

# Mapping Agricultural Water Governance in the Colorado River Basin

Faith Sternlieb, Ph.D. Candidate, Geosciences, Colorado State University

Melinda Laituri, Department of Ecosystem Science and Sustainability, Colorado State University

## Introduction

Emerging cooperative arrangements for water use, development, and conservation in the Colorado River Basin (CRB) indicate changes in both the political and environmental climate. These arrangements are geographically taking shape at the intersections of hydrologic, political, and social boundaries. Water agencies and organizations (e.g. private/public, national/local, governmental/non-governmental, etc.) are struggling with ways to address these complexities and, as a result, are creating new rules and arrangements that necessitate new datasets and visualization techniques. Agricultural (Ag) water supply organizations are central actors in new arrangements because they hold 70-80 percent of the water rights. In order to better understand these new rules and arrangements and how they affect Ag water supply organizations, the development of a geospatial database will facilitate the analysis of linkages between sectors and political jurisdictions at multiple scales that intersect with hydrologic adaptations throughout the basin. These intersections will identify locations where strategic arrangements with Ag already exist and where new arrangements may flourish.

This paper describes the process, evolution, and continued development of a basin-wide geospatial database describing agricultural water governance (complimentary to the project “Addressing Water for Agriculture in the Colorado River Basin,” this issue). For the purposes of this article, Ag water governance is the interface between Ag, hydrological, and human systems where formal and informal policies, rules, and

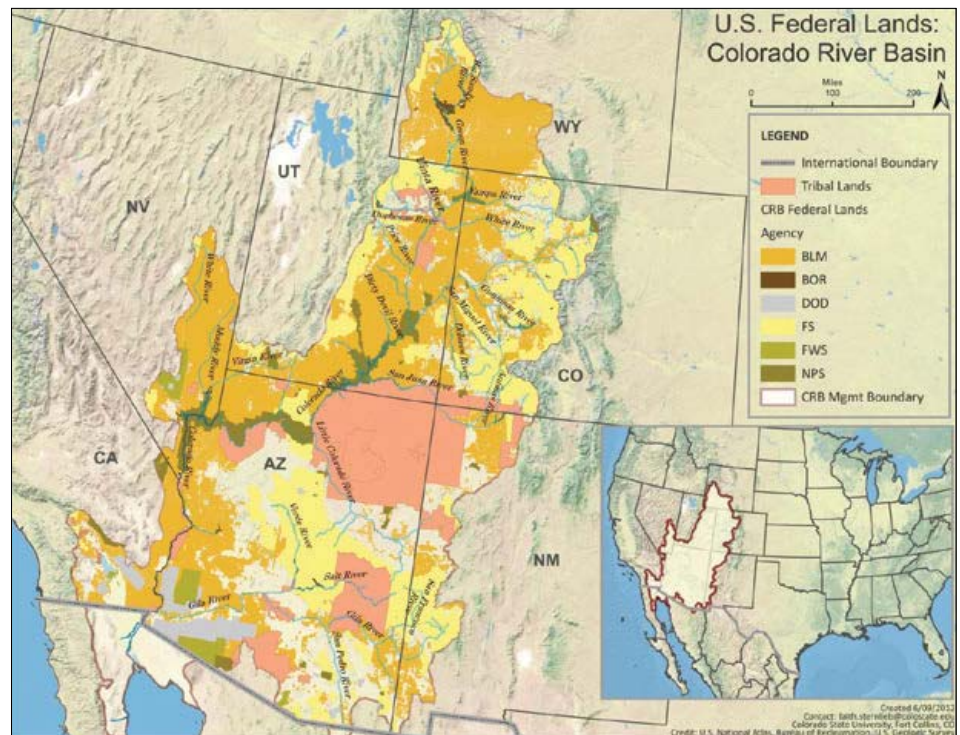


Figure 1. This map layout demonstrates U.S. Federal and Tribal Lands in the Colorado River Basin overlaid on a topographic basemap.

practices shape human interaction with the environment. The Colorado River Basin Agricultural Water Governance database is an effort to collect data about governance and heighten awareness about the changing circumstances of decision-making about water for Ag in the CRB. The aim of this project is to compile data for the entire CRB in one place to provide an online clearinghouse that will inform stakeholders, water users, and decision makers about Ag water in the basin.

