Hydrology Modeling for WIPP

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FIU Applied Research Center

Hydrology Modeling for the WIPP

Site Needs:

- DOE-EM needs to improve the current understanding of regional and local groundwater (GW) flow near the WIPP to compute the water balance, and derive more accurate estimates of groundwater recharge to better predict the propagation rate of the shallow dissolution front and its potential long-term impact on repository performance.

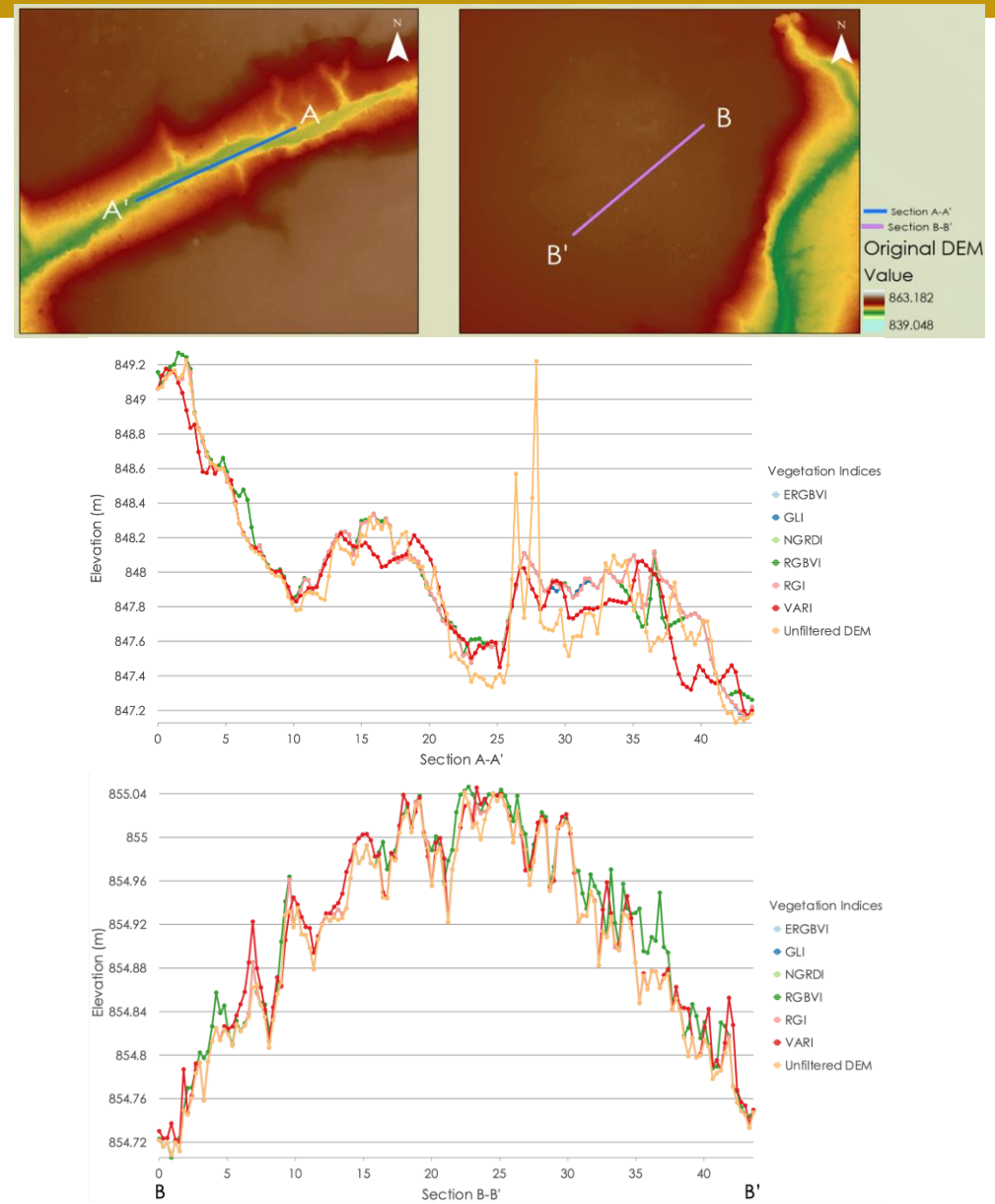
Objectives:

