Oregon Department of Transportation

South Coast Slides Study

EXECUTIVE SUMMARY

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Oregon Department of Transportation

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jla Public Involvement

Photo credit: Kittelson

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A Beautiful and Active Landscape

Oregon's south coast is known for its rugged, mountainous coastline and incredible beaches. The craggy terrain that makes this region so beautiful came from the active land mass that still shifts underneath residents' and visitors' feet. Moving plates in the Earth's crust create unique structures like coastal bluffs, but this motion also makes the coast prone to landslides.

As the primary north-south route for coastal residents, visitors, and freight and service companies, U.S. 101 must run through this active landscape. Every few years, landslides close parts of the highway, forcing detours, straining emergency responses, and disrupting local economies. At the Oregon Department of Transportation (ODOT), we can't undo our state's geology to stop landslides altogether. However, ODOT can work toward a more resilient coastal roadway system that improves slope stability and fosters safer and faster recovery efforts.

Photo credit: ODOT

About the Project

This project, the South Coast Slide Study, searched for sustainable, practical, and cost-effective solutions and strategies to reduce the travel impacts of 13 priority slide sites along US 101 between Port Orford and Brookings.

THE PROBLEM

When slides close parts of U.S. 101, drivers often must reroute via Interstate 5 (I-5), OR 42, U.S. 199, or Carpenterville Highway. These detours can add hours of drive time and can complicate freight and fuel shipment, access to healthcare, and emergency response services. Returning a slide-impacted roadway to safe and stable driving conditions can be time consuming and expensive.

Every day, U.S. 101 sees about 5,400 vehicle trips and 1,100 freight trips. Landslides impact commutes, tourist travel, coastal transit service, freight movement, and emergency services.

HOW ODOT CAN HELP

Because coastal geology is extremely variable, there is no permanent fix for landslides along U.S. 101. But targeted, small-scale, and cost-effective mitigation measures—such as drainage and stone columns—can help stabilize slides. Roadway mitigation measures like pullouts and destination and directional signs can help improve safety and reduce stress for drivers navigating detour routes when there are impacts on U.S. 101. Finally, detailed traffic control plans can help ODOT coordinate communication during slide emergencies, manage closures and detours, and organize repair work.

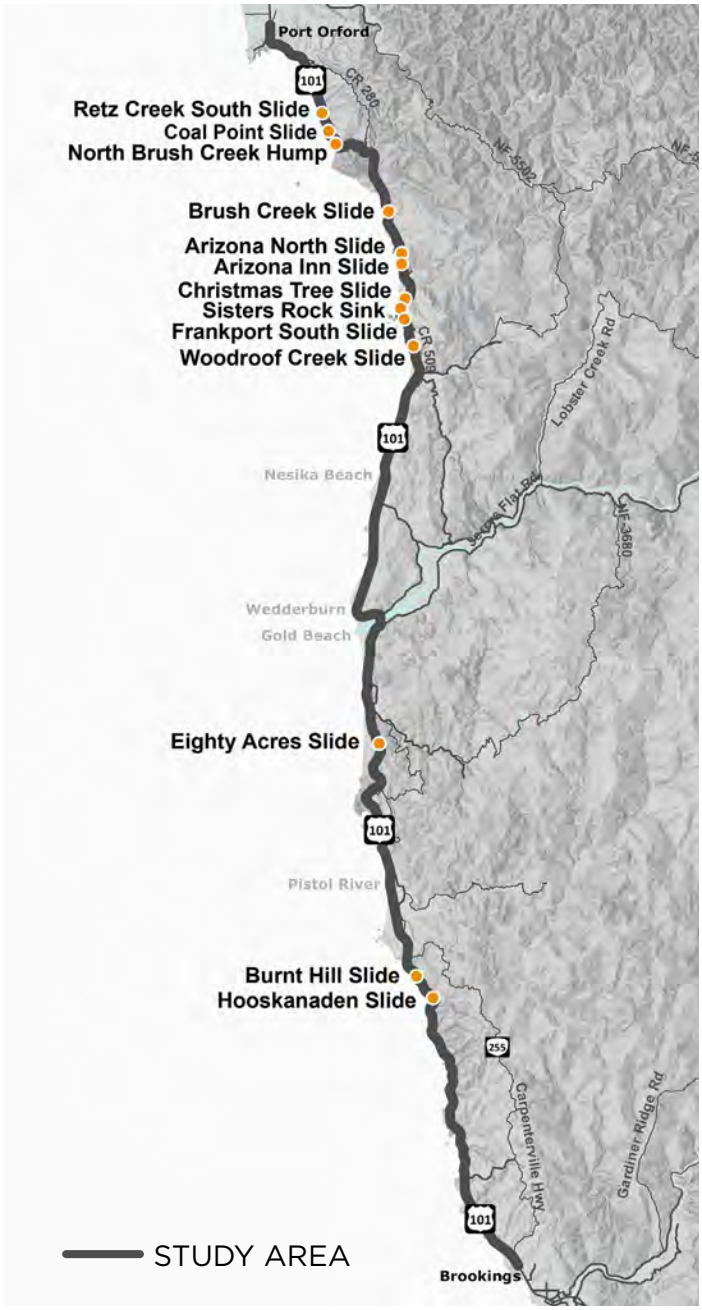
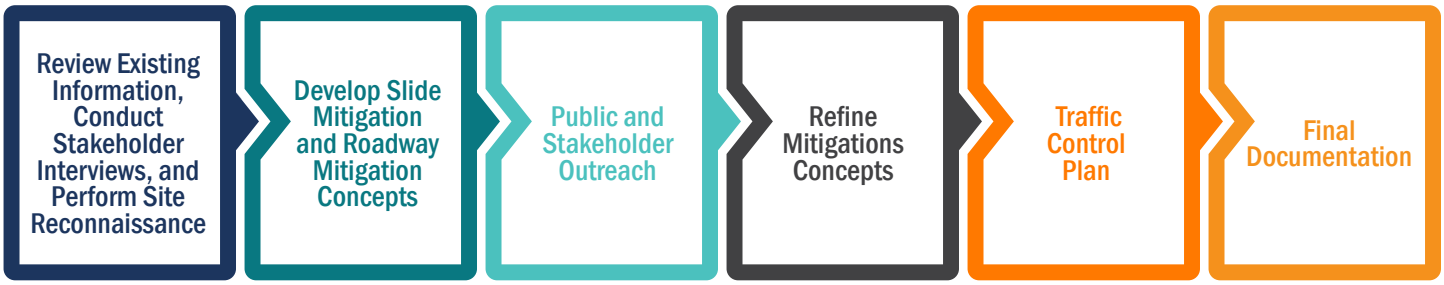


