Research Stage 1 Problem Statement

PROPOSED TITLE: Expanded Analysis of Precipitation- and Seismically-Induced Landslide Potential Considering Climate Variability

1. Concisely describe the transportation issue (including problems, improvements, or untested solutions) that Oregon needs to research.

Landslides are frequent hazards that result in major economic, environmental and social impacts for the operation, maintenance and construction of Oregon highways. These impacts are most often realized after extreme events, often triggered through heavy precipitation and less frequently through earthquakes, and may be conditioned to trigger more easily by prior disturbance, such as wildfire, elevated groundwater or prior rainfall events.

In Oregon, the most problematic and frequent causative factor of landsliding is heavy precipitation, particularly throughout the Oregon Coast Range and Cascades. This problem may evolve with observed drier, warmer summers and wetter, warmer winters, especially with increasingly frequent atmospheric river events. The role of antecedent groundwater is a demonstrated control on the amount of precipitation required to trigger landslides. Characterizing the potential for different storm events to trigger landslides by considering this climatic variability, both annually and with future projections, is key towards evaluating the risk and impact of landslides along critical ODOT corridors, but have only been considered at limited scales in Oregon.

While earthquakes are infrequent in Oregon, there is a significant chance of the Cascadia Subduction Zone (CSZ) rupturing in the next 50 years, with potential for a Mw8.0-9.0 megathrust earthquake and significant, long-duration shaking in western Oregon. This event could cause significant landsliding, especially near or on coastal lifelines. The role of seasonality (i.e. rupture during winter or summer) on potential landslide outcomes may affect the scale and location of landslides. Following shaking, the potential for lack of emergency access, uncertain mitigation strategies and prioritization, as well as potential closures along lifelines and other ODOT right-of-way, is poorly-constrained.

2. What final product or information needs to be produced to enable this research to be implemented?

To constrain evolving conditions, such as seasonality, that control the scale of landsliding during significant storms or an earthquake, data-driven approaches towards modeling hazard, susceptibility and risk must be considered. These approaches must leverage the diversity of Oregon's geological and climatic settings, consider the annual and longer-term changes in wet season conditions, and evaluate the potential impact to ODOT right-of-way, as landslides often lead to delays, road closures and hazardous conditions for drivers.

We propose leveraging and expanding upon prior ODOT research investments (SPR808) in research to expand the suite of conditions and the spatial extents evaluated for landslide susceptibility throughout the entire state of Oregon. SPR808 created a framework for evaluating the susceptibility *and* magnitude of shallow landsliding that could occur from various shaking and storm events. This prior

research used databases of landslides and a limited time series of remotely-sensed hydrologic data to consider the role of seasonality and projected climatic conditions on both precipitation-induced and coseismic landslides. Further, the project resulted in tools on potential closure times for various storm and earthquake scenarios. However, the framework only considered a limited set of critical corridors and was largely limited to shallow landslides (i.e. slides within the top few feet of the surface), was limited in spatial extent, and used smaller databases of landslides and hydrologic data. We propose expanding on this framework to (1) leverage larger databases of mapped landslides that represent more diverse geologic conditions, (2) utilize a longer time series of remotely-sensed and in-situ hydrological data, (3) modify the framework to consider various landslide sizes that are not limited to the near-surface and have different implications for closure, and (4) expand the scenario-based application of both seasonal precipitation- and seismic-triggering to the entire state of Oregon. We propose expanding on tools used to evaluate scenario-based closure times and material expenses for landslide-affected corridors, scaled to all tiers of ODOT right-of-way. Pending availability of various data streams, the team can build on APIs from NOAA or other weather services, along with remotely-sensed data, to provide a near-real-time landslide susceptibility map for use by ODOT professionals.

This research would benefit and complement existing efforts at ODOT including the *Unstable Slopes Program* and initiatives in the ODOT Climate Office. This information would also allow ODOT to work with other agencies to assess the overall risk to infrastructure on a regional to state scale, enabling projection of future impacts from landslide activity from our current baseline conditions. This research would enable enhanced evaluation of climate impacts on future landslide occurrence, which will worsen with increasing extreme events. The outputs would provide enhanced performance measures to assess and manage costs, prioritize areas of concern, provide an advanced tool for resilience project selection, and assess potential future route prioritization.

3. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

Name	Title	Email	Phone

4. Other comments:

This research would expand on the framework developed by SPR808 through (1) use of large-scale forensic analyses and high-resolution lidar to analyze much larger, publicly-available landslide inventories to provide realistic, spatially variable geotechnical and hydrological inputs for susceptibility mapping, (2) develop an approach to consider various landslide sizes and volumes in susceptibility analyses, (3) integrating longer-term, remotely-sensed hydrological data and NWS precipitation data and forecasts towards evaluating landslide hazards, and (4) assessing seasonally-dependent, scenario-based, projected risk to ODOT right-of-way by assessing landslide hazard with traffic data and delay costs. We will leverage openly-available datasets to characterize longer-term climate projections, which will be used to create risk maps for future scenarios that would enable ODOT to plan asset management and prioritization in the face a changing climate. Specific objectives include:

1. Expand forensic analyses for geotechnical properties across the State based on high-resolution DEMs and openly-available inventories of landslides. Improved characterization of geotechnical properties can be attained from back-calculation of equivalent shear strength parameters using inventoried landslides within a region, providing meaningful ranges and variability of geotechnical properties. The aforementioned landslide inventories are openly available (e.g. Statewide Landslide Inventory Database of Oregon – SLIDO, developed by DOGAMI) and can be expanded upon through manual or automated mapping procedures.
2. Advance and expand susceptibility analyses to integrate spatially-interpolated, forensically-determined geotechnical properties, hydrological conditions through integration of NWS data and longer-term times series of NASA SMAP data to characterize seasonality of groundwater conditions for both seismically-induced and precipitation-induced landslide susceptibility and hazard.
3. Use hazard maps and lifeline data (AADT, priority) to create landslide risk maps across the State of Oregon. Leverage tools with estimates of varied landslide volumes, debris clearing, material expenses, and traffic counts for ODOT right-of-way.
4. Develop scenario-based models and maps of projected risk from impacts of increasingly extreme precipitation events on landsliding for across the State of Oregon based on climate projections for the next 50 years.
5. Implement a near-real-time landslide hazard map into a webGIS tool for ODOT use.

