

**Final Report
to Arizona Water Institute
AWI-07-14 Verde River Ecological Flow Science – A Collaborative Approach**

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Executive Summary

Project Overview and Goals

The primary goal of AWI-07-14, *Verde River Ecological Flow Science – A Collaborative Approach*, was to assess the water needs of the Verde River ecosystem through an environmental flows (EF) approach. An EF approach provides the framework for assembling the data and information needed to delineate relationships between the hydrologic regime and the biologic system. This project was a collaboration among The Nature Conservancy, the Arizona Water Institute (Arizona State University (ASU), Northern Arizona University (NAU) and the University of Arizona (UA)) and the Verde River Basin Partnership. The project established an academic science lead team including researchers from ASU, NAU, the Arizona Geologic Survey (AZGS) and the Museum of Northern Arizona (MNA) with assistance from staff at AWI and The Nature Conservancy.

The steps of this project were:

- An orientation meeting of the team;
- A literature review and background report that summarizes the known relationships between the hydrologic and biologic system;
- A workshop to assemble person most knowledgeable of the system to refine flow-biology relationship models, identify key information gaps and establish a prioritized research agenda;
- Dissemination of the final report in both technical and publicly accessible formats and
- Integration of study findings with other studies and with Title II reporting requirements.

The project deliverables are: an experts workshop, a bibliography and database, a background report and a summary report as pdf files and as hard copies. The team has met the following milestones. Detailed discussion of progress is found in the body of the report, which follows.

Background/Research Methods

The Verde River Ecological Flows study was a collaboration of The Nature Conservancy, and the Arizona Water Institute. The study's purpose was to develop conceptual models of the Verde River ecosystem that link hydrologic variation to ecological response, in the hope that these models would guide future data collection and ultimately lead to better-informed water management. The first phase of the study, documented herein, included a synthesis of available literature and a two-day experts' workshop. The workshop tapped the knowledge and experience of an interdisciplinary group of experts in the fields of ecology, biology, hydrology, and geomorphology. The goals of the workshop were to develop conceptual models, document streamflow-ecology relationships, and develop a prioritized agenda for further research. This report describes the physical setting, riparian ecosystem, and wildlife resources of the Verde River; documents results and outcomes from the workshop; and identifies linkages between hydrologic variation and ecological response. Workshop participants recognized that although much is known, many questions remain. Thus, development of a prioritized research agenda was an important outcome from the workshop. Future phases of the study will begin implementing the research agenda.

Need and Purpose

The Verde River is a critical component of life in central Arizona and beyond, for both the natural and human communities (Figure 1-1). There is concern about how the growing human water needs of the area are going to be met while also preserving the important ecological values of the Verde River. Pro-active long-term water management, armed with credible information on the water needs of the ecosystem, can address and minimize consequences to the ecosystem from various growth and management scenarios before impacts happen. The Verde River Basin Partnership, formed pursuant to Public Law 109-110, Title II, is a collaborative, science-based water resource planning partnership. The VRBP is tasked with preparing a plan that identifies long-term water supply management options for communities in the Verde River Basin. In support of that plan, Title II directs the U.S. Geological Survey to prepare a water budget analysis for the Verde Valley, including “*an analysis of the potential long-term consequences of various water use scenarios on groundwater levels and Verde River flows.*” To be comprehensive, such an analysis must include consequences to the ecosystem resulting from human-induced changes in flow regimes and groundwater levels in various reaches of the river. The intent of the Verde River Ecological Flows study is to develop the science to describe those consequences.

Environmental Flows – A Way to Address Ecosystem Water Needs

In order to understand consequences to the ecosystem of various water use scenarios, it is necessary to understand the hydrology-biology relationships that form the basis for the water needs of the ecosystem. Ecosystem water needs encompass more than consumptive use by riparian vegetation, and include both streamflow regime (magnitude, frequency, duration, and timing of flows) and groundwater conditions (depth to groundwater and annual groundwater level fluctuations). At locations around the globe, water managers and planners are addressing the water needs of river ecosystems proactively by reserving some portion of river flows for ecosystem support, known as environmental flows. Environmental flows are being analyzed and implemented to address both human and ecosystem needs for water, in efforts to minimize future ecological damage. An environmental flow regime maintains, and may even improve, ecosystem health in rivers that have been impacted by human water needs (Dyson et al. 2003).

