

February 17, 2006

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ORPI/General

Memorandum

To: Superintendent, Organ Pipe Cactus National Monument

Through: William L. Jackson, Chief, Water Resources Division (WRD)
Gary Rosenlieb, Acting Chief, Water Operations Branch, WRD

From: Larry Martin, Hydrogeologist, Water Operations Branch, WRD
Colleen Filippone, Hydrologist, Intermountain Region

Subject: Trip report for travel to Organ Pipe Cactus National Monument, Feb. 8-9, 2006

Summary: The observed decline of flow from Quitobaquito Springs in recent years is attributed to a combination of drought effects, increased evapotranspiration and plugging of the collection system at the northeast spring. The condition of the northeast spring collection system will be investigated further by hand digging in the collection area to assess the degree of root penetration and sediment infilling within the gravel pack around the collection pipe. Recommendations will then be provided to the park regarding rehabilitation of the northeast spring collection system and vegetation control.

A proposal will be prepared to seek funding from the Arizona Water Protection Fund for spring rehabilitation and for construction of three monitor wells in the La Abra Plain ground-water basin, the primary source area for Quitobaquito Springs. These monitoring wells are needed to better understand overall groundwater conditions in the basin, causes of spring-flow variation and to what extent groundwater pumping in Mexico may be impacting flow at Quitobaquito Springs. We will assist park staff in preparing an entry for the project in PMIS.

Discussion: Regular monitoring of spring flow at Quitobaquito Springs from 1974-92 showed that discharge was generally around 30 gallons per minute (gpm), ranging from about 25-35 gpm. Monitoring in 1996-98 showed the flow decreasing to less than 20 gpm. Monitoring in 2005 showed that flow from the springs had decreased to about 14-18 gpm.

There are probably multiple causes contributing to the observed spring flow decline. These can be lumped into two categories; 1) decrease of the amount of source water reaching the springs collection area and 2) problems with the collection system and vegetation control at the spring. These are discussed further in the following sections.

Source water decrease: On the basis of discharge records for Quitobaquito springs, precipitation records and the hydrologic setting it is reasonable to conclude that source waters for the spring include both a regional groundwater component associated with the La Abra Plain groundwater basin (Carruth, 1996; Goodman, 1992) and a local component related to direct precipitation on the Quitobaquito Hills (Figure 1-note discharge response to precipitation in July and August 2005). Water levels in the La Abra Plain aquifer may have experienced decline related to groundwater pumping in Mexico and/or may reflect the cumulative effect of a prolonged drought in the area. Due to the lack of a monitoring well in the source area for the springs, it is not possible to determine how regional source water availability may be changing relative to historical levels in the immediate springs area. However, it is known that water levels at wells throughout the park have experienced declines in recent years thought to be related to drought (Filippone, 2005, in review). Declining source water availability related to runoff and infiltration of local precipitation are expected to be directly related to drought conditions.