- To develop a GW-basin model for the Nash Draw west of the WIPP using the DOE-developed open source ASCEM Amanzi Simulator (Advanced Simulation Capability for Environmental Management: Amanzi Simulator) to improve the current understanding of regional and local groundwater flow.
- Currently, ASCEM toolset is unable to account for land surface hydrology, which is essential for computing the water balance across multiple scales.
- The proposed work will therefore include utilization of the Advanced Terrestrial Simulator (ATS) code used for solving ecosystem-based, integrated, distributed hydrology. ATS builds on the multi-physics framework and toolsets (such as mesh infrastructure, discretizations, solvers) provided by Amanzi.
- ATS will provide surface process parameters (e.g., infiltration rate) for incorporation into the groundwater models within the ASCEM toolbox to facilitate sensitivity and uncertainty analysis of GW and SW flows.

Subtask 6.1: Digital Elevation Model and Hydrologic Network

FIU Year 1 Research Highlights:

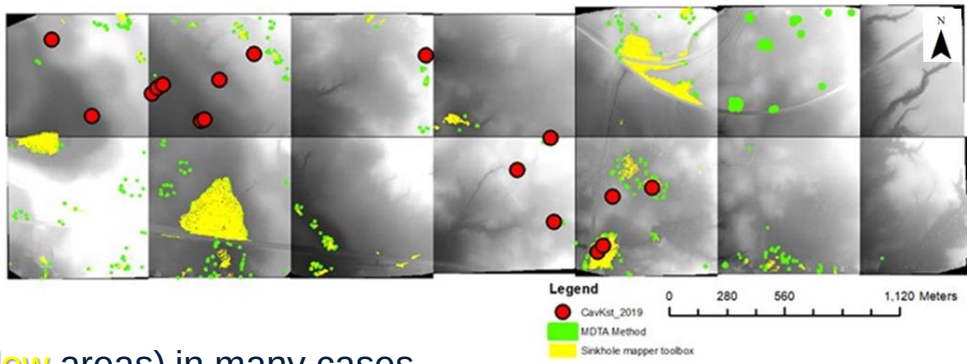
- RGB-based vegetation removal methods derived from lit. review tested to refine high-res DEM developed from drone imagery collected during pilot study in Basin 6 in 2020.
- DEM needed for LSM development and delineation of significant hydrological features (e.g., sink holes, brine lakes, gullies) that could contribute to regional GW recharge.
- Promising results with use of libLAS with Python to determine an optimum threshold value which separates the vegetation from the bare ground.
- Main issue was shadow effect due to time of day data was collected.
- Lit. review of shadow removal methods conducted and several applied with somewhat unsuccessful results.
- Proposed path forward:
  - Comparative analysis of vegetated areas on high-res DEM vs. satellite imagery (Landsat 8, Sentinel or NAIP)
    - Will require “scaling up” the DEM to the resolution of the satellite imagery for comparison
  - Comparative analysis of high-res DEM with NLCD vegetation density maps



Section profile graphs of vegetation indices using ArcGIS and libLAS in Python.

Subtask 6.1: Digital Elevation Model and Hydrologic Network

FIU Year 1 Research Highlights:

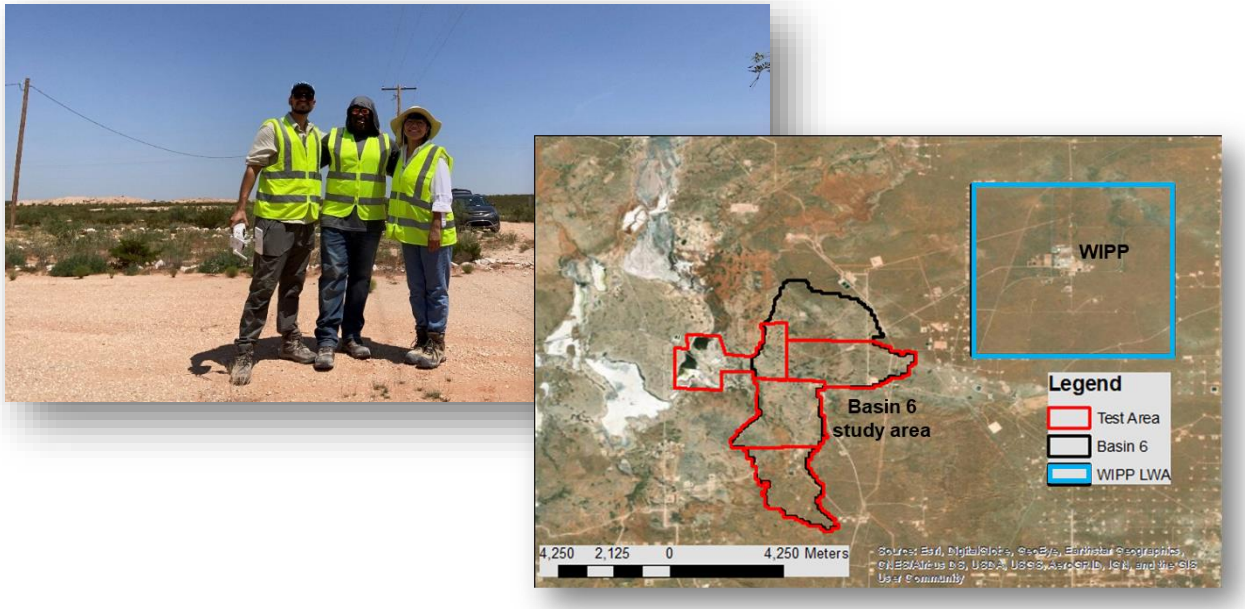


Sinkhole Detection:

- 2 GIS-based sinkhole detection methods (MDTA & Sinkhole Mapper Toolbox) tested using FIU's high-res DEM and results were compared with previous sinkhole inventory derived from GPS field mapping in Basin 6. (Goodbar et al, 2020)
- Sinkholes derived from the GIS-based detection methods (green & yellow areas) in many cases overlapped or were in close proximity to ground surveyed sinkholes (red dots). Numerous additional depressions also identified with the standard parameters used in the GIS-based detection methods.
- Mapped sinkholes from the Sinkhole Mapper Toolbox method currently being incorporated to refine Basin 6 mesh using TINerator mesh generator which will be used in ATS.

UAV-Based Field Survey of Basin 6:

- FIU research team traveled to Carlsbad, NM (Aug. 2021) to collect complete imagery dataset for Basin 6 study area (~24 km^2).
- Team was successful in capturing ~ 22 km^2. Site will be revisited early in FIU Yr 2 to complete the survey.
- Final data set will be processed as per the established photogrammetry work flow.



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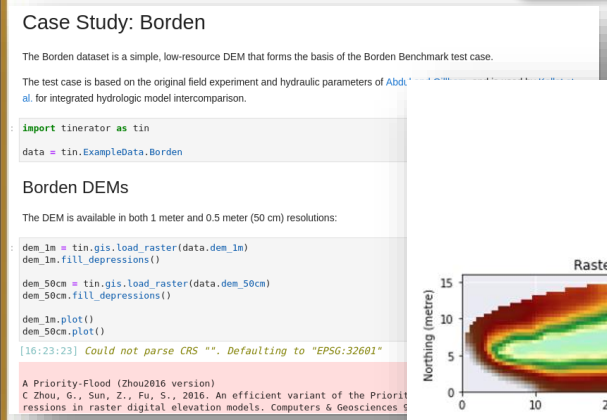
2021 Summer Internship

