10th Annual Geohazards in Transportation in the Appalachian Region

Mapping of Karst Hazards Using Remote Sensor Technology

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Sensor Technology Uses in Geological and Hydrological Applications

- Recent improvements in wireless sensor technology offers a wide range of possible applications to problems in earth sciences

- **Wireless sensor technology enhancements**
  - Inexpensive in terms of component cost and fabrication
  - Robust
  - Versatile
  - Long lived

- **Recent applications**
  - Land creep
  - Riverbed scour
  - Cave and conduit mapping
Normal Flow Conditions

High Flow and Flood Conditions

- Development of Scour around Bridge Piers
Neutrally Buoyant Sensor Instrumentation

Sonar ranging provides distance to conduit geometry

Magnetometer senses offset from magnetic North

Thermometer gives water temperature

2010 R&D 100 Award

Ultrasound sensors detect same feature during sequential samples to give velocity
Center Hill Dam
DeKalb County, TN

Center Hill dam impounds the Caney Fork River, 27 miles upstream from the confluence with the Cumberland River
Center Hill Dam

- Caney Fork River
- Left Rim
- Picnic Spring
- Piping & Seepage
- Center Hill Dam
- Reservoir
Center Hill Dam
Left Rim

- Built in 1948
- Set in limestone
- Plagued with seepage problems since inception
- Undergoing major grout program to remediate seepage
- Large cave feature located in gap of previous grout curtains
- Orientation, size, and morphology of cave is unknown
Center Hill Dam: Left Rim
Road Cut for Grout Curtain
Center Hill Dam: Left Rim
Road cut exposes morphology of cave features
Conceptual Approaches to Sensor Design

Water is accessed via boreholes drilled into road cut.

If spring discharge of cave is not large, through of neutrally buoyant sensors is not likely.

Sensors tethered to the surface are not likely to succeed.

Infiltrated water and obstacles in bottom of cave discourage use of sensors floating in water.

Vertical deployment of tethered sensors was determined as most promising configuration.
Components to Sensors

- Sensors constructed with off the shelf (inexpensive) components
- Relatively expendable
- Easily adaptable
Tethered Sensor Configuration

The prototype was designed for use in a 6-inch borehole.
Cave Measurement at Center Hill Dam

Three-inch diameter sensor probe
Cave Imaging via Borehole CP3

Borehole surface well characterized using sensor

Size and morphology of secondary void at base of borehole successfully imaged with sensor

Body of cave was not accessed by boreholes at the time of sensor survey
Cave Imaging Summary

Sensor technology developed for remote cave surveying was modified for cave surveying using boreholes.

Sensors rely on ultrasound and magnetometer readings to measure cave voids.

Multiple borehole survey results can be “stitched” together to provide a single integrated image of cave voids.

Cave measurements will be used to characterize cave orientation, size, and morphology and guide future grouting to optimize grout placement.

Post-grout injection sensor survey will provide a
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