SPR RESEARCH PROGRAM
SECOND-STAGE PROBLEM STATEMENT
FY 2017

ODOT Research Unit
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I. PROBLEM NUMBER AND TITLE

17-018 Coastal Landslide and Bluff Retreat Monitoring for Climate Change Adaptation and Targeted Risk Assessment

II. RESEARCH PROBLEM STATEMENT

Rising seas and extreme coastal weather events pose significant risks for the safety, reliability, and effectiveness of ODOT infrastructure and operations along the coast. Coastal landslides and shore cliff erosion are particularly sensitive to climate drivers with sea-level rise, storm frequency and intensity, wave scour, and rainfall amounts influencing landslide movement and coastal bluff erosion. Coastal bluff retreat rate is also directly proportional to climate change effects and in many locations directly threatens disruption of ODOT's coastal infrastructure. Though landslides and coastal bluff erosion are common processes that affect coastal highways every year, bluff retreat and rate of movement are not well characterized. In 2014, ODOT's Coastal Climate Change Vulnerability Assessment identified this limited information regarding coastal bluff retreat as an issue of concern.

Considering that ODOT is designated as a lead implementation agency for the Governor's climate change adaptation priority, together with the observation that at least 26 sites totaling nearly 20 miles along Hwy 101 have already been identified as areas of concern, the need to assess landslides and coastal bluff retreat in terms of both magnitude and rate of movement and retreat will become increasingly critical. The rate and magnitude of bluff retreat are essential measures to be used in prioritizing highway segments situated upon those bluffs. These parameters would allow the agency to both prioritize sites for repair and financially plan for mitigation projects that are timed to maximize the utility of the existing facility. In this regard the agency already knows which areas are impacted by bluff retreat, but without sufficient funding to address all of them at once it becomes critical to determine which ones have the shortest lifespan so that they can be addressed earliest. Research to directly address this concern is needed in order to optimize ODOT infrastructure planning, secure lifeline routes, and address the climate change adaptation focus of the Oregon Transportation Commission work plan.

Previous coastal landslide research for ODOT includes investigation of the Johnson Creek Landslide and Arch Cape site in Lincoln and Clatsop counties respectively. The Johnson Creek Landslide research study focused on the relationships between coastal bluff retreat, precipitation, and groundwater using standard survey methods to evaluate select cross-sectional areas of the coastal bluff at the toe of the landslide. A separate, brief analysis of the coastal bluff morphology of the Arch Cape site evaluated the use of terrestrial LiDAR (Light Detection and Ranging) technology for change detection. Compared to standard survey methods, terrestrial LiDAR provides a more accurate and efficient way to map, visualize, and quantify changes in coastal bluff erosion. Though aerial based LiDAR surveys conducted by the U.S. Army Corps of Engineers and DOGAMI/Oregon LiDAR Consortium have been produced for coastal landscape-level use, the resolution is insufficient for what is needed to accurately monitor coastal bluff retreat. In sum, given the limited research on coastal landslide movement and bluff retreat with respect to changing climate drivers, a more long-term and in-depth monitoring study with modeling potential is needed to provide useful information for ODOT infrastructure planning.

III. RESEARCH OBJECTIVES

The goal of this research for ODOT is to develop a more comprehensive data driven framework for prioritizing coastal asset management. This is new research for ODOT building upon recent smaller-scale foundational efforts and recommendations. The objectives of this project include the following tasks:

1) Select 5 representative sites reflecting a combination of coastal geologic terrains, landslide types, and coastal bluff erosion activities.
2) Determine current geotechnical and hydrological data, as well as landslide and bluff geometry and movement using traditional and advanced 3D technologies (LiDAR and real-time remote MEMS sensing).
3) Quantify changes in landslide movement, groundwater change, and bluff erosion rates over an extended 7 year timeline to fully capture the episodic nature of sea cliff erosion in the context of climate events.
4) Document observed and quantified changes with mid-project report at year 3. A final comprehensive report prepared for ODOT at the end of the monitoring study at year 7 is expected.

