

Snowy River Water Flow

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By Pete Lindsley, June 7, 2011



Turtle Junction is the Snowy River location about a mile from the natural entrance of Fort Stanton Cave where a data logger was placed and the first full flow cycle was recorded during 2010.

Abstract:

Water flowing in Snowy River of Fort Stanton Cave has interrupted the exploration of the passage several times in the past 10 years. Fortunately the Snowy River passage was dry during the visit by the congressional team that was able to push through the 2009 National Conservation Area (NCA) designation of Fort Stanton Cave. Both the BLM and the Fort Stanton Cave Study Project (FSCSP) have installed data loggers in the cave which now allow scientific recording in selected locations of the cave environment including barometric pressure, temperature, and water levels. Recovery of some of the Snowy River data loggers during the April, 2011, FSCSP expedition has allowed the team to begin analysis of the first full cycle of water flow in Snowy River which occurred in 2010. Charts of this flow in 2010 are presented with some suggestions of possible hydrology characteristics. This information is key to improved management of this important cave and karst resource, and suggestions are made for future management planning.

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Introduction:

The history of water flow in Snowy River has long been an item discussed by the cavers and scientists. At first it was believed that the passage had been dry for many years. Then an exploration trip was halted because the team found that the water was flowing. Then Snowy River went dry and exploration continued. Then we all began to realize that we should expect Snowy River to flow after large rain events in certain locations. Later we realized that large winter snowfall events could also cause Snowy River to flow. Fortunately, we have a good location at Turtle Junction where we can monitor the water flow only a mile from the entrance. Some day in the future we hope to have an access portal upstream where the water can be monitored in real time.

Steve Peerman reported that when the August 2008 FSCSP (Fort Stanton Cave Study Project) expedition started,

“Four days after Hurricane Dolly, we noted that Government Spring was running very high. As noted, the rainfall event from Hurricane Dolly was fairly well confined to Ruidoso itself and was not a region-wide thing. As I recall, the Rio Bonito drainage itself did not get that much rain and it wasn't doing anything terribly exciting. ... so we beat it back to SR to see if it was running, and it was!”

A water trace was performed as soon as possible while the water was flowing. The initial “through time” for the optical brightener (OB) to travel from Turtle Junction to Government Spring was “less than 21 hours”. This time was later adjusted to 18 hours after a second “shot” of OB was introduced.

Of course in 2008 we believed that this sudden water flow was a one-time event and that we may not see Snowy River flow again.



Data logger that is typical of professional data loggers used for water depth measurement

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In 2008 we quickly built a sensor that could be monitored by an inexpensive off-the-shelf commercial data logger and placed it in the flowing stream at Turtle Junction. Two more sensors from other projects were installed and a fourth precision water depth sensor (below) was installed while the water was flowing.

The initial data logger installation at Turtle Junction was followed by the installation of additional data loggers by both the FSCSP and the BLM in the main cave as well as some smaller caves. The 2008 event was key to our making sure we had stream flow data loggers in place in a timely manner to properly document the 2010 flow (sans hurricane). The 2010 water flow was the first full dry-wet-dry cycle we have measured and represents a more normal “wet” rainfall year due to a significant snow pack level in the winter followed by several good “monsoon rains” in the summer.

Since the cave is closed for bat hibernation during six months from October to April the following year, we have to rely on Government Spring to try to “guess” when the water quits flowing in Snowy River during the Fall. By verifying these “guesses” with the data from the data logger the following spring we hope to improve our accuracy of predicting when Snowy River quits flowing. Of course with the new WNS Protocol and closures it adds to the importance of monitoring as much of the Snowy River water flow as possible by using data loggers.

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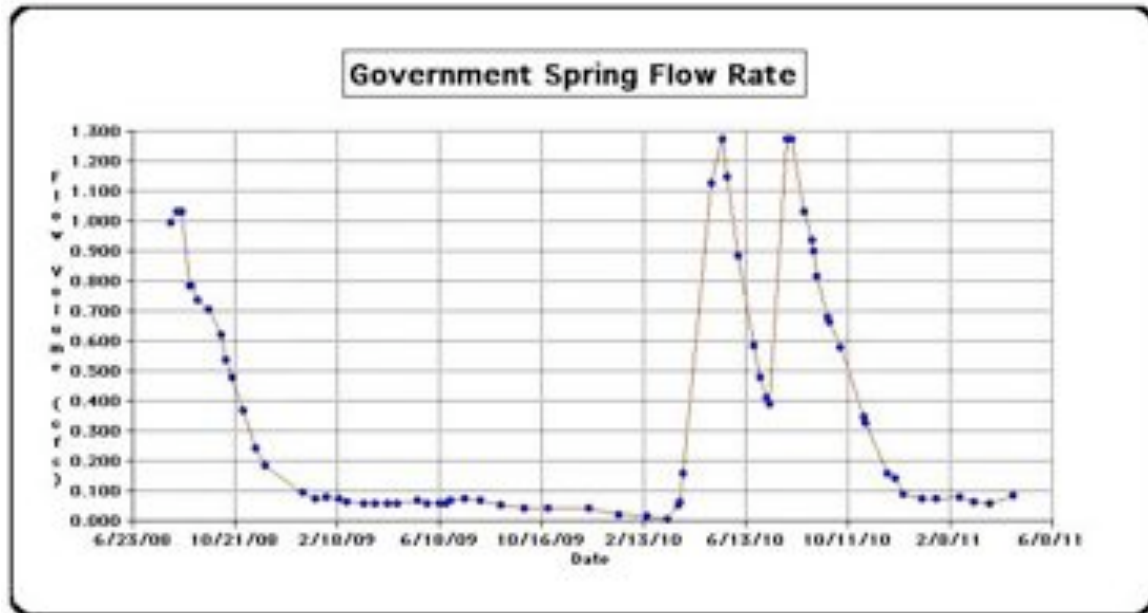


Steve Peerman installs a metal gauge on a post in the Government Spring pool formed by the installation of a weir. Later the temporary data logger installed at the Turtle Junction location in the cave was moved to the Government Spring location.



