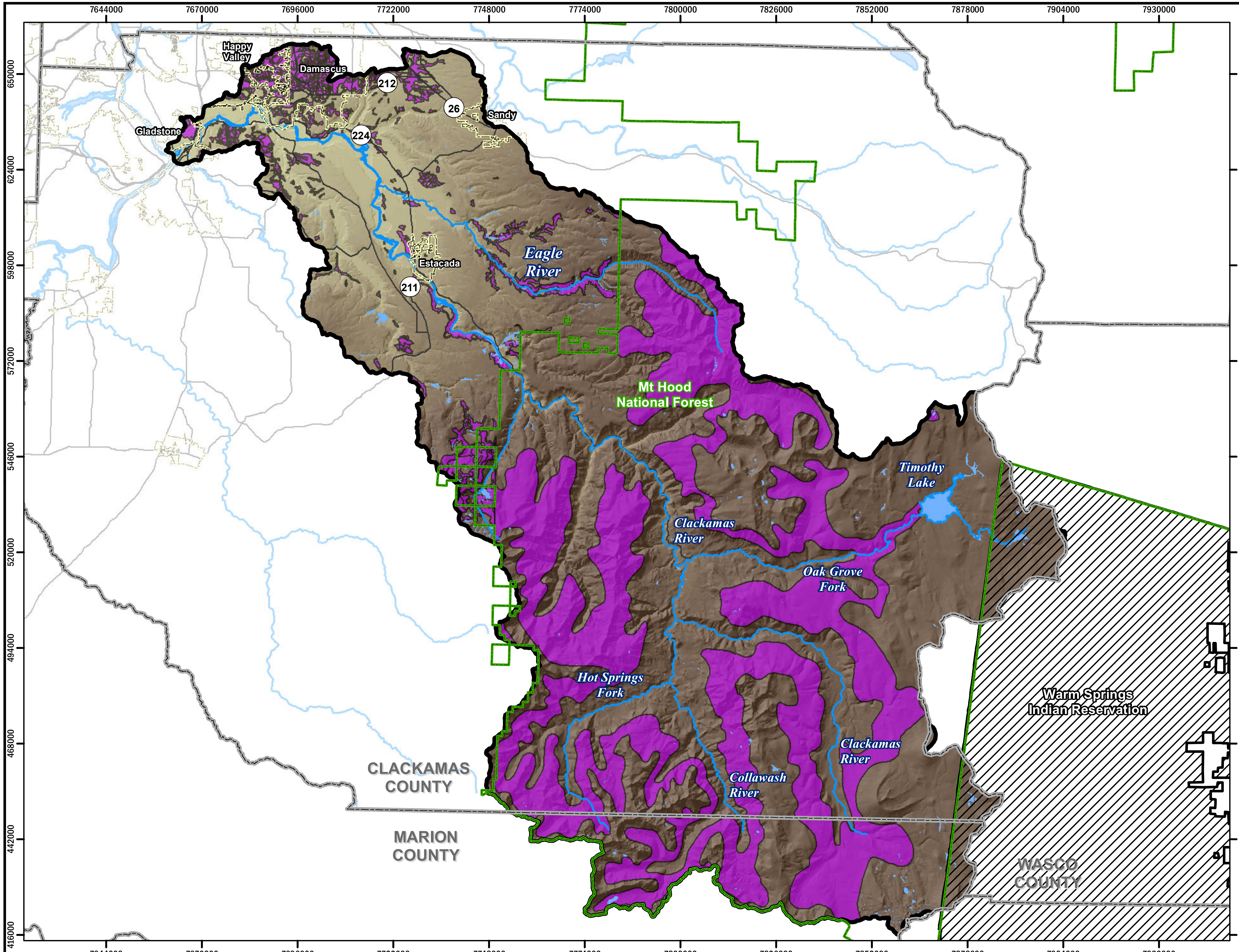


Figure 3.
Steep slopes in the Clackamas River watershed.

Figure 4.
Restrictive soil horizons in the Clackamas River watershed.



