

# **Landslide Hazards and Mitigation**

**WSDOT Rail, Freight, and Ports Division  
Washington State Department of Natural Resources  
Clark County  
BNSF Railway**

**May 12, 2025**

# Agenda

- Landslides can threaten your property!
- What causes landslides?
- How can you identify and prevent landslides?
  - Landslide mapping
- What are we doing to respond?
  - Landslide Mitigation Workgroup
  - Landslide mitigation construction projects
- How do landslides impact rail?
- Landslides in Clark County
- Contact us!

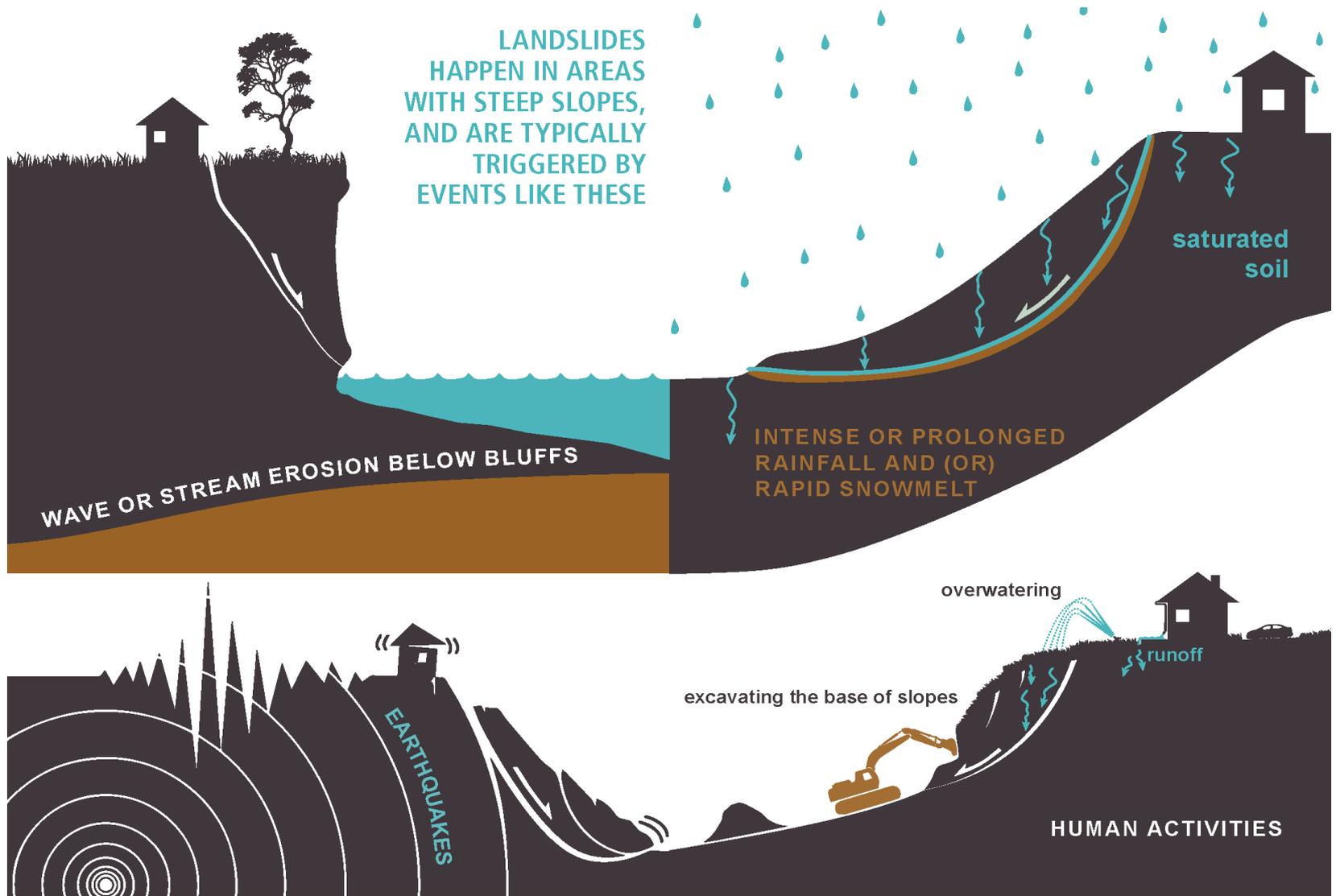
# Landslides can threaten your property



# Everett landslide derails train



# Landslide triggers



[www.dnr.wa.gov/geology](http://www.dnr.wa.gov/geology)