The photo on the left shows the “V” notch of the weir with the clear spring water topped with watercress. On the right you can see the water dropping down to the level of the Rio Bonito.

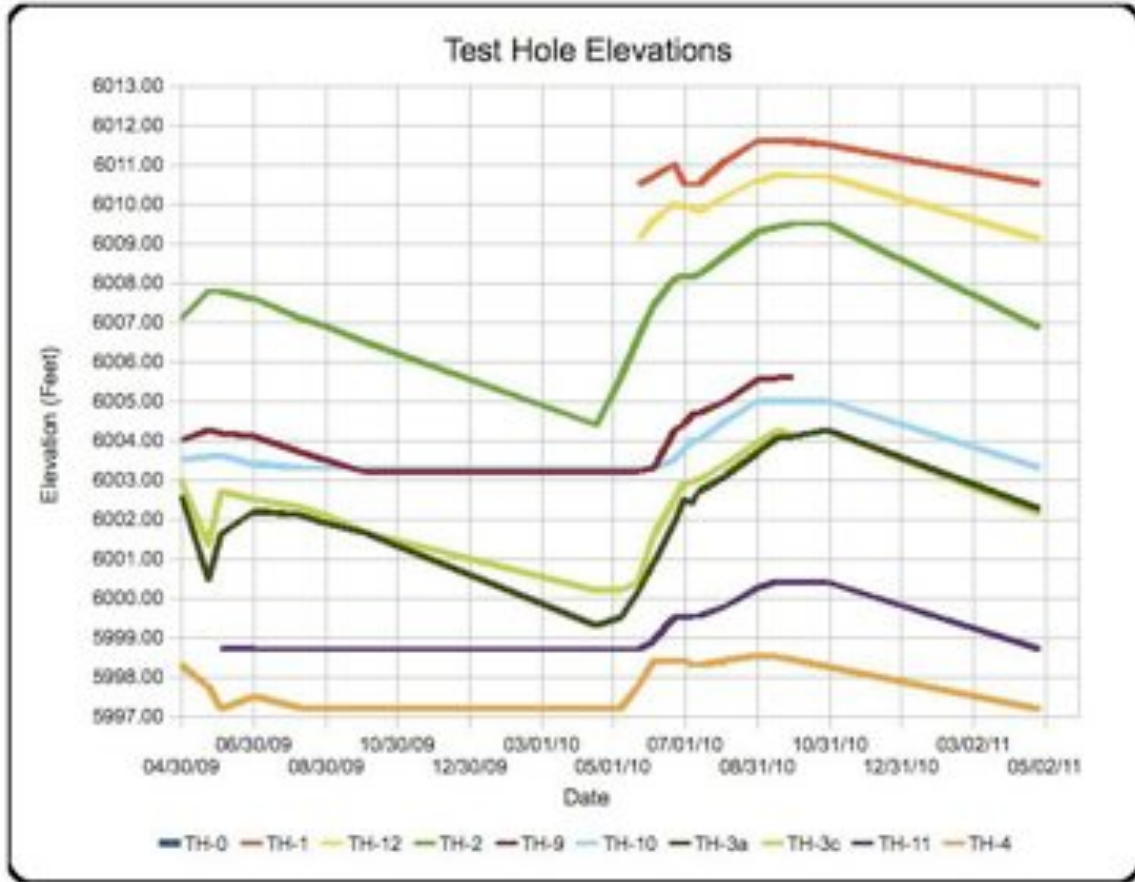
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The chart above is typical of data from Government Spring. By using the weir to control the outflow of the spring, an approximate water volume calculation may be made as shown above. Sometimes the vertical drop from the weir to the level of the Rio Bonito is not sufficient to achieve the best accuracy, and at least one time when the Rio Bonito was in flood stage, the homemade data logger was under water long enough to ruin our calibration. In the future we expect to replace the improvised weir and data logger with an improved design.

in historical times, soldiers from Fort Stanton actually built a boat well inside the main passage of the cave so that they could better explore the "lake" caused by rising waters from below. Surface weather is very important to understanding the Snowy River resource, and the whole Fort Stanton - Snowy River Cave National Conservation Area (NCA). The FSCSP has been monitoring the water level in the cave's numerous passages for many years on a less scientific basis. More recently, Steve Peerman has monitored the water levels in the "front part" of the cave by installing PVC pipes in the floor of the passage and making periodic measurements of the water level in the cave. The next graph is an example of the monitoring in the main passage and this sort of data will help us better understand the impact of surface rains and the various water levels in the cave in addition to the work in Snowy River.

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The graph above is an example of the water level variation at several test stations in the entrance passage of Fort Stanton Cave. During the 2010 season this water was much higher than normal due to the same influx of ground water that was observed in Snowy River.

