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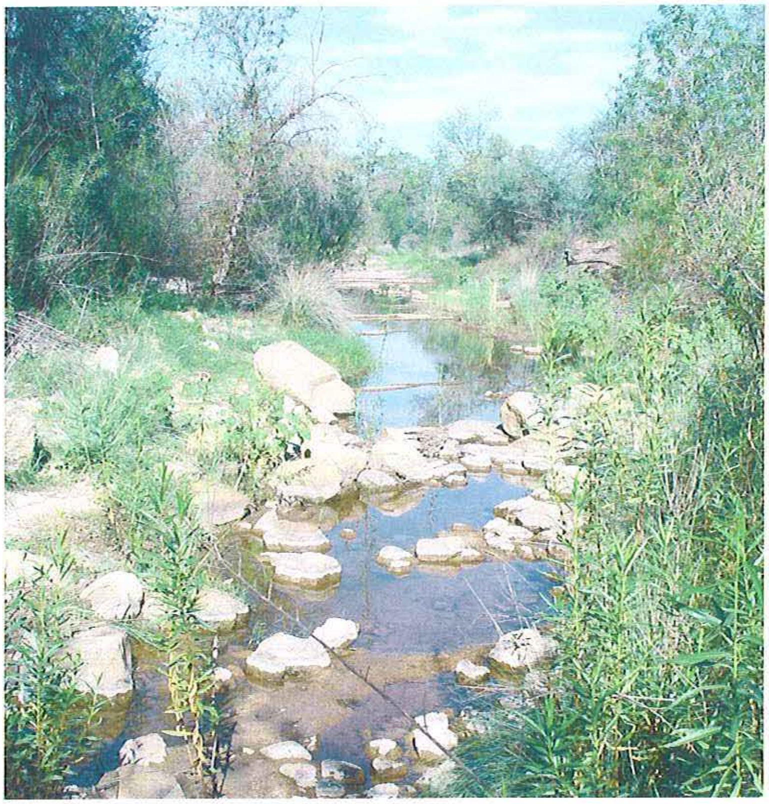
Saguaro National Park

Protecting Riparian Areas through Hydrological Monitoring



Pools in the middle reach of Rincon Creek, Saguaro National Park, Tucson, Arizona.

Final report to Western National Parks Association
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EXECUTIVE SUMMARY

Desert waters in Saguaro National Park are important and extremely sensitive resources for wildlife, plants, and people. The purpose of this project was to expand long-term hydrological monitoring to better protect the park's rare surface waters, particularly in the Rincon Creek watershed and in *tinajas* (rock pools) throughout the park, as well as to fully document a major flood in Rincon Creek on July 31, 2006. During 2007-2008 we monitored surface and subsurface water in Rincon Creek, expanded water monitoring and research in Chimenea Creek and other areas of the Rincon Mountain District, and summarized a large amount of data on rainfall, surface water flow, and sedimentation during the flood event. Results of this project were summarized in a series of comprehensive technical reports to the park that provide Saguaro National Park with an improved understanding of its principal water sources.

INTRODUCTION

Desert waters in Saguaro National Park, including Rincon Creek near the park's southern boundary of the Rincon Mountain District, are among the great natural treasures of the park, yet until recently very little was known about their hydrology. The riparian woodland community in Rincon Creek has the greatest diversity of birds in Saguaro National Park and is one of the richest bird areas in the Tucson area (Powell 2004). The creek and its tributaries, including Madrona and Chimenea Creeks, also support a large number of sensitive reptiles and amphibians, including the lowland leopard frog, as well as mammals and plants (Edwards and Swann 2003). In metropolitan Tucson current use of water exceeds natural recharge (Pima County 1999), and surface waters in the Rincon Mountain District may be threatened by urban pressures, including groundwater withdrawal outside the park.

In recognition of the importance of, and potential threats to, these rare desert waters, several years ago Saguaro National Park began an interdisciplinary scientific program to better understand them. This program included an intensive study of the Madrona Pools in Chimenea Creek (Edwards and Swann 2003); a research and long-term monitoring program for lowland leopard frogs and their aquatic habitat (Wallace et al. 2008); and research associated with a water rights case on Rincon Creek (NPS in prep.). We also initiated both research and long-term monitoring on the effects of wildfires on aquatic resources, particularly stream pools (Parker 2006, Wallace et al. 2006).