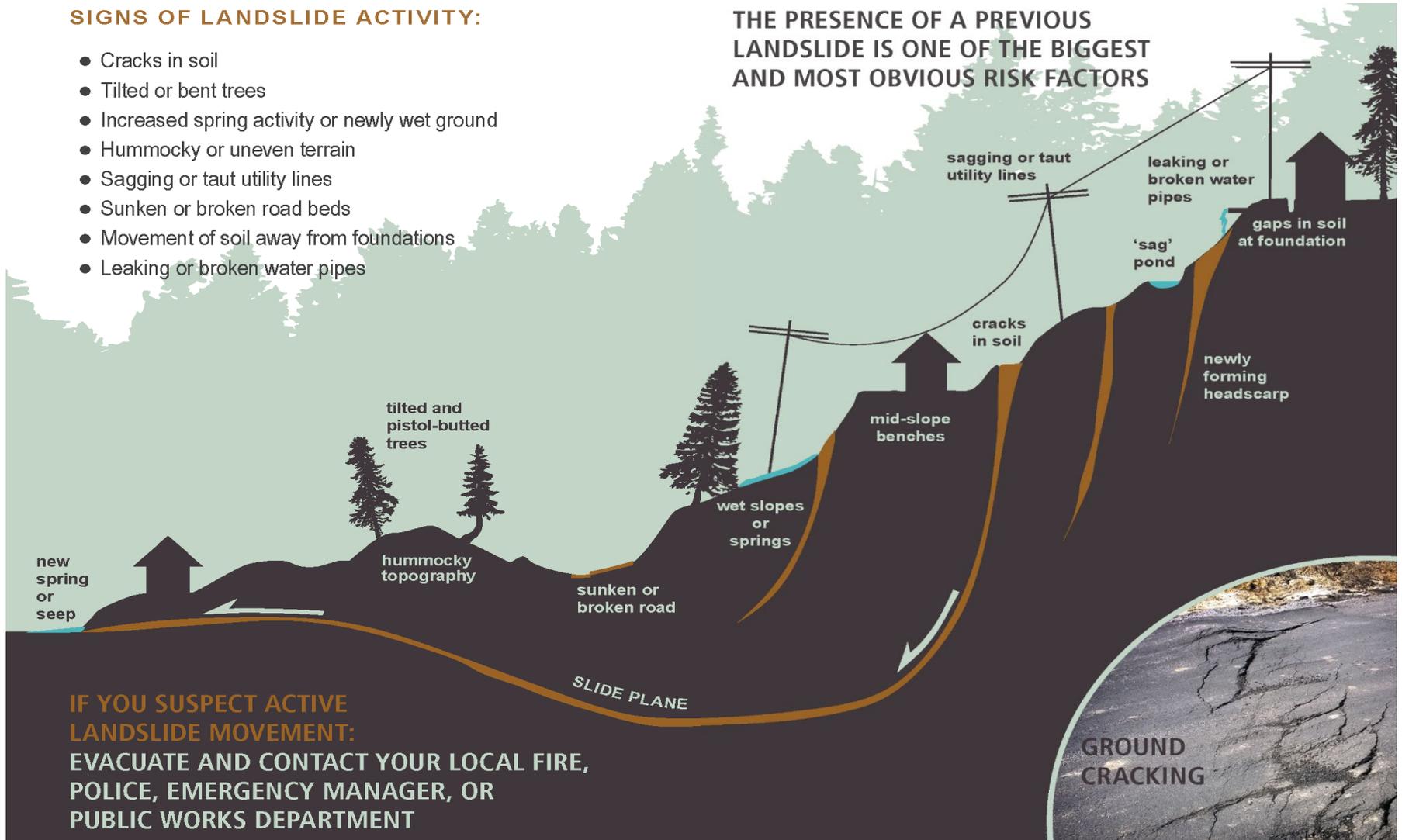
[www.oregongeology.org](http://www.oregongeology.org)

# Landslide warning signs

## SIGNS OF LANDSLIDE ACTIVITY:

- Cracks in soil
- Tilted or bent trees
- Increased spring activity or newly wet ground
- Hummocky or uneven terrain
- Sagging or taut utility lines
- Sunken or broken road beds
- Movement of soil away from foundations
- Leaking or broken water pipes

## THE PRESENCE OF A PREVIOUS LANDSLIDE IS ONE OF THE BIGGEST AND MOST OBVIOUS RISK FACTORS



# The role of water and plants



**62.3 lbs**

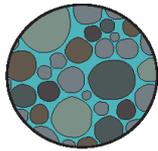
## WHY IS WATER IMPORTANT?

One cubic foot (7.5 gallons) of water weighs 62.3 lbs!

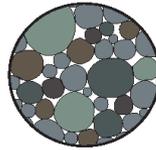
When water is added to a slope the weight increases the downward force, putting surrounding homes at risk

## PLANT ROOTS ARE VITAL

Live tree roots strengthen slopes. After a tree is cut down, it takes between 5 and 8 years for the roots below to lose their strength.



