Sinkholes and Karst Flooding: What Role Could Climate Change Play?

Nature's Call to Action II Conference, Frankfort, Kentucky
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Sinkholes And Other Geohazards Were Big News Items in 2013 and 2014

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Homes on either side of deadly 100ft sinkhole that swallowed Florida man to be demolished

- Jeff Bush, 37, was sucked into the hole under his home in February
- Demolition of homes on either side will take place today
- Repairing the homes would have cost more than 50% of their value

By DAILY MAIL REPORTER

NATION AND WORLD

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Sinkhole frenzy erupts after Florida bedroom sucked down

By Michael Wines
The New York Times

POSTED: 03/16/2013 12:01:00 AM MDT

The recent bizarre death of a man who vanished into a huge sinkhole that opened beneath his home in suburban Tampa, Fla., unleashed a wave of sympathy, and not a little fear, among fellow Floridians. This is the so-called sinkhole season in Florida, a time when homes, cars and — rarely — people can drop into the abyss without warning.

A giant sinkhole in Seffner, Fla.,

But for fans of sinkholes, of which there are more than one might think, this i

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Sinkhole swallows pricey Corvettes at hallowed museum

By Thom Patterson, CNN
updated 6:21 PM EST, Wed February 12, 2014

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Most People Have the Understanding That There Is At Least Some Connection Between Sinkholes and Climate

Questions that Arise:

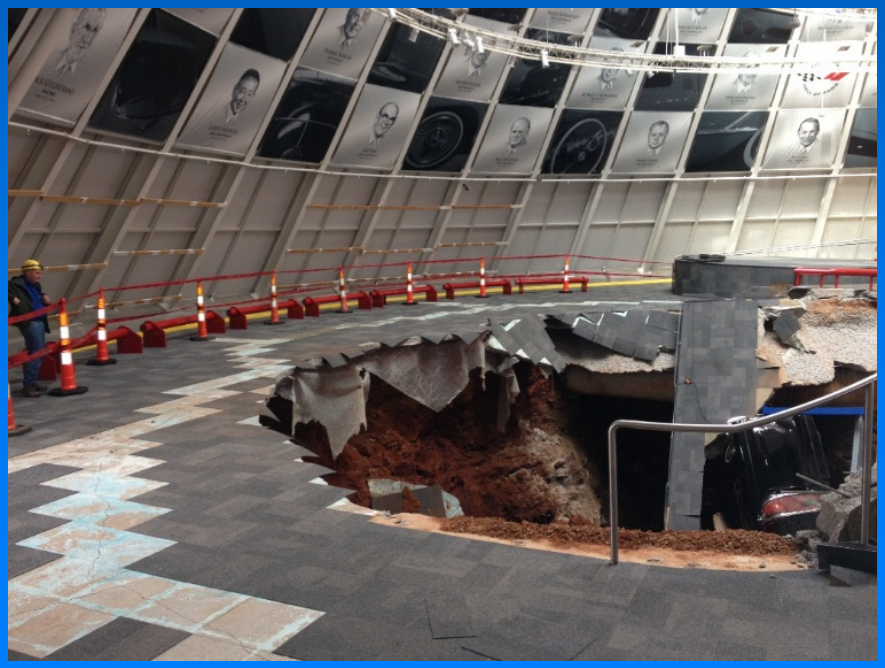
- What Exactly Causes Sinkholes to Form?
- Are Sinkhole Hazards Increasing in Frequency?

Per ABC news (March 1, 2013 report), insurance claims associated with sinkholes in Florida have more than doubled between 2006 and 2009.

- What Role Could Climate Change Play?

What are Sinkholes?

Generally speaking, sinkholes are closed topographic depressions that result when soil or overburden collapses suddenly or gradually into subsurface cavities.



Natural Sinkholes

- The vast majority of sinkholes are naturally occurring geologic features.
- These occur where the rock below the land surface is being dissolved over time by naturally acidic and circulating groundwater.
- Common surface expressions:
  - Subsidence sinkhole or doline (top)
  - Cover-collapse sinkhole (middle)
  - Combination of the two (bottom—note collapse or “swallet” in middle of grassy depression)

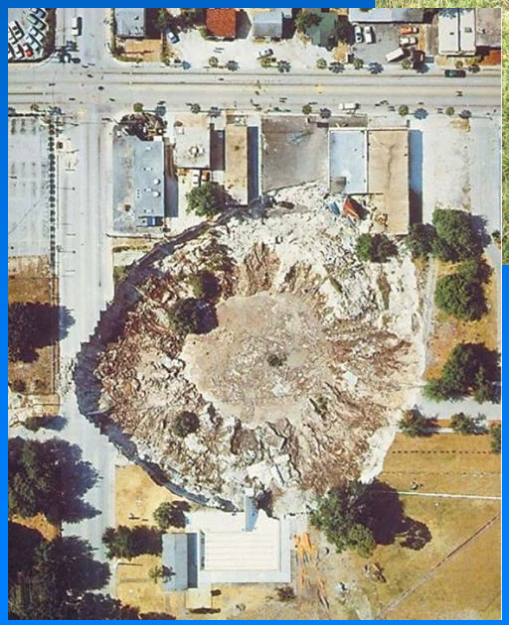
Human-Induced Sinkholes

Consequences of land-use practices, especially:

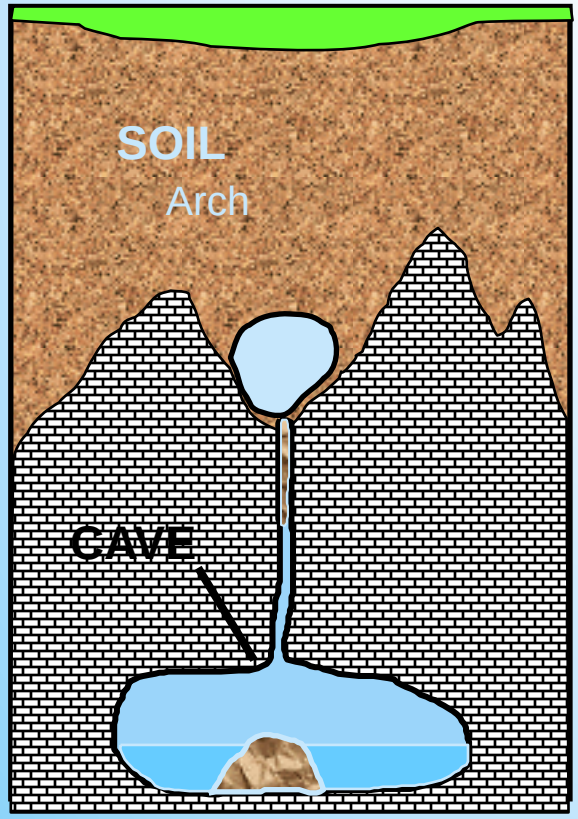
- Groundwater pumping (shallow water table and concentrated or intensive withdrawals).
- Alteration of surface drainage.
- Subsurface mining.
- Highway construction practices.
- Other: abandoned septic tanks, leaking pipelines, buried and decaying organic material such as tree roots or trash.

Cover-Collapse Sinkholes

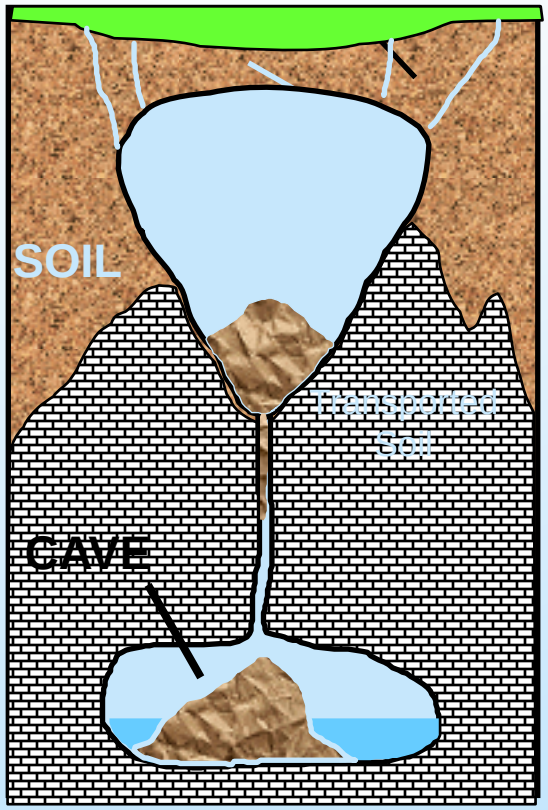
- These are most reported but are actually less common than subsidence sinkholes.
- They form as a result of both natural processes and human activities.
- They often occur in early spring or following intense storms or during rainy season.
- They also occur following periods of drought, which can lower the water table leaving overburden or bedrock unsupported.



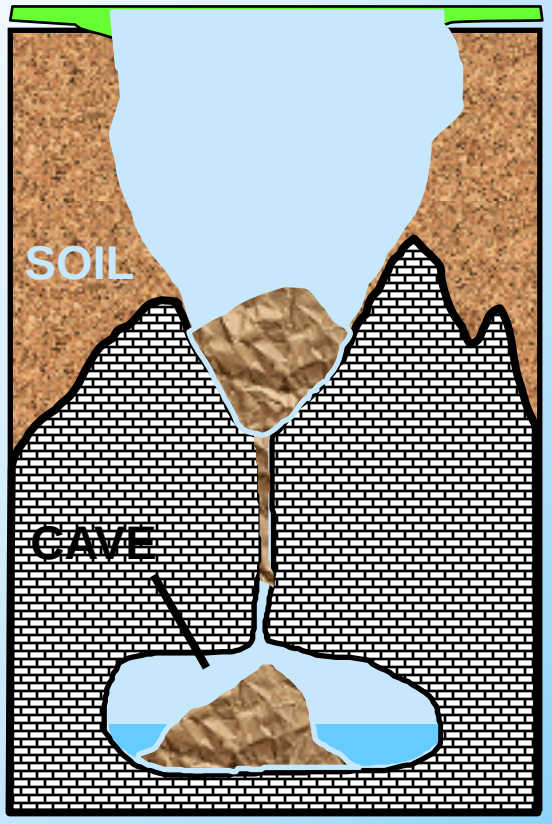
Cover-Collapse Sinkhole Development



Initial development of a soil arch



Development of the void and propagation of stress cracks



Collapse of soil arch. The soil that fell into the cave is carried away by the stream.

