the Valley View

Cascabel ...hard to find....harder to leave.

Issue #9 An Occasional Cascabel, Arizona Newsletter November 2018

In this issue…

We follow Chris Eastoe and Barbara Clark on the exploration of water migration patterns in our valley, the other half of his hydrology presentation at the Community Center last spring. In addition, we'll add an occasional feature that will be called Cascabel Moments, as a means of capturing an interesting or quirky moment to add to our history.

UNDERSTANDING CASCABEL GROUNDWATER – PART 2

By Chris Eastoe and Barbara Clark

We have been asked to provide more information from the Cascabel groundwater isotope study in the form of a second newsletter article. In particular, we wish to explain how it is possible to map different kinds of groundwater, and how this approach helps in the understanding of Cascabel's aquifers. For those interested in a more technical account of the study, a peer-reviewed scientific article has been published in the Journal of Contemporary Water Research and Education, issue 164, pages 19-41. Please note, however, that the information provided below is itself technical in nature and, for those lacking a scientific background, it may at times be difficult to follow. Fortunately, the general concepts included here are quite accessible and are useful in helping to develop an understanding of how scientists determine the path that underground water takes.

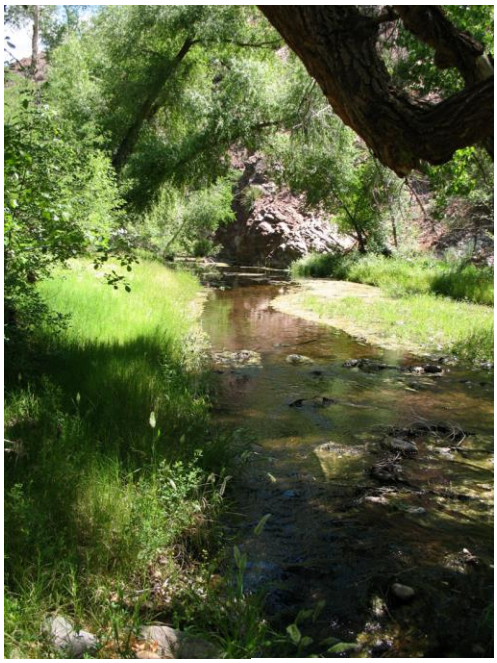

Photo Mick Meader

How can we identify different kinds of water?

Hydrologists use several techniques for tracing the flow of water. Essentially, they attempt to label the water in such a way that it can be recognized without question as it flows through an aquifer (an aquifer is usually defined as a layer of permeable rock or sediment that water can flow through). For instance, one approach, useful in cases where the water is expected to flow quickly through an aquifer of

interest, is to add a tracer such as a fluorescent dye or a stable substance like sulfur hexafluoride that is rare in nature. Another technique involves using the dissolved salts (like sodium chloride, calcium bicarbonate) that occur naturally in all groundwater. It might then be possible to use the total amount of dissolved solids as a label, or the relative amounts of different salts. A third approach uses labels that are part of the water molecule itself.

To understand this third approach, it is useful to know that water consists of hydrogen (H) and oxygen (O). Both H and O have multiple isotopes (i.e. they have an equal number of electrons and protons but can differ in the number of neutrons, and thus can be distinguished from each other relatively easily).

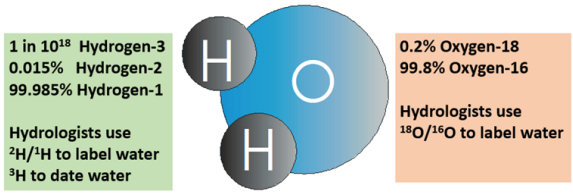

Fig. 1. Sketch of a water molecule, with abundances of hydrogen and oxygen isotopes.