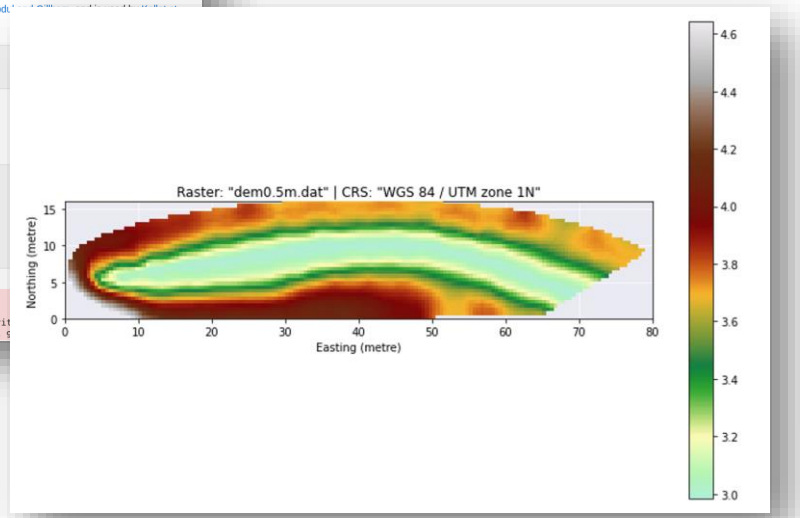
Los Alamos NATIONAL LABORATORY

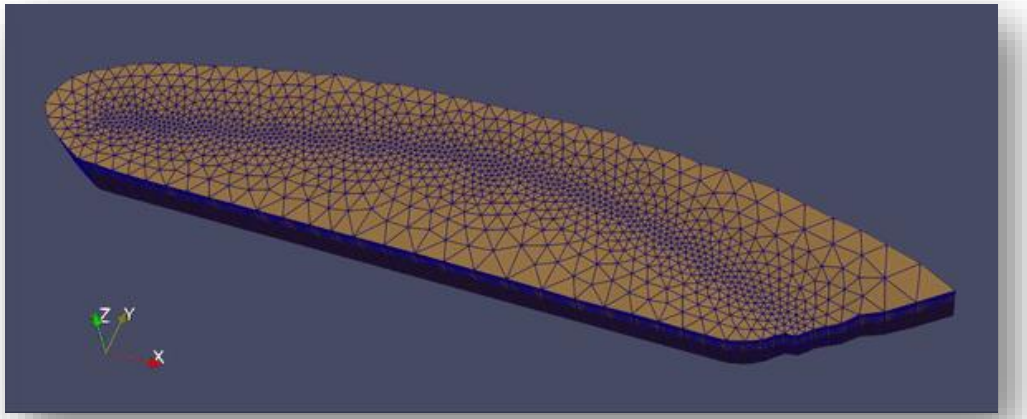
- Mentors: David Moulton and Daniel Livingston
- Objective: Study the impact of surface features (sinkholes, swallets, etc.) in conjunction with soil properties and vegetation types, on the groundwater recharge over a range of design storm events in Basin 6.
- Internship goal: Gain knowledge and expertise in using several open-source software to generate meshes from DEM data, to set up meteorological forcing data, and to develop input files for the ATS to perform a series of simulations.

tinerator

ParaView







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Workflow using Borden Watershed

Amanzi- ATS

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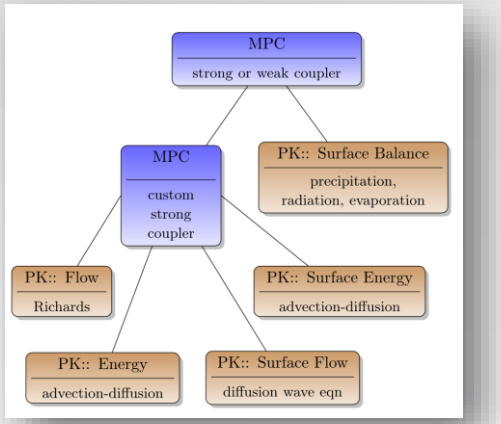
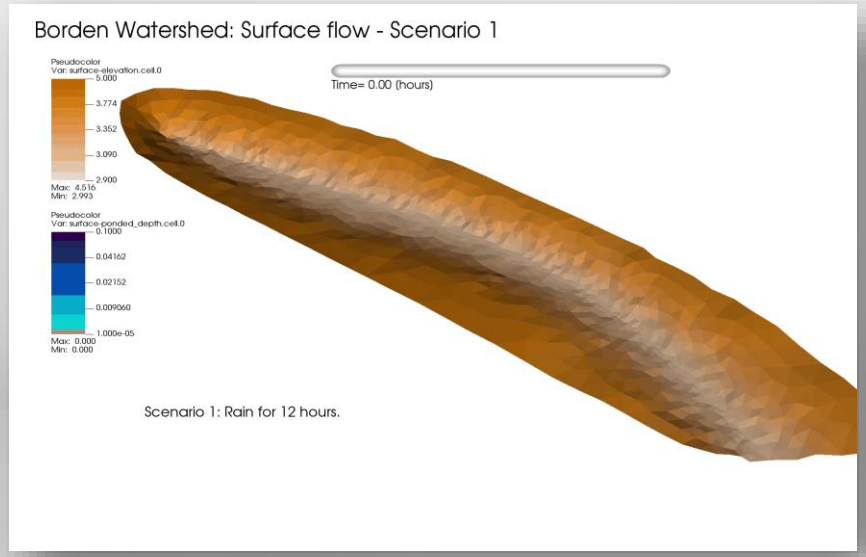
Input Parameter XML File



Example schematic PK-tree for coupled surface/subsurface thermal hydrology, driven by a surface energy balance model, as in ATS.
PK layout for Arctic system.