**Wet soil**  
grains pushed apart  
reducing soil strength



**Dry soil**  
grains touch,  
increasing soil strength

## REDUCE WATER ON SLOPES:

- Maintain healthy vegetation
- Use drought-resistant plantings
- Fix leaking plumbing immediately
- Direct downspout runoff well away from slopes
- Plant trees and shrubs, which uptake water more efficiently than lawns



native trees and plants

buffer zone

**MAINTAIN A  
BUFFER OF NATIVE  
PLANTS BETWEEN  
YOUR HOUSE  
AND THE EDGES  
OF STEEP SLOPES**



**DEEP ROOT SYSTEMS  
GIVE STRENGTH TO SLOPES**

[www.dnr.wa.gov/geology](http://www.dnr.wa.gov/geology)

[www.oregongeology.org](http://www.oregongeology.org)

# Protect your property

## THERE ARE ACTIONS YOU CAN TAKE AS A HOMEOWNER TO REDUCE THE CHANCES OF A LANDSLIDE AFFECTING YOUR PROPERTY:

DO

- Drain water from surface runoff, downspouts, and driveways well away from slopes
- Plant native ground cover on slopes
- Consult with a professional before significantly altering existing slopes uphill or downslope of your home
- If you suspect you are on a landslide, contact a licensed engineering geologist or a geotechnical engineer for an evaluation
- Check online maps, such as SLIDO (Oregon) or the Washington Geologic Information Portal to see if you might live in a landslide area

- Do not add water to steep slopes
- Avoid placing fill soil on or near steep slopes
- Avoid placing yard waste or debris on steep slopes
- Avoid excavating on or at the base of steep slopes

DO NOT



**YOU AND YOUR NEIGHBORS SHARE MORE THAN FENCES. YOU ALL SHARE THE RESPONSIBILITY OF KEEPING YOUR SLOPES SAFE.**

[www.dnr.wa.gov/geology](http://www.dnr.wa.gov/geology)

## LOOK FOR WARNING SIGNS ON YOUR PROPERTY

If you live on or near a steep slope, evaluate your property for signs of landslide movement. Many (but not all) signs of landslide activity are listed below. A high score may indicate the presence of a landslide.

### INSIDE YOUR HOME:

- Cracks in walls
- Nails popping out of walls
- Bulging walls
- Separation of chimney from walls
- Creaking/popping noises
- Light switches coming out of walls
- Doors/windows hard to shut
- Twisted beams
- Cracks in floors
- Water seeping into basement

### OUTSIDE YOUR HOME:

- Changes in surface drainage
- Bulges in retaining walls or tilting of walls
- Cracks developing in the soil
- Pistol-butted or bent trees
- Broken water, utility, or sewer lines
- Cracks in sidewalks or foundation
- Stretched or leaning utility lines



**CONSULT A PROFESSIONAL BEFORE PURCHASING PROPERTY IN SLOPING AREAS**

[www.oregongeology.org](http://www.oregongeology.org)

# Resources

Protect Your Home and Property

## A Homeowner's Guide to Landslides

for Washington and Oregon



Washington

Ore

For More Information

### IF YOU ARE IMPACTED BY OR SUSPECT AN ACTIVE LANDSLIDE:

- Evacuate
- Contact your local fire, police, emergency manager, or public works department
- Contact a licensed professional



### LANDSLIDE RESOURCES

#### OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

SLIDO Landslide Information Database  
[www.oregongeology.org/sub/slido](http://www.oregongeology.org/sub/slido)

#### U.S. GEOLOGICAL SURVEY

Landslide Hazards Program  
[landslides.usgs.gov](http://landslides.usgs.gov)

#### WASHINGTON GEOLOGICAL SURVEY

Washington Geologic Information Portal  
[www.dnr.wa.gov/geologyportal](http://www.dnr.wa.gov/geologyportal)

#### WASHINGTON STATE DEPARTMENT OF ECOLOGY

Slope Stabilization and Erosion Control Using Vegetation  
[www.ecy.wa.gov/programs/sea/pubs/93-30](http://www.ecy.wa.gov/programs/sea/pubs/93-30)

THIS PAMPHLET WAS MADE IN COOPERATION WITH



Oregon Department of Geology and Mineral Industries



WASHINGTON STATE DEPT OF NATURAL RESOURCES

This pamphlet offers some general guidance a homeowner should consider regarding their home and property. Landslide conditions vary from site to site—if you are concerned about your property, it is always best to consult a professional.

### FACT SHEET: LANDSLIDE HAZARDS

#### SHALLOW LANDSLIDE HAZARD FORECAST SYSTEM

In cooperation with the National Weather Service and NOAA, we have developed a model based on recent and predicted rainfall data that may forecast hazards and may reduce losses from landslides. Visit the site at [www.dnr.wa.gov/slhf](http://www.dnr.wa.gov/slhf).