Legend

- Restrictive soil horizon
- County boundary
- National Forest boundary
- Clackamas River Watershed boundary
- Warm Springs Indian Reservation
- City limits

N

0 14,000 28,000 56,000
feet

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ODEQ 2010

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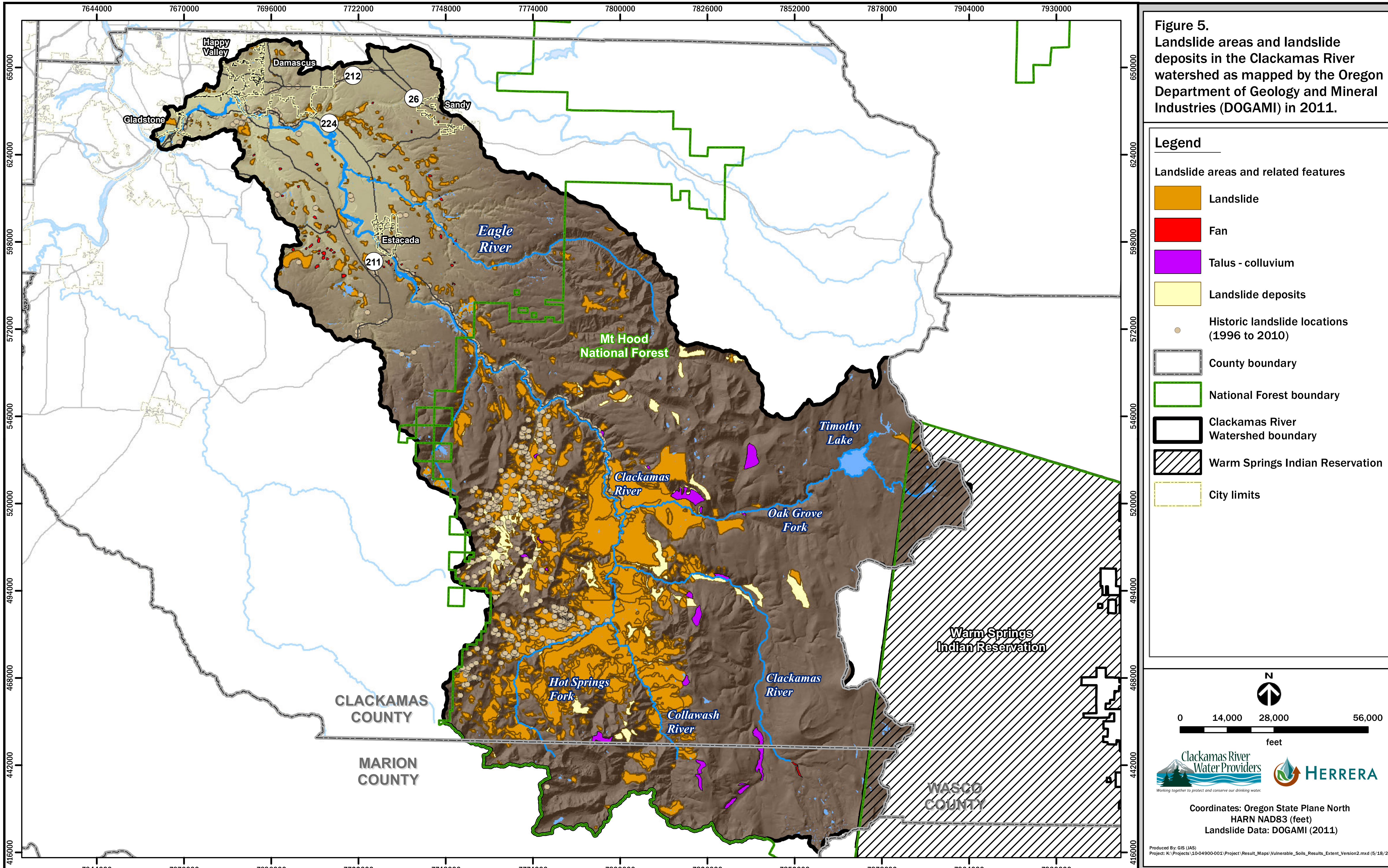

Figure 5.
Landslide areas and landslide deposits in the Clackamas River watershed as mapped by the Oregon Department of Geology and Mineral Industries (DOGAMI) in 2011.