

Landslide Hazards and Mitigation

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

May 12, 2025

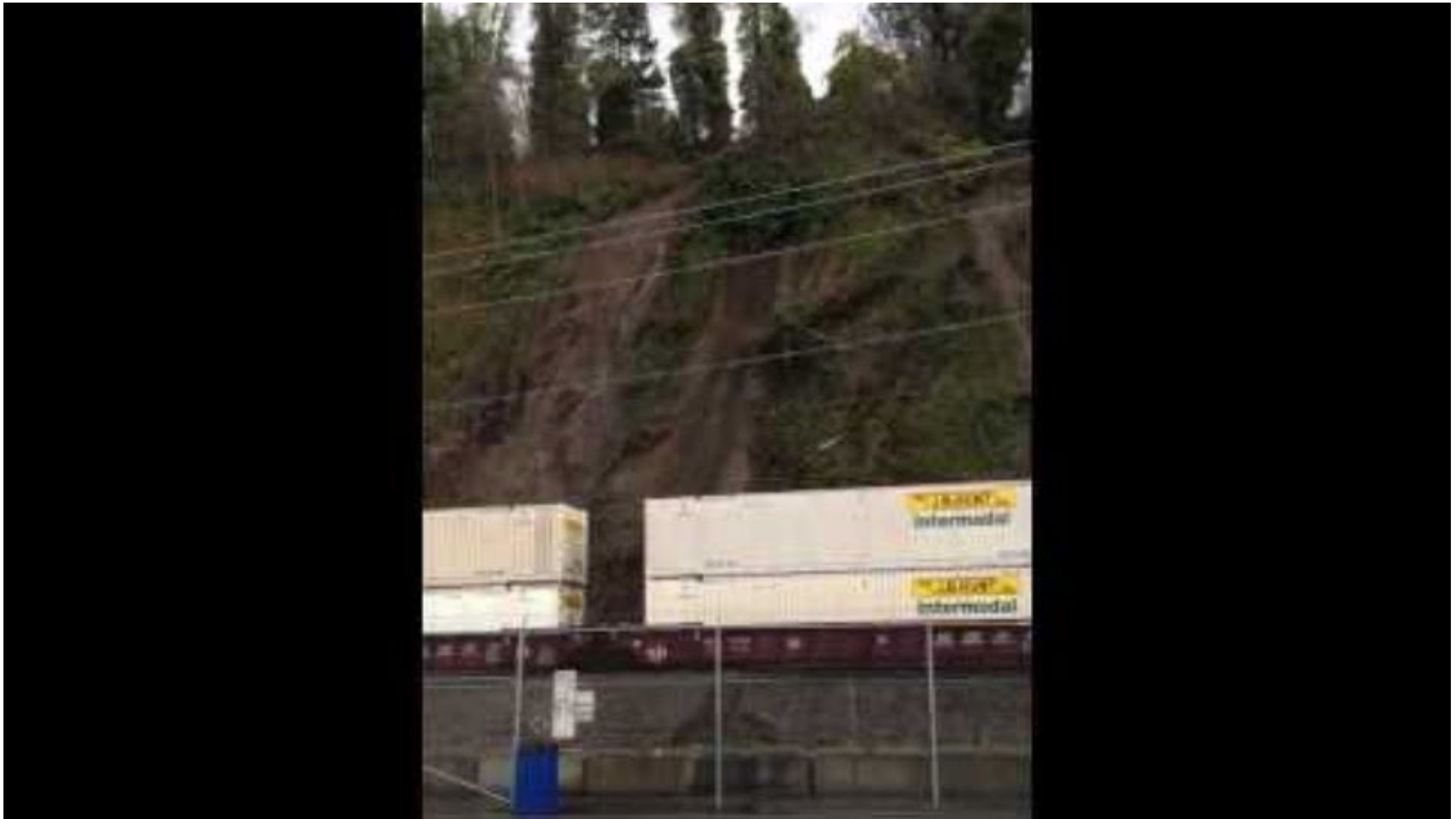
Agenda

- 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!