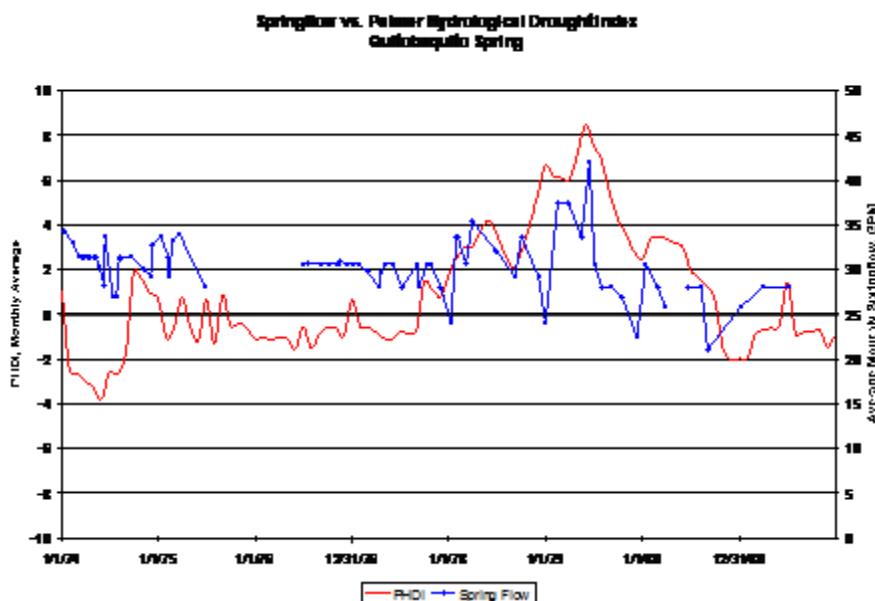
Groundwater Pumping: Inadequate hydrogeologic data are available to determine the potential for water table lowering by groundwater pumping south of the Mexican border. It is relatively certain that groundwater flows across the border within deep alluvial deposits in the basin center. Goodman (1992) cites declining water levels in the alluvial aquifer as the cause of the Pozo Salado well going dry in 1988. Water in the springs source area are part of the same system, and lack of any water level data in the basin other than Bonita well at the far northern edge is a concern. However, the current amount of irrigated farmland in Mexico does not appear to be so extensive as to create a regional lowering of the water table (such as has occurred in the Ogallala Aquifer in the Great Plains States). However, the recharge rates and recharge area for the basin are also substantially less than that of the Ogallala. While we are of the opinion that groundwater pumping in Mexico is not the primary cause of spring flow declines, it would be prudent to establish a groundwater monitoring program for the La Abra Plain area to document changes to water table elevations in response to precipitation and drought and to aid in identification of present or future impacts that might be attributable to groundwater pumping in Mexico.

The groundwater monitoring program would require installation of two new monitoring wells and repair or replacement of an existing monitoring well at Bonita. The monitoring well at Bonita is important as it is far from any areas of groundwater pumping and will show the natural variation of the water table in the basin recharge area in response to precipitation and drought. One of the new monitoring wells would be located along Puerto Blanco Drive about five miles east of Quitobaquito. This well would be a replacement for the Pozo Salado Well which has gone dry due to water table decline in the area. This new well would provide information regarding the amount of water table drawdown in the southeastern part of the La Abra Plain and would provide data needed to assess how much of the decline was due to groundwater pumping in Mexico. The second new well would be located along Aguajita Wash, east of Quitobaquito Springs. This well would provide water table elevation and water chemistry data for the east side of the Quitobaquito Hills, believed to be the source area for the discharge at the springs. Once this well is completed, comparison of water table fluctuations in the monitoring well just east of the springs with spring discharge rates should allow us to determine whether spring flow changes are a result of decreased availability of groundwater in the aquifer, changes in the efficiency of the collection system at the springs, vegetation, or other causes.

Drought: Drought is without a doubt a factor in the reduced discharge at Quitobaquito in recent years. Comparison of measured springflow with the Palmer Hydrological Drought Index for the area shows a fairly strong correlation, as shown in Figure 2. This part of Arizona has been in a drought for seven of the past ten years, beginning in 1996. As it happens, the winter of 1996-1997 was the last time when discharge rates above 30 gpm were observed at Quitobaquito.

Both Goodman (1992) and Carruth (1996) concluded that the source of water discharging at Quitobaquito Springs is infiltration of precipitation and runoff from the hills surrounding the La Abra Plain. The large storage volume for groundwater in the basin underlying the La Abra Plain dampens the effect of short-term departures from average precipitation. However, we would expect that flow from the springs would gradually decrease during an extended drought, just as we would expect that recovery of flow at the springs will be a gradual process after precipitation amounts return to near (or above) normal.

Figure 2. Comparison of historical spring flow rates and a regional drought index.



Northeast spring collection system efficiency decline: The ability of groundwater at the northeast spring to enter the collection system is very likely reduced by penetration of roots into the gravel and perforated pipe at the spring. Flow might also be impeded by silt working its way into the gravel bed, making it less permeable. NPS records indicate that the northeast spring collection system required rehabilitation in 1975 and again in 1989 (NPS WRD files and Barnett and Sharrow, 1992). At present, a substantial growth of thick vegetation surrounds both the northeast spring collection system and the area immediately upslope of the southwest spring.