Photo credit: ODOT

STUDY PROCESS

This project was a collaborative effort between ODOT staff, geotechnical experts, experienced roadway engineers, and people who live and work in the communities along U.S. 101.

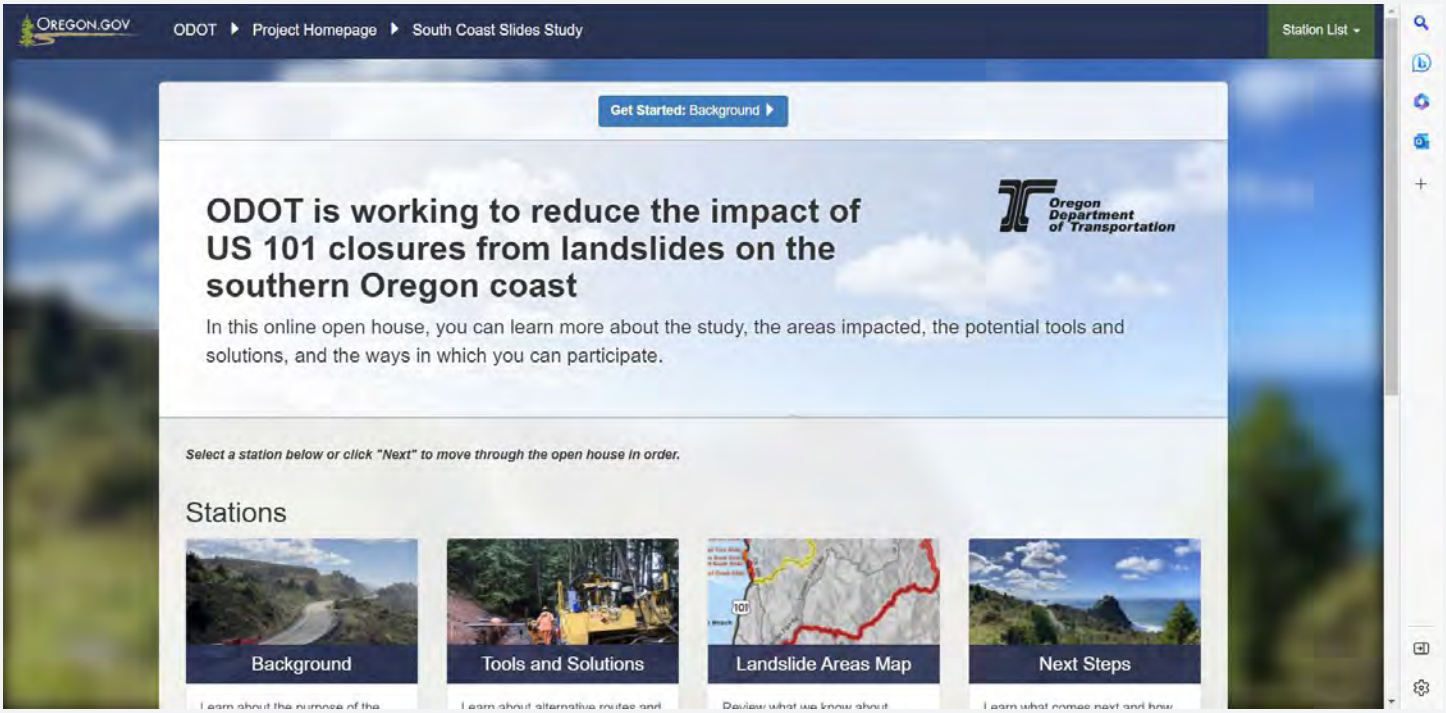


Public Involvement

To understand the challenges faced by communities living along sections of U.S. 101 impacted by slide events, the study team listened to members of the public through a project website, survey, stakeholder interviews, and an online open house. Feedback from these activities helped inform the project's mitigation measures.

Conversations with the public revealed three key themes:

- Carpenterville Highway can be difficult to traverse for drivers of oversize vehicles like semi-trucks and buses.
- Many people who live along U.S. 101 rely on this highway to get to work and access services.
- Clear and rapid communication from ODOT is critical during and after slide events.
- Coordination with the Coquille Indian Tribe and other interested tribes will be important prior to any land disturbance to protect important cultural and archaeological resources.

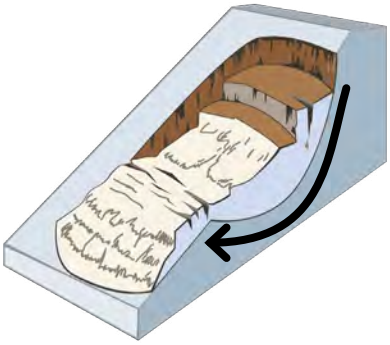


The project website helped share project updates and collect feedback from the public.

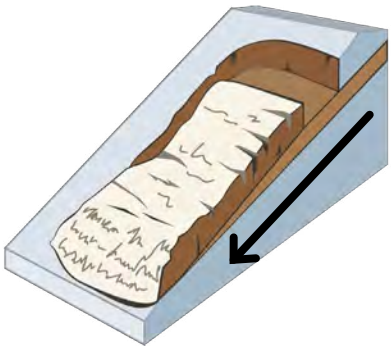
Landslide Basics

WHAT ARE LANDSLIDES?