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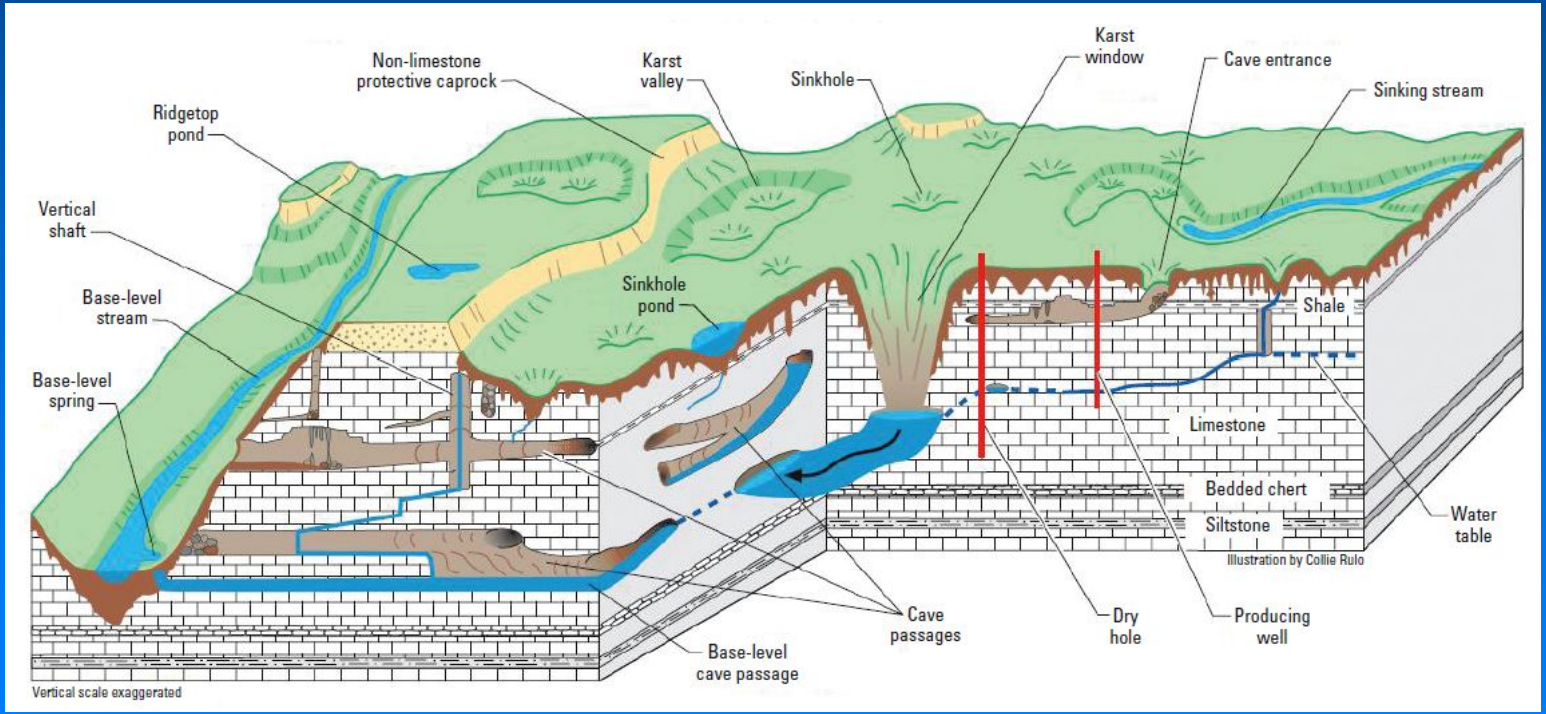
Most Sinkholes Occur in Karst Areas

Karst is a landscape or geologic terrane formed on soluble rock, usually limestone, in which the geographic and drainage features are characterized by sinkholes, sinking streams, subterranean drainage, caves, and springs.



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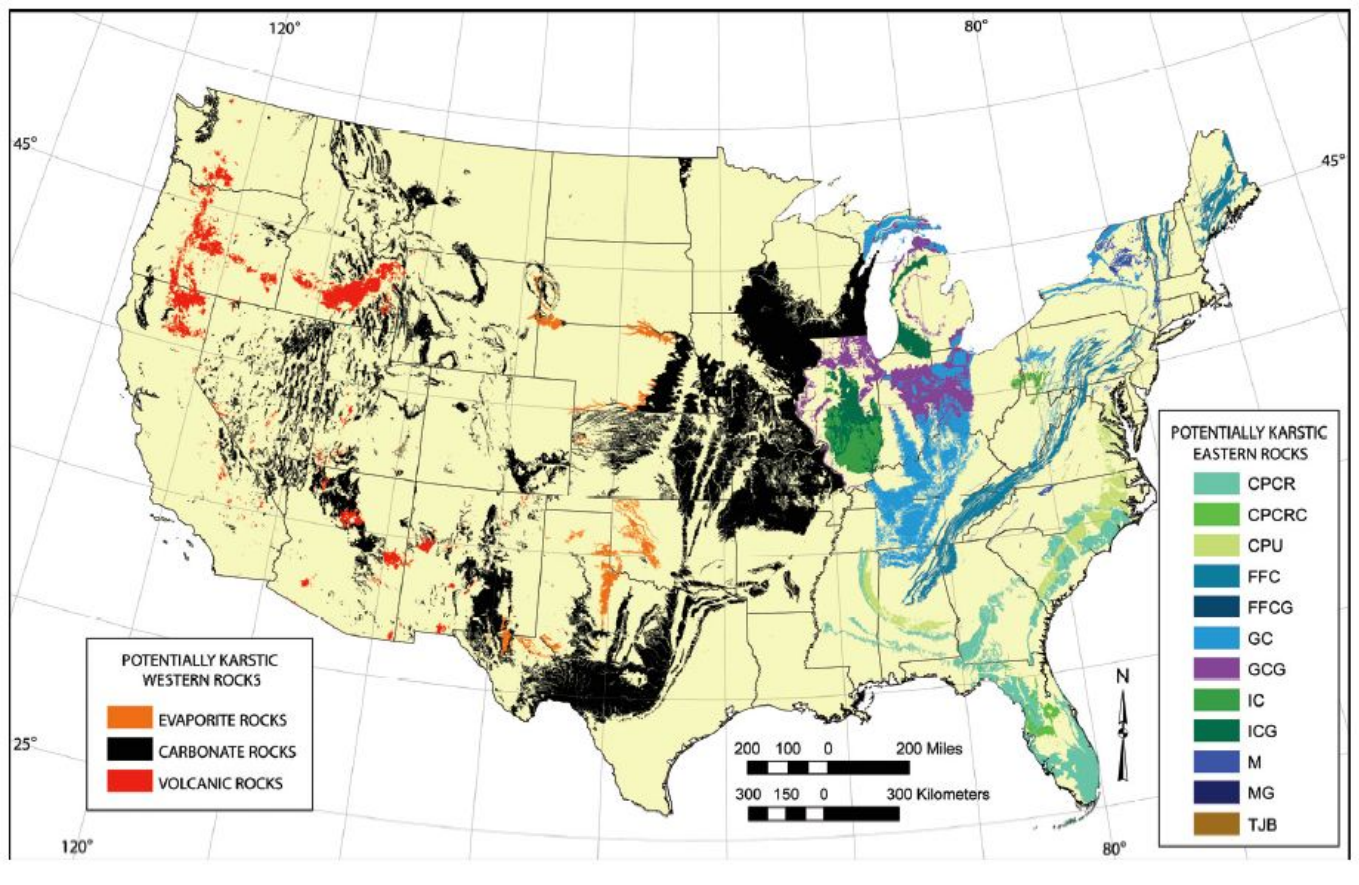
Karst Areas in the United States

- Approximately 20 percent of the USA is underlain by soluble karstic or potentially karstic rocks.
- Closer to 50% east of the Mississippi where extensive areas of carbonate rocks such as limestone crop out at or near land surface.
- About 40% of groundwater used for drinking water in USA comes from karst aquifers.

