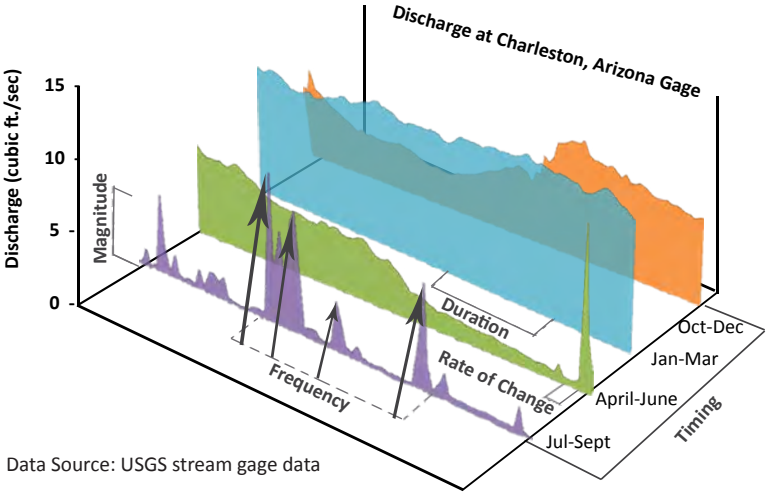
Water Resources Research Center
A University of Arizona Water Resources Research Center Project

Environmental Flows and Water Demands: North/Northeastern Arizona Region

Water is an increasingly scarce resource and is essential for Arizona's future. With Arizona's population growth and continued drought, citizens and water managers have been taking a closer look at water supplies in the state. Municipal, industrial, and agricultural water users are well-represented demand sectors, but water supplies and management to benefit the environment are not often considered. This bulletin explains the water demands of the environment in the North/Northeastern Arizona Region, an area including the Coconino Plateau, Grand Wash, Kaibab Plateau, Little Colorado River, Shivwits Plateau, Paria, and Virgin River groundwater basins.



Data Source: USGS stream gage data

Figure 1. **Elements of Environmental Flow Occurring in Seasonal Hydrographs**

This North/Northeastern Arizona Region bulletin also introduces information essential for considering environmental water demands in discussions about water management. Environmental water demands (or environmental flow) refers to how much water a freshwater ecosystem needs to sustain itself. Arizona's native animals and plants are dependent on dynamic flows, which are commonly described according to five elements: magnitude, duration, frequency, timing and rate of change. For example, seasonal flood events (e.g. timing) and constant flows (e.g. duration) cue important biological events, like reproduction. The five elements of environmental flows are displayed in Figure 1 through a hydrograph of the San Pedro River's flows over the course of a year.