5) Develop GIS/LiDAR based management framework for targeted risk assessment and climate change adaptation planning including guidelines for future evaluations of coastal infrastructure sites.

IV. WORK TASKS, COST ESTIMATE AND DURATION

Task 1: Select representative coastal landslide and bluff sites for monitoring. Five high-risk coastal landslide sites will be selected that are susceptible to sea level rise, increasing rates of ground movement, and/or shore cliff retreat due to increased wave scour and higher, more intense precipitation events. Site preference will also be based on locations with historic data and available pre-instrumented locations such Arch Cape (US 101, MP 35.95), which is an example of an existing landslide within the coastal bluff where further erosion will undermine the slide itself. Other proposed sites of potential interest include Silverpoint slide (MP 31.8), Spencer Creek (MP 134), Arizona Inn (MP 312.3), and Hooskenaden (MP 344.1).

Task 2: Obtain and organize pre-existing geotechnical data. For previously researched sites, gather relevant data useful for current project. Use previous limitations, lessons learned, and research insights to help development of *Task 3*.

Task 3: Establish protocol for 7 year monitoring project. Given the extended duration of this project, detailed, specific Standard Operating Procedures and Business Rules for data acquisition, storage, processing, analysis, and potential model development will be provided and documented for review.

Task 4: Equip and monitor selected sites bi-annually for a 7 year duration. Determine baseline geotechnical and hydrogeological properties by hyperspectral imagery, LiDAR scanning, and installation of instrumentation to measure groundwater pressure, precipitation, and landslide movement for those sites not already equipped as well as for equipped sites with existing instrumentation. Bi-annually collect data and monitor changes for each measurement for all sites. Provide mid-project deliverable draft of the risk framework model in report and presentation format to the TAC including data summary, project trajectory, and near-term or interim benefits and applications for ODOT.

Task 5: Deliver final report. Document findings and provide recommendations after final LiDAR and other geotechnical and hydrological measurements are completed. 7-year changes in landslide movement, groundwater data, and bluff erosion rates for each site will be quantified. Use existing advanced statistical analysis and landslide modelling methods such as CCM (Contour Connection Method), three-dimensional slope stability analysis and remote sensing techniques merged with a GIS framework to compare and contrast sites to guide development of recommendations for prioritizing other coastal assets (part of final report). Year 1 (Task 1-3, equipping, sites and year 1 monitoring for Task 4): $297,857. Years 2-7 (Tasks 4 and 5): $287,143. *The 7 year, 5 site cost is $585,000*[1].

V. IMPLEMENTATION

This research would be used by ODOT to inform project-level risk and decision making where coastal infrastructure is threatened by landslides and erosion. It will also inform planning and land-use at a policy-level regarding shoreline protection where infrastructure is threatened by future coastal bluff retreat. Clear projections of the timeline at which infrastructure loss occurs provides ODOT with the information needed to influence decisions concerning the use of shoreline protection measures to protect public property or other adaptation strategies on a higher decision-making level. Further, this research could be used by the agency to justify exceptions to land use goals and other environmental restrictions when proposing construction projects to protect infrastructure. This includes exceptions to Statewide Goal 18 (Beaches and Dunes) regulated by the Department of Land Conservation and Development and coastal permits issued through the Oregon Parks and Recreation Department.

VI. POTENTIAL BENEFITS

ODOT needs a coordinated research program to establish the system and tools to initiate, manage, and analyze data to assess coastal landslide and erosion risks. The findings from this project will enable ODOT to relate climate events to site conditions, changes and risk levels. Results from this project will also inform climate impacts to groundwater changes, their effects on landslide movement, and to differentiate these effects from those related to coastal erosion rates at the most vulnerable sites. Advanced methods for geotechnical investigation and monitoring of landslides used for this study would subsequently be adapted for common agency practice resulting in more accurate, efficient landslide monitoring and mitigation efforts.

VII. SUBMITTED BY

Stage 1 Submitter	***Stage 2 Submitter***	***ODOT champions***
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[1] Including $20,000 ODOT Administration fees.