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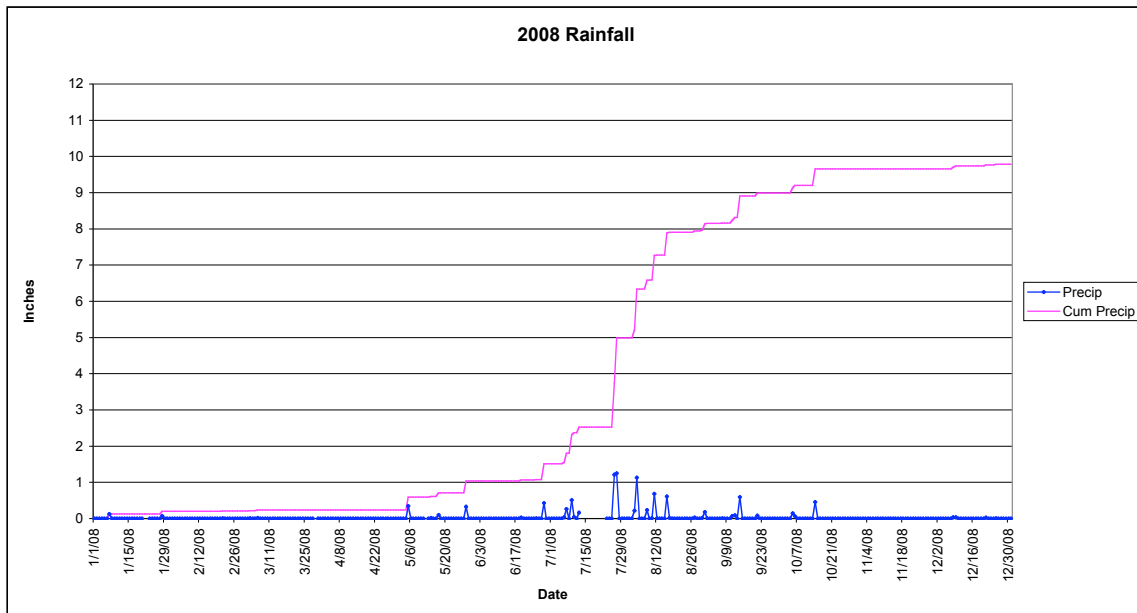
Weather Stations

There are numerous weather stations in the NCA karst area that may be used to gather data points that can be correlated for various water and barometric data comparison. (A web page on the FSCSP web site lists many of these stations and can be accessed at [<http://FSCSP.org/weather.html>].) One of these stations, located at the airport less than 4 miles from the entrance to Fort Stanton Cave, is called KSRR and is accessed on the internet at:

[<http://www.wunderground.com/history/airport/KSRR/2010/2/14/DailyHistory.html?theprefset=SHOWMETAR&theprefvalue=1>]

Daily weather information is given on this “Weather Underground” site as well as historical information from several years in the past. (Interested readers can find their own local weather stations by using the search tool on this site.)

One can go back in history on this site to the time that Hurricane Dolly came ashore and dumped a reported 12 inches of rain on Ruidoso in about 24 hours on July 27, 2008, causing extensive flooding. Yet, it hardly shows up on this KSRR weather gauge at the airport.

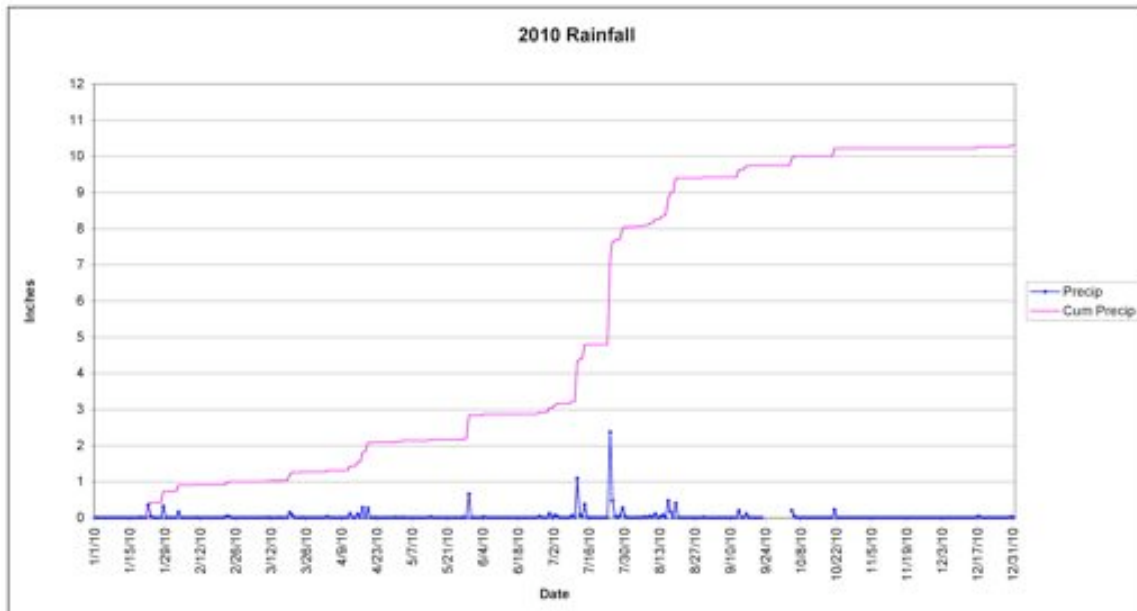


Tracking rainfall and matching it up with water levels in Snowy River is not always a trivial task. Sometimes one has to look at data from several sources, and almost always the scientist wishes they had just one more data logger or weather station data set to use in their search for the “truth” about the cave’s hydrology.