The purpose of this WNPA research project was to expand and formalize long-term water monitoring related to these projects to help ensure the long-term protection of sensitive riparian areas in Saguaro National Park, particularly Rincon and Chimenea Creeks. Major goals were to support the National Park Service's current effort to seek inflow stream rights in Rincon Creek as well as to expand water monitoring in the sensitive Madrona Pools area of Chimenea Creek and other streams. However, an important secondary goal was to compile data from the major flood of the summer of 2006.

A large rain event early in the evening of July 31, 2006 led to huge surface flows in the Tucson area. One of the largest was in Rincon Creek, which peaked at over 14 feet and a water volume provisionally estimated at 15,000 cubic feet/second (Gwen Gerber, unpublished data) - the largest flood recorded since monitoring began in the 1950s. Although the park's most important stream gage survived and recorded the event, the US Geological Survey (USGS) gage and private property were destroyed by the flood. However, because so much data on riparian resources had been gathered before the flood, and continued to be gathered afterwards, Saguaro National Park had a unique opportunity to quantitatively assess the impacts of this event, which we felt would be extremely valuable in future decisions related to groundwater resources, fire management, and recreational management.

The major objectives of this project were to:

1. Reinstall or re-survey several stream gages damaged by the flood and continue monitoring of stream gages and wells in Rincon Creek;

2. Re-survey tinaja geomorphology to determine the effects of the flood on burned and unburned canyons;

3. Formalize hydrological monitoring in the park so that it can continue as a model volunteer program;

4. Prepare a comprehensive report and display on the 2006 flood that would include a summary of rainfall data, stream gage data, photographs, and flood-plain mapping.

We received technical support for this project from Paul Christensen and Gwen Gerber of the NPS Water Resources Division, Water Rights Division; from Colleen Filippone, NPS hydrologist; and from Jeff Balmat, NPS Sonoran Desert Inventory and Monitoring network. The non-profit Rincon Institute supported this project through working with private landowners for access to Rincon Creek and we also received advice on aquatic herpetofauna from Cecil Schwalbe from the USGS Sonoran Desert Field Station. This was an innovative program due to its cooperative nature and reliance on skilled volunteers.

METHODS

<u>Stream monitoring</u>. During January 2007-July 2008 we collected data on stream flow, pool volume, and well levels using manual methods and automated dataloggers. For stream flow in Rincon Creek, we manually read two gages and downloaded an automated stream gage every two weeks following established protocols. In addition, every two weeks we collected data on the wetted length of Rincon Creek (the proportion of the creek that was covered with water) and also recorded depths along 5 established cross-sections as an index of water volume available for wildlife in the creek.

In addition, in 2007 we purchased and installed new dataloggers and software to replace 3 dataloggers that were failing. Also in 2007 we assisted the NPS Water Rights Division in resurveying stream gages following USGS standards.

Tinaja geomorphy. To document changes in tinaja sedimentation following the 2006 flood, we re-surveyed 24 tinajas for which we had detailed data on bedrock and sediment topography dating from 2005-2006. Using survey equipment (auto-level, metal probe, and survey rod) on a grid system across the pool, we measured depth to bedrock and depth to sediment at 50-200 locations within each pool. We mapped the sediment and bedrock contours using the computer mapping program Surfer (Version 8.05, Golden Software Inc.), which also estimates sediment and water volume and area. We compared estimates from 2007 with estimates from the same pools in 2005-2006.

Hydrological monitoring using volunteers. We established a water monitoring protocol (Zylstra et al. 2007) for the entire Rincon Mountain District based on tinaja surveys that can be done by volunteers. Within 8 drainages we selected at least two perennial or semi-perennial tinajas from surveyed tinajas (above). Each tinaja had a natural "vertical datum", usually a single point defined by the intersection of two rock cracks, from which a single measurement could be taken that would allow us to calculate pool volume. During this study, we tested this protocol at two of the Madrona Pools in Chimenea Creek. Volunteers measured the distance from the water surface to the vertical datum, then, based on a graph developed for each pool (Perger 2006, Zylstra et al. 2007), we estimated pool volume for each survey date.

