APPLYING SEISMIC VELOCITY MAPPING FOR LANDSLIDE SHEAR-PLANE IDENTIFICATION, THEODORE ROOSEVELT NATIONAL PARK

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Scenic Loop road within the South Unit of Theodore Roosevelt National Park, ND circumnavigates thousands of acres of dramatic badlands, providing sweeping vistas for park visitors. The southern extent of Scenic Loop road winds near the top of steep hoodoos and buttes. These geologic features are comprised of poorly lithified claystones of the Bullion Creek and Sentinel Butte formations, and are highly erodible and residual clay soils are dispersive. As a result, roadway damage due to erosion and landsides is common along this portion of Scenic Loop road. Cold-patching and limited remediation efforts have been completed by the National Park Service during the lifetime of the roadway. During the winters of 2019-2020, a portion of the roadway was destroyed by a landslide making the Loop road impassible. This slide is one of many areas along the southern extent of Scenic Loop road where mass movement has been observed and has caused/is causing roadway damage, and prompted the need for engineering mitigation. Seismic velocity mapping, via refraction tomography and multichannel analysis of surface waves, was used to infer the depth of landslide shear-planes at multiple locations along the southern portion of Scenic Loop road, and aid in engineering design of landslide mitigation, drainage needs and roadway reconstruction. Given the low density and poor induration of the bedrock at this site, strong velocity contrasts between displaced and un-displaced landslide debris are not evident in the geophysical results. However, subtle velocity variations in the shallow near-surface are observed in both the p-wave refraction and s-wave surface wave analysis results. Strong correlations emerged when comparing the depths of these subtle velocity anomalies to shear-plane depths measured at sites with borehole inclinometers. These subtle correlations persisted at multiple other landslide locations and allowed for the interpretation of landslide shear-planes at sites with limited in-situ measurements of slip. The results of the geophysical investigation have been used to inform slope stability geotechnical modeling and the design of roadway repair and slope stabilization in order to re-open the Scenic Loop road.