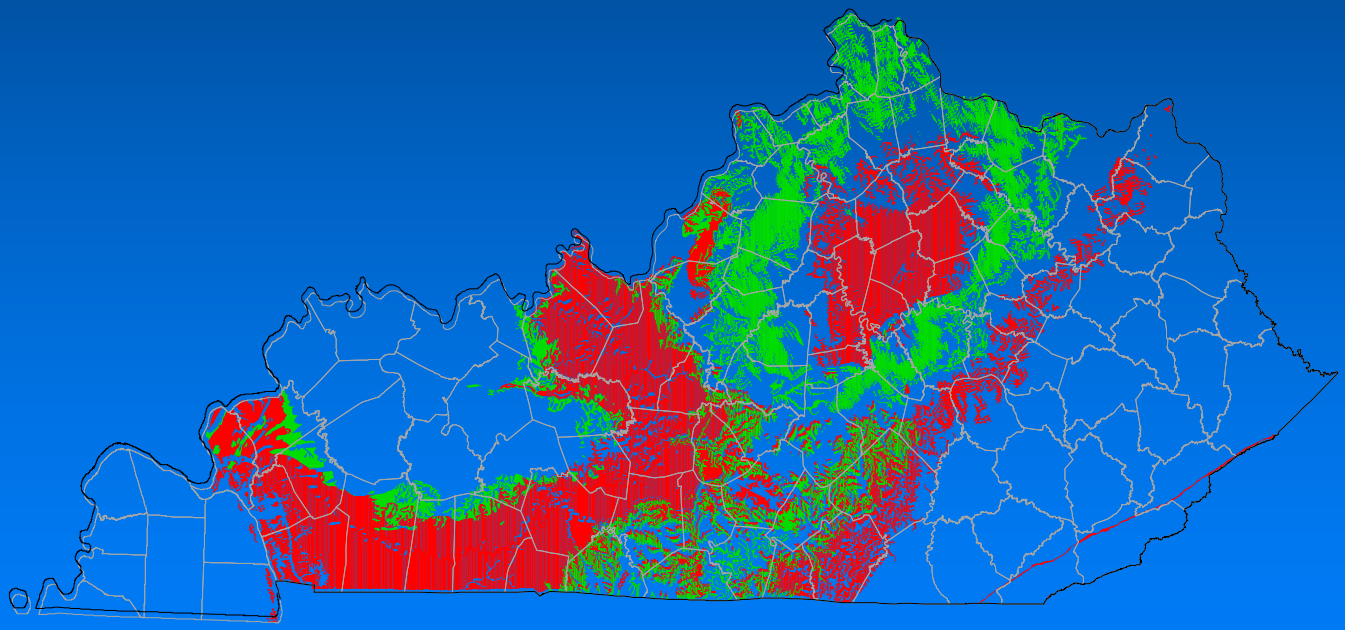


Source: U.S. Geological Survey

Karst Occurrence in Kentucky

Approximately 50-60% percent of the state has karst or potential for karst.

- **Areas shown in red have high potential for karst.**
- **Areas shown in green have moderate potential for karst.**
- **Areas shown in blue have no karst or limited potential for karst.**



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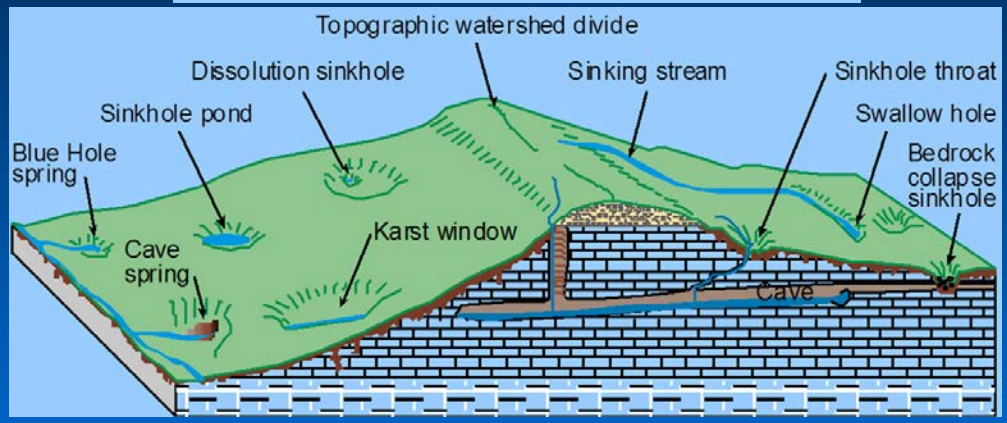
Are Sinkholes Occurring with Increasing Frequency?