#### FREQUENTLY ASKED QUESTIONS

**Where do landslides occur?**  
 Landslides can occur on gentle to steep slopes but they are most common on steep

### WASHINGTON GEOLOGICAL SURVEY

## Landslide Hazards in Washington State



2009 NILE LANDSLIDE

Washington is one of the most landslide-prone states in the country, with hundreds to thousands of events each year. The direct cost of landslide damage includes the repair of roads and property. Indirect costs, such as loss of property value and tax revenue, and environmental effects, such as the degradation of water quality, can exceed direct costs.

### FACT SHEET: WHAT ARE LANDSLIDES?

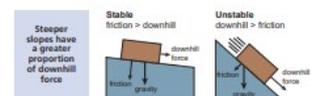
### WASHINGTON GEOLOGICAL SURVEY

## What Are Landslides And How Do They Occur?

A landslide generally refers to the downhill movement of rock, soil, or debris. The term landslide can also refer to the deposit that is created by a landslide event. This fact sheet is meant to provide general information only; real landslides have many variables.

#### THE ROLE OF GRAVITY

Landslides nearly always move down a slope. This is because the force of gravity—which acts to move material downhill—is usually counteracted by two things: (1) the internal strength of the material, and (2) the friction of the material on the slope. A landslide occurs because the force of gravity becomes greater than either friction or the internal strength of the rock, soil, or sediment.



#### THE ROLE OF WATER

The addition of water to material on a slope can make landslides more common. This is because water adds significant weight to the slope as it seeps into the ground, becoming groundwater, and adding to the gravitational force. Water also lowers the strength of the material which can make it less able to withstand the force of gravity. Water also reduces friction (see The Role of Friction), making it easier to move material downhill. These processes help to explain why landslides are much more common during the rainy season, and especially common during or right after large storms.



#### THE ROLE OF FRICTION

The amount of friction between a deposit of rock or soil and the slope that it rests on plays a large role in when landslides happen. Imagine trying to slide a large rock along a flat surface—it's not difficult because of the friction between the rock and the surface. Pushing the rock is easier if the surface slopes downhill or is slippery. The same is true for landslides—steeper slopes have less friction, making landslides more common. Any change to the Earth's surface that increases the slope (for example, river incision or the removal of material at the base of a slope by humans) or that reduces the friction of a slope (such as the addition of water) can increase the likelihood of a landslide.

General information about landslide hazards and possibilities has many variables and are not predictable.

#### OF AN IMPENDING LANDSLIDE

Some landslides may provide clues that they happen suddenly without any warning signs. Signs include: opening, downslope movement of rock, soil, or vegetation; surface cracks; changes in the surface; increased sediment, especially after storms.

#### IF YOU OBSERVE A LANDSLIDE IN PROGRESS

It is not safe to do so! Landslides are dangerous, unpredictable. A landslide can easily destroy or bury a car or house. Call immediately to your county Emergency Manager.

#### SIGNALS OF A POTENTIAL LANDSLIDE

Signs include: spring and/or seep activity, or newly saturated ground; trees on a hillside; trees, or bulges in the ground; leaning telephone poles, deformed fences, or bent trees; cracks in walls, ceilings, or foundations; water, septic, or sewer lines; trees or structures leaning; their foundation; movement of soil away from foundations; water wells that suddenly run dry.

#### IF YOU THINK A LANDSLIDE MAY OCCUR

You should be reported to your county Emergency Manager so they can be properly evaluated (See RESOURCES on back page).

#### REPORT LANDSLIDES

Report landslides to your county Emergency Manager: [ml.wa.gov/other-links/lemd-contact-us](mailto:ml.wa.gov/other-links/lemd-contact-us)

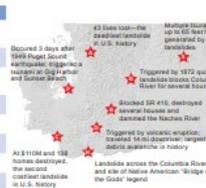


WASHINGTON STATE DEPT OF NATURAL RESOURCES

Washington Geological Survey • MS 47007 • Olympia, WA 98504-7007 • 360-902-1450 • [www.dnr.wa.gov/geology](http://www.dnr.wa.gov/geology) • [email: geology@dnr.wa.gov](mailto:geology@dnr.wa.gov)

#### SOME HISTORIC LANDSLIDES IN WASHINGTON STATE

Slide or area name	Date
(A) SR 530 (Ika Oso or Hazel)	Mar. 2014
(B) Nile	Oct. 2009
(C) Aldercrest-Banyon	Feb–Oct. 1928
(D) Mount St. Helens	May 1980
(E) Lake Roosevelt	1944–1953
(F) Tacoma Narrows	Apr. 1949
(G) Ribbon Cliffs	Dec. 1872
(H) Bonneville	mid-1400s



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<https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides>

# DNR Landslide Mapping

N A T U R A L  
R E S O U R C E S

## PROTOCOL FOR LANDSLIDE INVENTORY MAPPING FROM LIDAR DATA IN WASHINGTON STATE

by Stephen L. Slaughter, L.E.G., William J. Burns, C.E.G.,  
Katherine A. Mickelson, L.G., Kara E. Jacobacci,  
Alyssa Biel, and Trevor A. Contreras, L.E.G.