2006 flood. To determine the magnitude of the flood in Chimenea Creek, we established two cross sections immediately after the flood when flood debris was still visible in two locations approximately 490' apart. Using a total station (Nikon Inc., Japan) we surveyed across the channel in each cross-section to determine depth to bedrock and water area; we also surveyed an 850' longitudinal profile of Chimenea Creek that included the two cross sections. We used a USDA Forest Service software program (WinXSPRO) to estimate the number of cubic feet per second (cfs) in Chimenea Creek during the maximum flow on July 31, 2006. To develop a rain timeline for the Rincon flood, we obtained rainfall data from Happy Valley, Madrona Ranger Station, Manning Camp (NPS, unpublished data), and Rincon Creek (Pima County).

RESULTS

Stream monitoring. Provisional results of monitoring of stream flow and well levels in Rincon Creek during 2007-2008 are summarized in Figure 2 and in Perger (2008a). As a result of sustained flows during the period, Rincon Creek pools and monitoring wells contained water throughout the study period. As is typical, stream flow gradually decreased during the dry seasons (April-July and September-November) following flow events during winter (December-March) and summer (July-August) rain events.

Provisional analysis of the data collected during this study indicate connectivity between surface water in the creek and in the shallow alluvial aquifer; generally, water levels in the aquifer decline when water levels in creek pools decline, and rise when water levels in the pools rise (NPS, in prep.).

Tinaja geomorphology. During the dry (May-July) pre-monsoon season in 2007, we re-surveyed sediment volume in 24 tinajas (Ratzlaff 2007). Sedimentation varied among tinajas and canyons, but there was an increase in sedimentation in 19 of the 24 pools surveyed (Table 1). Sediment in tinajas increased in all canyons surveyed except for Loma Verde Canyon, where 4 of the 6 pools surveyed had less sediment volume in 2007 than in 2005-2006. However, 3 pools where sediment increased had been excavated in an experimental lowland leopard frog habitat restoration project following the 2005-2006 surveys. Figures 3-4 show a photo of a typical tinaja and output from survey data.

Hydrological monitoring using volunteers. Of the two pools in Chimenea Creek where we recorded weekly water levels, pool 1d (Figure 5) contained water throughout the period. Pool 11 dried during the spring of 2006 but contained water most of the time and water levels in both pools appeared to be strongly correlated (Figure 6).

2006 flood. We calculated maximum discharge in Chimenea Creek during the 2006 flood to be 10,816 cfs at the downstream cross-section and 10,888 cfs at the upstream cross section (Perger 2008b). The close coincidence of these two measurements may be fortuitous due to the subjective nature of the Manning's roughness coefficient. The elevations of the high water marks in each cross section were similar (Figure 7), indicating that at cross section locations there were few significant obstructions or turbulence. The slope of the stream at high water between the two cross-sections was calculated to be 7.3%, and the average slope at low water (the slope of the thalweg, or stream channel) over the entire 850 ft. survey reach was determined to be 6.9%.

Rainfall records indicate that the most intense part of the storm was centered over the Happy Valley saddle, which received nearly 4 in. of rain during the night of July 31, 2006. However, Rincon Creek received significant rainfall in all of its tributaries both at high and low elevations. The estimated maximum discharge in Rincon Creek during the flood was calculated to be approximately 15,000 cfs (USGS and NPS unpublished data), higher than for Chimenea Creek, a tributary. Data from the flood are summarized in Perger (2008b), a lay report that included photos (Figure 8) from park staff and neighbors and was distributed to interpretive and other staff.

DISCUSSION

Results of this study are summarized in a series of reports (Perger 2008a, 2008b, Ratzlaff 2007, Zylstra et al. 2007). The hydrological data gathered with the support of WNPA has direct management applications in Saguaro National Park, and is also very useful for long-term monitoring. Hydrological data gathered on Rincon Creek, as well as some data from the Madrona Pools, will be used both directly to support a water rights case to preserve surface water in Rincon Creek, as well as to support biological studies that may also contribute to this claim. Flood investigations will be valuable in future planning efforts, such as locating new trails and recreational facilities.