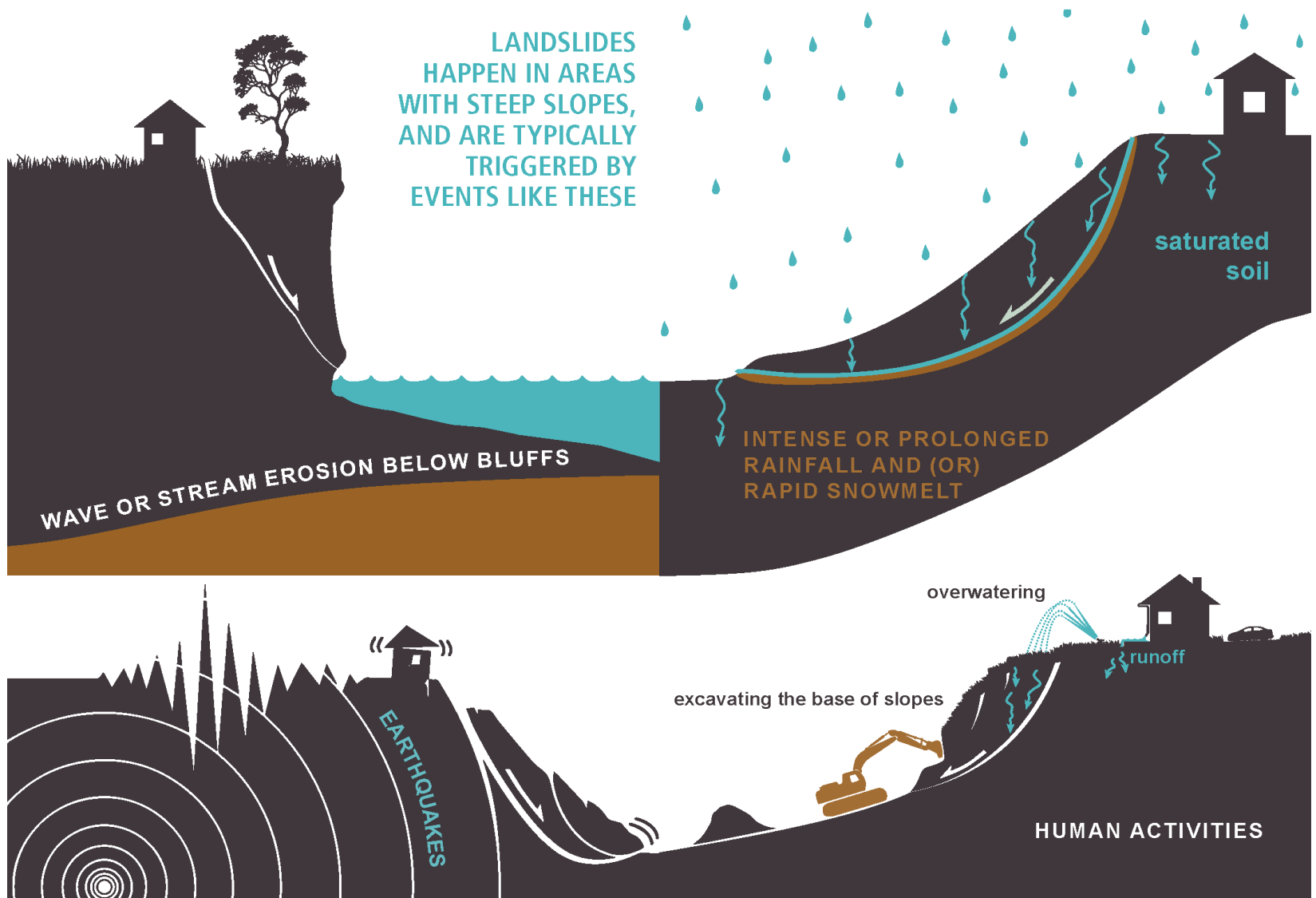
Landslides can threaten your property



Everett landslide derails train



Landslide triggers

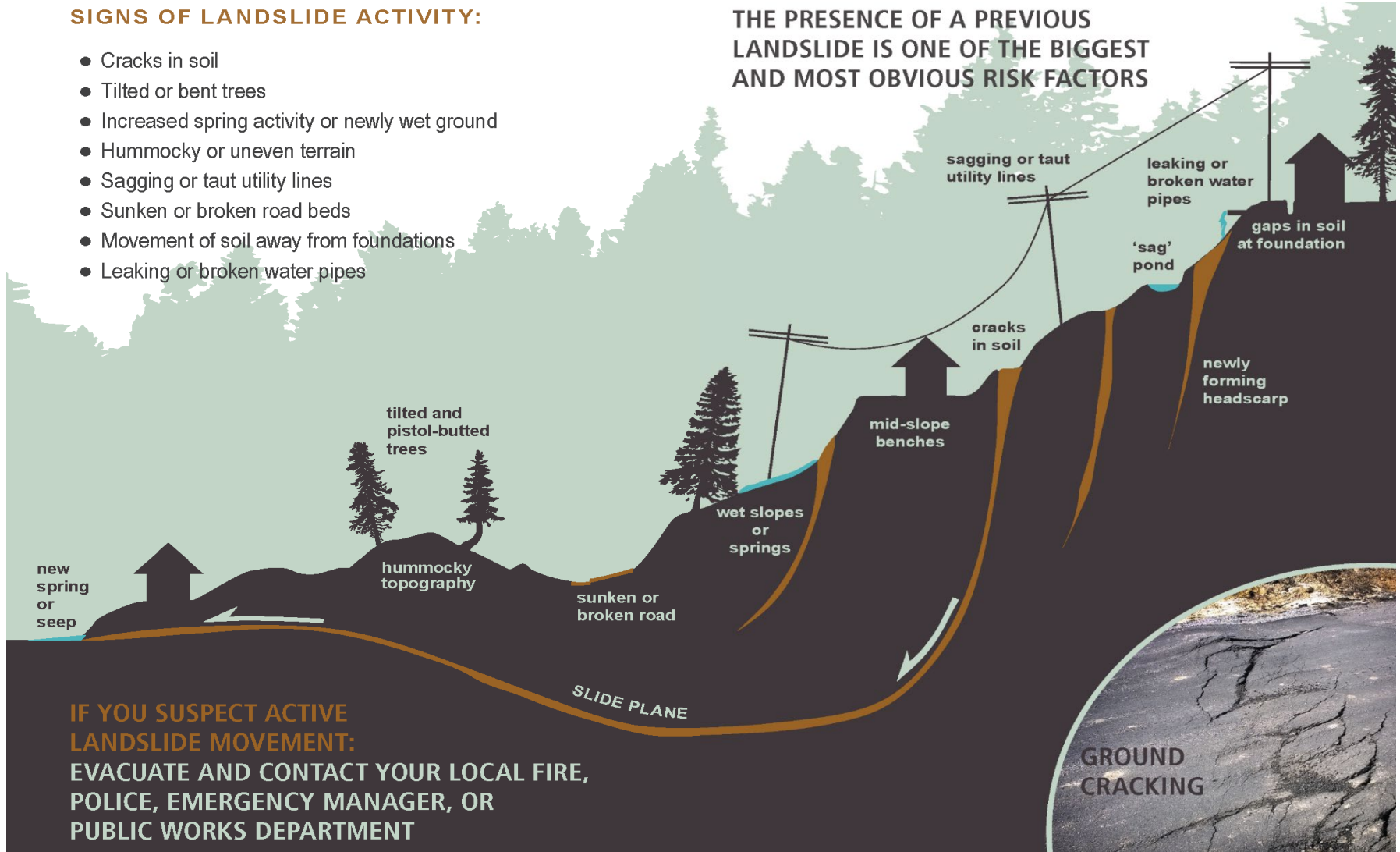


Landslide warning signs

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



IF YOU SUSPECT ACTIVE LANDSLIDE MOVEMENT:

**EVACUATE AND CONTACT YOUR LOCAL FIRE,
POLICE, EMERGENCY MANAGER, OR
PUBLIC WORKS DEPARTMENT**

The role of water and plants

62.3 lbs

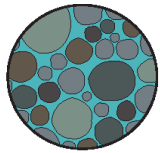
WHY IS WATER IMPORTANT?

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

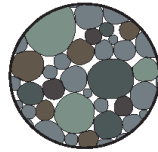
When water is added to a slope the weight increases the downward force, putting surrounding homes at risk

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.



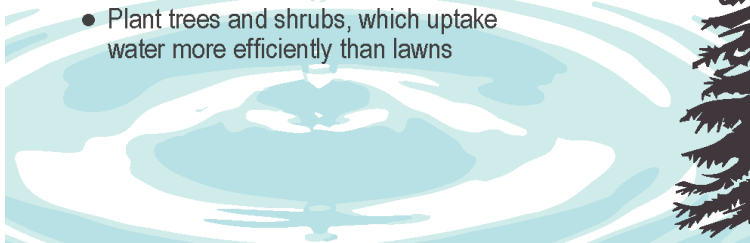
Wet soil
grains pushed apart
reducing soil strength



Dry soil
grains touch,
increasing soil strength

REDUCE WATER ON SLOPES:

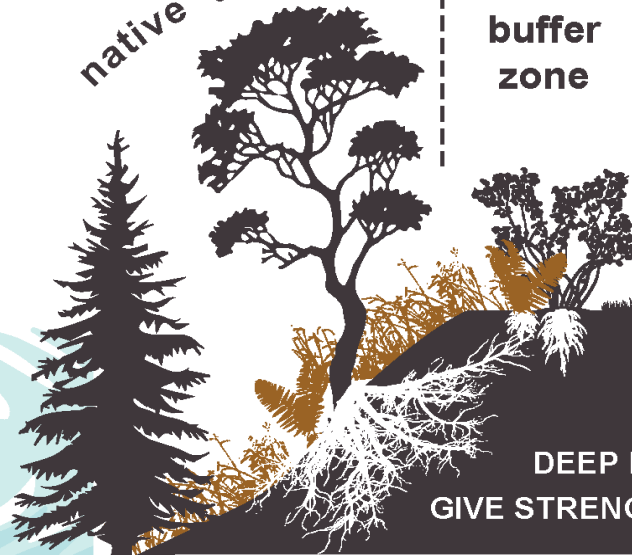
- Maintain healthy vegetation
- Use drought-resistant plantings
- Fix leaking plumbing immediately
- Direct downspout runoff well away from slopes
- Plant trees and shrubs, which uptake water more efficiently than lawns



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

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

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:

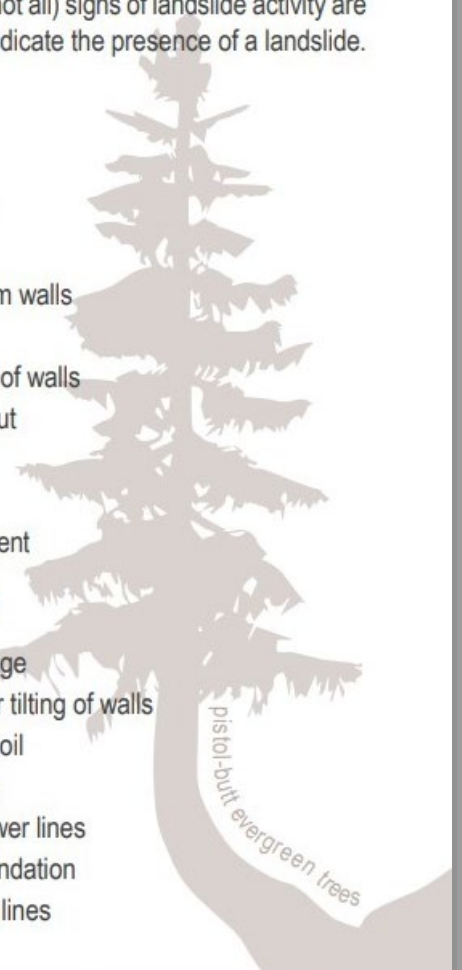
- ☐ Cracks in walls
- ☐ Nails popping out of walls
- ☐ Bulging walls
- ☐ Separation of chimney from walls
- ☐ Creaking/popping noises
- ☐ Light switches coming out of walls
- ☐ Doors/windows hard to shut
- ☐ Twisted beams
- ☐ Cracks in floors
- ☐ Water seeping into basement

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



Resources

Protect Your Home and Property

A Homeowner's Guide to Landslides

for Washington

Washington

Ore G

LANDSLIDES ARE ONE OF THE MOST COMMON AND DEVASTATING NATURAL HAZARDS IN THE PACIFIC NORTHWEST. THE DAMAGE CAUSED IS NEVER COVERED BY

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

U.S. GEOLOGICAL SURVEY

Landslide Hazards Program
landslides.usgs.gov

WASHINGTON GEOLOGICAL SURVEY

Washington Geologic Information Portal
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

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/slhm.