For example, most H atoms contain one proton and zero neutrons, and these are called hydrogen-1 or ^{1}H (for their mass, which is near 1 unit). A few contain one proton and one neutron, and these are called deuterium, hydrogen-2 or ^{2}H (with a mass near 2 units). Hydrogen-1 and hydrogen-2 are stable isotopes; i.e. they do not undergo radioactive decay. A very small number of hydrogen atoms have two neutrons and one proton, mass near 3, and these are called hydrogen-3, ^{3}H or tritium. Hydrogen-3 is radioactive. For oxygen, the stable isotopes have masses 16 and 18. The isotope abundances shown in Fig. 1 are about average for the Earth. In fact, the ratios vary slightly between samples of water, particularly in the case of rainwater and groundwater. The ratios change because processes such as evaporation and condensation operate slightly differently on heavier and lighter water molecules.

The stable isotopes of O and H are very useful tools for distinguishing different types of groundwater. They label the individual water molecules themselves. The labeling reflects such things as the temperature of condensation of rain droplets and the amount of evaporation that occurs before infiltration into the ground. Once a labeled batch of water has infiltrated into an aquifer, the labeling remains stable. In usual, low-temperature situations, the labeling can change only as a result of mixing with differently-labeled water. All of this means that determining how water flows underground does not require scientists to literally follow the entire flow from one end to the other. Instead, they can just test the underground water at various points and determine how it matches with earlier samples found upstream.

The basic measurements for groundwater isotope studies are the ratios $^{2}H/^{1}H$ and $^{18}O/^{16}O$. The ratios themselves are clumsy numbers to compare, so hydrologists convert them into more convenient "delta values". We will not cover the definitions of the delta values here. As delta-values become higher (less negative), this corresponds to increases in the ratios $^{2}H/^{1}H$ and $^{18}O/^{16}O$. The isotope data are used on a graph of hydrogen plotted against oxygen. When water samples appear as different clusters of points on this kind of graph, each cluster is interpreted as a different kind of water.

The Cascabel groundwater map

As a result of considering two kinds of tracers – the stable isotopes and total dissolved solids (measured as electrical conductivity of water samples), we have identified five areas, which we shall call domains, of groundwater with distinctive properties. A notable feature of the domain map (Fig. 2) is the identification of a domain (Domain 5) associated with Hot Springs Canyon,in which the groundwater

differs from other groundwater (Domain 3) supplied from the eastern flank of the San Pedro Valley. This distinction, and its reflection in the flood-plain aquifer downstream of the mouth of Hot Springs Canyon (in Domain 2), is the topic of the rest of this article.