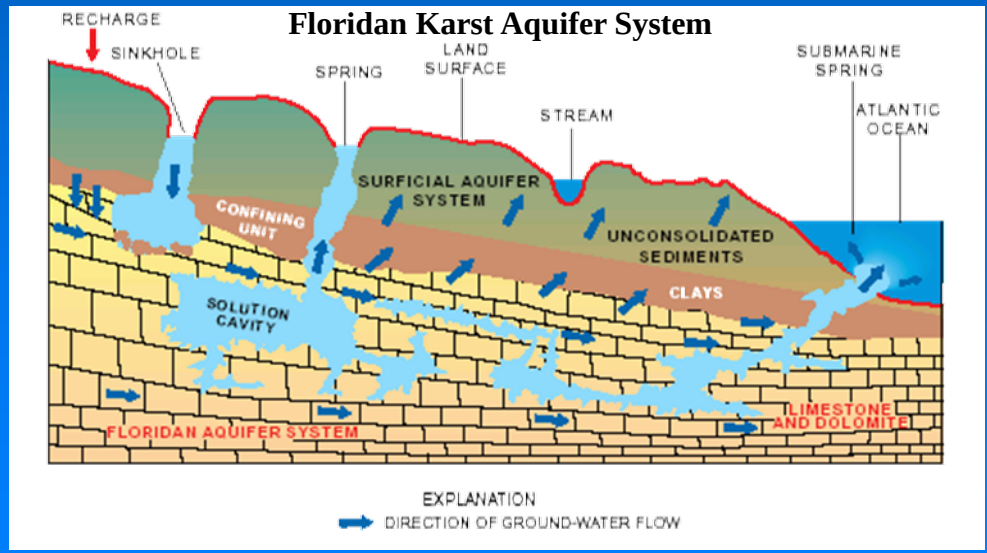
- Don’t really know. Not much data are available. Vast majority occur in rural areas and are never reported.
- More land development in areas susceptible to karst may make it seem like sinkholes are increasing.
- Frequency of human-induced sinkholes likely is increasing in urbanized and suburban areas where land use practices are affecting natural surface and subsurface drainage characteristics.

Sinkholes are Components of the Natural Drainage System in Karst Areas

- In many karst areas, this natural drainage system is analogous to a storm sewer network.
- Sinkholes are essentially catchment basins that collect surface runoff and drain it to underground streams (caves or conduits) in the karst aquifer.

Typical Kentucky Karst Aquifer System





Sources: top—KGS; bottom—USGS

Other Hydrologic Components of Karst Drainage Systems

Sinking or Disappearing Streams—Water input points

Cave Streams or Conduits—Water throughput

Karst Springs—Water discharge

Sinkhole Flooding

- Natural occurring process where storm intensity/duration overwhelms subsurface drainage capacity.
- A high or rapidly rising water table is often a contributing factor.
- Can be exacerbated by human activities that increase runoff or alter natural surface drainage; trash or accumulation of flood debris; subsurface grouting of karst cavities, etc.

Karst Flooding— The Case of Flood Creek and the town of Orleans, Indiana

Lost River basin (HUC-8 basin)

USGS
science for a changing world

Prepared in cooperation with the U.S. Army Corps of Engineers and the Indiana Office of Community and Rural Affairs (OCRA)

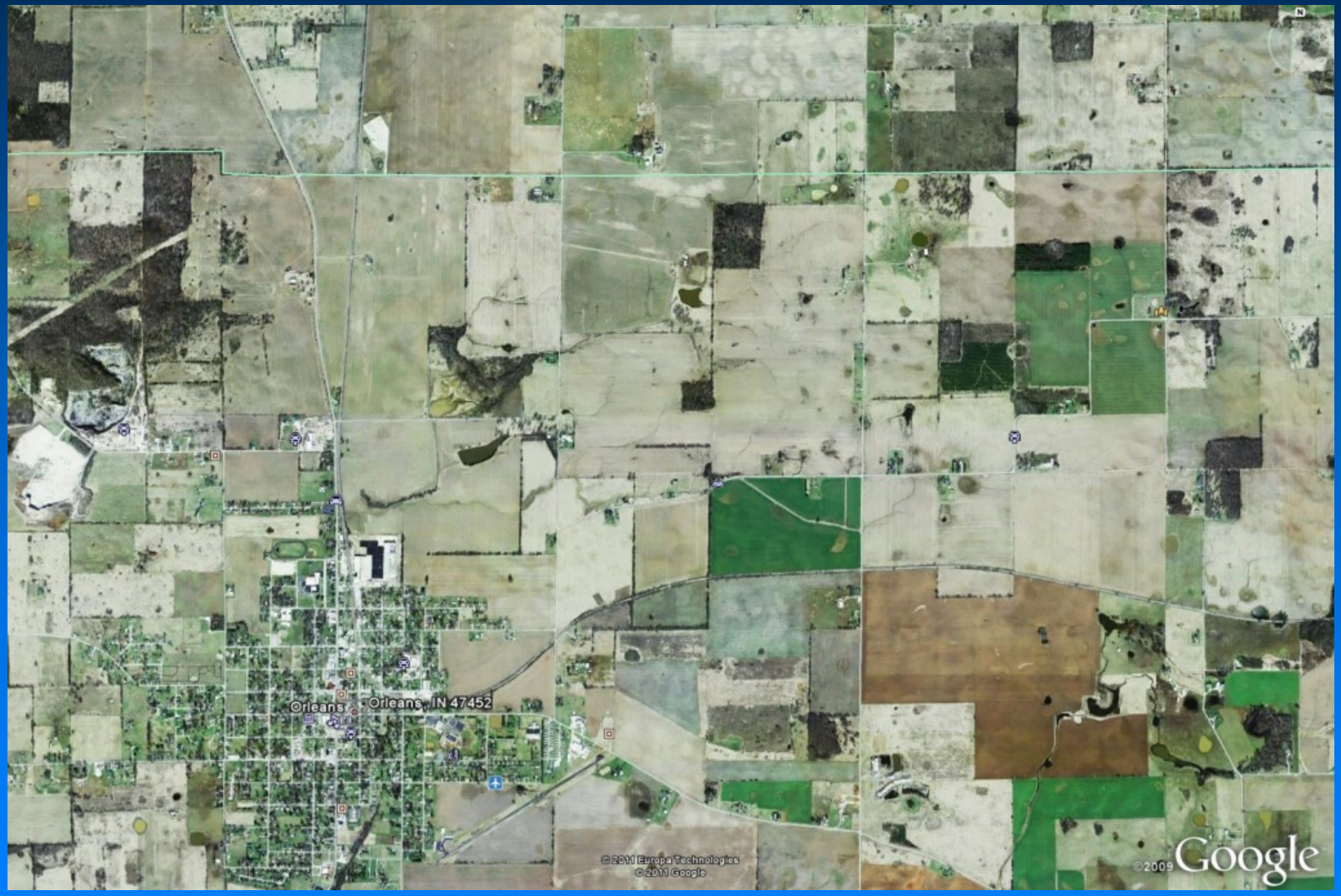
Surface-Water and Karst Groundwater Interactions and Streamflow-Response Simulations of the Karst-Influenced Upper Lost River Watershed, Orange County, Indiana

Scientific Investigations Report 2014–5028

U.S. Department of the Interior
U.S. Geological Survey

Flooding in Orleans, Indiana, in 2008 and 2011

The Sinkhole Plain and Flood Creek Watershed
Orleans, Indiana



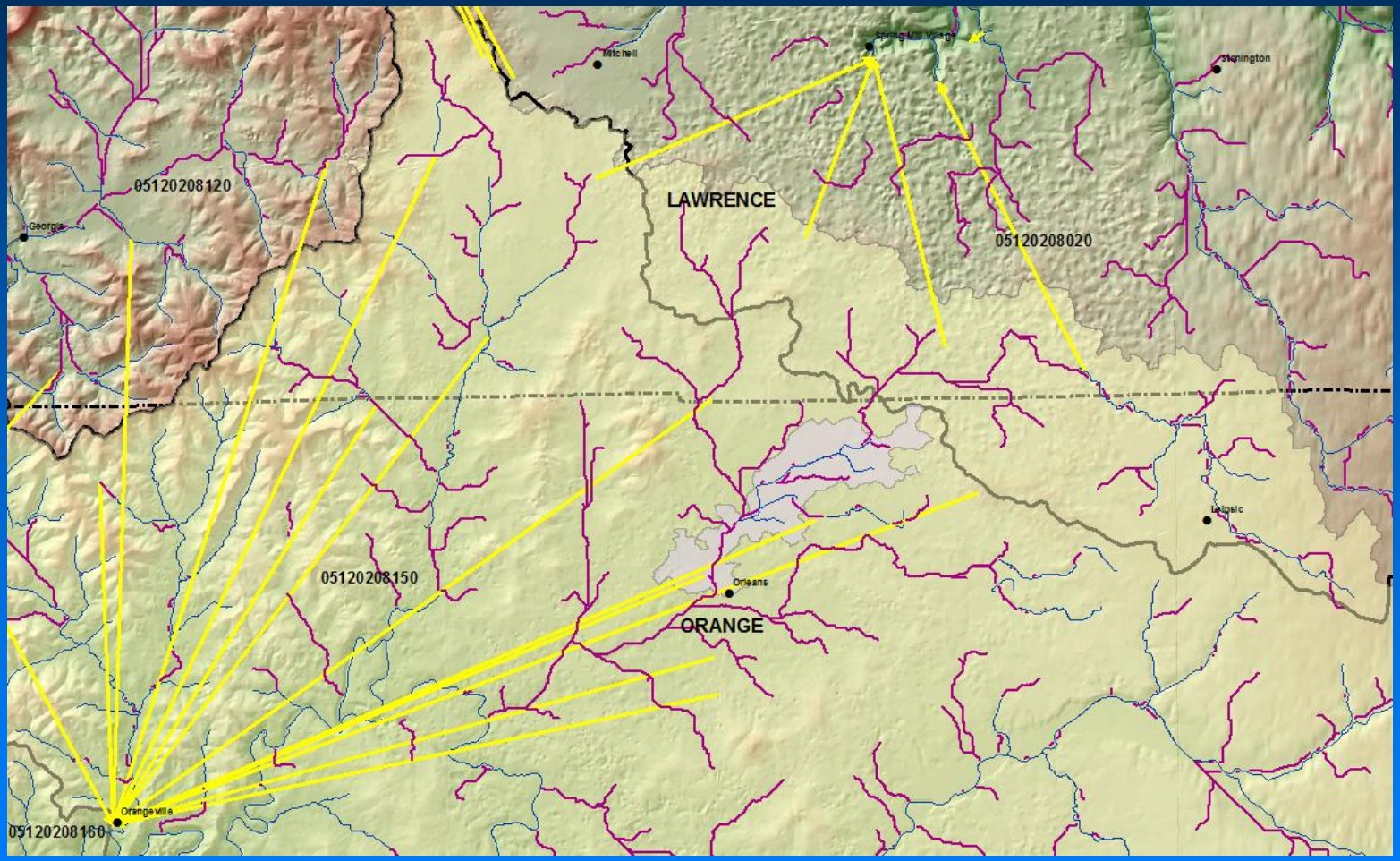
Views of Flood Creek

Flood Creek, looking downstream from location of a small surface reservoir.

Flood Creek drains underground via a cave opening under normal flow conditions.