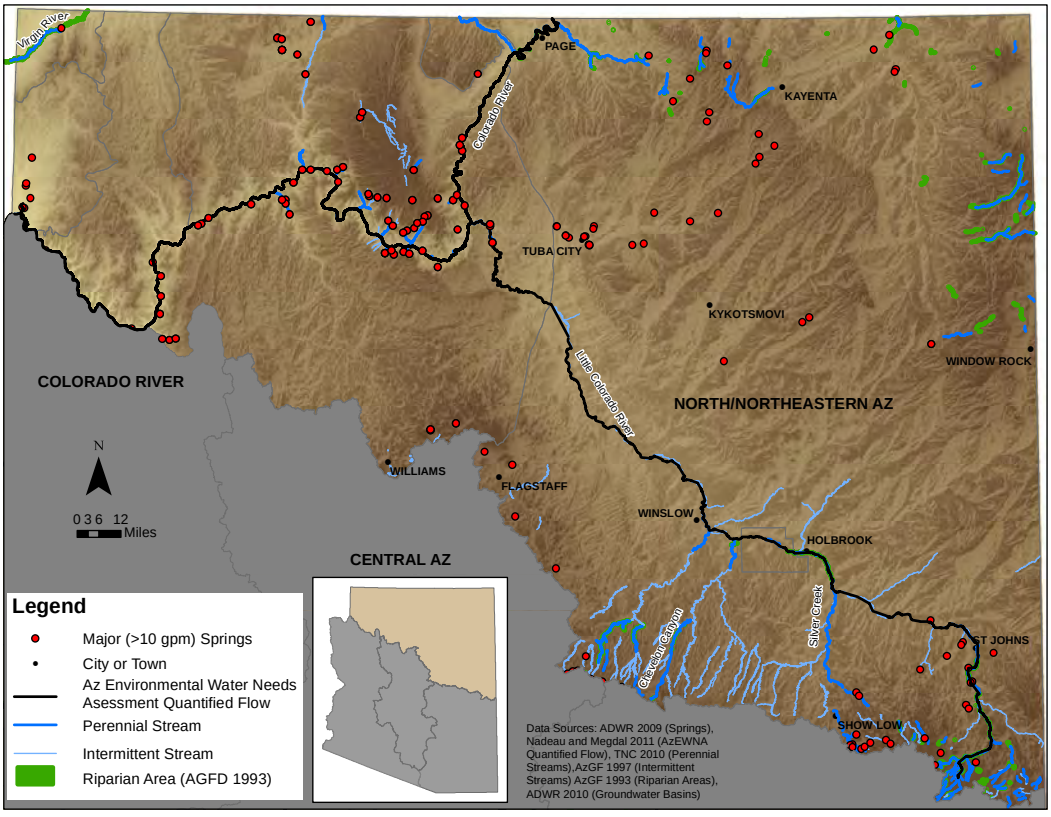


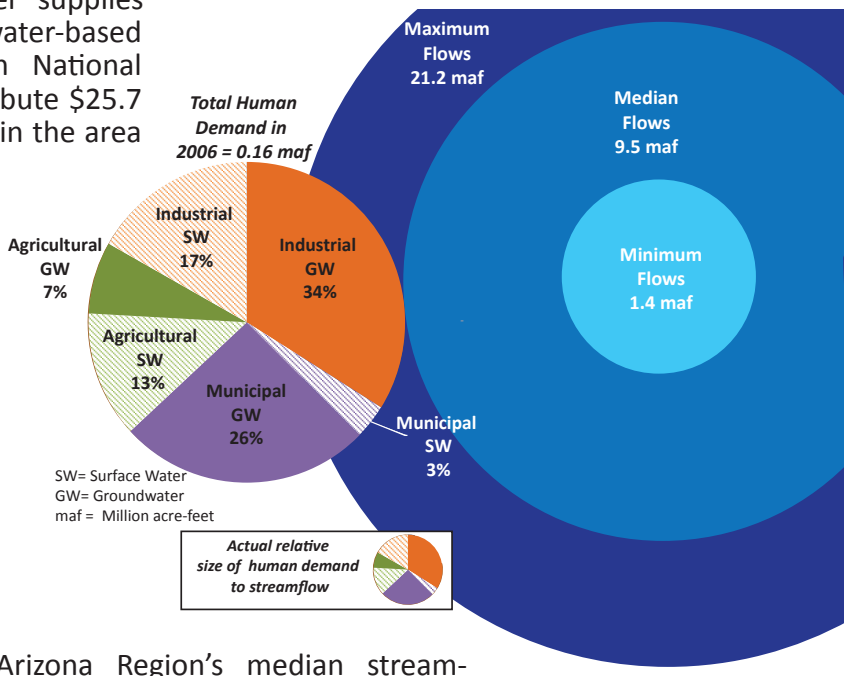
Figure 2. **Streams with Quantified Environmental Demands and Surface Water Resources in the North/Northeastern Arizona Region**

To consider the environment alongside other water sectors, we must first study the water demands of ecosystems. In this region there are no streams where the current amount of streamflow supporting the environment has been estimated. There are, however, two streams where some aspect of environmental water demands has been quantified. The streams with quantified demands (black lines) are shown on Figure 2 in relation to key surface water resources. This region contains perennial (those that flow year-round) and intermittent (those that flow only part of the year) streams, riparian areas, and many major springs.

Humans have an interconnected and dependent relationship with the environment. Nature provides recreation opportunities, economic benefits, and water supplies to sustain our communities. For example, water-based recreational activities in the Glen Canyon National Recreation Area and the Grand Canyon contribute $25.7 million to the economy and support 585 jobs in the area (Bureau of Reclamation 2008).