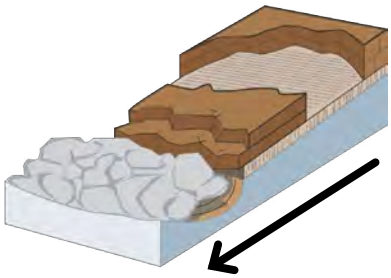
Landslides are movements of rock, soil, or debris along a failure plane. Sliding movements typically take three forms: rotational slides, translational slides, and block slides. In a rotational slide, the slope fails in a scooping motion. In a translational slide, the failed soil and rock moves parallel to the slope. In a block slide, a chunk of earth fails in a single or several large chunks that move parallel to the slope but remain largely together. The angular path along which a slide shifts is called the **shear plane**.



Rotational Slides



Translational Slides



Block Slides

Most slides in the study area are caused by shallow groundwater levels, coastal wave erosion at the base of the slide, or a combination of the two.

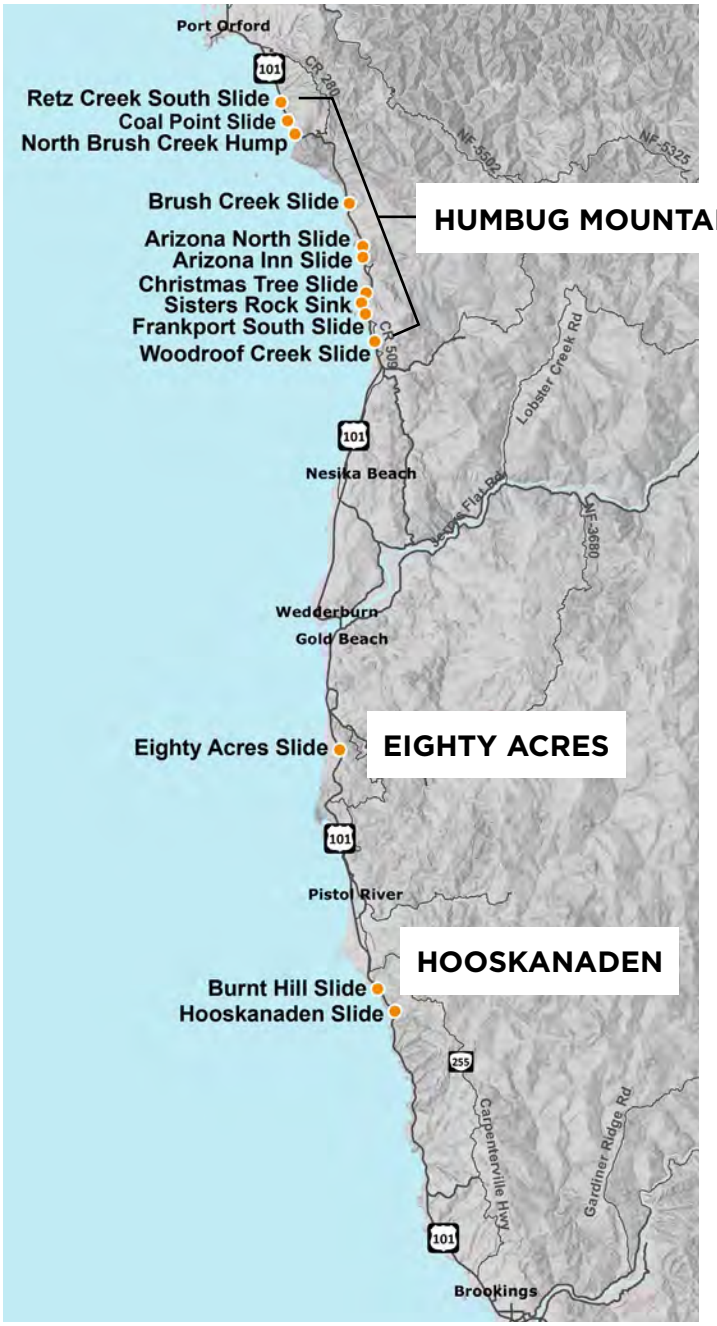
WHAT CAUSES SLIDES?

Slide causes are twofold. There are geological conditions that set up a slope for slides, such as slope steepness, soil type, soil and rock layering, and faults. There is also often a triggering event, most often heavy rainfall, earthquakes, or sudden snowmelt. Water can reduce shear strength within soil and rock layers when it seeps beneath the surface.