## Geography

The CRB encompasses seven U.S. states (Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming), two Mexican states (Baja California and Sonora), and at least 43 U.S. tribes (not including Mexican indigenous tribes). The Colorado River boundary in Figure 1 is defined by the

Bureau of Reclamation. The length of the Colorado River when measured from the Green River, Wyoming is 1,700 miles (2,736 km) long or 1,400 miles long when measured from Rocky Mountain National Park (43°09'13"N 109°40'18"W) to the mouth of the Gulf of California otherwise known as the Sea of Cortez (31°39'N 114°38'W). The drainage basin encompasses an area of 246,000 square miles (637,137.08 square km). The hydrology of the river is highly controlled through a series of dams and reservoirs which harnesses water for energy, consumptive, and non-consumptive purposes in the basin. Ninety percent of native in-stream flows originate from snowmelt of the Green (Wyoming), Gunnison and San Juan Rivers (Colorado). The current average flows are estimated at 14.7 million acre feet, and the total storage capacity is at 60 million acre feet. The majority of

Table 1. Federal agencies and their classifications under the Department of the Interior (DOI) that own and administer land in the Colorado River Basin: Bureau of Land Management (BLM), Bureau of Reclamation (BOR), Department of Defense (DOD), the Forest Service (FS), Fish and Wildlife Service (FWS), and the National Park Service (NPS).

DOI Agencies	Federal Lands Classification	Area in Miles <sup>2</sup>	% of Land in the CRB*
BLM	National Conservation Areas, National Monuments, National Recreational Areas, Public Domain Land, Wilderness, Wilderness Study Areas	82,920	34%
BOR		1,173	< 1%
DOD	Air Force, Army Corps of Engineers, Marine Corps, Navy	5,596	2.3%
FS	National Forests, National Recreation Areas, Wilderness, Wilderness Study Area	47,014	19%
FWS	National Wildlife Refuges, Wilderness	3,739	1.5%
NPS	National Historic Parks, National Historic Sites, National Memorials, National Monuments, National Parks, National Preserves, National Recreation Areas, Wilderness, Wilderness Study Areas	8,805	3.5%
	<b>TOTAL</b>	<b>149,247</b>	<b>60.8%</b>

\* These percentages are based on the Bureau of Reclamation Colorado River Basin management boundary, obtained from the BOR Lower Basin Office, which includes the Mexican portion of the basin. The area is estimated to encompass 246,000 mi<sup>2</sup>.

Table 2. Due to the complexity of overlapping jurisdictional boundaries in the Colorado River Basin, identifying boundary types and governance layers clarifies how decisions are made and who is affected by those decisions.

Boundary Type	Governance Layer	Description
Physical	Hydrologic Unit Code	Based on natural drainage systems defined by the National Hydrology Dataset (USGS)
	Hydrographic	Based on drainage basin delineated by each state and tribe
Administrative	Legislative	Based on federal, state and tribal laws and policies
	Judicial	Based on U.S. Federal, District and Appellate Court system
	Political	Based on governmental jurisdictions (federal, state, tribe, county, municipality, city)
Sector	Agricultural Water Supply Organization	Based on state statute and organizations' bylaws

outflows include trans-basin diversions (San Juan Chama, Central Utah Project, NCWCD/Big-Thompson, Colorado River Aqueduct/All American Canal, Fryingpan/Arkansas) and evaporation from major reservoirs.

The majority of land (60.8 percent) in the CRB is owned and administered by the U.S. federal government and under the jurisdiction of the Department of the Interior (DOI) of federal agencies (Figure 1, Table 1).

Tribal lands constitute 16 percent or 40,462 square miles (104,797 square km) of the CRB and are federal lands that are overseen by the Bureau of Indian Affairs (BIA) but administered independently as sovereign nations by the respective tribal governments. Although farmers and ranchers depend on the federal lands for grazing their livestock, all of the farming and Ag production takes place on the remaining private lands. The federal agency that has the largest presence in the CRB for water supply is the Bureau of Reclamation. In light of their water management responsibilities, the bureau holds the least amount of land (less than one percent).