We are not aware of any previous attempts to monitor water in tinajas and other surface water sources in Saguaro National Park. These precious water sources have high value not only for wildlife, but for campers and hikers as well. Tinajas provide recreational opportunities, drinking water, and spiritual nourishment. It is essential to the park that they be preserved for future generations, yet very little is known about their hydrology, biology, water chemistry, or geomorphology. We anticipate that monitoring protocols developed during this project will be used to provide a better understanding of long-term processes affecting tinajas and will contribute to further research on tinajas in the future.

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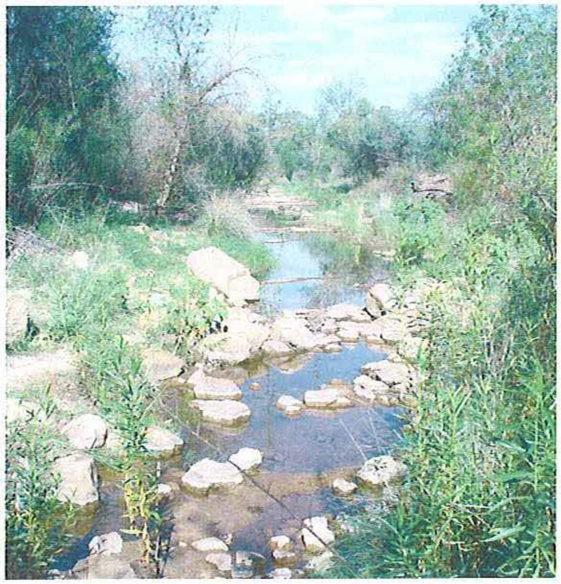

Figure 1. The middle reach of Rincon Creek, along the southern boundary of Saguaro National Park, Rincon Mountain District. Unlike most streams in the park, the middle reach of Rincon Creek flows along a broad valley floor.

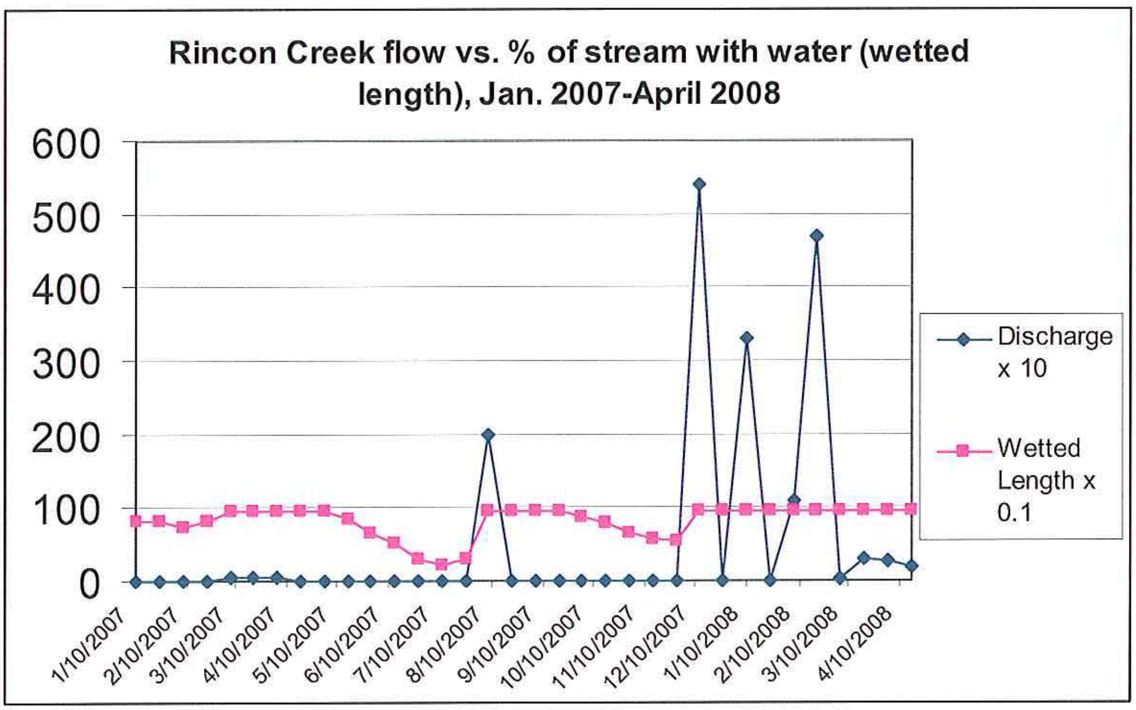

Figure 2. Rincon Creek streamflow (mean daily discharge in cfs x 10) and the wetted length (in m x .1; total length approximately 1 km) of the middle reach of Rincon Creek from January 2007 through April 2008. Provisional data from the USGS stream gage #09485000 and this study. Rincon Creek typically flows following large precipitation events during winter and summer, with flow diminishing during late spring and late fall.