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



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?

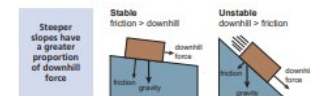
WASHINGTON GEOLOGICAL SURVEY

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.

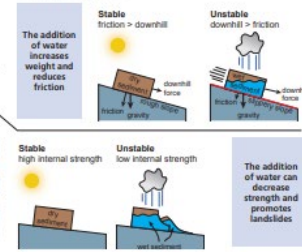
THE ROLE OF GRAVITY

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 very 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 increases the friction of 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.

side general information about landslide hazards and possibilities have many variables and are not predictable.

OF AN IMPENDING LANDSLIDE

npredictable. Some landslides may provide clues that they happen suddenly without any warning signs. rround, downslope movement of rock, soil, or vegetation. ff levels, sometimes with increased sediment, especially attracted storm events

INS OR OBSERVE A LANDSLIDE IN PROGRESS

it is safe to do so! Landslides are dangerous, unpredictable. A landslide can easily destroy or bury a car or house. immediately to your county Emergency Manager.

S OF A POTENTIAL LANDSLIDE

pring and (or) seep activity, or newly saturated ground, y trees on a hillside nds, or bulges in the ground ning telephone poles, deformed fences, or bent trees v and (or) growing cracks in walls, ceilings, or foundations at water, septic, or sewer lines heir foundation; movement of soil away from foundations water wells that suddenly run dry

OU THINK A LANDSLIDE MAY OCCUR

uld be reported to your county Emergency Manager so rly evaluated (See RESOURCES on back page).

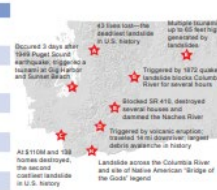
REPORT LANDSLIDES

Report landslides to your county Emergency Manager: ml.wa.gov/other-links/emd-contact-us



SOME HISTORIC LANDSLIDES IN WASHINGTON STATE

| Slide or area name | Date |
|-------------------------------|----------------|
| (A) SR 530 (aka Oso or Hazel) | Mar. 2014, |
| (B) Nile | Oct. 2009 |
| (C) Aldercrest-Banyon | Feb.–Oct. 1998 |
| (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 |



WASHINGTON STATE DEPT OF NATURAL RESOURCES

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

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

DNR Landslide Mapping

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

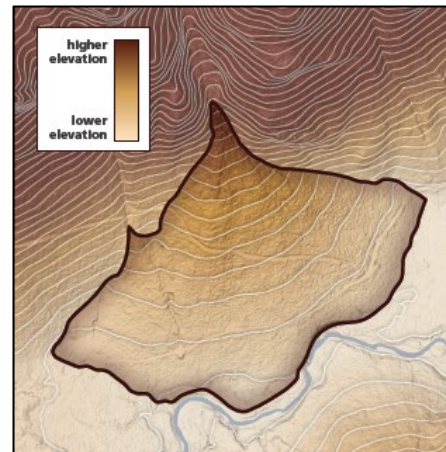
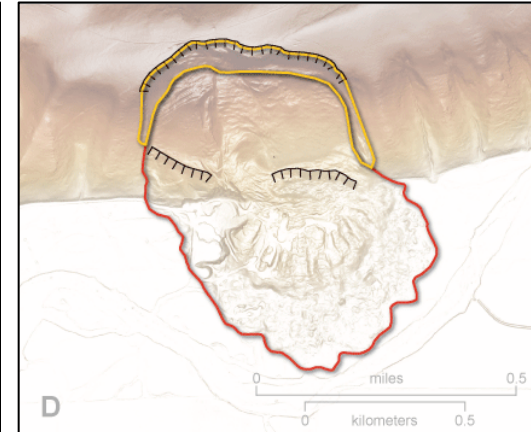
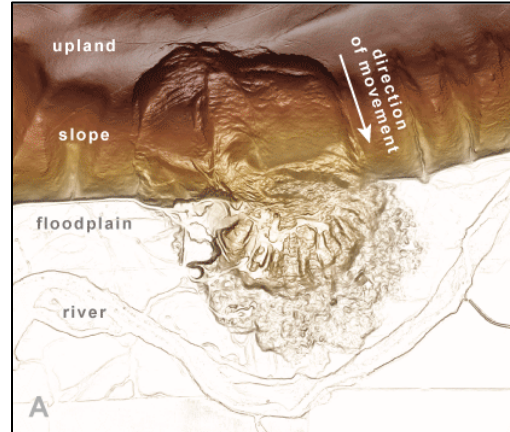
BULLETIN 82
April 2017

