Coldwater Cave Groundwater Basin Study

Introduction:

The Coldwater Cave groundwater basin is an area which is drained by sinkholes, sinking and loosing streams, and springs that are related to Coldwater Cave. This type of surface and underground drainage is typical of a karst area. Karst is a term used world-wide to describe the distinctive landforms that develop on rock types (limestone, dolomite, gypsum) that are readily dissolved by water. Coldwater Cave is formed in the Dunleith Member of the Galena Formation, an Ordovician-aged limestone

Purpose:

The purpose of this study is to establish the boundaries of the Coldwater Cave groundwater basin, identify the underground flow routes within the groundwater basin, to understand the relationship between surface and underground creeks, and to determine how long it takes groundwater to move from sinking streams at the surface to the springs that drain the basin. The results summarized below are preliminary; a more detailed report is in progress.

Methods:

The drainage basins of surface creeks and streams can be identified by looking at topographic maps. Groundwater basins are not so obvious. Many times they do correspond with topographic basins. However, in karst groundwater basins, approximately 20-30% of the time, they do not correspond to topographic basins.

Karst groundwater basin boundaries can be established by dye tracing methods which use fluorescent dyes, charcoal dye receptors and water samples. The boundaries of karst groundwater basins can change due to high or low water conditions so in order to get an accurate picture of the basin, tracing needs to be conducted during different water level conditions. .

The fluorescent dye/charcoal method is used for qualitative traces. These kinds of traces are used to identify the flow path of underground streams. With this method, a small amount of dye is placed in a sinking or loosing creek, or in a sinkhole. Dye receptors are placed in the area springs to trap the dye. Once the receptors are analyzed, those which show positive confirm the underground connection between the sinking or loosing stream and the spring.

Quantitative dye traces are conducted to determine the travel time of underground streams. With this method, a small amount of dye is placed in a sinking or loosing creek or in a sinkhole. Rather than using dye receptors, water samples are collected at set intervals over a 24 to 48 hour period. Analysis of the water samples will show when the dye passed the sampling location. Both dye tracing methods were used to study the Coldwater Cave Groundwater Basin.

Fluorescent Dyes:

Three fluorescent dyes were used for this study: They included:

Dye	**Color Index Name**
Eosine	Acid Red 97
Fluorescein	Acid Yellow 73
Rhodamine WT	Acid Red 52

All of these dyes are non-toxic and biodegradable. Eosine and Fluorescein come in powder form and are mixed with water on site. Fluorescein is a red powder which turns green when mixed with water. Eosine is a red power which stays red when it is mixed with water. Rhodamine WT is bought pre-mixed and is red in color and turns the water red.

The amount of dye that used for each trace was determined by the speculated distance that the dye needed to traverse in order to reach a monitoring point.

Dye Receptors:

In order to determine if dye has passed through the system, charcoal dye receptors are placed in springs or at stream passage intersections of cave passages to trap dye. The dye receptors are made up of 4.6 grams (less than two teaspoonfuls) of activated coconut charcoal. The charcoal is enclosed in a 2 x 2 inch packet made up of fiberglass screening (like the kind used for window screens). The packet is secured to rocks or other natural features at the mouth of a spring. In the cave, we secured the receptors to 3 lb. vinyl-coated weights. These are further secured to mud banks with tent stakes.

Monitoring Sites:

A total of 24 sites were used to monitor for dye. Thirteen sites were located within Coldwater Cave. Eleven sites were located either at springs or at places on the Upper Iowa River. All sites were not used for all traces. During the qualitative traces, charcoal dye receptors were placed at various sites. During the quantitative trace, water samples were taken from the shaft entrance of Coldwater Cave.

Dye Trace Analysis:

Once the dye receptors were collected from each monitored site, they were sent to the Water Quality Lab at Mammoth Cave National Park, Kentucky. The charcoal receptors were washed and half of the charcoal was placed in a plastic container. An elutant was poured on the charcoal and the sample was allowed to sit for 45 minutes. If the charcoal picked up dye, it would be removed by the elutant. The elutant is poured into a clear plastic vial and analyzed on a scanning spectrofluorphotometer. This instrument measures the unique emission and excitation wavelengths for the various dyes and can detect dye to parts per billion.

Dye Trace Results:

A total of nine dye traces were conducted from July 2002 through August of 2003. Figure 1 shows all of the dye trace results. Following is a summary of the traces.

For Traces 1, 3 and 4, dye was injected at a sinking stream at Elliot Creek (Trace 1 & 4) and at a loosing stream at lower Coldwater Creek (Trace 3). All of the dye was detected either at Serendipity Spring or on the Upper Iowa River several hundred feet downstream of that spring. No dye was detected in Coldwater Cave or at Coldwater Spring. These traces indicate that the sinking stream at Elliot Creek and the loosing section of Coldwater Creek are not part of the Coldwater Cave Groundwater Basin.

Trace 5 dye was injected at Pine Creek where it flows just south of A18. The dye was detected at Carolan Spring. Trace 6 dye was injected inside of Coldwater Cave approximately one mile downstream of the Flatland Entrance shaft. Dye was detected at three major side passage located upstream of the natural spring entrance. Dye was also detected at Coldwater Spring and at Carolan Spring.

Trace 7 was the only quantitative trace done in this study so far. Dye was injected in Deer Creek in a section of the creek that looses water. Dye was detected in the upstream section of the cave, at the Flatland Entrance shaft and at Coldwater Spring. It took a total of 19 hours for the dye to travel from Deer Creek to the Flatland Entrance Shaft. This means that the dye was traveling at 500 feet per hour. During a quantitative dye trace conducted in 1986 during much higher water level conditions, dye was injected in a sinkhole approximately 500 feet downstream of the Deer Creek sink point. Dye was detected at the Flatland Entrance shaft less than 6 hours after injection. Travel time for the dye during high water was approximately 2000 feet/hour.

During Trace 9, dye was injected in Pine Creek in an area where the creek looses water in several places. Dye was detected in the major side passages in the upstream section of the cave, at Coldwater Spring and at Carolan Spring.

Traces 5, 6, 7, and 9 indicate that Coldwater Spring and Carolan Spring are both part of the Coldwater Cave Groundwater Basin. Deer Creek and Pine Creek both loose water to Coldwater Cave.

For Trace 2, dye was injected in East Pine Creek where it flows across the Willowglen Nursery. For this trace, dye was not detected at Hoppin Spring. However, there was a positive trace at the bridge that crosses East Pine Creek on Pine Creek Road. It's most probable that the dye flowed out of Marlow Spring. We speculate that this spring drains the lower section of East Pine Creek during high water and during normal flow drains areas of Silver Creek to the northeast.

Dye was injected at the bridge located south of A18, near the Willowglen Nursery. The creek was sinking approximately 1000 feet downstream of the bridge. Dye was detected only at Hoppin Spring. This shows that Hoppin Spring is part of a completely separate groundwater basin from the Coldwater Groundwater Basin and from the basin that drains to Marlow Spring.

Rimstone River Spring, which is located downstream of the Pine Creek Road bridge never showed any dye. This means that this spring is part of yet another groundwater basin. Its source of water is unknown but we speculate that this is part of the Silver Creek underground drainage.

Conclusions:

During the course of this study we found not only the boundaries of the Coldwater Cave Groundwater Basin, but also found that there are 4 additional groundwater basins located parallel to and adjacent to the Coldwater Cave Groundwater basin. Figure 1 shows the inferred flow routes of water through four of the 5 basins. Information from a quantitative dye trace conducted in 1986 coupled with that from the 2003 quantitative trace illustrate that groundwater can move from surface inputs to springs in a matter of hours.

Our fieldwork has shown that the headwaters to all of the surface creeks in the area are fed by shallow springs. These springs may be small perched aquifers that have formed in the glacial tills and loess deposits that form the soil horizon above the carbonate bedrock. These springs flow all year round.

For most of the year, Coldwater Creek runs dry because it looses its water underground along its course. Due south of A18, a small spring resurges in the streambed of Coldwater Creek and then sinks again several thousand feet downstream.

Pine Creek and East Pine Creek are fed by several perched aquifer springs which keep them flowing all year round though there are sections of both creeks that loose water to the local groundwater basins.

Future Work:

More work is necessary in the Coldwater Cave Groundwater basin to get more detailed information on flow paths and their relationships to surface creeks, to determine underground flow rates during normal water level conditions and to see if the boundaries of the groundwater basin change during high level conditions (as is typical for most karst groundwater basins). Similar work needs to be conducted at the groundwater basins that drain to Serendipity, Hoppin, Marlow and Rimstone River Springs.

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