The northeast spring was constructed by excavating an area at the spring outlet to the shallowest of bedrock or 36" below grade. A perforated pipe (1/4 inch holes at 3-1/4 inch spacing, last 5 ft above collector vault not perforated) was laid in the excavation and covered with gravel. This was covered with plastic sheeting (engineering specs ask for filter fabric overlay). Silt from the

pond was placed over the plastic sheeting to provide a substrate for vegetation to help control erosion.

Park staff report that in the past they have removed roots from the perforated pipe in the northeast spring and that flow seemed to increase for some time after that. The hillside surrounding the northeast spring is covered with woody shrubs to within a few feet of the spring. According to photographs and staff reports, this has not always been the case. It is likely that roots from these shrubs have grown into, and are plugging, the perforated pipe and the gravel pack; preventing the free flow of water into the collection system. It is also possible that the plastic sheeting has been punctured and that some of the overlying silt has infiltrated into the gravel surrounding the perforated pipe, further reducing the permeability of the gravel bed. Removal of roots from the collection pipe will not address the problem, as the perforations and gravel pack will remain plugged. With the gravel pack plugged, groundwater will be absorbed by plant roots and/or diverted around the collection system and will remain unavailable.

It will almost certainly be necessary to remove the woody shrubs from the immediate vicinity of the spring, and keeping them cleared, from an area about ten feet distant from the spring collection area.

Increase in plant water use: Park staff indicates that there was less vegetation around both the northeast and southwest springs in the past. Discharge measurements at the southeast spring in the past year show a steady decline in flow rate between April and July 2005 (see Figure 1). The decline in discharge during this period totals about four gpm. Following rains that occurred in late July and August, discharge rates rebounded temporarily but then again declined somewhat. However, in spite of the fact that there has been no rain at the park since mid-October 2005, discharge rates at the southwest spring climbed by early February to the same level they were at in April 2005 following several months of above average rainfall. These data suggest a present day groundwater baseflow contribution to the springs of around 18 gpm, reduced by up to 22% by plant use during months when evapotranspiration demand is high.

Other potential causes of spring flow decline: The observed decline in spring flow might also be due to leaks in the pipeline carrying water from the northeast spring to the southwest spring. This doesn't seem like a likely cause as the pipe is not pressurized and there are no areas of phreatophytic plants along the pipeline route that would be indicative of a leak. This possibility will be investigated by measuring the flow rate at both ends of the pipeline.

It is also possible that some of the groundwater might be discharging at a new spring orifice. There is no evidence that this has occurred, there are no new areas of phreatophytic vegetation in the area. Some of the smaller adjacent springs no longer have any surface expression, indicating a general loss of groundwater discharge in the Quitobaquito area from the aquifer underlying the La Abra Plain.

Conclusions: Declines in combined flow rate from the two springs are most likely attributable to three causes. Two of these, northeast spring collection system efficiency and plant water use, are within our control and one of these, climate, is not. It would be prudent to install monitoring wells and conduct regular water table monitoring in the La Abra Plain to obtain real data regarding the amount and extent of water table drawdown north of the border so that we will be making decision based on data, rather than opinions.

A proposal for funding construction of monitoring wells and rehabilitation of the northeast spring collection system will be submitted to the Arizona Water Protection Fund.

If there are any questions regarding this trip report, please call me at (970) 225-3515.

References

Carruth, R.L., 1996, *Hydrogeology of the Quitobaquito Springs and La Abra Plain Area, Organ Pipe Cactus National Monument, Arizona, and Sonora, Mexico*, U.S. Geological Survey Water-Resources Investigations Report 95-4295, 23 pp.

Goodman, Brian Scott, 1992, *Hydrogeology of the Quitobaquito Springs Area, La Abra Plain, and the Rio Sonoyta Valley, Organ Pipe Cactus National Monument, Arizona and Sonora, Mexico, 1992*, M.S. Hydrology Thesis, University of Arizona, 212 pp.

Barnett, J.J. and D. Sharrow. 1992. *Water Resources Management Plan Organ Pipe Cactus National Monument Arizona*. National Park Service 138 pp.

Filippone, Colleen. 2005. *Groundwater*. Chapter submitted to park for inclusion in upcoming ORPI Ecological Monitoring Report.

cc:

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Figure 1. Discharge and water temperature at Quitobaquito southwest spring flume April 7 through February 6, 2006; precipitation at Pozo Nuevo climate station.