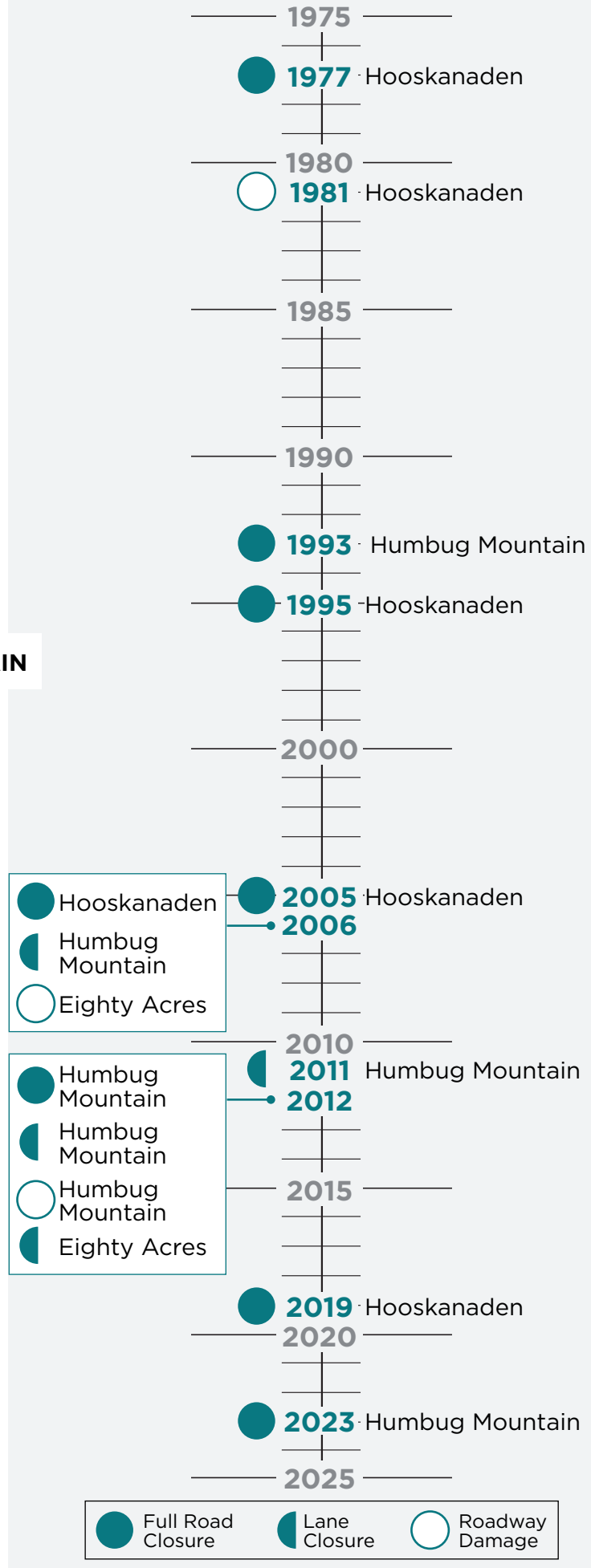
Coastal erosion at the Hooskanaden slide site. Photo credit: ODOT

Study Slides

For this study, ODOT examined 13 slide sites along U.S. 101 to better understand how to mitigate the effect of slides on transportation safety and efficiency. Although each slide has unique conditions and solutions, many slides have similar impacts to traffic. To help streamline recommendations, ODOT grouped slides into three zones. As shown in the graphic below, the zones are Zone 1: Humbug Mountain, Zone 2: Eighty Acres, and Zone 3: Hooskanaden.



EVENT HISTORY BY SLIDE ZONE



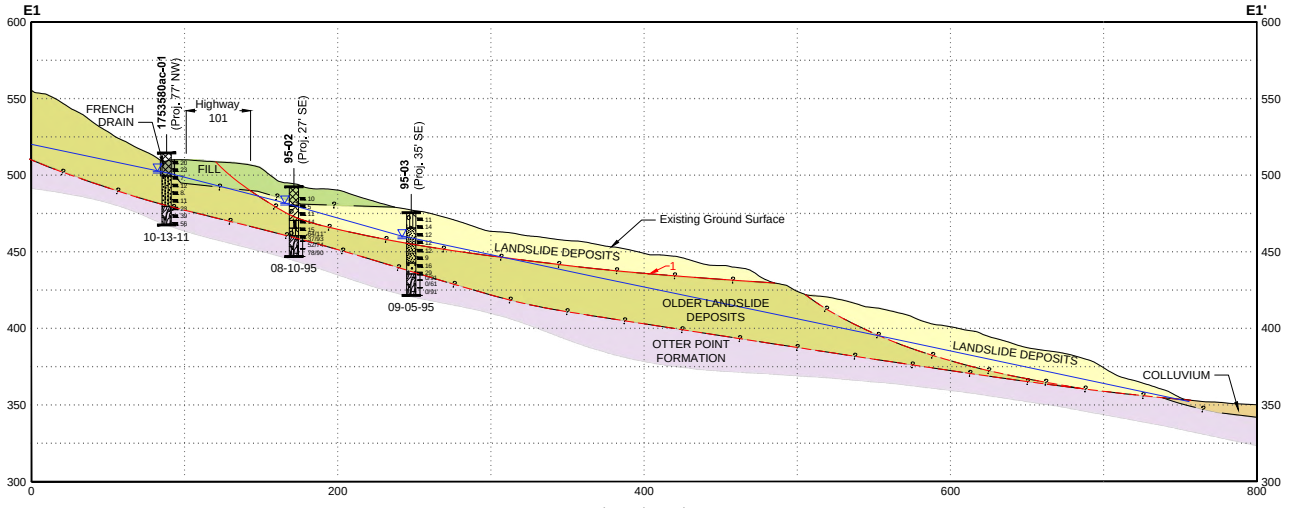
Slide Mitigation

ODOT can't undo Oregon's coastal geology—after all, it formed up to 65 million years ago! But, depending on the particular slide's characteristics, ODOT can help reinforce slopes and decrease the frequency of slides.

UNDERSTANDING SLIDES ON U.S. 101

To understand the particular conditions of each study slides, the study team used both technological tools and field observations. They obtained maps of the surface of slide areas using LiDAR and InSAR. LiDAR uses light waves from lasers to create an image of the earth's surface. InSAR uses radar from satellites to measure how much the surface has moved over a particular period of time. In the field, the team recorded conditions that may lead to an increased risk of landslides like seeps or springs, shallow groundwater, or unstable slopes. The team also noted observations of previous slide activity like leaning trees and roadway settlement, and other visible areas of movement.

For the study's complete geotechnical results, check out Appendix C and Appendix D.



Geotechnical specialists documented the characteristics of each slide. Credit: Shannon & Wilson

CHOOSING THE BEST MITIGATION MEASURE

To match each slide with its best mitigation measure, the team evaluated options according to safety; cost of construction and maintenance; construction feasibility, mobility impacts (such as roadway or lane closures); sensitive environmental resources; and adjacent land use or ownership.

To learn more about each slide's particular geometry, geology, and mitigation measures and costs, check out Appendix E.