Table 1: Amount of bedrock pool volume consisting of sediment in pools located in seven different drainages in Saguaro National Park, Rincon Mountain District.

Pool Number	2005-2006 Survey	2007 Survey
Box Canyon 6	0%	13%
Box Canyon 1	27%	44%
Chiminea 2J	20%	36%
Chiminea 1L	0%	1%
Chiminea 1E	18%	27%
Chiminea 1C	14%	9%
Loma Verde 10	153%	82%
Loma Verde 9	36%	38%
Loma Verde 6	110%	46%
Loma Verde 4	101%	63%
Loma Verde 2	95%	77%
Loma Verde 1	44%	46%
Loma Verde AV2	32%	86%
Madrona 13	0%	9%
Madrona 9	31%	42%
Madrona 2	42%	79%
Rincon North 2	23%	47%
Rincon 5	0%	85%
Wild Horse 19	0%	62%
Wild Horse 15	26%	23%
Wild Horse 13	0%	1%
Wild Horse 8	7%	42%
Wild Horse 4	75%	80%
Steel Tank 4	0%	32%

Figure 3. Pool 8 in Wildhorse Canyon, a typical tinaja in Saguaro National Park.

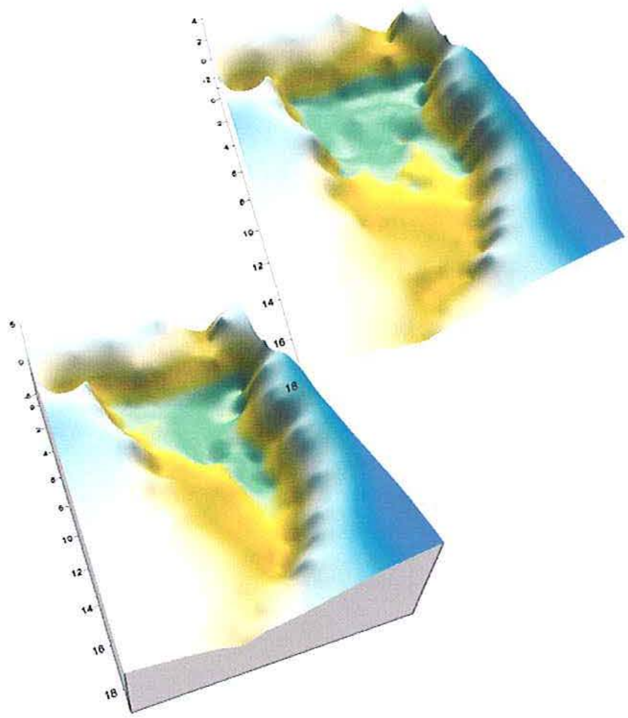

Figure 4. Pool 8 (as in Figure 3), showing 2007 output from topographic surveys. Bottom figure shows bedrock countours, and top figure shows sediment contours. Sediment in pool increased from less than 10% of the total pool volume in 2006, before the flood, to more than 40% after the flood.

Figure 5. Pool 1d, in the "Madrona Pools" of Chimenea Creek, Saguaro National Park.