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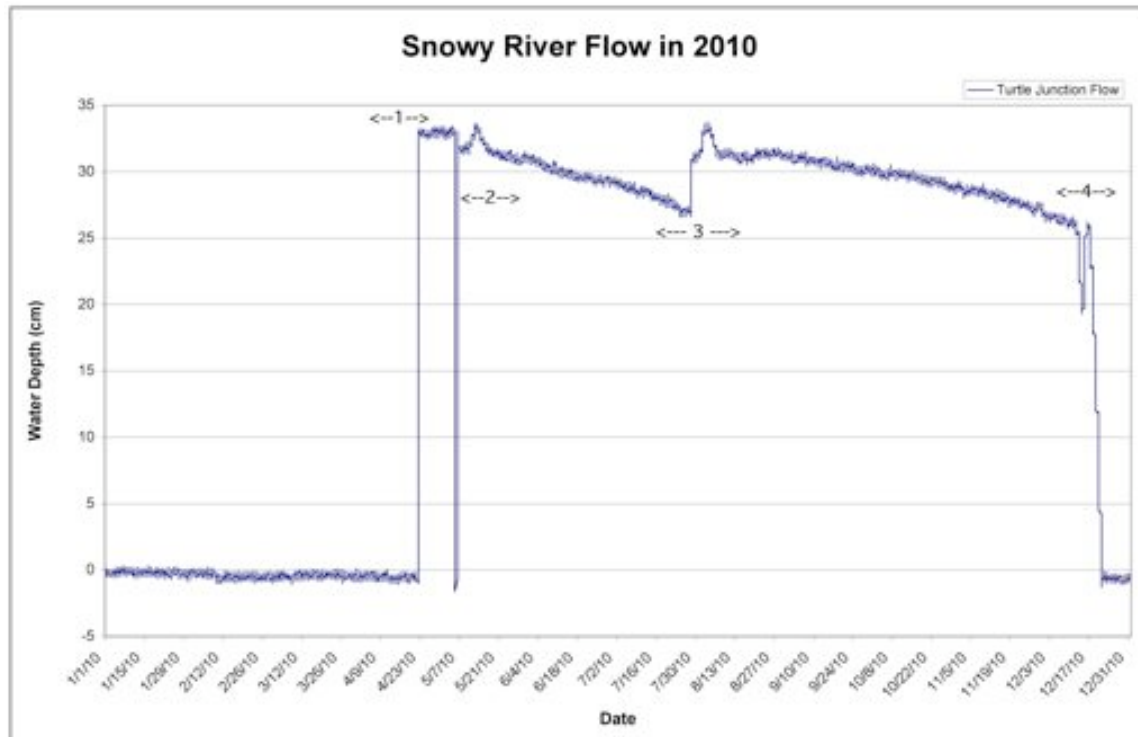
First Full Cycle Snowy River Data Set:

The graph below can be compared to the 2008 year when Hurricane Dolly dumped on Ruidoso. The total amount of 2010 rain from this KSRR station is about the same, but the shape is different. We had some rainfall early in the year starting in late January, and this was on top of the high snowfall during the winter of 2009. Also note the two relatively large rainfalls in July; we will comment on this later. It would be even more interesting if we could add in data from “upstream” surface stream flows like the Rio Bonito and other features, but for now we will leave this as “homework” for the most interested readers of this paper.



In January, 2011, we were fairly certain that Snowy River had quit flowing from our observations of Government Spring. During the April, 2011 expedition one of the goals was to retrieve the data logger at Turtle Junction so that we could download the data that had been recorded during 2010. We were rewarded with a full data set that not only indicated that the water stopped flowing on December 21, 2010, but it also showed some variation in the water levels which have been called “rain events” for purposes of this paper. Actually, the data shown in the next graph is a combination of two sets of data. Shortly after the flow started in April, 2010, the data logger was removed from the cave and data was downloaded on May 5, 2010. The data logger had been recording a mostly “dry” Snowy River since it was placed at Turtle Junction on July 3, 2009. When the logger was replaced in flowing Snowy River it did not go back into the exact same location, hence the small jump in the data.

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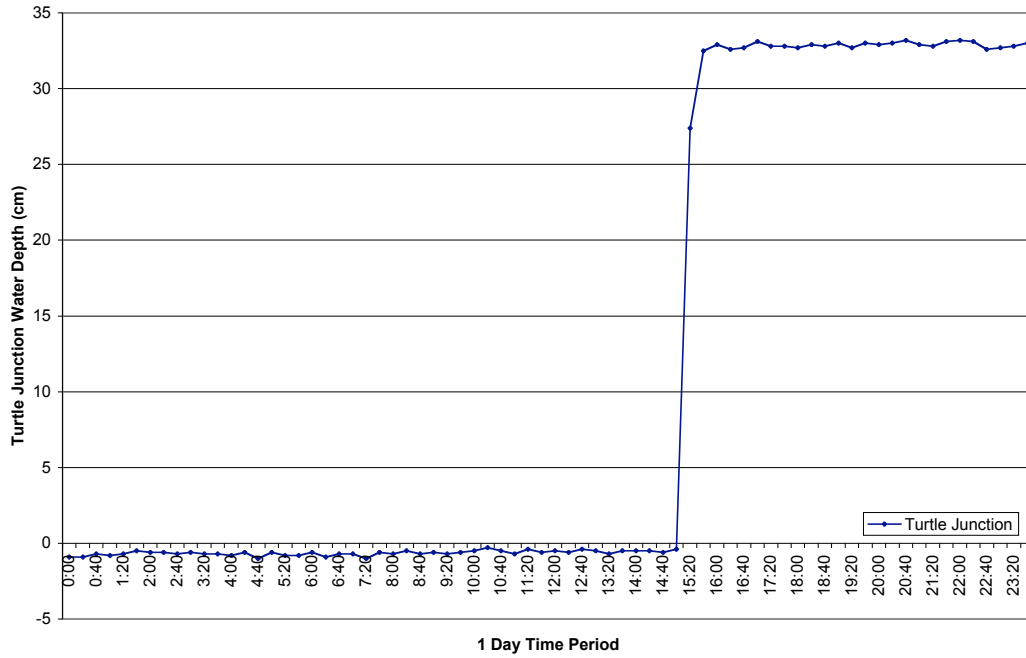
Portions of this full cycle graph are expanded into more detailed graphs as indicated by the four numbered regions of the graph. Shortly after the flow started (Graph #1), the data logger was removed to download data, then it was replaced at a slightly shallower location. Shortly after that point there was a “rain event #1”. In the late July to early August time period heavy surface rain caused a 2nd water event. Then in the middle of December 2010, the water flow stopped shortly after a 3rd water event that lasted only a day or so. Over about a week the flow seemed to dip about 6 cm, then rise back to the previous flow level before tapering off back to the “dry” condition.

Graph #1: Snowy River Starts Flowing

The initial flow in Snowy River is a very quick rise! On April 22, 2010, the (uncorrected) value was -0.4 cm (“dry”) at 1500, and was 32.5 cm at 1540 hours. A wall of water apparently flowed down Snowy River very quickly. (We expect that data from other BLM loggers in Snowy River may allow a velocity calculation.)

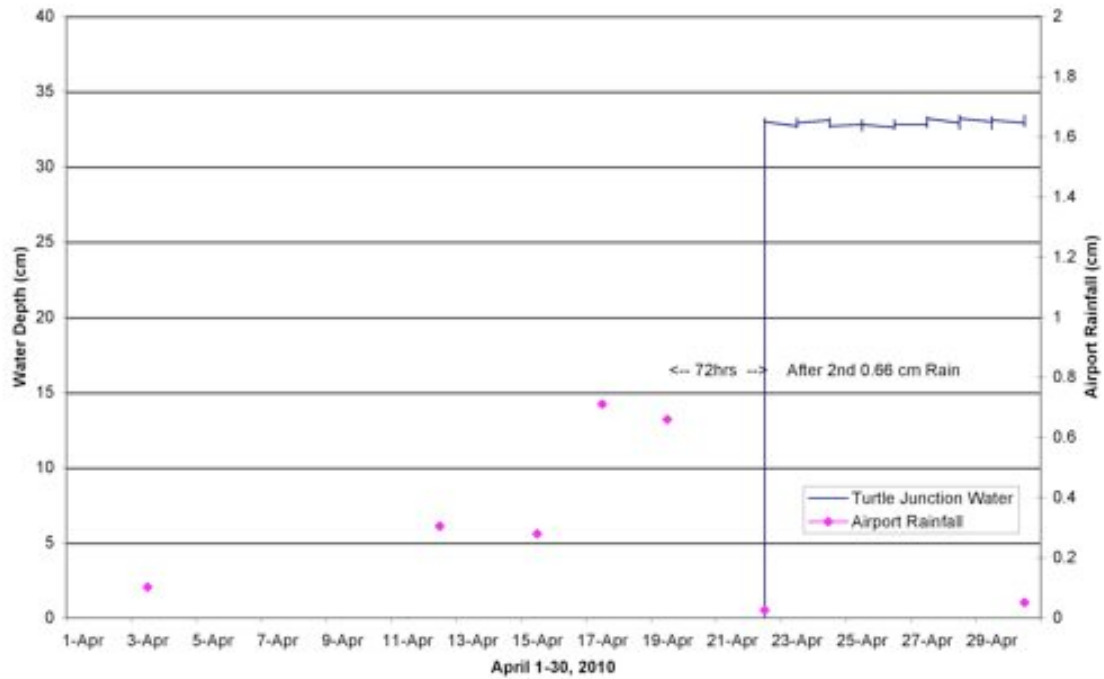
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Snowy River Rise 4-22-2010



In the 1-day graph above, the sharp rise and start of the Snowy River flow was at 1520 hours on 4-22-2010. Looking at the rainfall data from the KSRR weather station near the airport we see that there was a small 0.71 cm rain on 4-17-2010 followed by a second 0.66 cm rain around 1600 hours on 4-19-2010.

April 2010 Snowy River Flow Starts

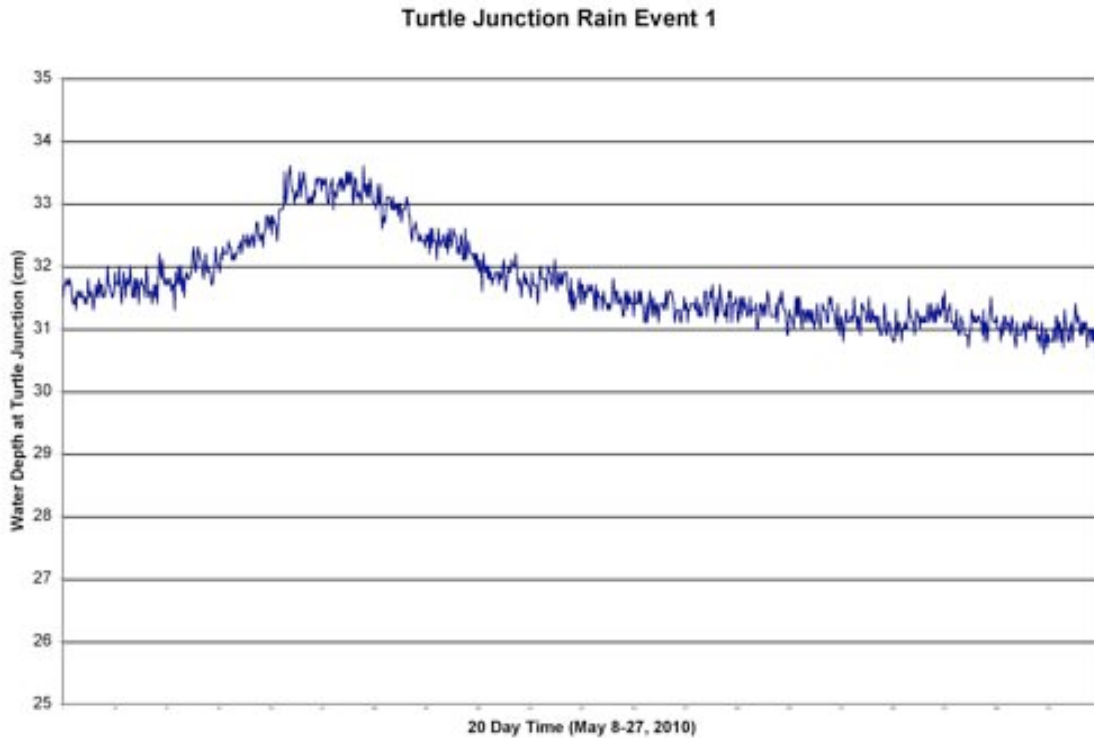


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The above chart covers the whole month of April 2010, and shows the recorded amounts of KSRR rainfall data. It shows that Snowy River started flowing about 72 hours after rains on the 17th and 19th. But if you consider that the KSRR rain total over those three days was really only slightly over a half inch, it brings to question “what happened here to make Snowy River so suddenly start flowing around 13 inches deep” at Turtle Junction? Were other localized areas receiving more rain than the KSRR station shown here? Or was it more like a bucket that was almost filled and when the last 1/4 to 1/2 inch of rain arrived it overflowed?

Graph #2: First “water event”

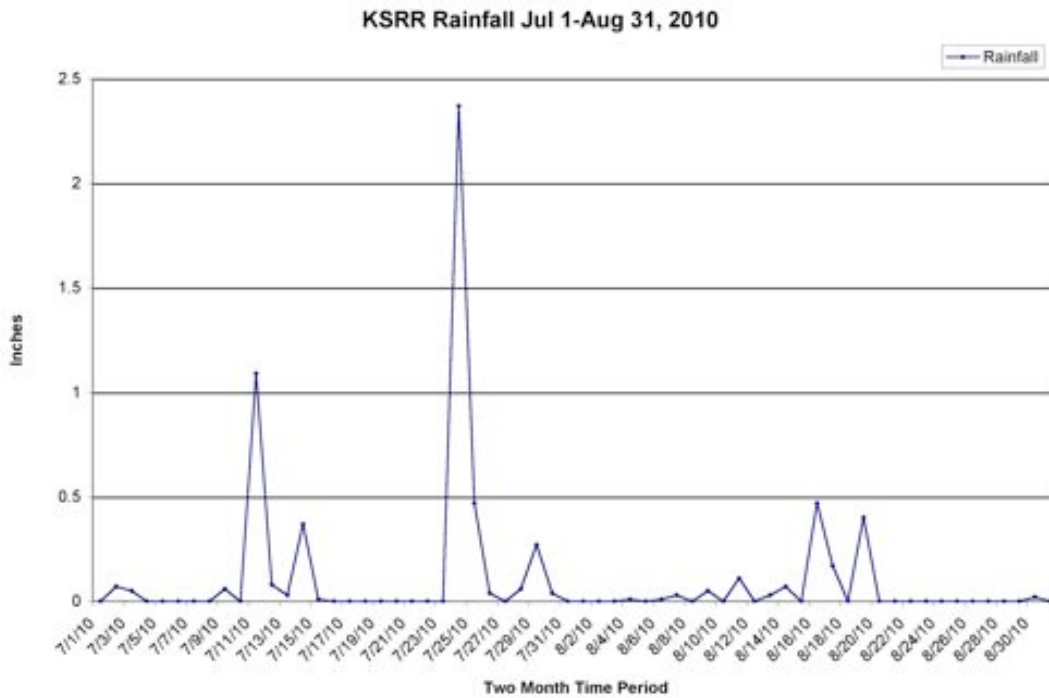
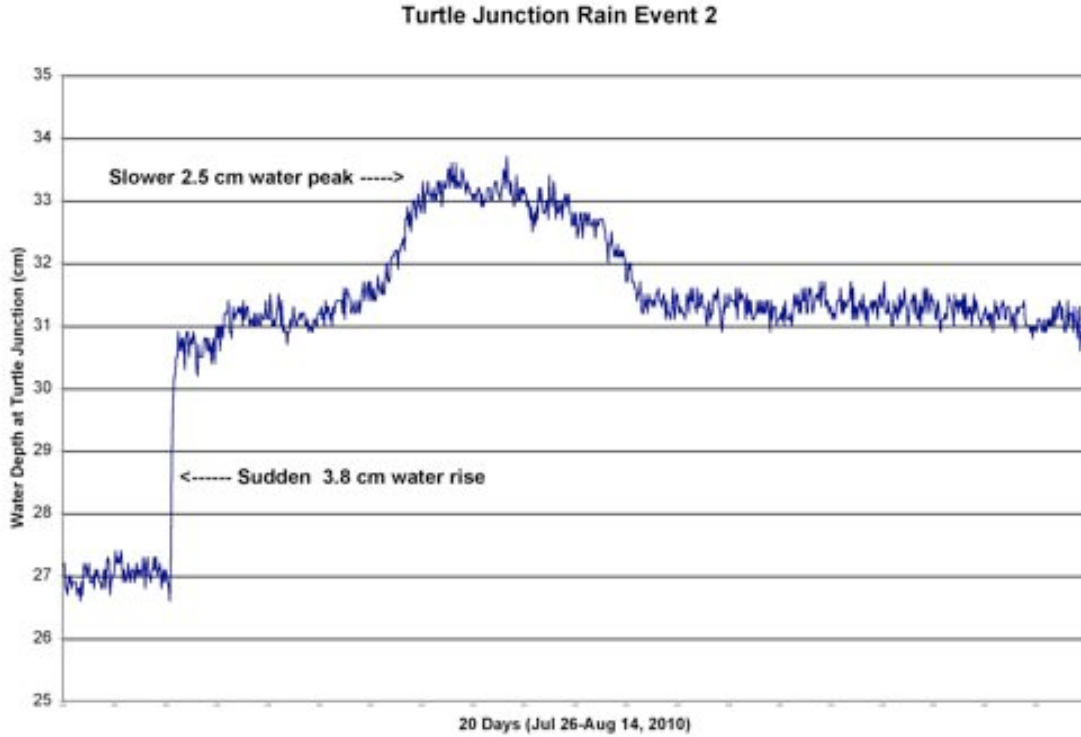
The 20-day graph below shows a small rise between May 8 and May 27, 2010. Looking at the KSRR weather data we did not notice any significant rain shown for the May 1-28th period. (However, it did rain 0.66 inches on May 29, 2010.) Perhaps this apparent 2 cm rise could have been related to the upstream “source” of the water, but since we have not yet explored this area we currently have no exact scientific explanation of the hydrology involved.



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Graph #3: Rain Event #2

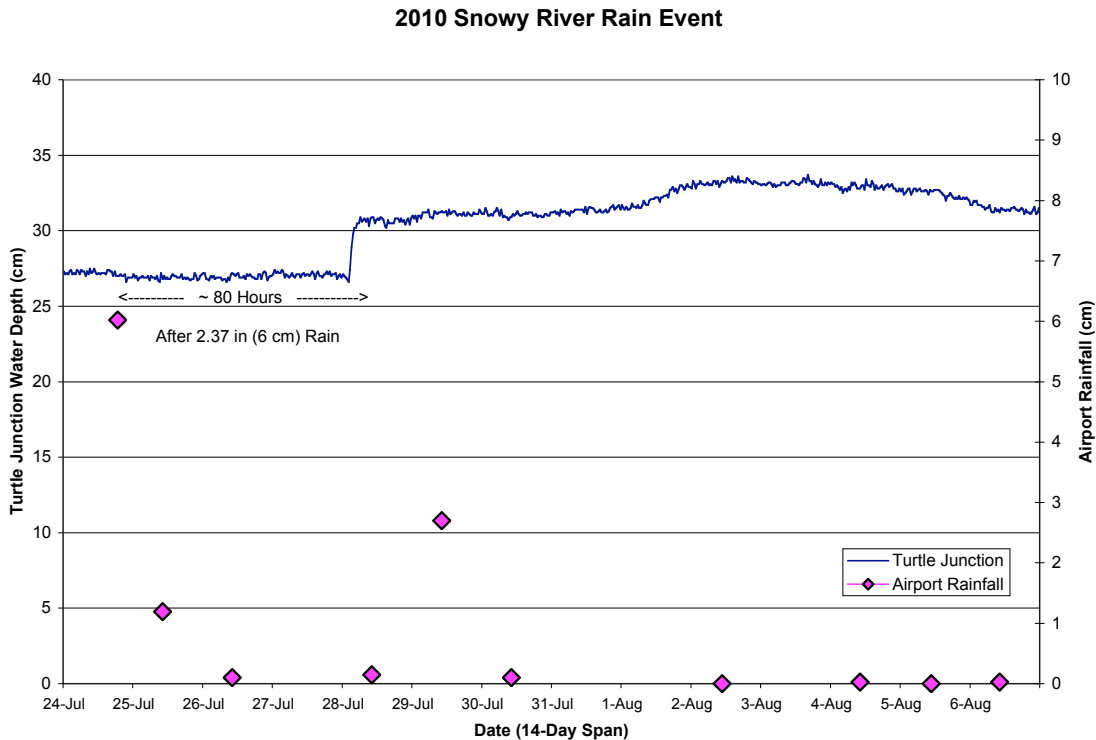
This chart shows a second larger rise between July 26nd and August 14, 2010. Initially there was a sudden 3.8 cm rise, followed a few hours later by a slower 2.5 cm peak.



Typically the NCA area experiences most of its annual rainfall during July and August.

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If we plot the Turtle Junction water information with the airport rainfall information to include both the sharp increase in the Turtle Junction logger and the 2.37 inch rainfall, the result is the next chart. From the chart above we also notice that there was another good rain slightly over an inch a couple of weeks prior to the 2.37 inch rain. So at this time Snowy River was flowing and we may have expected to see a slight rise following the 1 inch rainfall. Instead what we saw was a sharp increase of 3.8 cm approximately 80 hours after the 2.37 inch rainfall, followed by a much slower rise of another 2.5 cm several days after the “big rain”.