WASHINGTON  
GEOLOGICAL SURVEY

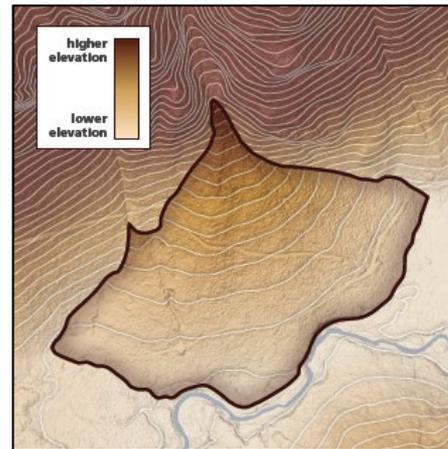
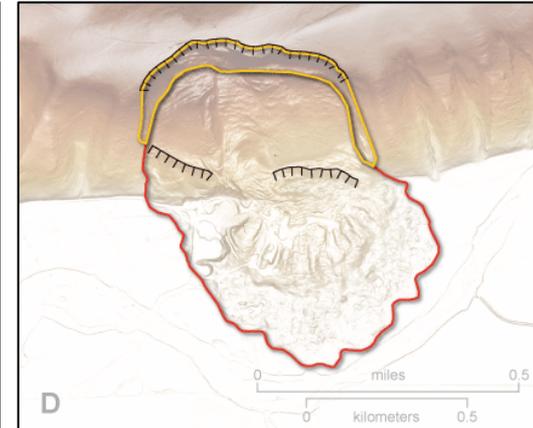
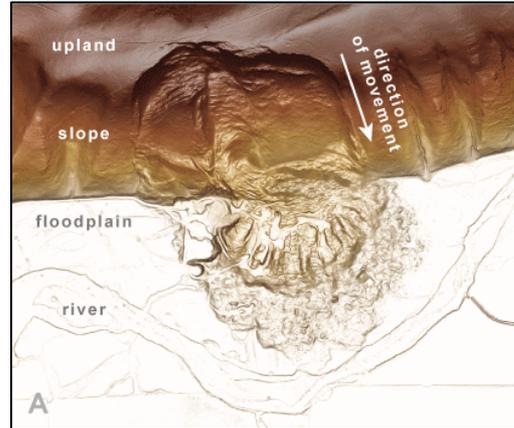
BULLETIN 82  
April 2017