PEER REVIEWED

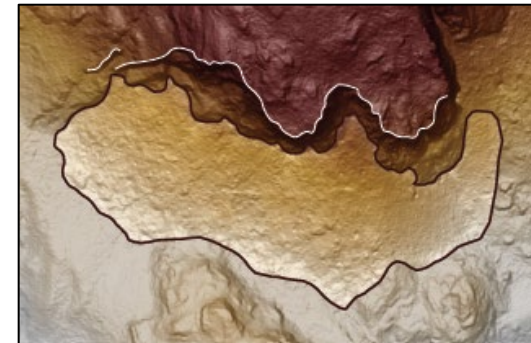


WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES

Landslides

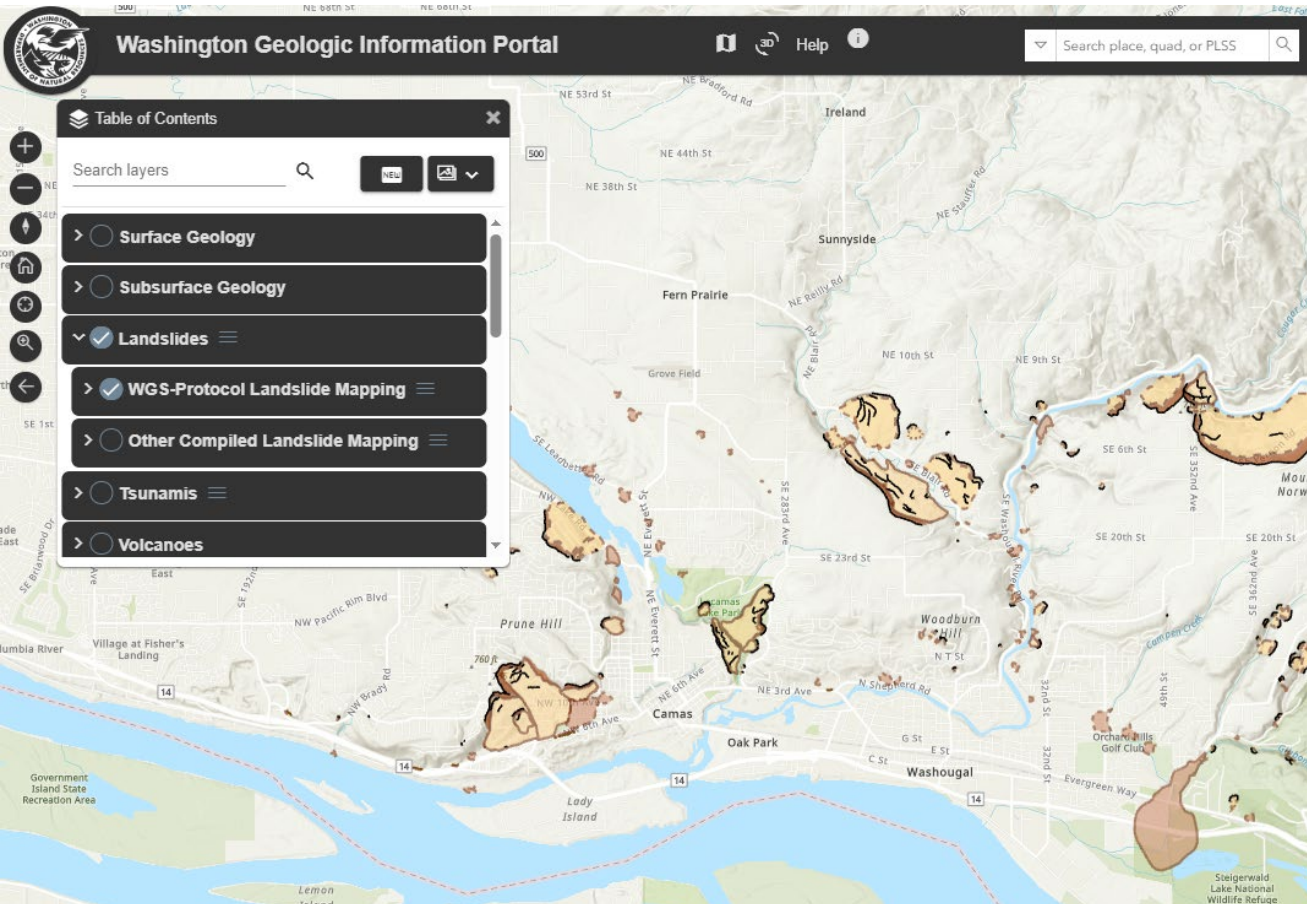


Fans



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

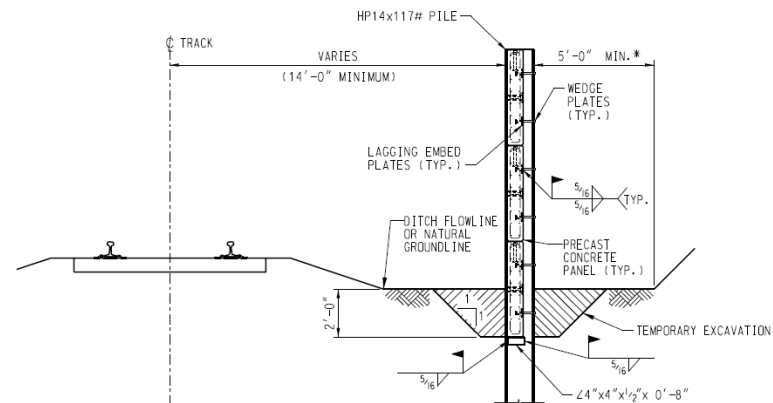
- Railroad ditches are not designed or intended for conveyance of public water
- Divert drainage away from railroad right-of-way via site plan design or by tying into existing stormwater infrastructure



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

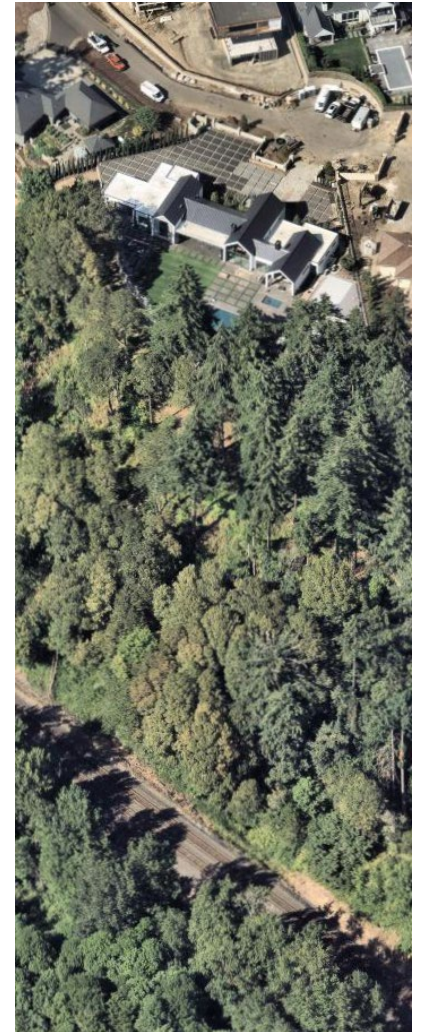


2015

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; 564.397.4078

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

Contact: devengineer@clark.wa.gov; 564.397.4559

Protected Areas: wetlands, habitat, shoreline

Contact: WetlandHabitatReview@clark.wa.gov; 564.397.5855

Forestry

Contact: hunter.decker@clark.wa.gov; 564.397.4852

Contact Information

WSDOT Rail, Freight and Ports Division:

- Rail@wsdot.wa.gov
- 360-705-7900

WA Department of Natural Resources:

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

BNSF Railway:

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

Q&A