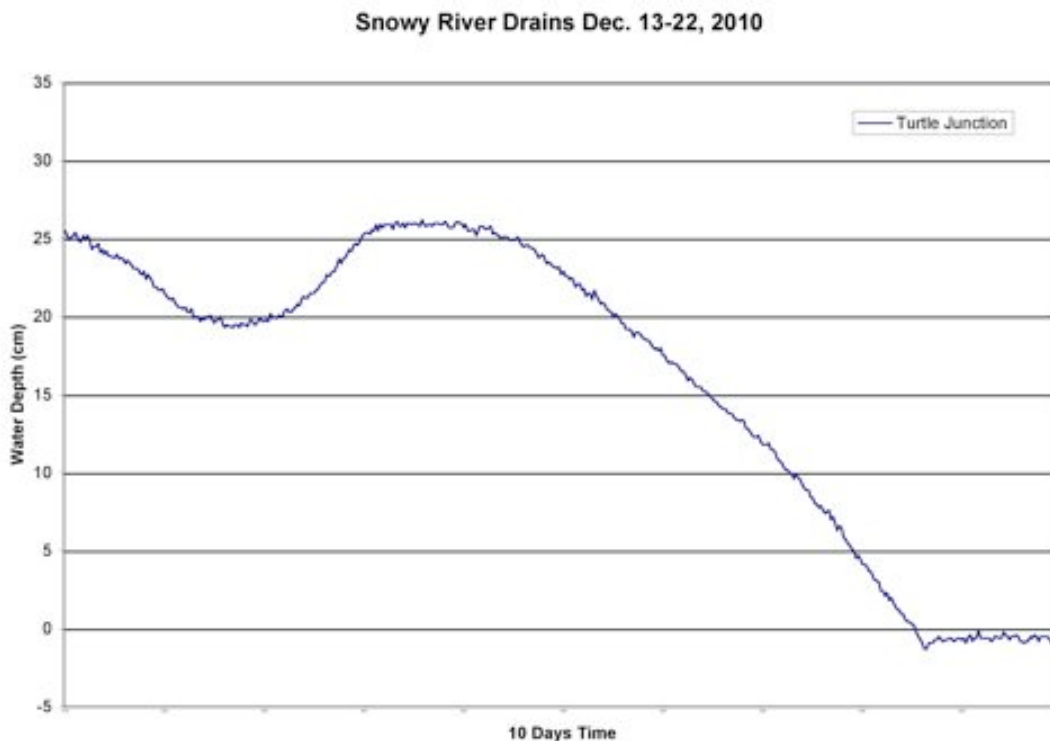


What could have caused this unexpected behavior in Snowy River? One idea that has been presented by several geology-hydrology-thinking experienced cavers is that ***Snowy River could be fed by an overflow route far upstream.*** Cavers are familiar with various personal experiences both in this cave and others, including caves with running streams that are sometimes impacted by strong area rainfalls. One idea is that a larger underground stream located more to the South has a “normal” flow rate that is easily handled by its passage cross section and streambed slope, but when it’s capacity is suddenly exceeded, it overflows into the far upstream Snowy River Passage and now, suddenly, Snowy River begins to flow. (Perhaps the capacity of this yet to be discovered connecting passage is limited due in part to downstream siphons which limit the flow.) The water flows down Snowy River and the initial rise is usually quite rapid as evidenced by the graphics in this report. Even after the flow has started, another significant rainfall event can again cause a rapid rise as illustrated in the graph above.

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Graph #4: Snowy River flow stops

Snowy River takes longer to “drain” than to “fill” for the observer at Turtle Junction, most likely due to pooling water taking longer to drain. Actually, the graph below shows yet another rain event just before the start of the “drain”, on December 17, 2010, but so far we have been unable to correlate this with surface rainfall. Five days later on December 21, 2010, Snowy River was dry at Turtle Junction.



Conclusions

Data logger and rainfall information has allowed us to better understand the hydrology of Snowy River. But to best manage a resource as significant as the “Snowy River Cave” so that one can fully understand the source of the pure water, and make sure that this water is not polluted, for instance, by 20 year old septic tanks that may not have been pumped for 10-15 years, one needs to have access to better data than currently exists. More data loggers installed at more locations in Snowy River is strongly suggested. Certainly one can try to use surface geophysical techniques such as resistivity, low frequency radar, conductivity and seismic instrumentation to try to “find” the cave passage below the ground. But when the depth of the cave is several hundred feet below the surface these techniques are still in their infancy when it comes to finding unknown cave passages that may or may not have water flowing in them. I believe that continuing strong support of both timely underground exploration and documentation plus expanded scientific data collection will benefit this gem of a natural resource.

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References:

Photo & Graphics

Page 1: View of Snowy River at Turtle Junction. (P. Lindsley photo#2194 on Oct. 1, 2009. L-R is Joe Arcure, Mike Bilbo, Robert Darrah (or David Gamaleri?), and Cal Currier.

Page 2: Data logger. (J. Corcoran photo)

Page 3: View of the four sensor systems in the Snowy River water at Turtle Junction. The large sensor is the Frederickson/ Lindsley water level sensor (note that only the 15" sensor band is above water). The small floating object is the HOBO temperature recorder. The Schlumberger DIVER and McLean sensor systems are on the right under water. (Photo by John McLean)

Page 4: Steve Peerman at Government Spring 12-31-2007. Lindsley gauge and clear water on 3-13-2010. Downstream view on 10-30-2010. (P. Lindsley photos.)

Page 5 & 6: Graphs by Steve Peerman.

Other graphs by Pete Lindsley.

Internet Links:

FSCSP.org Weather Stations:

[<http://FSCSP.org/weather.html>]

Weather Underground KSRR site:

[<http://www.wunderground.com/history/airport/KSRR/2010/2/14/DailyHistory.html?theprefset=SHOWMETAR&theprefvalue=1>]