How water is used in the North/Northeastern Arizona Region is shown in Figure 3 by comparing the relative scale of human water demands by sector to existing minimum, median, and maximum flows available in the environment. The pie chart of human demands (right) reflects the 0.16 million acre-feet annually withdrawn by all sectors (municipal, industrial, and agricultural) by source in the region. Human demand in this region is only a tenth of the minimum annual flows for the gaged rivers in the region.

***Figure 3:* Human Demand and Current Flow in the North/ Northeastern Arizona Region (circle size indicates relative amount of water)**

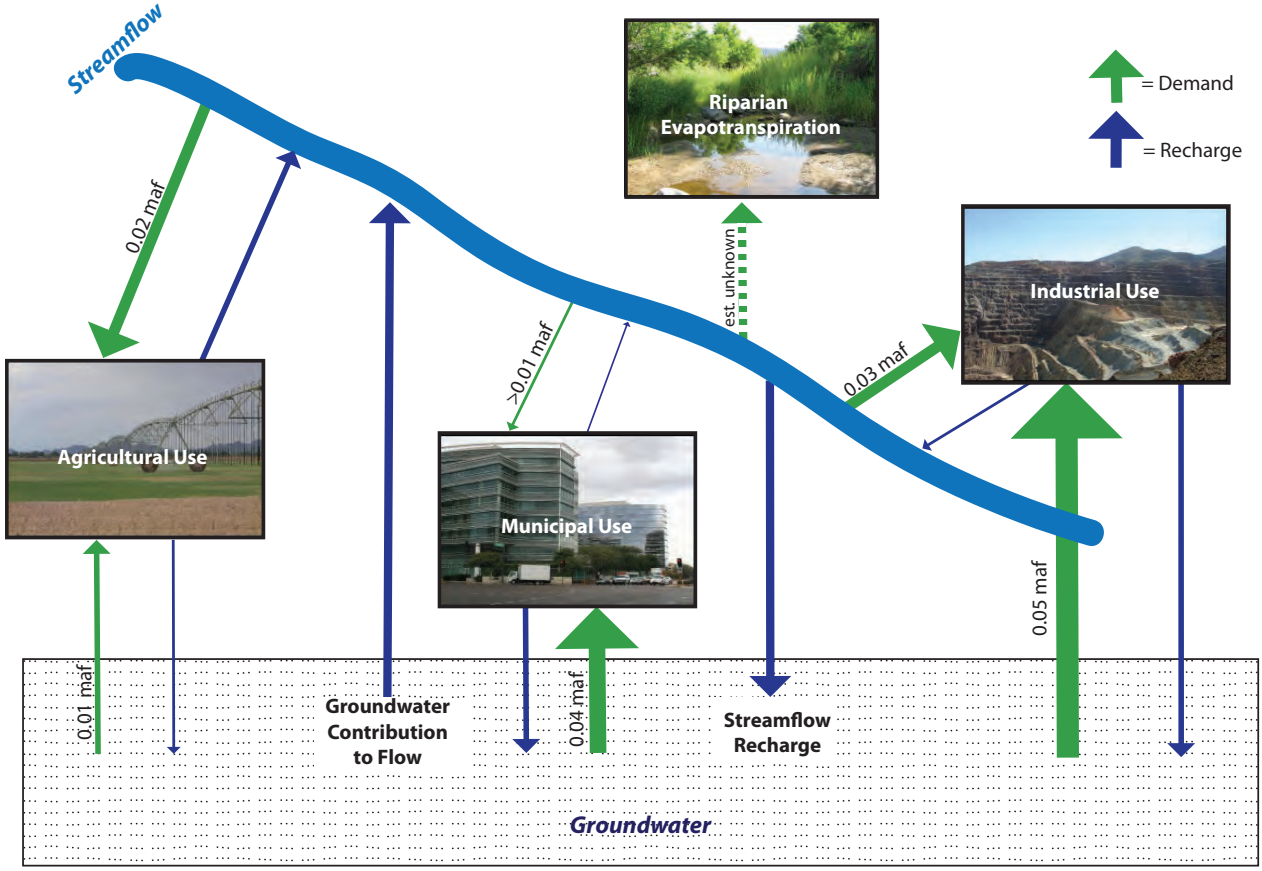


**In 2006 an additional 0.015 maf of effluent was also used to meet demand*

Data Sources: ADWR 2010 (streamflow as measured by stream flow gages), WRDC 2011 (human demand)

Figure 4 shows the North/Northeastern Arizona Region's median streamflow as a single "stream" and how it interacts with groundwater and human demands. Outflows to human and environmental demands are marked by green arrows, while flows into the environment are represented by blue arrows. Note that all human sectors return some water to the environment after use. Also, water traveling through a river to uses downstream can support aquatic and riparian (streamside) ecosystems along the way. These connections between environmental and human demands can create opportunities for water management that is mutually beneficial.

