Polk County Vulnerability Assessment Additional Flood Modeling Project

CHNEP Work Assignment for the CFRPC

Charlotte County Purchase Order Number: 25000387

Technical Memorandum

From: Adrian F. Santiago Tate, CEO, HighTide Intelligence
To: Curtis Knowles, Central Florida Regional Planning Council
Subject: Task 2 – Technical Memorandum
Date: September 8, 2025

1. Purpose & Scope

This memorandum summarizes the methodology, modeling process, and key results of the flood scenario modeling conducted for Polk County, Florida, as part of the Comprehensive Vulnerability Assessment (CVA). The modeling addresses the County's exposure to extreme rainfall. Four distinct flood scenarios were simulated to assess potential impacts: the 200-year and 500-year 24-hour rainfall events, each under average and saturated soil conditions.

The deliverables documented herein fulfill Task 2 of the Polk-CHNEP-001 Task Order executed under HighTide Intelligence's continuing services contract with the Central Florida Regional Planning Council (CFRPC). This task was completed in compliance with the Florida Adaptation Planning Guidebook and the Resilient Florida GIS Data and Metadata Standards.

This document is accompanied by all required modeling files, GIS outputs, metadata, and a complete technical report by Halff Associates, HighTide's modeling subcontractor. Together, these deliverables meet all technical requirements set forth by CFRPC and CHNEP and are intended for integration into Polk County's final CVA.

2. Deliverables and Data Products

The following items are submitted in fulfillment of Task 2, as outlined in the Task Order.

Flood Models

- HEC-RAS model files for each scenario, including geometry, terrain, rainfall, infiltration, and configuration files
- Four modeled flood scenarios: 200-year and 500-year rainfall events, each under average and saturated ground conditions, delivered as maximum flood depth and water surface elevation rasters (GeoTIFF format)

Exposure Analysis

- Shapefile and CSV identifying critical assets affected in each scenario, with flood depths
- Tables and figures summarizing impacts, provided in PDF format

Technical Documentation

- This technical memorandum summarizing the modeling process, scenarios, and methodology
- A detailed technical appendix authored by Halff Associates
- Federal Geographic Data Committee (FGDC)-compliant metadata files for all geospatial deliverables

3. Model Description

The flood scenarios were simulated using HEC-RAS 6.6, a two-dimensional (2D) hydraulic modeling platform developed by the U.S. Army Corps of Engineers. This software supports rain-on-mesh modeling, which allows rainfall to be applied directly across the terrain surface. HEC-RAS was selected for its ability to represent complex terrain, variable infiltration, and low-frequency rainfall scenarios.

Separate models were developed for East Polk and West Polk County, divided along the Central Highlands ridge and primary watershed boundaries. The underlying terrain surface for both domains was built from bare-earth Light Detection and Ranging (LiDAR) datasets collected primarily in 2018, with additional data from 2017, and processed to ensure compatibility and hydrologic consistency across the entire county.

This model setup enabled consistent analysis across different sub-watersheds, supported asset-level flood exposure mapping, and aligned with the standards and deliverables required under the Resilient Florida program.

A full description of model setup, data inputs, and validation procedures is provided in Section 5.

4. Flood Scenarios Modeled

The following section describes the four flood scenarios modeled. As written in the Task Order, the term “compound” flood scenario was included but not precisely defined. In common usage, compound flooding can refer to multiple interacting sources of floodwater (e.g., riverine and storm surge). In consultation with the project team, compound rainfall flooding was interpreted as a scenario where prior saturation increases runoff during a subsequent storm. This was simulated using standard hydrologic modeling techniques described below.

The following four flood scenarios were modeled using 24-hour design storm depths from NOAA Atlas 14, Volume 9:

1. 200-year, 24-hour event (0.5% Annual Chance)
2. 500-year, 24-hour event (0.2% Annual Chance)
3. Compound 200-year event: Assumes saturated ground conditions
4. Compound 500-year event: Assumes saturated ground conditions

To simulate compound flooding, the model was rerun using Curve Number (CN) values adjusted to reflect Antecedent Runoff Condition III (ARC III), representing low infiltration due to already saturated soils. This approach approximates the hydrologic effect of back-to-back storm events.

Each scenario was run on both East and West Polk model domains. The simulations were configured to run long enough to capture peak discharges and the full hydrograph recession. A 30-second computational timestep was used to balance model stability with runtime efficiency.

5. Methodology Summary

The HEC-RAS model was configured using a rain-on-mesh approach, which simulates precipitation directly onto the terrain surface. This method was selected due to its suitability for the flat and complex topography of Polk County and its ability to simulate distributed overland flow without requiring predefined stream channels.

