**Sinkholes and Karst: Why Should an Environmental Professional Care?** presented by Sam B. Upchurch, P.G., Ph.D., Vice President and Senior Principal Geologist, SDII Global Corporation and summarized herein by Erin Kane of TBAEP.

According to Dr. Upchurch, karst can present environmental professionals with a complex set of challenges when it comes to site remediation. Karst is a term used to describe a series of landforms created by the movement of water through soluble rocks.

**Karst morphology** includes *sinkholes*, *springs*, *epikarst*, *karren*, *arches*, *caves* and several additional landforms which are generally hidden from sight (i.e., beneath the ground surface).

The term **Epikarst** refers to a zone of weathered rock at the upper surface of the limestone, which in west-central Florida formed between three and 20 million years ago (MYA). It can form on both the exposed and unexposed areas of limestone.

**Karren** is a type of landform consisting of a pinnacle- and depression-laden surface of solid rock. Upchurch noted that these areas are very problematic when it comes to contamination as they act as places where dense non-aqueous phase liquids (DNAPL) can hide.

**Fractures** present yet another challenge, and according to Upchurch, often determine the movement of fluids through rock. These fractures can be tiny or very large, and are not the same as faults, which form as the result of movement of rock along a break. In limestone rock, the flow of water through fractures can dissolve rock and enlarge the fractures themselves. Characterization of fractures can be very useful in determining the how contaminants will behave in karst terrain. There are several methods for characterization, including:

- *Photolineament*: study of aerial photographs to determine linear features at the land surface – photolineaments are NOT always indicative of a fracture;
- *Geophysics*: ground penetrating radar (GPR), electric resistivity, seismic refraction and reflection; and
- *Subsurface testing*: the installation of test borings and wells, standard penetration testing, use of a cone penetrometer, etc.

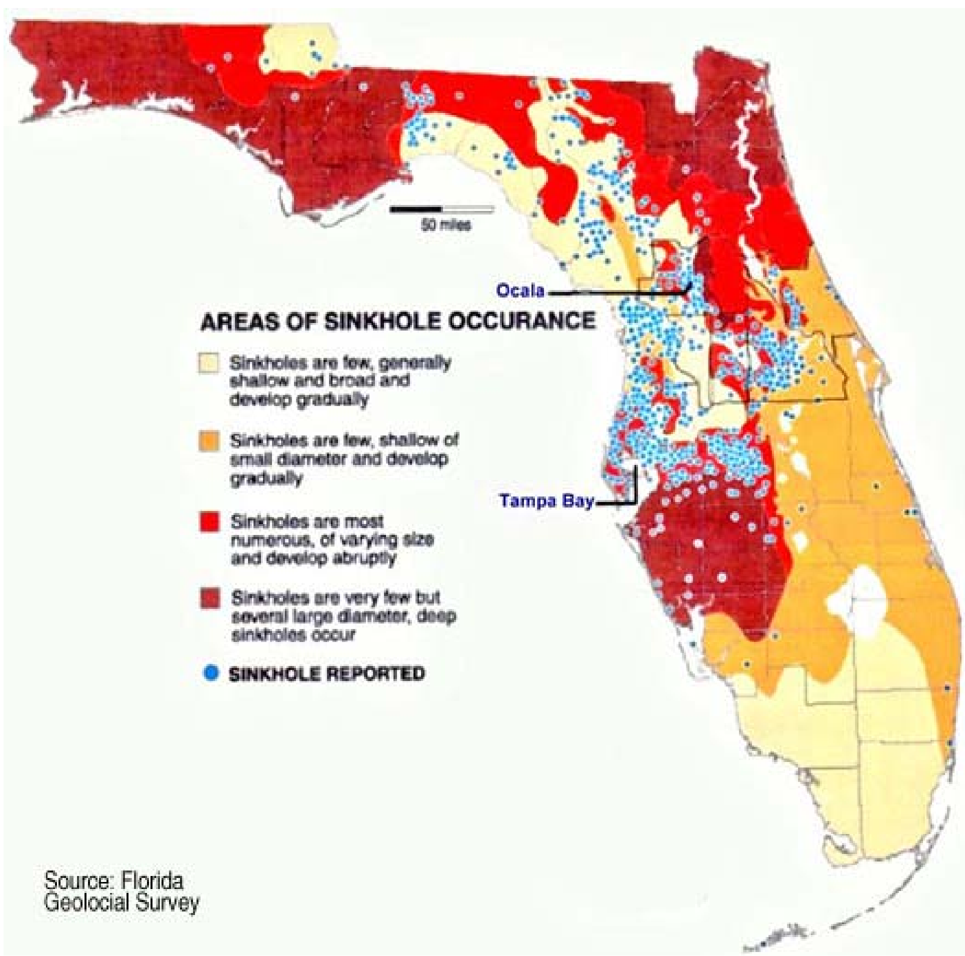
According to Dr. Upchurch, there are three basic Sinkhole types:

1. **Rock-Collapse Sinkholes:**
   - Least common
   - Aka “Rock Collapse” sinkholes
   - Solid rock roof suddenly collapses into a void space
   - Forms a sinkhole with steep, rocky sides
   - Example – Devil’s Millhopper in Alachua
   - (http://www.funandsun.com/parks/DevilsMillhopper/devilsmillhopper.html)

2. **Cover-Collapse Sinkholes**:
   - More common
   - Form when the overburden (either soil or unconsolidated sediments) subsides into the void space because it can no longer support its own weight
   - Forms an hourglass or cone-shaped sinkhole
   - Example – Winter Park, Florida (1981)
   - http://www.uwsp.edu/geo/faculty/ozsvath/images/winter_park_sinkhole.htm

3. **Cover Subsidence Sinkholes:**
   - Most common in Florida
   - Aka "Solution" Sinkholes
   - Develop over the course of hundreds of years
   - Form as the upper surface of limestone is dissolved and the cover slowly subsides into voids and fractures

Sinkhole Claims in Florida, according to Upchurch, tend to be concentrated in heavily populated areas. Sinkhole-related damage to structures can occur before any visible hole or depression forms at the land surface. Structures can usually be preserved and repaired by instating preventative measures.  This generally involves pumping grout into sandy soil matrices, or underpinning the structure when clayey soils are present.



The Florida Geological Survey maintains and provides a downloadable database of reported subsidence incidents statewide. While this data may include some true sinkholes, the majority of the incidents have not been field-checked and the cause of subsidence is not verified: http://www.dep.state.fl.us/geology/gisdatamaps/sinkhole_database.htm

According to Dr. Upchurch, **Paleo-sinkholes** present another often unforeseen problem to environmental professionals, contractors, developers and property owners. The term paleo-sinkhole refers to sinkholes that formed between 2 and 8 MYA, which were filled and buried by transgressions of the sea and other waterbodies. These can often go unnoticed and may re-activate if water movement is stimulated, such as in an area of a well field, or even pump and treat systems installed to remove contamination from groundwater. Some "sinkholes" are not actually true sinkholes. This common misconception is associated with a process known as liquefaction. This occurs when the liquid (i.e., groundwater) is removed from sediments or soils, causing the volume to decrease, which may be followed by a massive collapse.

The major characteristic of karst aquifers that presents a challenge to environmental professionals is *conduit flow*. In Florida, the limestone is basically a cemented sand (i.e., VERY porous). This allows *matrix flow* (flow through the rock itself) to contribute substantially to groundwater flow. With this type of environment, contaminants can be stored in the soil or intergranular rock matrix and later leach out via conduits. This can lead to *"sequestered contaminants*" which may show again even after it appears that all contaminants were removed. In these types of environments, it is very difficult to predict the fate and transport of contamination.

- Where are the contaminants?
- Are the concentrations heterogeneous or homogenous?

Other challenges and/or concerns with Karst include:

- the use of sinkholes for waste disposal – as garbage pits;
- the collapse or leakage of septic and/or sanitary waste containers;
- sinkholes acting as surface and/or groundwater recharge points for aquifer systems.

To conclude, Dr. Upchurch noted that the presence of karst topography can cause huge problems for environmental professionals and other parties involved with site development, site assessment and remediation activities in the state of Florida. The potential presence of sinkholes, underground streams, paleo-sinkholes, and other karst features should be considered when designing environmental investigations.