***Figure 4:* Water Demand and Use in the North/Northeastern Arizona Region (Arrows indicate relative size of demand and recharge)**



Data Source: WRDC 2011

In the North/Northeastern Arizona Region more stream reaches have intermittent flow (57%) than perennial flow (43%). In this region 25% of all stream reaches have been studied: 42% of all perennial and 13% intermittent stream reaches (see Table 1a). There are 14 known studies (11 quantitative and 3 qualitative) in this region that characterize some aspect of environmental water demands. These studies provide information on the flow velocity, water quality, and duration of floods needed to support native species.

***Table 1a*: Data Coverage for Flow Demands in North/ Northeastern Arizona Streams**

% Area Perennial/ Intermittent	% Total Studied	% Perennial Streams Studied	% Intermittent Streams Studied
(Miles)			
43%/57% *(1120/1470)*	25% *(660)*	42% *(475)*	13% *(185)*

Table 1b categorizes available information for the Colorado and Little Colorado Rivers, the only streams in the region with environmental flow information, by the elements of flow that have been studied. Although both rivers have been studied for most or all of the five flow elements, these studies focus on the responses of a few species to multiple components of flow alteration. No study in this region addresses the flow demands and responses for the whole ecosystem. Ten of the 11 quantitative studies in this region examined multiple species' needs, and 4 of the 11 quantified both environmental flow demands and ecological responses to flow. Only one study, on the Colorado River, fully describes the flow volumes needed to maintain riparian ecosystem function. Based on flow experiments conducted in the Grand Canyon, high flows at the level of 77,700-88,300 cubic feet per second (cfs) lasting 3 or fewer days are recommended for regeneration of riparian vegetation (Kearsley and Ayers 1999).

***Table 1b*: Flow Components Studied and Information Gaps for Perennial Streams in the North/Northeastern Arizona Region**

River Name	Magnitude	Duration	Frequency	Timing of Flow	Rate of Change	Water Quality*
	(% of the Stream Reach Studied)					
Little Colorado River	S	S	S	S	S	S
Colorado River	S	S	NS	S	S	S

* Does not include studies of water quality alone, these studies were not reviewed for this report. S = Entire stream surveyed, S = Reach (% of stream surveyed), NS = Not surveyed

Data Source: Nadeau and Megdal 2011

Official designations by the state and/or federal government are made to protect stream reaches with high environmental values. These designations include Wild and Scenic Rivers, Instream Flow Permits and Applications, Arizona Department of Environmental Quality Unique Waters, Endangered Species Act Critical Habitat, and Federal Conservation Lands such as National Forest Wilderness or National Parks. A few stream reaches, such as on the Virgin River, have multiple designations (see Figure 3 for the number of designations on stream reaches in this region). Having many designations on one reach can be an indication of an area with significant environmental resources. Different designations provide different types of protections for environmental flows, but having three designations does not necessarily mean the reach is better protected than a reach with one designation.