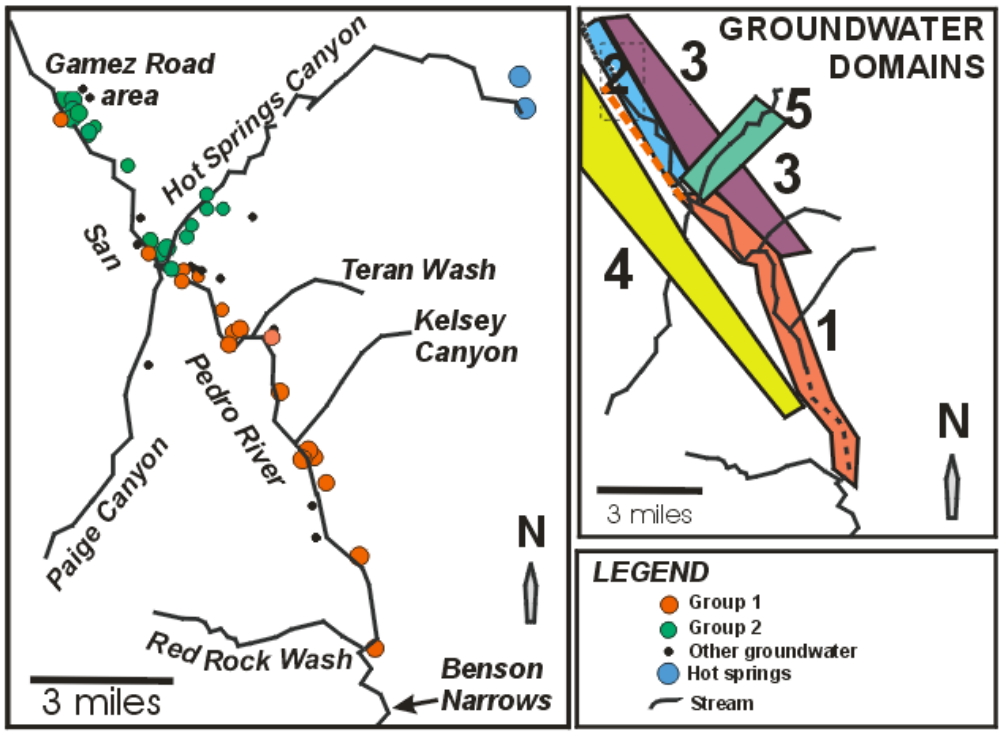

Fig 2. Maps of the San Pedro Valley at Cascabel. The left panel shows the distribution of samples grouped by isotope composition (compare Fig. 3B). The right panel shows the groundwater domains identified on the basis of isotope composition and total salt content.

Why is Hot Springs Canyon water distinctive?

Hot Springs Canyon drains the southern end of the Galiuro Mountains, where Hooker Hot Spring and a cluster of adjacent, smaller hot springs provide a continuous source of water to the canyon. Tributaries to the canyon provide local runoff from areas like those providing water to Domain 3. Water from the hot springs has an isotope composition that is unusual for groundwater in the Cascabel area. Two samples, which represent the Hooker Hot Spring and another hot spring near Bass Canyon, plot well below the fields of other groundwater in Cascabel (Fig. 3A). The difference is thought to arise from the age of the water – probably thousands of years since it was rainwater that fell under cooler climatic conditions. Water supplied by Hot Springs Canyon to the alluvial aquifer (Domain 5), evolves by evaporating as it flows across the hard-rock floor of the mountain canyon, and by mixing with recent rain water (like that contributing to Domain 3). The water discharging from the mountain canyon ("base flow" in Fig. 3A) has an isotope composition like much of the groundwater from the alluvial part of the canyon (Domain 5). Domain 5 groundwater continues to mix with runoff from the canyon flanks, but the mixture remains distinct in isotope composition from Domains 1 and 3 – with one exception: a sample collected in 2015 from a well near where Cascabel Road crosses Hot Springs Canyon. Groundwater from that well had plotted in Domain 5 in 2007, but by 2015 the groundwater had isotopes like those of Domain 1. We shall return to that sample below.