Slumped trees indicate previous ground movement in the central part of the Eighty Acres slide area. Photo credit: Shannon & Wilson

Preferred Slide Mitigation Types for U.S. 101

Shear keys use elements such as stone columns, shear piles, drilled shafts, or excavation backfilled with stone embankment to reinforce shear planes.

Example of a constructed shear key mitigation.

Photo credit: Shannon & Wilson

Horizontal drains are drainage pipes drilled horizontally into the slide mass to lower the groundwater.

Example of a constructed horizontal drain mitigation.

Photo credit: Shannon & Wilson

Trench drains are long, thin excavations backfilled with free-draining material used to both lower shallow groundwater and to cutoff and redirect surface water.

Example cross-section for trench drain.

Photo credit: http://www.svr-vlo.org.uk/floodline_no50-59.htm

Soldier pile tieback wall is a type of retaining wall that is meant to support the roadway while allowing the slide downslope from the wall to continue moving. Ground anchors (tiebacks) will connect the ground beneath the shear plane to the retaining wall to prevent movement of the roadway.

Example of a soldier pile tieback wall.

Photo credit: Shannon & Wilson

RECOMMENDED SLIDE MITIGATION

Reducing the frequency of roadway maintenance and lane closures due to landslide movements, will require construction outside the existing roadway footprint. Coordination with the Coquille and other Indian Tribes will be important to protect cultural and archaeological resources.

Zone 1: Humbug Mountain

RETZ CREEK SOUTH SLIDE

3 shear planes: average inches of ground movement per month 0.98; 0.16; 0.03.

Causes: coastal erosion of toe and relatively shallow groundwater.

Preferred mitigation: shear key with stone columns.

Property impacts: ODOT, State Parks

COAL POINT SLIDE

4 shear planes: average inches of ground movement per month 0.07; 0.01; less than 0.01; 0.09.

Causes: shallow groundwater, coastal erosion of toe.

Preferred mitigation: horizontal drains or trench drains.

Property impacts: ODOT, State Parks

NORTH BRUSH CREEK HUMP

3 shear planes: average inches of ground movement per month 0.05; 0.03; n/a.

Causes: shallow groundwater, highway cut at toe, coastal erosion of toe.

Preferred mitigation: extend the existing shear key previously installed at the site to a deeper depth using stone columns.

Property impacts: ODOT, State Parks

BRUSH CREEK

1 shear: average inches of ground movement per month n/a.

Causes: coastal erosion of toe.

Preferred mitigation: shear pile wall.

Property impacts: ODOT

ARIZONA NORTH SLIDE

3 shear planes: average inches of ground movement per month 1.52; 0.09; 0.02.

Causes: coastal erosion of toe, shallow groundwater.

Preferred mitigation: horizontal drains.

Property impacts: ODOT, private property

ARIZONA INN SLIDE

2 shear planes: average inches of ground movement per month 0.08; 0.08.

Causes: shallow ground water, coastal erosion of toe.

Preferred mitigation: horizontal drains.

Property impacts: ODOT

CHRISTMAS TREE SLIDE (AKA FRANKPORT NORTH)

1 shear plane: average inches of ground movement per month 0.15.

Causes: shallow groundwater, coastal erosion of toe.

Preferred mitigation: soldier pile tieback wall.

Property impacts: ODOT

SISTERS ROCK SINK

2 shear planes: average inches of ground movement per month 0.13; 0.02.

Causes: shallow groundwater; coastal erosion of toe.

Preferred mitigation: trench drains.

Property impacts: ODOT

FRANKPORT SLIDE

3 shear planes: average inches of ground movement per month 0.16; 0.01; 0.01.

Causes: shallow groundwater, coastal erosion of toe.

Preferred mitigation: trench drains.

Property impacts: ODOT, State Parks

WOODROOF CREEK SLIDE (AKA HORNEBLENZER SLIDE, SKILL RIDGE SLIDE, SQUIRE SLIDE)

1 shear plane: average inches of ground movement per month n/a.

Causes: shallow groundwater, erosion of toe by Woodruff Creek.

Preferred mitigation: soldier pile tieback wall.

Property impacts: ODOT

Zone 2: Eighty Acres

EIGHTY ACRES SLIDE

1 shear plane: average inches of ground movement per month 0.75.

Causes: shallow groundwater.

Preferred mitigation: shear key.

Property impacts: ODOT

Zone 3: Hooskanaden

BURNT HILL SLIDE

1 shear plane: average inches of ground movement per month n/a.

Causes: coastal erosion of toe leading to progressive block failure; shallow groundwater.

Preferred mitigation: shear key with stone columns.

Property impacts: ODOT

HOOSKANADEN SLIDE

1 shear plane: average inches of ground movement per month 2.95.

Causes: shallow groundwater; coastal erosion of toe.

Preferred mitigation: stockpile material outside slide limits.

Property impacts: ODOT

Because this slide has significant movement over a large area, typical mitigation measures, such as shear keys and walls, would have extreme costs. The most cost-effective solution for this slide is to be ready for repair with material stockpiles.

Photo credit: ODOT

Managing Traffic During Slide Events

In addition to strengthening slopes, ODOT is also committed to improving the response to a slide by evaluating detour routes and providing traffic management and communications during a closure.

For a full discussion of ODOT's traffic control and communications plans, check out Appendix I.

COMMUNITY CONTEXT

About 23,000 people live in Curry County, many along U.S. 101. The main communities here are Brookings, Gold Beach, and Port Orford, and many of the residents living in these towns are older adults who rely on U.S. 101 to get to medical appointments at nearby hospitals. Commercial fisheries and their associated freight traffic help support local economies.

Tourism is vital to the economic health of many coastal towns along US 101. In 2018, visitors to Curry County spent more than $135 million. Peak season for tourists occurs in the warm and sunny summer months, but the high season for landslides occurs over the fall, winter, and spring, seasons when heavy rain and snow bring excess moisture to the ground. Such seasonality means that the majority of people impacted by landslides along U.S. 101 are local residents, commuters, and freight drivers.