VisIT



Overland Flow scenario.

Applying Workflow to Basin 6

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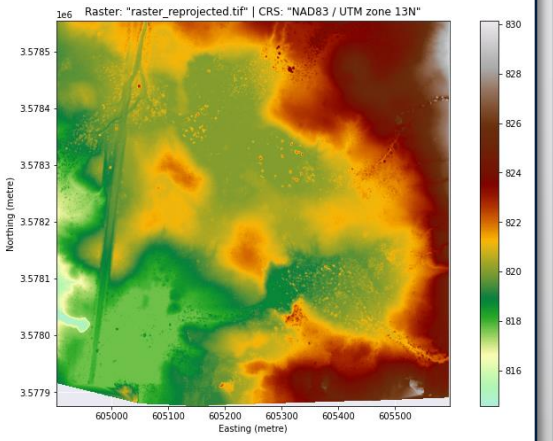
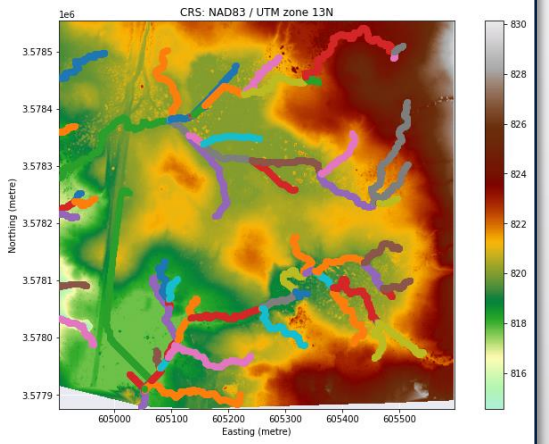
Loading DEM → Watershed Delineation → Sinkhole Face sets