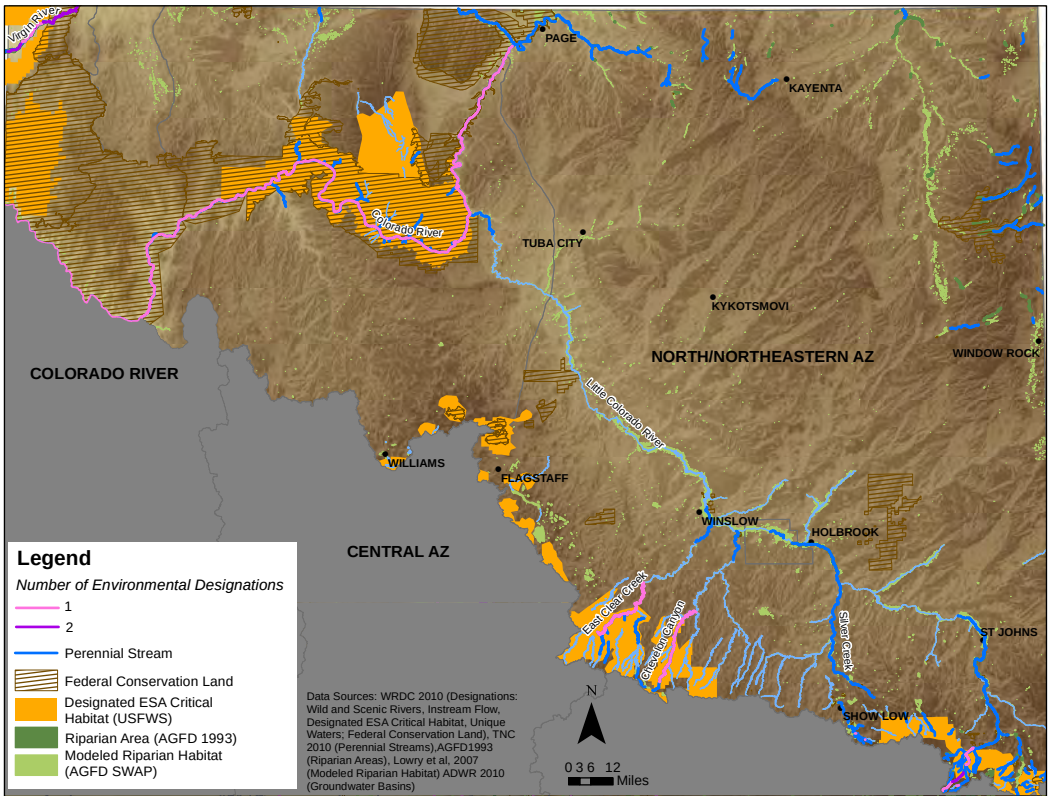


***Figure 3:* Environmental Resources and Designations in the North/Northeastern Arizona Region**

Statewide, ecosystem-level flow requirements remain poorly understood. Small scale studies that prescribe flows for a single reach exist for some areas, but cannot be applied across basins or regions. Two areas of agreement have emerged from studies done across the state: (1) riparian areas need both access to sufficient groundwater and carefully-timed flood flows to maintain water levels for established plants and for new plant growth; and (2) change to any element of flow can impact Arizona's aquatic and riparian ecosystems if flows are altered beyond the range of tolerance of native species.

Little Colorado River near Greer, Arizona Photo Credit: Arizona Department of Water Resources

The North/Northeastern Arizona Region has a wealth of natural resources in its streams, springs, and riparian areas, however, only two streams have been studied and only one study in the region fully describes the flows necessary to maintain riparian function. Overall, water demands of the environment in this region are not well understood.

Information available in the region on the relationships between components of flow and biological factors can be used for considering potential impacts of future water decisions. By comparing various environmental flow demands, such as species-specific water demands, with current conditions, areas needing protection or restoration can be identified. These pages present a brief overview of the information available for the North/Northeastern Arizona Region; more detailed information to help inform planning efforts throughout this region is available by contacting the WRRC.

How you can apply this information

Those working to address the demands of all water sectors in Arizona can apply this information to:

- Determine how environmental flows interact with other demand sectors regionally,
- Identify factors putting environmental flow demands at risk,
- Identify studies needed to address key information gaps about environmental flows,
- Determine local priorities for ecosystems, and then identify water needed to preserve or restore those,
- Develop scenario analyses for water planning that incorporate the environment, and
- Share the information widely to increase understanding of regional resources and challenges.

Contact Info

For assistance applying information about environmental water uses and needs in water planning, questions about methods used to create this bulletin or requests for our environmental water demand data please contact:

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The WRRC offers public presentations about this information as well as direct support for water planning processes as part of our Connecting the Environment to Arizona Water Planning (EnWaP) project.

wrrc.arizona.edu

Water Resources Research Center

The University of Arizona. College of Agriculture and Life Sciences

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