## Geospatial Database Development

The geospatial database is currently under development. Much of the spatial data for the CRB is accessible online but is dispersed on the internet through various non-governmental organizations and governmental agencies. In addition, some of the data may or may not be available for download and/or viewed. Challenges in creating such a geodatabase include data collection and compilation from multiple sources (some of which are private and hold proprietary information) at multiple scales and for different purposes. Compounding the challenges are the different types of data such as satellite imagery, paper maps, historical records, and field data collection, as well as techniques used to collect data including global positioning systems, surveying instruments, and photogrammetry, among others. Finally, data collection at a coarse versus fine resolution, disparate standards for metadata, and minimal coordination in data collection efforts make it difficult to mainstream datasets.

The spatial data is organized in "governance layers" which describe physical and administrative jurisdictions as well as jurisdictions



that are socially and/or hydrologically organized. Governance layers are defined by two key components: 1) mandated or naturally occurring geographic boundaries and 2) decisions made based on those boundaries. Each governance layer may be represented in a geospatial database by a geospatial file. Each jurisdiction is governed by distinct rules, actors, and cultural, social, and behavioral codes. By overlaying governance layers in a geographic information system (GIS), jurisdictions overlap, affecting multiple levels of decision-making. Governance layers describe the complexity of water governance in the CRB because they demonstrate overlapping organizations and arrangements as well as the norms and behaviors of actors who have different and sometimes opposing claims in the use, management, and development of water resources.

Special districts such as Ag water supply organizations are central to water development in the CRB. Such service and supply organizations can be classified in two types: 1) private owned by shareholders, and 2) public, which are federal, state, or quasi-governmental. Private Service and Supply Organizations are water utilities, mutual water companies, carrier ditch companies, and mutual ditch and irrigation companies. Public Service and supply organizations are municipalities, irrigation districts, conservancy districts, conservation districts, reclamation districts, water control districts, fresh water supply districts, and municipal water districts. “Water supply organizations such as irrigation and conservancy districts are formed primarily to raise revenue (by property taxation and bond sales) and to construct and operate irrigation projects. Some [organizations] contract with the federal government to administer government-financed reclamation projects” (Getches 2009, p. 453).