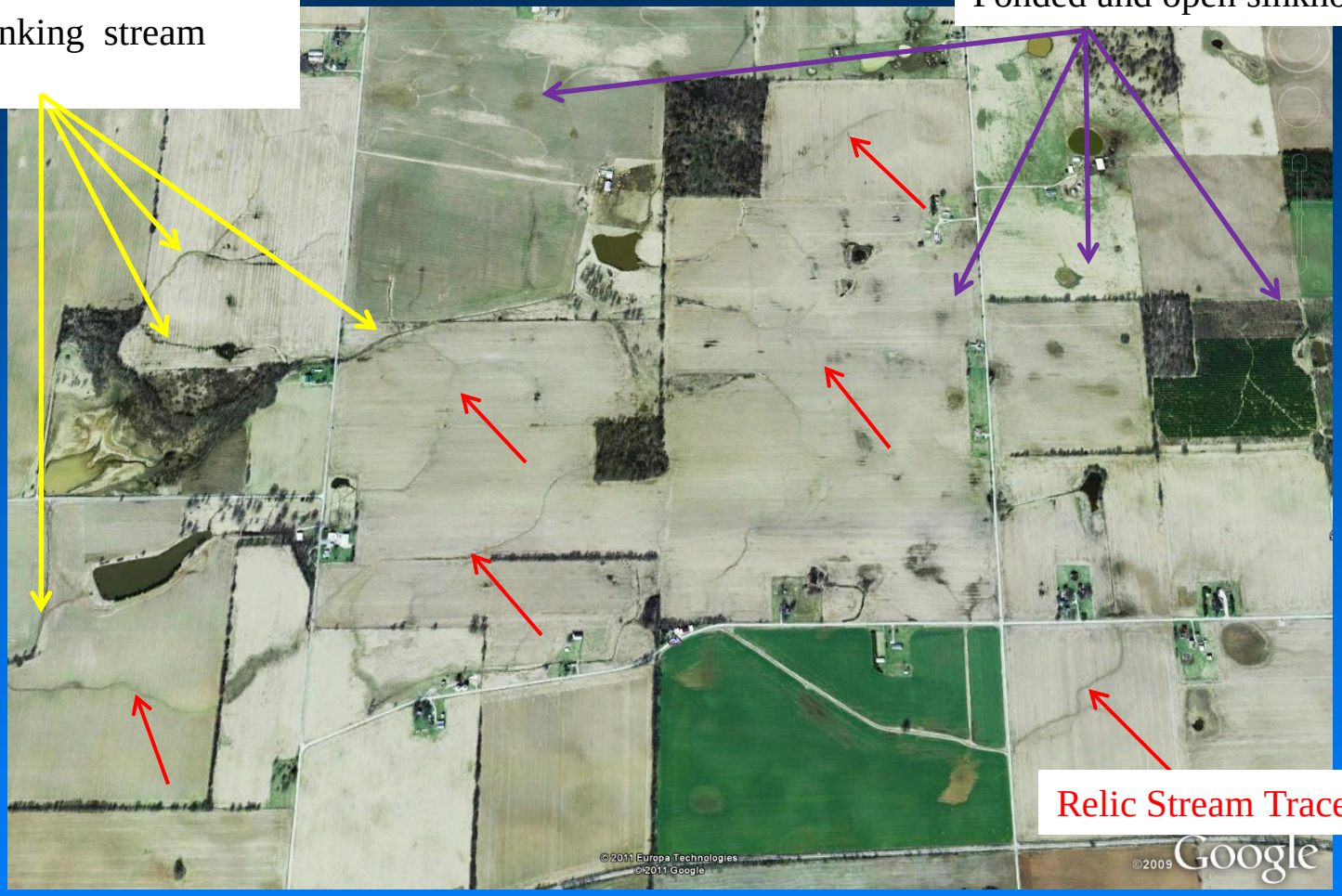
Overtopping of channel during high-flow conditions occurring during November 29, 2011.

Present-Day Flood Creek Watershed is a Remnant of a Larger Former Surface Stream Network

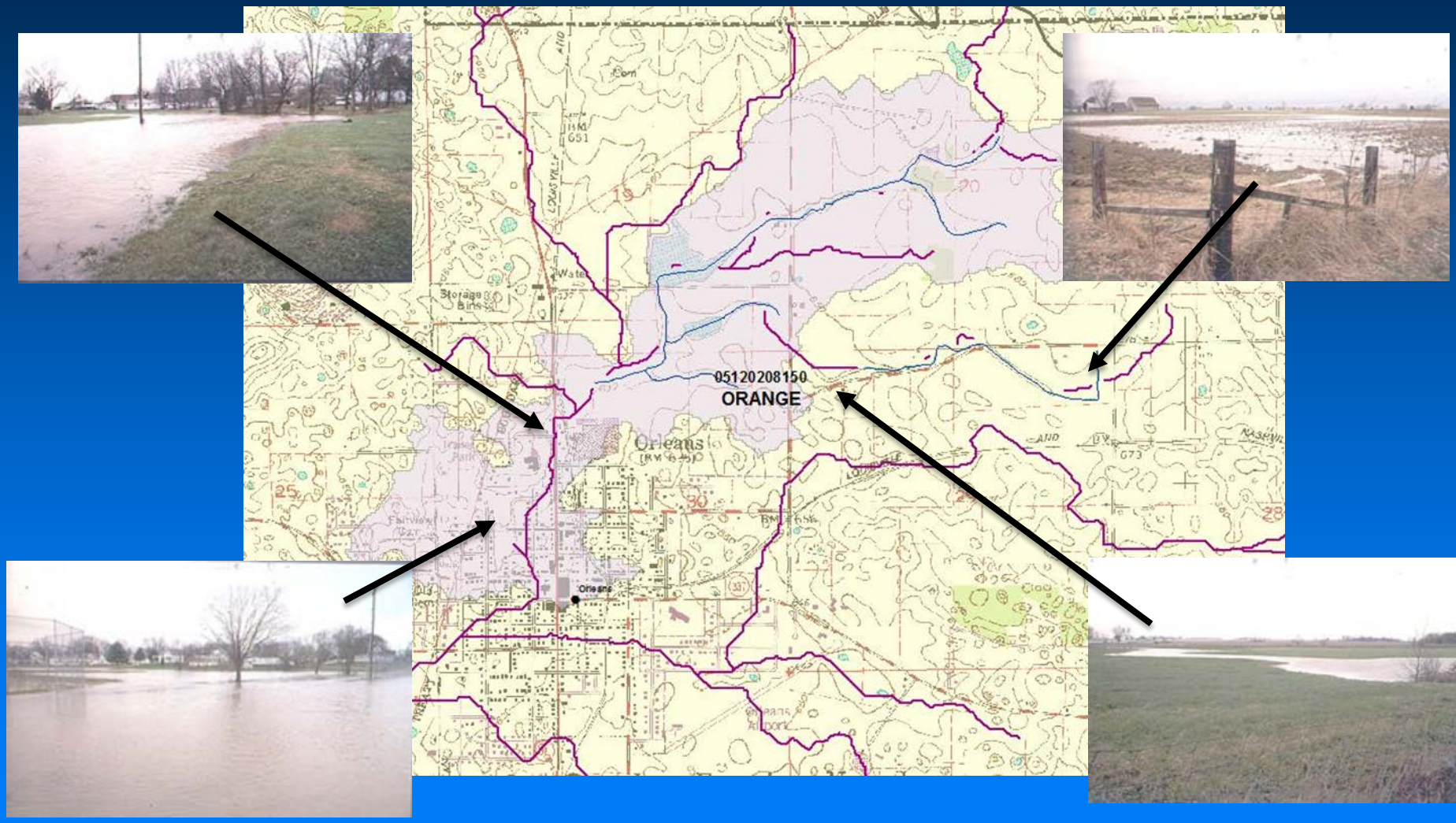


Source: Taylor and Nelson, 2008

Closer Examination of Flood Creek Watershed

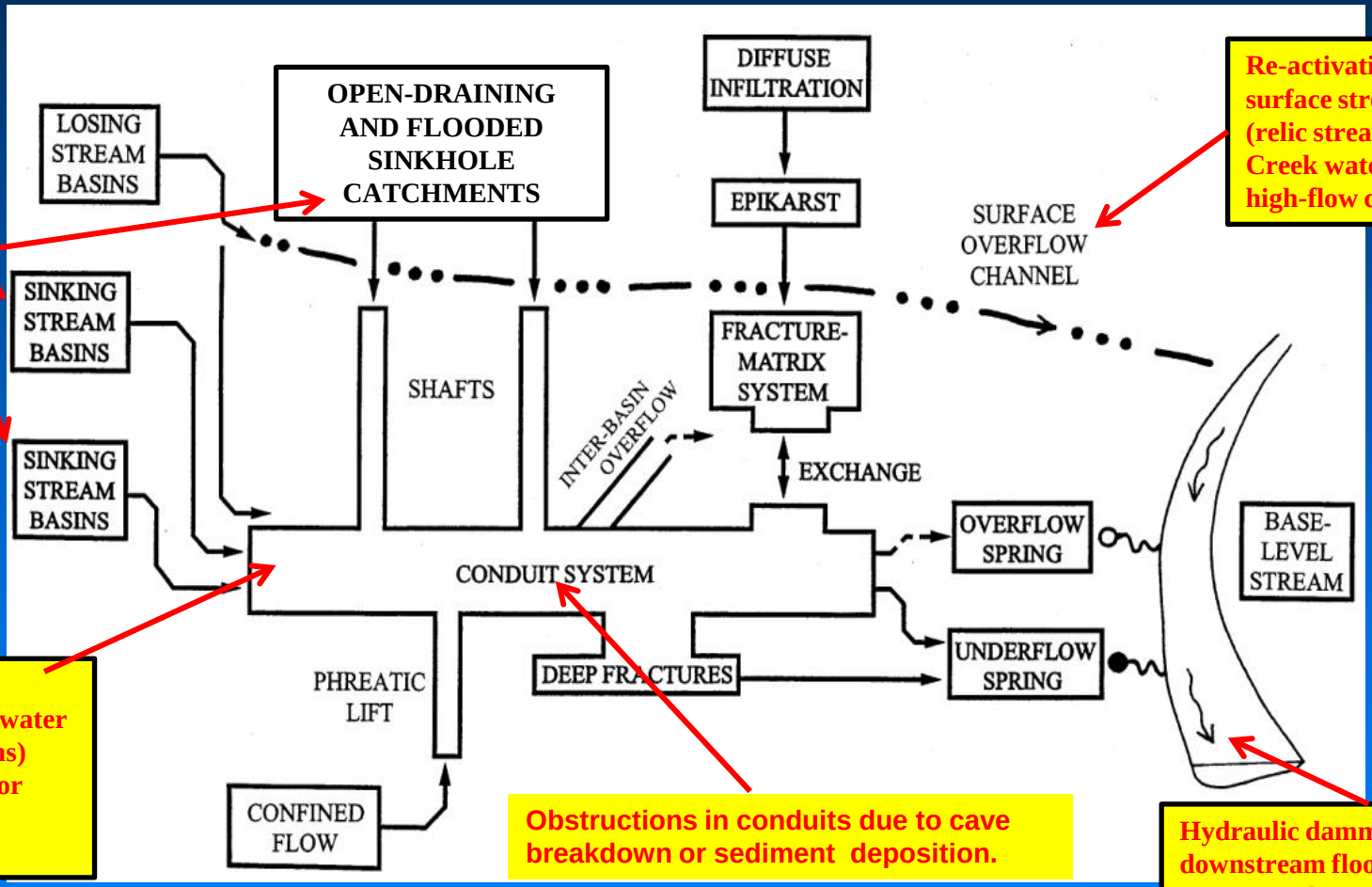


Re-Activation of Former Surface Route for Flood Creek During 1993 Event



Factors Identified to Contribute to Karst-Related Flooding in Orleans

Drainage capacity of Flood Creek cave (swallet) and local sinkholes overwhelmed by storm intensity and obstruction (timber rafts, sediment, trash).



Re-activation of former surface stream reaches (relic streams) in Flood Creek watershed under high-flow conditions.

Rapid rise in the groundwater table (water levels in cave streams) during storms, and/or slow recession of groundwater levels.

Obstructions in conduits due to cave breakdown or sediment deposition.

Hydraulic damming caused by downstream flooding of outlet springs and/or receiving surface stream (Lost River).

Modified from White (1988) and Ray (2001)

How Could Changing Climatic Conditions Influence Sinkhole Occurrence and Karst Flooding?

1. Increased Rainfall/Storm Intensity: Increased soil saturation and surface runoff (to sinkholes and sinking streams)→ increased subsurface injection of stormwater → enhanced dissolution; rapid rise in water table; hydraulic damming of cave stream passages → increased flooding potential.

2. Temperature & Freeze/Thaw Cycles: Soil heaving affects soil permeability structure→ increased infiltration→ enhanced soil piping and dissolution →potentially increased sinkhole development.

3. Drought: Compacts soils but also may increase soil macropore permeability (cracks), increases soil instability by decreasing soil moisture and cohesion, lowering of water table decreases hydraulic pressure→ collapse of unsupported subsurface voids.

Changes in Drought Intensity and Duration Has Potential to Drastically Affect Karst Water Supplies and Sensitive Unique Ecosystems

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Questions?

Thank You!