FINDING OTHER ROUTES

When a slide occurs, it can disrupt transportation by blocking lanes with debris, making roadways unsafe to drive on, or by pulling away parts of the roadway entirely. ODOT plays an important role in responding to slides and helping drivers—of personal, emergency, freight, and transit vehicles—find safe routes around them.

However, identifying detour routes can be challenging, as many of the coast's roadways are similarly susceptible to slides and weather events or are not designed to ODOT's standards for the traveling public. For example, there are several U.S Forest Service roads in the area; however, they are narrow and steep and were designed for hauling logs, not two-way traffic. Because of this, commercial traffic is not allowed on them without a special permit. The same conditions that trigger a slide may also make detour routes impassable. For some slide locations, it's not possible to find a safe and adequate detour route that is also short.

Photo credit: ODOT

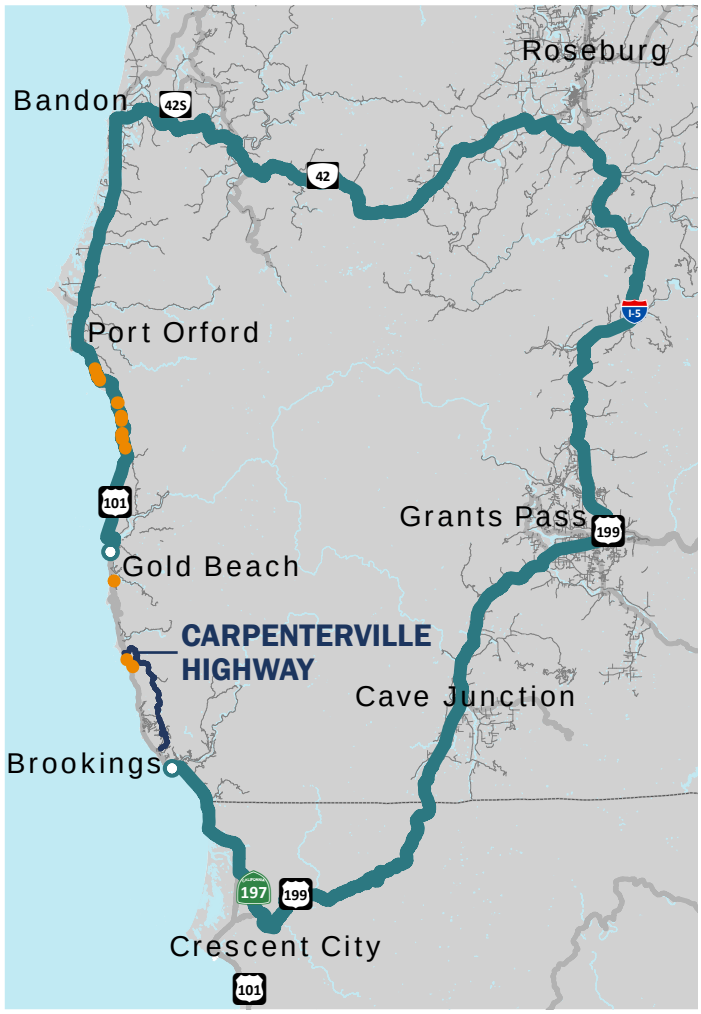
AVAILABLE ROUTES FOR SLIDES ON U.S. 101: CARPENTERVILLE HIGHWAY AND INTERSTATE 5

To qualify as a **detour**, a route must be useable by the general public and freight and must be able to support its regular traffic *plus* diverted slide traffic. This means they must be paved and meet ODOT safety standards.

After studying—and driving—several potential routes, the study team identified one local detour that could help get traffic around study area slides safely and efficiently. Many potential routes had to be ruled out because they terminated at private property or had hairpin turns, steep terrain, or unpaved surfaces.

The southern bypass route along Carpenterville Highway is an acceptable detour route for traffic blocked by the Hooskanaden and Burnt Hill Slides. The route is about 19 miles in length with a posted speed limit of 55 mph. The route takes approximately 40 minutes to drive, compared to about 20 minutes along US 101.

Although Carpenterville Highway is an acceptable detour route, this roadway is also susceptible to slides and may not always be a viable alternative. It also has restrictions for loads that are overweight, over width, or long. Historically, pilot cars have been used to allow larger freight vehicles to navigate the corridor. If Carpenterville Highway is impacted by a slide event as well or if the events occurs in Zone 1: Humbug Mountain or Zone 2: Eighty Acres, the only detour is I-5. This detour can add up to 5 hours of travel time, depending on where the trip is beginning and ending.



Carpenterville Highway offers a detour around the Hooskanaden and Burnt Hill Slides. For other slides, I-5 is the primary north/south detour route.

Carpenterville Highway has new curve warning signs to help alert drivers to changes in steep grades and sharp corners. Photo credit: Kittelson

WHAT ABOUT A BRIDGE OR NEW ROAD? WOULDN'T THAT ELIMINATE SLIDE CLOSURES?

For more than 20 years, ODOT has studied both the technical and financial feasibility of major construction projects to reduce slides along U.S. 101, including a suspension bridge across the Hooskanaden slide, a full reconstruction of Carpenterville Highway, a new northern bypass route, and a new east-west connection to I-5. Each study concluded that the costs and risks of a major project far outweighed its benefits. For example, that suspension bridge over the Hooskanaden slide would cost more than $300 million, and reconstructing Carpenterville Highway would cost about $440 million. Even if these efforts were feasible, the improvements would be similarly susceptible to the coast's unstable land masses. Vibrations from major construction efforts could even trigger new slides or awaken existing ones.

ROADWAY IMPROVEMENT MEASURES

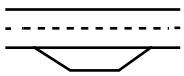
Cost-effective roadway improvements can help speed up recovery efforts and improve safety and efficient travel. Due to the surrounding topography, the many active slides in the area, severe weather events, and other environmental constraints, there are a limited number of technically and fiscally feasible engineering roadway improvement options available for U.S. 101 and Carpenterville Highway. ODOT assessed straightening curves, paving sections that are currently gravel, and roadway widening, but these options were determined to not be feasible.