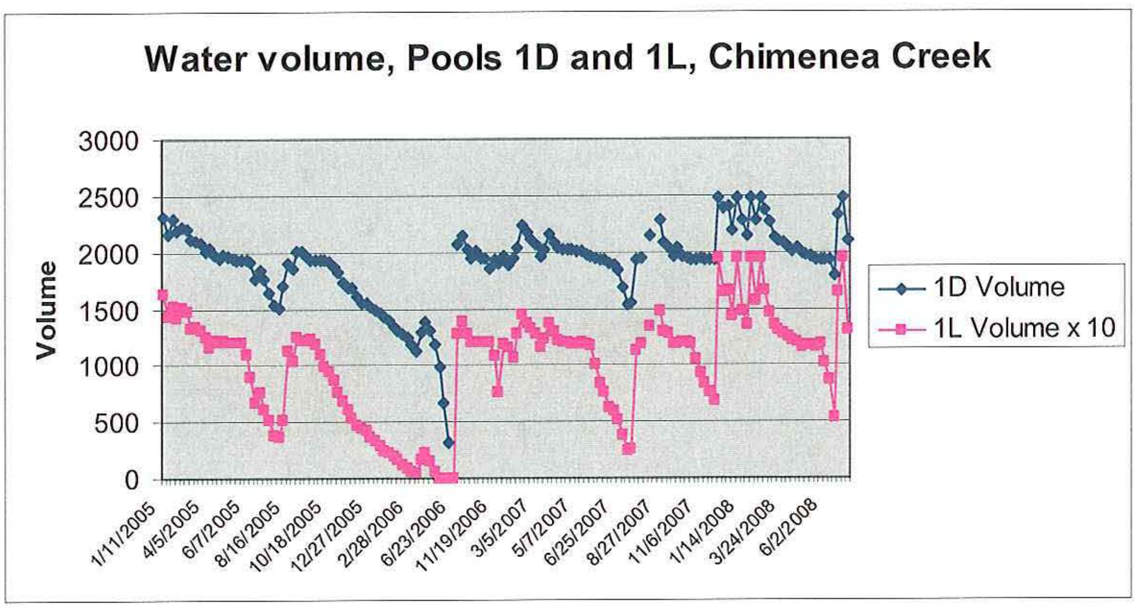

Figure 6. Water volume in pools 1d and 1l, Madrona Pools of Chimenea Creek, during 2005-July 2008. Based on weekly readings from datum; see Gable (2005) and Perger (2006) for details of estimating volume. Pool 1l went dry during the drought in June 2006, but pool 1d retained water.

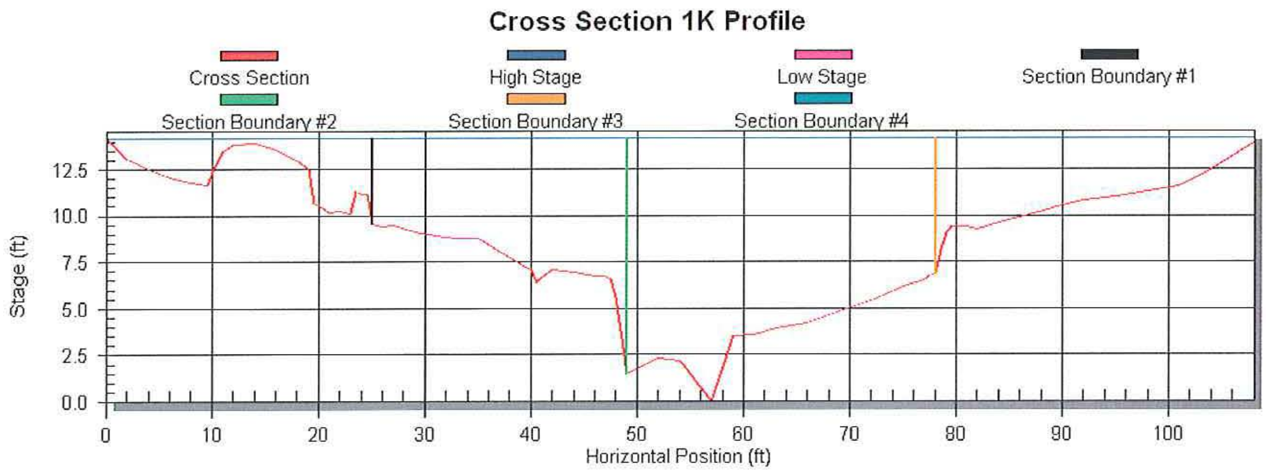

Figure 7. Cross section of Chimenea Creek, used to estimate the volume of water at the height of the 2006 flood. We estimated a flood of >10,000 cfs (cubic feet/second).

Figure 8. USGS gage in Rincon Creek, which stood for 53 years before the 2006 flood.