Data collection has become more prevalent, and an increasing number

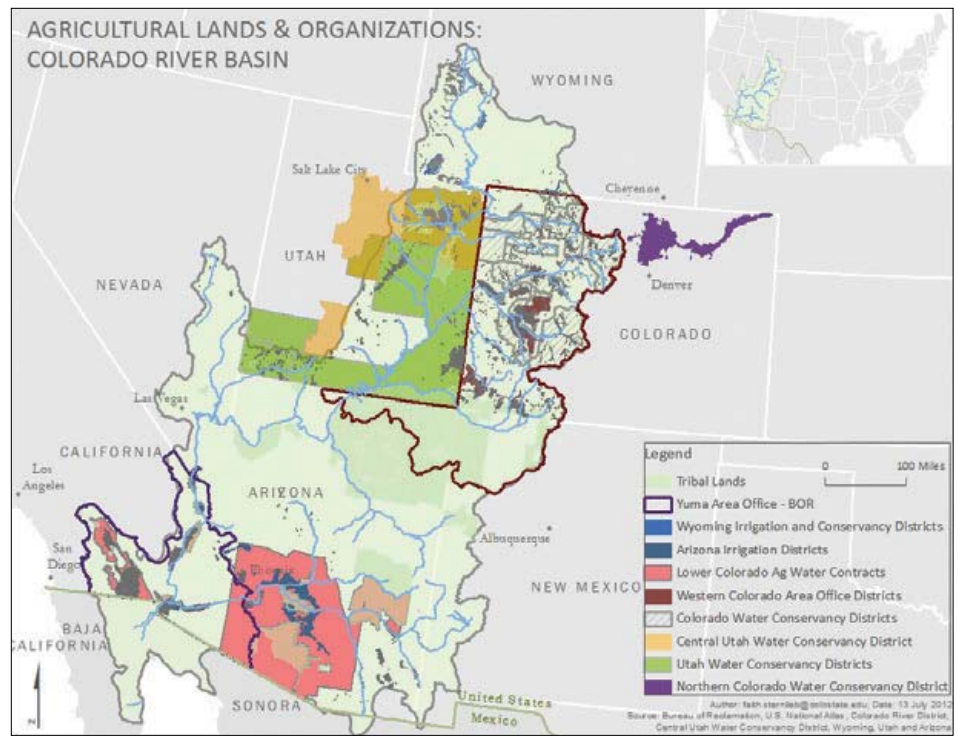


Figure 2. Irrigated and agricultural lands overlaying Ag water supply organizations in the CRB. Ag water supply organizations represented are those that have: a) contracts with the Bureau of Reclamation, b) subcontractors for Colorado River water through Bureau projects (e.g., irrigation districts that have subcontracts for Central Arizona Project water), or c) entities responsible for water supply through state legislature (e.g. Water Conservancy Districts in Utah).

of organizations are collecting data and producing reports, resulting in fragmented datasets. This is especially true in the CRB. Data have been collected continuously from different governmental agencies, CRB states, Ag water supply organizations, and non-profit organizations, as well as local public and private entities. This data collection exercise has been conducted in parallel with The Nature Conservancy-funded project discussed in this issue. Geospatial data includes:

- Hydrologic boundaries defined both by state and by hydrologic unit
- Boundaries for Ag water jurisdictions within the basin including but not limited to Bureau of Reclamation projects (including infrastructure), irrigation districts, water conservancy districts, conservation districts (relating to water management and administration), water users associations, and private irrigation and ditch companies

- Boundaries that demonstrate environmentally sensitive areas such as salinity control areas, wild and scenic stretches of the Colorado River and tributaries, and areas where endangered species are of concern or are actively being protected

Spatial data in the database also includes governance layers describing Mexican jurisdictions. In addition, we are in the process of integrating data on Ag and irrigated lands collected as part a project of The Nature Conservancy in collaboration with CSU (see article on Ag lands in the Colorado River Basin in this issue) and the Geospatial Centroid. Data on Ag water supply organizations together with Ag lands are being compiled to create one comprehensive geospatial database for the CRB (Figure 2).

## Future Research

The Agricultural Water Governance project on CRB and The Nature Conservancy’s project on irrigated

Ag in the CRB combine two datasets that have never before been created. To demonstrate this dataset, an interactive geospatial database is under development. The aim of compiling this dataset is to capture Ag water supply organizations that use Colorado River water and deliver the information through a basin-wide database accessible to water users. The breadth,

depth and purpose of the database are dependent in part on the contributions and sharing of information and data by Ag water users in the CRB and will be useful to them as the water landscape in the CRB changes. Complimentary information about Ag water supply organizations including water rights, contracts, and federal and state policies will be collected and compiled to add

value to the dataset. Representing this information spatially will complement the water quality/availability data that has been collected, processed, and made available. The best available data has been collected. If you are interested in more information about this project or would like to include your data in this database, please contact Faith: [Faith.Sternlieb@colostate.edu](mailto:Faith.Sternlieb@colostate.edu).

## Upper Yampa Scholarships Announced

The Upper Yampa Water Conservancy District John Fetcher Scholarship provides financial assistance to a committed and talented student who is pursuing a water-related career in any major at a public university within the state of Colorado. Congratulations to this year's scholarship recipients, Tyra Monger and Benjamin Von Thaden.

### Tyra Monger

- University: Colorado Mesa University
- Anticipated Graduation: 2014
- Major: Environmental Science and Technology
- Areas of Interest: Watershed

“Being raised on a cattle and hay ranch outside of Hayden, I understand the value of water. I also have understood and been schooled in the value of being a great steward of the land/water. Once I have graduated from Colorado



Mesa University, I am hoping to find a career working in Colorado. Being an outdoors person and being able to maintain the environment have been my lifelong dreams. Currently I am an Environmental Science/Technology major with a Watershed minor. I believe that these programs will become an ever more important field of study to our country and economy. One of the hopes for my future is to return to Routt County to volunteer to further nourish 4-H programs. 4-H provides skills to young adults that can be used throughout their lives as they fulfill their careers. I hope to also be able to help on my family ranch.”

### Benjamin Von Thaden

- University: Colorado State University
- