Sinkhole Vulnerability Mapping Project
Geologic Hazard Mapping Need

• Summer of 2012 TS Debby triggered the formation of thousands of sinkholes in Florida

• This exposed the lack of a good planning tool to mitigate large scale events or sinkhole swarms

• ...and eventually lead to the FDEM contacting the FGS about developing a tool for evaluating the relative vulnerability of an “area” to sinkhole formation
Geologic Hazard

• Sinkholes are a geologic hazard

• Vulnerability depends on natural (geologic, hydrologic and meteorological) and human (water pumping, terra-forming and ground loading)

• Sinkhole hazards or risk of impact from the presence of them increase with population
  • are not reported unless impact infrastructure
Underlying Geology

• Major sections of Florida’s peninsula is made up of carbonate rock and overlain by variable thicknesses of sand and clay

• These carbonate rocks dissolve slowly over time due to chemical processes and create karst terrains

• Karst terrains are characterized by sinkholes, caves, springs, disappearing/reappearing streams and other land surface depressions
Types of Sinkholes

• Two types of sinkholes

  • collapse – form when the roof of an underground void can no longer support the weight of the overburden causing a sudden collapse into voids

  • subsidence – form when the overburden slowly migrates into the cracks and fissures in the underlying rock resulting in an apparent depression in land surface
Cover Collapse Sinkhole – Natural

- Normal conditions
- Drought
- Intense rainfall

Modified from USGS
Cover Collapse Sinkhole - Induced

Modified from USGS
Cover Subsidence Sinkhole

Source: USGS
Triggering mechanisms

• Changes in water-table elevation
  • Natural (TS Debby case study)
  • Pumping (Frost-Freeze case study)

• Rainfall and soil piping

• Land surface disturbance
  • Construction/Excavation/Loading
    • Landfills
    • Reservoirs

• Focused infiltration: runoff, stream diversion or retention ponds
Buried Karst and Infrastructure

Excavated retention basin

Cap over solution pipe
Methodology - Weights of Evidence (WofE)

- Combines spatial data from diverse sources to describe and analyze interactions and make predictive models (where will contamination likely occur?)
- The magnitude of the weights depends on the measured association between data layers and “type” occurrences (for FAVA: contaminated wells)
- Uses a statistical association between contaminant occurrences and a data layer to estimate probability that an area will contain a contaminated occurrence (i.e., a training point)
WofE continued..

- Combined evidence involves the estimation of a response variable (probability or favorability for determining relative vulnerability) using a set of predictor variables (sinkholes).

- Weights are estimated from the measured association between known sinkhole occurrences and the values on the maps used as predictors.
WofE Terminology

- Evidential Theme (data layer)
  - Overburden thickness
  - Soil drainage
- Predictor Theme (training points or contaminant occurrences)
  - Known sinkholes/karst terrain
- Response Theme
  - Model output
  - Relative vulnerability map
Training Points as Predictors

- Point coverage of locations at which a “type” occurrence is present
- Occurrences can be sinkholes or karst features
- The set of point locations is used to calculate the weights for each data layer, one weight per class, using overlap relationships between points and the various classes
Response Theme

- An output map that displays the probability that a unit area contains a point
- Calculated by estimating the combined weights of the data layers
- Output theme is displayed in classes of relative vulnerability (one area is more vulnerable than another) favorability