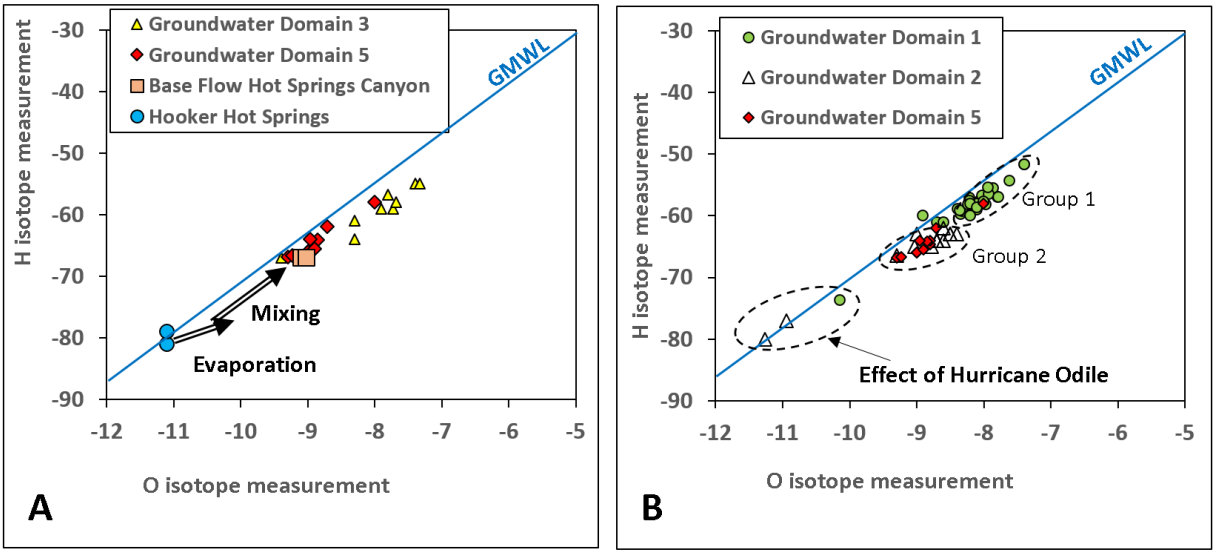

Fig. 3. Plots of hydrogen and oxygen isotope composition in Cascabel groundwater. The compositions are shown as numbers derived from laboratory measurements; we have not explained here how those numbers are calculated. A: How Domain 5 groundwater develops from Hooker Hot Spring water by evaporation and by mixing with Domain 3 water. B: The isotope distinction between Group 1 (Domain 1) and Group 2 (Domains 2 and 5). The distribution of Groups 1 and 2 is shown in Figure 2. A few measurements were affected by floodwater of unusual isotope composition after Hurricane Odile in 2014. The lines labeled GMWL (global meteoric water line) show where average rainwater from most of the world would plot.

Where else do we find Hot Springs Canyon water in Cascabel?

The samples from Domain 2 (east side of the San Pedro flood plain, downstream of Hot Springs Canyon) correspond with those from Domain 5 in Fig. 3B, but not with Domain 1 (San Pedro floodplain upstream of Hot Springs Canyon. We can divide the samples in Fig. 3 into two separate groups with just a few intermediate samples. Group 1 corresponds to most of Domain 1, and Group 2 to Domains 2 and 5. When we make a map showing where groups 1 and 2 are found, we see that there is a single aquifer supplied from Hot Springs Canyon, stretching from the end of the mountain canyon to Gamez Road, and possibly beyond. This aquifer is dammed by clayey, impermeable sedimentary rock that crosses the San Pedro River just upstream of Gamez Road. The aquifer has historically discharged into the riverbed at this point, creating a perennial reach of the river; in recent years the surface flow has dwindled to almost nothing.

This interpretation is confirmed by measurements of total salt content in the groundwater samples; low salt content is found in both Domain 5 and Domain 2, and the content gradually increases northwards in Domain 2.

Note on Fig. 2B that there may be a parallel stream of Domain 1 groundwater that also discharges into the river near Gamez Road. The existence of parallel streams of groundwater that do not mix may indicate parallel buried river channels that are able to convey groundwater separately.

What is happening at the Hot Springs Canyon crossing?

Samples taken in 2007-2009 indicated a sharp boundary (less than 50 yards) between Domains 1 and 2 in this area. Records of the Arizona Department of Water Resources showed gravel and sand – i.e. no barrier to groundwater flow) across the boundary, and a water table sloping northwards across the boundary. The isotope change at the well near the road crossing suggests that water from the San Pedro floodplain upstream of Hot Springs Canyon is gradually moving into the aquifer supplied with water from Hot Springs Canyon. More measurements would need to be made in the area to confirm the suggestion.

Conclusion

Tracing groundwater flow often reveals surprises because of the degree to which that flow does not necessarily correspond to surface formations. Certainly this is the case in Cascabel. Continued study in the area would likely reveal further unexpected information and a deeper understanding of the Cascabel region. In addition, it is important to recognize that changes in above-ground conditions have the possibility of affecting the below ground flow in a manner that is currently unforeseeable.

Rainfall 2018 January to October			
	Narrows	3-Links	Clayworks
January	0	0	.18
February	2.45	2.80	3.47
March	0	0	.01
April	0	0	0
May	0	0	0
June	.92	.98	.84
July	4.50	1.95	3.26
August	1.61	1.59	1.80
September	5.06	1.95	1.77
October	3.05	1.68	2.46
Total	**17.59**	**10.95**	**13.79**
	A. Wilkinson	K. Waldt	B. Clark