Terrain data were developed by merging multiple LiDAR-derived digital elevation models (DEMs) covering Polk County and adjacent areas. These DEMs were hydraulically conditioned to better reflect real-world flow paths, including culverts and roadway underpasses. Where direct culvert inputs were not available, a process known as terrain "burn-in" was applied to lower the elevation along known or suspected flow paths. This technique helps eliminate artificial blockages and improve drainage representation. Breaklines were used throughout the model to preserve key terrain features such as road crowns, ditches, and canal banks, ensuring appropriate elevation transitions and hydraulic connectivity across the domain.

The model was divided into two domains (East and West Polk) based on topographic ridgelines and watershed boundaries. Each domain was assigned a separate 2D mesh, which used smaller cell sizes in areas of interest (e.g., near critical infrastructure, roadways, or rivers) and coarser mesh in flatter, undeveloped areas. This variable resolution helped balance model precision and runtime efficiency.

Infiltration was represented using spatially distributed CN grids derived from a combination of land cover data from the 2021 National Land Cover Dataset (NLCD) and soil hydrologic group data from the NRCS SSURGO database. These inputs allowed the model to assign infiltration rates and runoff potential to each grid cell based on surface and subsurface characteristics. A second set of CN grids was developed using ARC III, which represents saturated ground conditions and simulates reduced infiltration and increased runoff. These saturated CN grids were used for the compound storm scenarios.

Rainfall depths were based on NOAA Atlas 14, Volume 9 and corresponded to 24-hour, 200-year (0.5% annual chance) and 500-year (0.2% annual chance) storm events. The temporal distribution of rainfall was defined using the 24-hour rainfall distribution curve developed by the Florida Department of Transportation, which simulates a realistic rainfall pattern over time. Because Polk County covers a large area, areal reduction factors were applied to the total rainfall depths to account for spatial variability in storm intensity.

Each of the four flood scenarios, the 200-year and 500-year rainfall events under both standard and saturated soil conditions, was simulated independently for East and West Polk domains. Simulations were run for a duration sufficient to capture the full hydrograph, including rising and falling limbs. A 30-second computational timestep was used to ensure numerical stability and appropriate detail in flow dynamics.

To validate model performance, a 100-year design storm scenario was simulated and compared to discharges from the FEMA Flood Insurance Study and available USGS gauge records. Results showed that peak discharges were within 10 percent of observed or published values at most locations, consistent with acceptable standards for model calibration.

6. Cross-Walking of Raw Data

Several cross-walking steps were essential to converting raw datasets into usable model inputs:

- Soil and Land Cover Data: Soil hydrologic groups from NRCS SSURGO data and land cover from NLCD were combined to create composite CN values for infiltration.
- Rainfall Depths: Point-based NOAA precipitation depths were converted to spatially applied hyetographs using standard distribution curves and applied uniformly across the model domain.
- Terrain Conditioning: Raw LiDAR-derived terrain was altered using aerial imagery and road network data to introduce culvert pathways and eliminate false flow barriers.
- Infiltration Layers: The composite CN layer, together with impervious surface data, was translated into a spatially varied infiltration grid used directly by HEC-RAS.

7. Results Summary

Flood modeling results include maximum flood depth and water surface elevation rasters for each scenario. The outputs were used to assess the flood exposure of critical infrastructure and other assets throughout Polk County, which were provided by CFRPC. Key findings include:

- The Bartow Wastewater Treatment Facility is inundated under both 500-year scenarios, with and without saturated soil conditions. This flooding confirms stakeholder concerns and highlights the facility's vulnerability during extreme rainfall events.

- A power substation near the Walmart in North Bartow is inundated under all modeled scenarios, including both 200-year and 500-year events with and without saturated soil conditions. This site was validated using aerial imagery from Hurricane Milton.

- Highway 92, along the south side of Lake Parker, is a major east-west corridor in the Lakeland area. The model shows partial inundation under all scenarios except the 500-year compound event, during which the roadway is fully flooded.

8. Public Access and Use

In accordance with project requirements, the model and results are designed for public use. All model files, GIS data, and metadata have been transmitted to CFRPC and CHNEP for inclusion in public records. These files will be accessible to other modelers, agencies, and members of the public wishing to replicate or build upon this work.

9. Funding Acknowledgement

This project was funded by the Coastal and Heartland National Estuary Partnership (CHNEP) through Bipartisan Infrastructure Law (BIL) funding provided by the U.S. Environmental Protection Agency. HighTide thanks CHNEP, CFRPC, and Polk County for their partnership and contributions throughout this work. The modeling and analysis presented herein will be formally integrated into Polk County's Comprehensive Vulnerability Assessment and used to inform long-term resilience planning across the County.