The following mitigation measures have been identified to improve U.S. 101 and/or Carpenterville Highway:

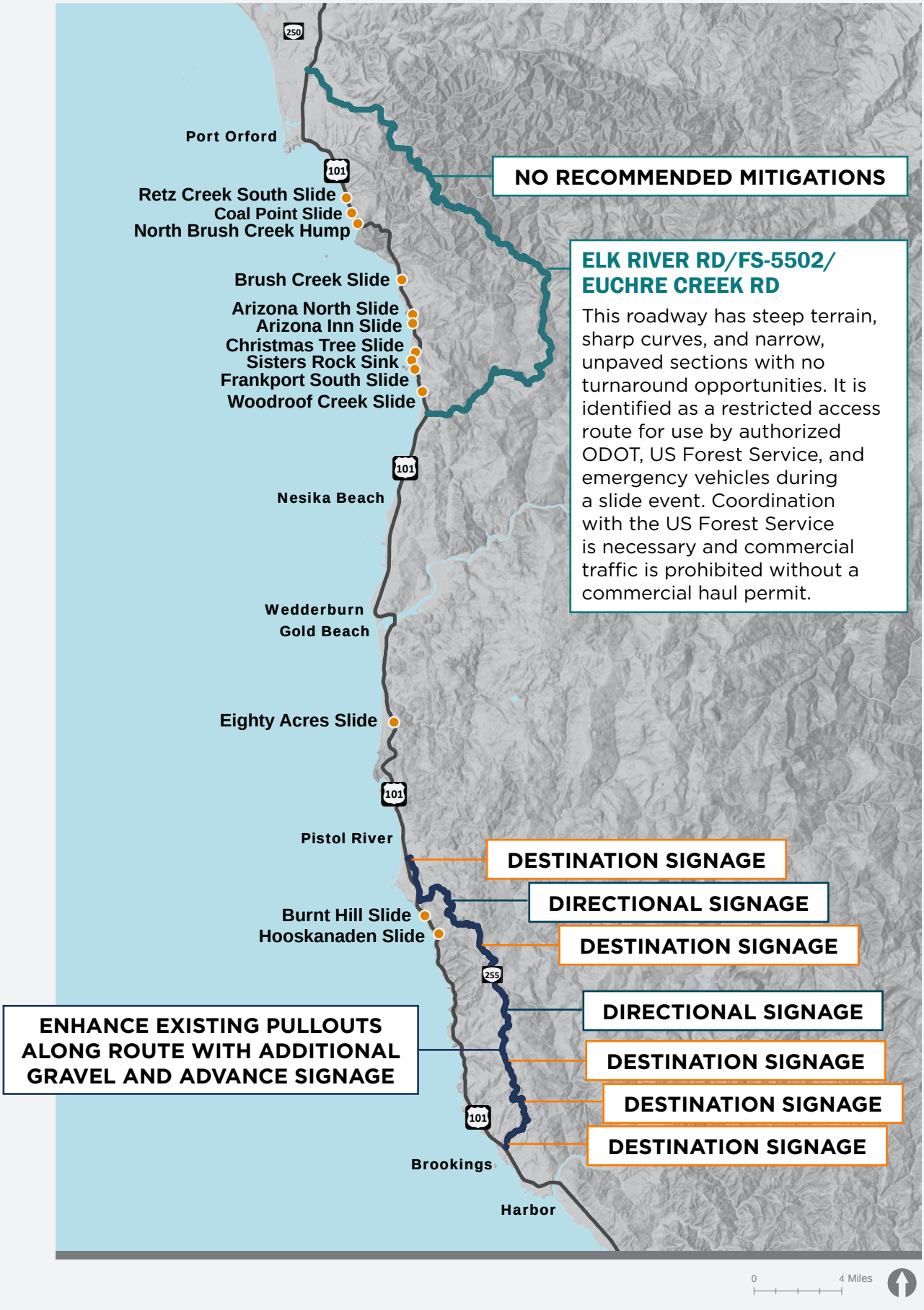
Evaluating Options

To match the right measure with the right slide site, ODOT evaluated mitigation tools according to numerous criteria, including:

- Mobility and safety.
- Land ownership.
- Annual maintenance costs.
- Construction costs.
- Cost vs. benefits.
- Landslide risk. Sensitive environmental resources.

MITIGATION	BENEFITS	LOCATION
 Enhance Existing Pullouts	Allows vehicles to pull out of traffic flows and facilitates detour operations	Carpenterville Hwy
 Destination Signage	Increase driver comfort and reduce temporary traffic control signage during an event	
 Directional Signage		