PEER REVIEWED

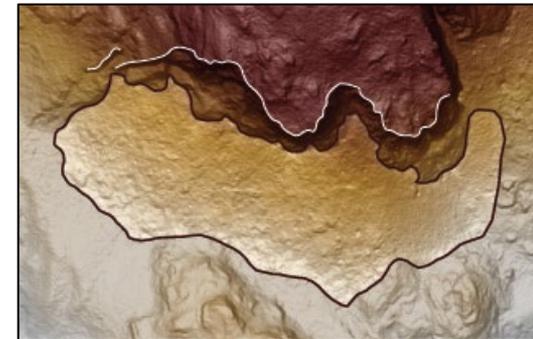


WASHINGTON STATE DEPARTMENT OF  
**NATURAL RESOURCES**

## Landslides

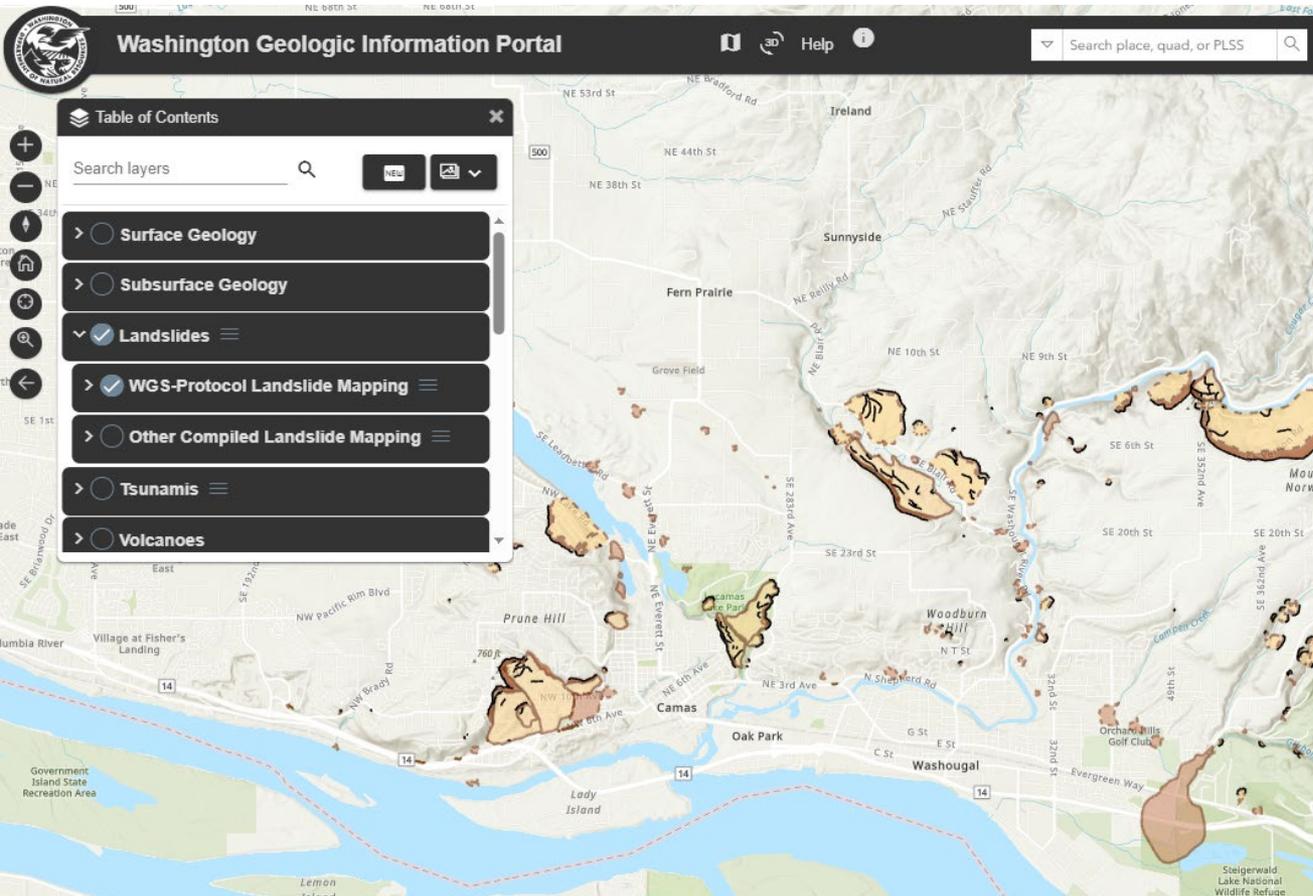


## Fans



## Rockfall

# DNR Landslide Mapping



Landslide mapping for Clark County will be published December 2026

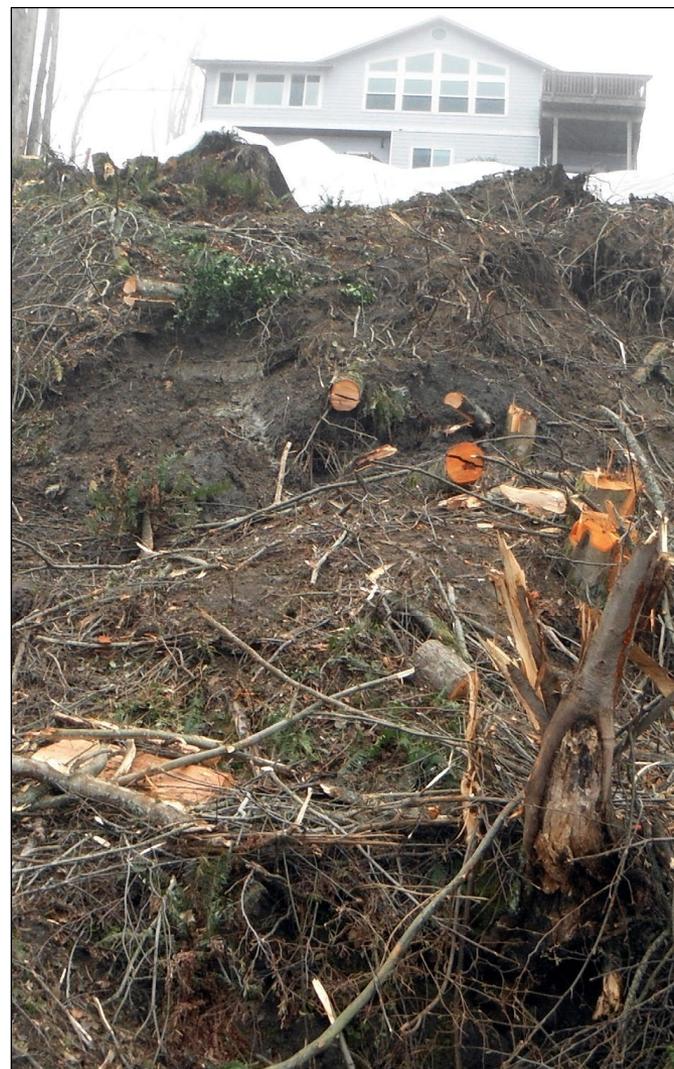
# Landslide Mitigation Workgroup

## Landslide Mitigation Team

- Washington State Department of Transportation (WSDOT)
- BNSF Railway
- Local municipalities (Clark County)
- Department of Natural Resources (DNR)
- YOU!

