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## Soil Analysis of Samples from Areas Adjacent to the Truck Gravel Course and Mesa Dust, U.S. Army Yuma Proving Ground

The goal was to provide soil and terrain characterization in support of Yuma Proving Ground (YPG) vehicle testing conducted at YPG Combat and Automotive Systems Division. A vehicle that was tested on slopes ranging from 35%-38% grade failed to perform as expected on these lower slopes, and further testing thus ceased. The project was conducted at Yuma Proving Ground, AZ in 2017. Our analyses showed that the actual grade measurements for sites 1 and 4 were less than YPG slope estimated and were greater than actual grade measurements for sites 2 and 3. The test vehicle should have performed better in sites 1 and 4 based on slope alone. We concluded that there were likely relative, localized differences in physical characteristics that impact vehicle performance and testing.

Summary of Project Details: We characterized the sand dunes at each of the four sites to include basic physical properties such as near surface moisture content, bulk density, and particle size distribution (PSD), and conducted soil strength assessments and characterized grades. Dune slope was calculated from 5cm digital elevation models we created from unmanned aerial system (UAS) measurements using photogrammetric methods. Elevation was measured using a map grade Trimble GPS. Soil strength measurements were collected using a Humboldt dual-mass dynamic cone penetrometer (DCP) to calculate California Bearing Ratio (CBR, %) and bearing capacity along the slope at three or four spots on each dune profile. Sediment samples were collected at these same locations to assess dry bulk density and PSD in the soil laboratory at DRI. We provided the results of all measurements to allow YPG to guide determinations about the suitability of their sites to meet vehicle test specifications.

Management Implications: We showed that variation in the subsurface affects test conditions on dune slopes. Therefore, we recommended that YPG take steps to conduct further categorization of specific characteristics of the dunes, specifically subsurface moisture content, bulk density, PSD, and shear strength at locations 1-4 or other relevant sites. To ensure that local conditions meet vehicle test requirements, which has not always occurred, we suggested that YPG employ additional UAS and ground-based characterization of other ISD locations prior to future vehicle testing. Lastly, we recommended that they initiate a detailed assessment of soil, grade, and strength characteristics across the three manufactured dune slopes at YPG Sand Slopes and Sand Dynamometer test courses.