Preferred Roadway Improvement Mitigations



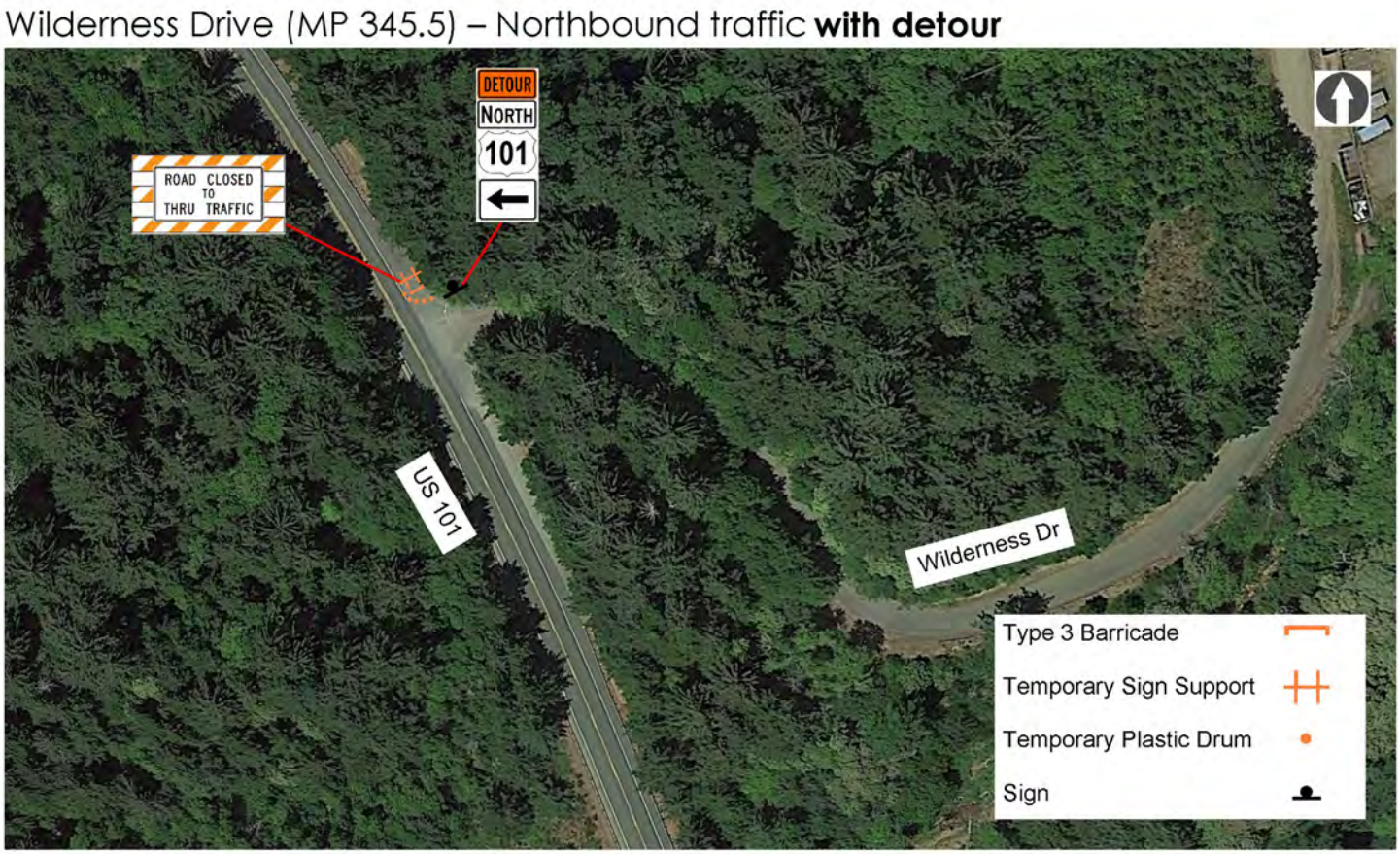
These locations along U.S. 101 and Carpenterville Highway will provide space for larger vehicles to pull off the main roadway and offer signage to increase driver comfort navigating during an event.

PLANS FOR REROUTING TRAFFIC

Depending on the nature and severity of a slide, ODOT's response can take many forms. Sometimes the fix can be made in a few days; other times the road requires more work to return to full operations.

To aid efforts to get people where they need to go, ODOT developed a response plan for each slide zone and the detour along Carpenterville Highway.

Each plan accounts for different scenarios based on slide severity and offers guidance for where to place traffic control measures like road closure or detour signs and how to get the word out to agencies and public. To read each plan in detail, see Appendix I.



This traffic control guidance for a Hooskanaden slide event scenario helps ODOT know where to place the orange plastic drums, barricades, and road closure notices that tell drivers where to go during a detour.

TRANSPORTATION COMMUNICATION PLANS

Clear and prompt communication after a slide occurs and throughout the assessment and reconstruction processes helps communities recover faster and more completely from a slide. To keep up ODOT's track record with strong communication during slide events, ODOT refined its post-slide communication plans.

Typical ODOT Communications Process

1. Event occurs.
2. Event is reported to ODOT.
3. The local Transportation Maintenance Manager (TMM) handles initial notifications to ODOT dispatch, geotechnical, and public information groups.
4. ODOT staff notify local public information partners to help alert the public of the event.
5. ODOT staff determine what should be done based on the type of event, dispatch staff, and set up the initial road closure.
6. ODOT staff begin coordination efforts with local and regional partners to maintain or reroute services and operations, as needed and as able. Partners include both public and private entities, such as cities, Curry County, US Forest Service, California Department of Transportation, transit providers, emergency services, fuel and freight providers, delivery services, utility companies, waste collections, and impacted private property owners.
7. ODOT staff watch the weather and the slide to know whether adjustments to the traffic control or geotechnical response are needed.
8. ODOT staff create an action plan to repair and reopen any closed lanes.

To read the full communication plan for U.S. 101 and the Carpenterville Highway detour, check out Appendix I.

What can you do?

STAY INFORMED!

To get the latest news and updates about road conditions and landslide event, use the following links:

South Coast Slides Study Webpage: https://www.oregon.gov/odot/projects/pages/project-details.aspx?project=22228

TripCheck: https://www.tripcheck.com/Pages/Road-Conditions?mainNav=RoadConditions&curRegion=0#

Latest News Releases: https://www.oregon.gov/odot/pages/news-releases.aspx

Ask ODOT: https://www.oregon.gov/odot/Pages/Ask-ODOT.aspx

Photo credit: ODOT

Technical Appendix

APPENDICES

A. **Landslide Prospectus Sheets**

B. **Technical Memorandum #1 Project Purpose and Need Statement**

C. **Technical Memorandum #2 Inventory**

D. **Technical Memorandum #3 South Coast Site Reconnaissance Report**

E. **Technical Memorandum #4 Slide Area Alternative Analysis and Mitigation Concepts**

F. **Technical Memorandum #5 Roadway Conceptual Alternatives**

G. **Online Open House Summary**

H. **Stakeholder Interview Summary**

I. **US 101 Traffic Control and Communications Plan Between Port Orford and Brookings**