Landslides are **damaging** for homeowners, railroads, local governments, the local economy, and the traveling public.

Our **goal** is to prevent landslides on or near train tracks by educating the public about how human activities contribute to landslides and can damage your property.



# Amtrak Cascades corridor

## Amtrak Cascades:

- 18 stations from Vancouver, BC to Eugene, Oregon covering 461 miles with two daily roundtrips north of Seattle, six daily round trips south of Seattle
- WSDOT and ODOT contract with Amtrak to operate the service
- Amtrak operates on BNSF and Sound Transit tracks in Washington

## Landslide History:

- More than 200 landslides occurred in the last 15 years along the Amtrak Cascades corridor in WA
- Human activities like slope management, stormwater discharge, and failing drainage systems are substantial contributors to landslides
- Landslides that reach the railroad tracks result in cancelled or disrupted passenger and freight trains each year
- Landslides are costly for landowners, possibly resulting in damage to the home, loss of property value, increased costs for insurance and repairs, increased liability, or damage to others' property



# Host railroad coordination

- Tracks on the Amtrak corridors in Washington are primarily owned by BNSF Railway, a private freight railroad
  - Amtrak Cascades, Empire Builder and Coast Starlight passenger services operate on BNSF tracks
  - Sound Transit owns the tracks between Tacoma and Nisqually
- BNSF imposes a 48-hour moratorium on passenger rail service when landslides reach the train tracks



# Landslide mitigation construction projects

## Landslide mitigation efforts between Seattle and Everett

- WSDOT awarded three separate CRISI grants from FRA
- Leveraged \$4.5 million in state funding into more than \$12 million total project funding through the federal grants and BNSF contributions
- WSDOT administers the grants, and BNSF constructs catchment walls and other forms of slope stabilization



# BNSF's landslide mitigation policies and best practices

## Stormwater policy

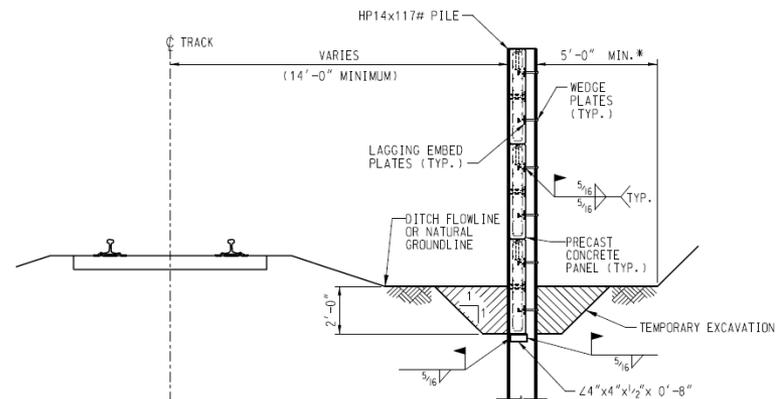
- Railroad ditches are not designed or intended for conveyance of public water
- Divert drainage away from railroad right-of-way via site plan design or by tying into existing stormwater infrastructure