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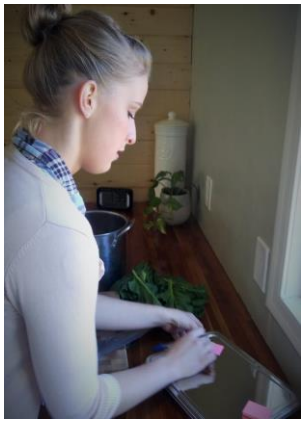
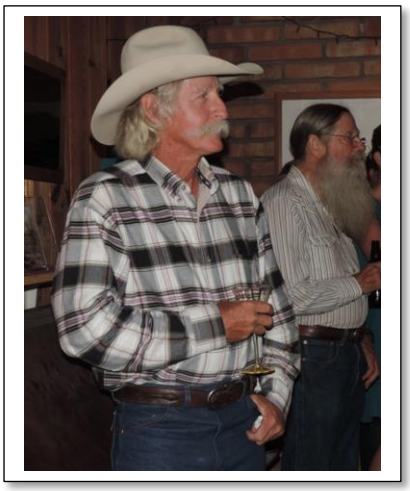
Printed copies available at the Community Center or by request



Cascabel's own Meals on Wheels ~ Louisa's Kettle Kart

As of the first Monday of September, Louisa Foreman began offering to cook dinner M/W/F and deliver it. Some thought it a treat and others order weekly. "When I came up with the idea, I had no clue if there'd be a response at all, but I knew I loved cooking, and I loved the presentation side of cooking." Trays/meals are $10 apiece.
Delivery days are from 4 pm-6pm and all recipes are all-natural, gluten free and peanut free, delivered to your door with her gracious smile. Louisa says that Monday are her busiest, often reaching 20 meals. Here's her email if you're interested louisamforeman@gmail.com

Photos: Elaina and Ben Foreman

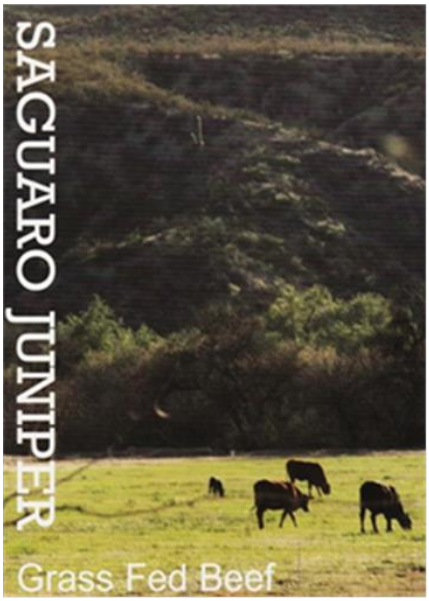


Woody Hume retires as herd manager of Saguaro Juniper

On a late August evening, the community gathered with great enthusiasm to celebrate Woody's birthday and retirement. His service to the ranch and care of its animals and land have been legendary. Jim Corbett's concepts of wildland management have been his guide.

Photos Sue Newman

Now taking 2018-19 orders for halves or quarters
www.saguaro-juniper.com/food/beef.html



Cascabel Moments

February 2005 – Cascabel Road was raised by some 8 inches to eliminate the trench it had become and was also widened. Overhanging branches were cut back, saving some antennas.

Photo Sue Newman

San Pedro River Reports on Facebook

Leslie and Ross Maynard have been providing a great service to the valley, especially during the monsoon season, by noting the passable condition of the washes after a storm. Redington often reports in when things are bad up that way. And Caleb Quisenberry often notes hazards on our email bulletin. But the other day the report told of another event. The new FedEx driver. He had been leaving packages with no notice, some including heavy dog food bags at gates where they couldn't be seen. Wildlife could have had a feast. But the driver made a wrong turn at Maynards. "The new driver (afraid to get another complaint) drove onto my property, took the tractor trail down to the river, slid off the road bank and is hung up on a tree. I can't get to him with my tractor. If Foremans can't get him out, FedEx will have to send a driver out AFTER ROUTE, evaluate, then call a wrecker." Foremans did come to the rescue. And the Penske rental truck going up and down the road is the replacement vehicle for the present. Never a dull moment.

Lower San Pedro Watershed Alliance

Standing with Cascabel for values that extend beyond our lifetimes.
LowerSanPedro.org or write to
LowerSanPedro@gmail.com

photos Morris Taylor
NOV 2017