5. State of Oregon Decision Making Lenses

State decision making lenses are a part of the state of Oregon's policy structure. State policy and federal policy are not always aligned. The state will prioritize research according to state policy, however ODOT may be required to skip prioritized proposals based on constraints placed on the use of federal funds. If state funds are available ODOT will attempt to fund prioritized research that is deemed ineligible for federal funding.

Please complete the following three sections. Your answers to these questions will be applied on a programmatic basis to support agency decisions. Answering yes to the questions below is not required. Resolving a narrowly focused technical research problem may meet agency needs without answering yes to any of the following questions. The ODOT Research Section will seek a balanced portfolio some projects will answer yes to one of the three categories below (e.g. climate, equity, and/ or safety) and other projects in a different category.

We are looking for an overall program balance and no one project is expected to balance all categories. Generally, a research problem statement is expected to be able to answer yes with clear and verifiable information in only one of the three categories below, some projects may be able to answer yes in two or even three categories. Some projects (i.e. needs focused on specific elements of infrastructure design), may have no 'yes' answers but may still be a high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. To that end, we seek research that reduces carbon emissions from construction activities and materials, and from maintenance equipment and operations. Oregon envisions a transportation system that is resilient, this means a system that is durable in the face of seismic events and extreme weather to avoid negative impacts, withstand them or bounce back quickly to resume system function. We seek research that improves the ability of the transportation system to adapt or cope with more frequent and extreme weather events. This may include innovations in data and data sharing, construction materials and

project design, communication, emergency planning and response, and more. Similarly, we seek research that avoids negative impacts on key habitats and ecosystems that can buffer or reduce damage to infrastructure and improve environmental conditions for wildlife and native vegetation. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

5a. Will addressing the transportation issue identified as a need in Question 1 develop, or **validate methods for the estimation, measurement, or monitoring** of transportation generated greenhouse gases (GHG)?

☐Yes ☒No ☐Unsure

5b. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☐Yes ☒No ☐Unsure

5c. Will addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☐Yes ☒No ☐Unsure

5d. Will solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐Yes ☒No ☐Unsure

5e. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, or monitor, transportation system resilience in response to expected climate events, effects, or natural disasters in general?

☒Yes ☐No ☐Unsure

5f. Will solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation?

☐Yes ☒No ☐Unsure

5g. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

The role of climatic variability and seasonality are strong controls on the potential for landsliding given a disturbance. That is, wetter conditions such as those observed in February, may result in decreased precipitation or shaking required for triggering. The opposite may occur during summertime conditions. Being able to evaluate how seasonality, both current and projected, may affect exposure of ODOT right-of-way to landslide impacts is key for prioritization, planning and resilience.

Equity

Equity can have many dimensions and impacts relating to communities and transportation. It is important that problem statement proposals clearly explain the equity dimensions or impacts being examined. Oregon commits to social equity in the OTP, specifically to *improve access to safe and affordable transportation for all, recognizing the unmet mobility needs of people who have been systemically excluded and underserved. Create an equitable and transparent engagement and communications decision-making structure that builds public trust*. We seek research that studies elements of this goal or applies analysis to specific transportation topics to ensure the resulting research recommendation is consistent with agency equity goals. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

5h. Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes ☒No ☐Unsure

5i. If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☐Yes ☒No ☐Unsure

5j. Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐Yes ☒No ☐Unsure

5k. Is the intended final product or information expected to support ODOT's equity efforts (Including but not limited to supporting one of the equity related objectives of the ODOT's Strategic Action Plan or Oregon Transportation Plan) ?

☐Yes ☒No ☐Unsure

5l. If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

Safety

Research outcomes may include interventions and countermeasures to prevent or reduce the frequency of crashes or other causes of transportation-related injury or death; or may include measures to reduce severity of injury (including prevention of death) after a crash or other injurious event. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan, Oregon Transportation Safety Action Plan and Oregon Transportation Plan.

5m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes ☒No ☐Unsure

5n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐Yes ☒No ☐Unsure

5o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☐Yes ☒No ☐Unsure

5p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☒Yes ☒No ☐Unsure

5q. Will solving the **transportation issue** support improving safety through **investing strategically**? 5r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

The creation of landslide hazard and risk outputs provides a direct means of evaluating corridors most exposed to landslide hazards, which directly affect worker and traveler safety. Better communicating these hazards through maps makes these data more accessible and opens up avenues for communication and collaboration with relevant, affected parties.

6. Corresponding Submitter's Contact Information:

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7. ODOT Sponsor Contact Information (Required if Submitter is not an ODOT employee)

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This form is not a grant application or contract document. Please do not include proprietary information on this form. Once this form is received ODOT may revise and publish the problem statement. If selected, ODOT will assign investigator(s) of the department's choosing to conduct research.