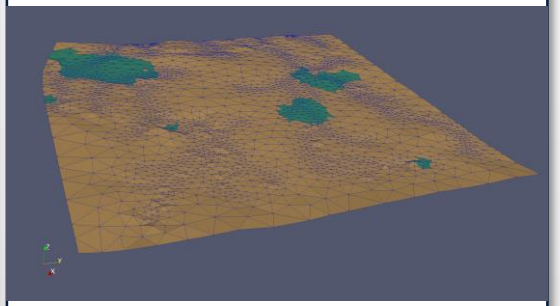
ParaView

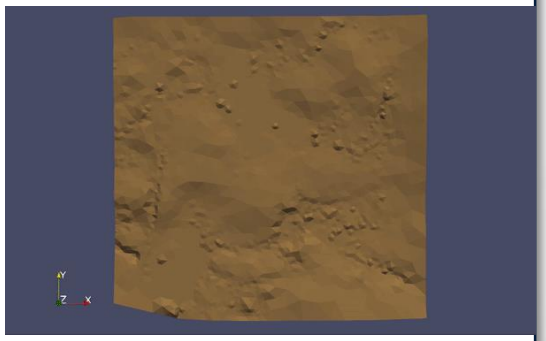
Mesh Visualization



Section of Basin 6 - .05 m DEM



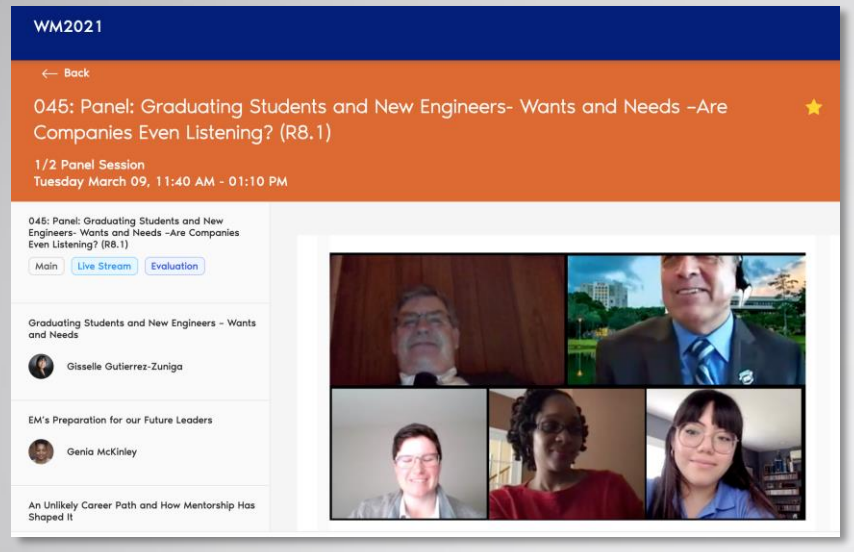


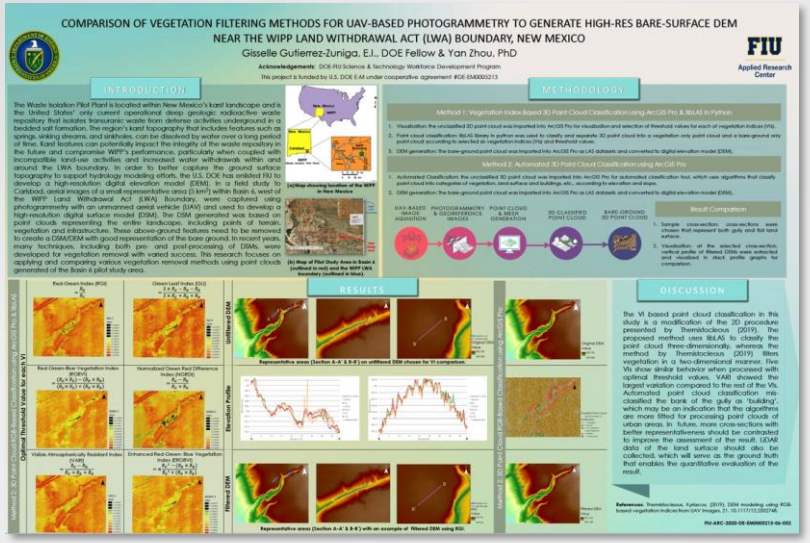


Five layer mesh of a part of Basin 6. Layer depths strongly exaggerated for effect.

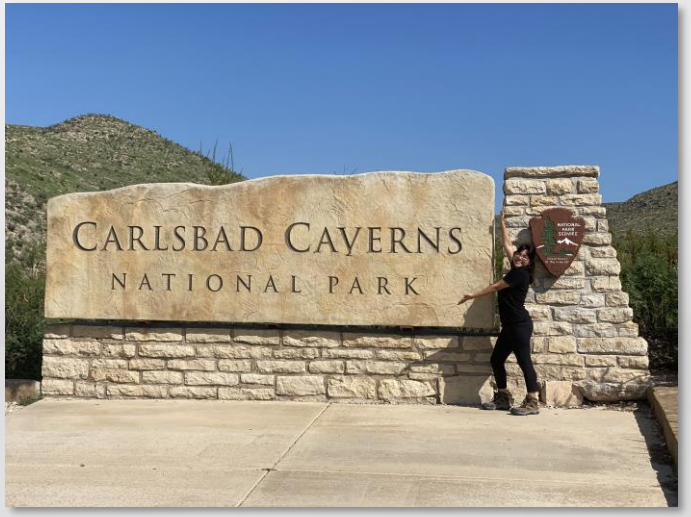
Fellows Program Highlights

Waste Management Symposia 2021





Field Work



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Future Work

- Complete DEM development for Basin 6
  - Compare areas of vegetation to satellite imagery (Landsat 8, Sentinel, or NAIP)
  - “Scale up” the drone imagery to the satellite imagery for comparison and vegetation density maps
  - FIU intends to return to Carlsbad, NM early in the new FIU Year 2 fiscal year to complete the survey.
- Complete LSM development for Basin 6
  - Continue training on ATS.

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Thank You! Questions?