Landslide behind catchment wall – Mukilteo, WA

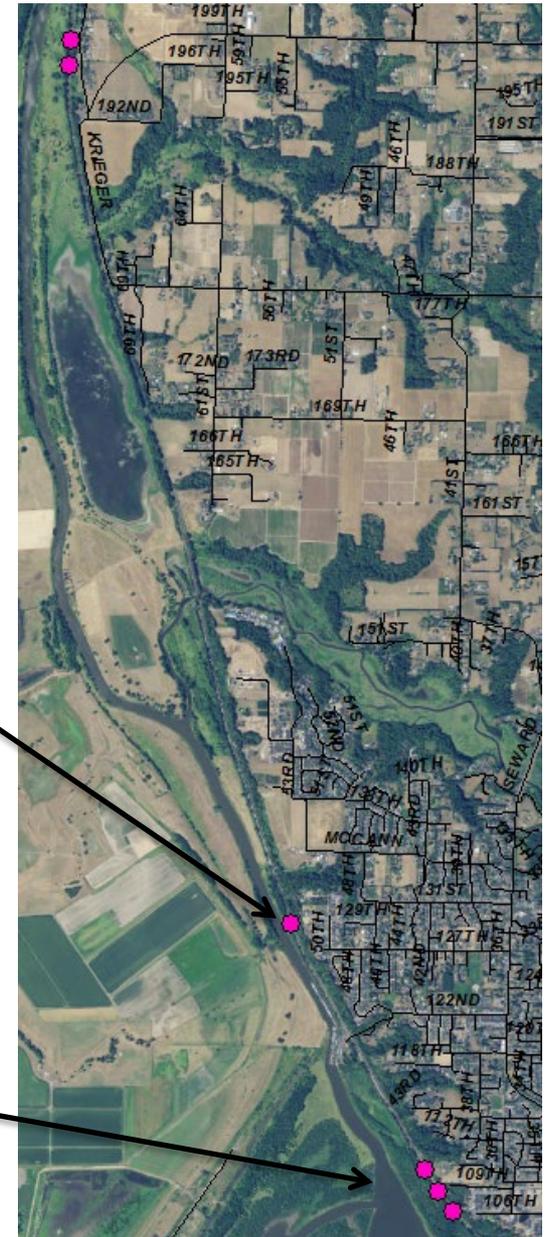
## Catchment wall program

- Over 2 miles of catchment wall constructed since 2013 in partnership with WSDOT and federal agencies
- Over 12,000 CY of debris removed from behind catchment walls since 2018



PARTIAL WALL SECTION

# Clark County landslides above railroad tracks



# Landslides increase in Clark County

- Slides seen in Clark County, near Felida and Ridgefield
- New housing developments in Clark County
  - Properties near the bluffs are at higher risk of landslide activity
  - Important to talk about best practices for addressing vulnerable slopes



2009

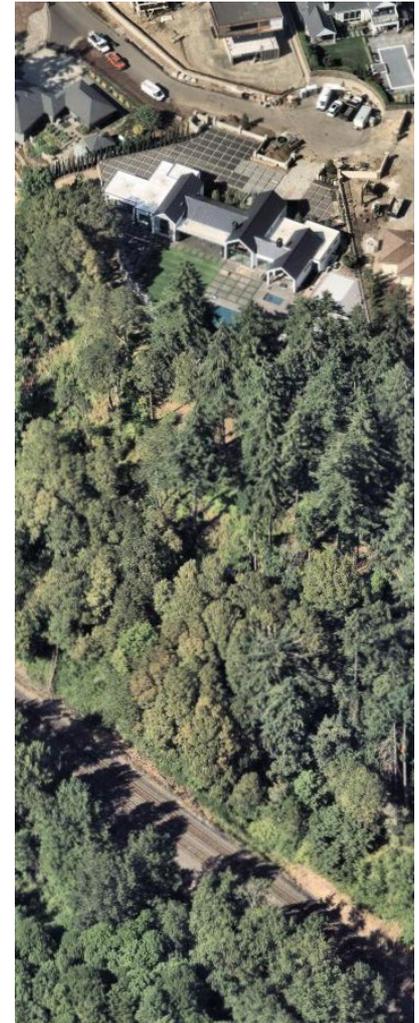


2015

# Clark County Permits/Reviews



- Clearing of natural/native vegetation on slopes may be regulated under the County's Geohazard (40.430), Wetlands and Fish and Wildlife Habitat Conservation Areas (40.445), Shoreline Master Program (40.460), and Forest Practices (40.260.080) codes.
- Areas beyond property lines may be BNSF right-of-way or owned by an HOA.
- Explore your property in [MapsOnline](#).



# Clark County Permits/Reviews



**Building:** structures, walls or retaining walls (4 ft.), fences (7 ft.)

Contact: [permitservices@clark.wa.gov](mailto:permitservices@clark.wa.gov); 564.397.4078

**Engineering:** grading, stormwater/drainage, slope stabilization, geohazard

Contact: [devengineer@clark.wa.gov](mailto:devengineer@clark.wa.gov); 564.397.4559

**Protected Areas:** wetlands, habitat, shoreline

Contact: [WetlandHabitatReview@clark.wa.gov](mailto:WetlandHabitatReview@clark.wa.gov); 564.397.5855

**Forestry**

Contact: [hunter.decker@clark.wa.gov](mailto:hunter.decker@clark.wa.gov); 564.397.4852

# Contact Information

## WSDOT Rail, Freight and Ports Division:

- [Rail@wsdot.wa.gov](mailto:Rail@wsdot.wa.gov)
- 360-705-7900

## WA Department of Natural Resources:

- [Kate Mickelson](#), Landslide Hazards Program Manager, [kate.mickelson@dnr.wa.gov](mailto:kate.mickelson@dnr.wa.gov) and 360-810-0006
- [Tricia R. Sears](#), Geologic Planning Liaison, [tricia.sears@dnr.wa.gov](mailto:tricia.sears@dnr.wa.gov) and 360-628-2867

## BNSF Railway:

- **Emergencies:** 1-800-832-5452

# Q&A