The Nature Conservancy (TNC) has been working with international experts to develop a collaborative, interdisciplinary, and adaptive framework for developing environmental flows (Richter et al. 2003; Richter et al. 2006). Because there are always conflicting needs for water, it is critical that an environmental flow recommendation have a sound science basis. The purpose of this study was to begin developing that science basis. The decisions of how to apply the knowledge gained – whether to work toward environmental flows on the Verde River – will be part of on-going water management discussions in the Verde River watershed. We do not make policy recommendations herein, but concentrate on the science of delineating the water needs of the Verde River ecosystem.

An early step in developing the science frequently involves experts’ workshops to develop consensus on existing knowledge, ecosystem water needs, and research goals (Richter et al. 2006). In Arizona, this approach was used to analyze ecosystem water needs on the Bill Williams River, with the results used to guide operations of Alamo Dam (Shafroth and Beauchamp 2006; <http://billwilliamsriver.org/Streamflow/>). A similar approach was taken here, modified for an unregulated river.

The Verde River Ecological Flows workshop was facilitated by staff from TNC’s Global Freshwater Team. The workshop provided a forum for synergy among experts, who worked together to define what is well-known and extensively documented, what is understood but little documented, and what is poorly understood. Based on these findings, workshop participants developed a prioritized research agenda,

designed to gather the data to further refine and quantify flow-ecology response models.

Flow-Ecology Response Functions

Plants and animals that depend on aquatic and riparian ecosystems have developed life cycles that are keyed to the natural pattern of streamflows, including intra-annual and inter-annual flow variations (Figure 1-2, Appendix 3). Groundwater levels in floodplain alluvial aquifers are also highly responsive to streamflow regimes. Flow-ecology response functions document these relationships by illustrating how a selected biological variable would be expected to change in response to alteration of a specific hydrologic variable. Developing flow ecology response functions correlates ecological risk, which cannot be managed directly, to streamflow conditions, which can be managed through wateruse policies. Thus, results from an ecological flows study can help water managers integrate human and ecosystem water needs in a spatially comprehensive manner.

An example of a flow-ecology response function is shown on Figure 1-3. There are many biological and hydrological variables that could be selected for developing flow-ecology response functions; experts in the workshop selected the key relationships that they believed to be the most important for the Verde River. Flow-ecology response relationships can first be described in conceptual terms, and relationships can be further quantified as data become available. For certain elements of the Verde ecosystem, such as cottonwood trees, considerable data exist linking recruitment, sapling survival, and growth to streamflows and groundwater levels. Other elements, such as fish, have more complex responses and thus are more difficult to quantify. However, for even the most complex organisms, certain aspects of the life cycle are known and can be documented with respect to flows. The long-term goal of this flow-ecology study is to understand the ecological needs of plants and animals that depend on the Verde River so that human communities can sustainably share the water resources of this beautiful landscape.

Key Science Findings

See the Report in appendix A, *Ecological Implications of Verde River Flows*. Here is a summary:

Key Stakeholder Engagement and Outcomes

The project team (NAU/UA/TNC/Arizona Geologic Survey/Museum of Northern Arizona) has completed the orientation meeting, a literature review, bibliography and background report summarizing the known relationships between the hydrologic and biologic system, and the workshop held May 23-24th, that assembled experts in the Verde or other ecosystems. Attendees refined flow-biology relationship models, identified key information gaps and established a prioritized research agenda. Over the summer, the team prepared the final workshop report in both technical and publicly accessible formats. When funding becomes available from Congress for USGS work with the Verde River Basin Partnership, the findings will be integrated with other studies and Title II reporting requirements.

Conclusions/Implications/Recommendations (including proposed future work and funding)

A Research Agenda for the Future

A major goal of the Verde River Ecological Flows workshop was to identify critical gaps in our knowledge, and to develop a prioritized research agenda to fill those gaps. The experts stressed that data

collection needs to be integrated among the physical and biological science disciplines. Priority research goals include better characterization of the river and its floodplain with representative cross-sections and longitudinal profiles, developing information on the flood stage that can be expected with various flow levels, and documenting depth to groundwater at representative study sites. Biological research priorities include measuring vegetation attributes at the same representative sites, and quantifying fish habitat availability as it relates to stream flow. Results from such integrated data collection should provide the essential platform for quantifying the responses of plants and animals to changes in river flow.

Appendices (e.g. deliverables such as workshop or other report)

*AWI-07-14 Interim Report
Ecological Implications of Verde River Flows*

Appendices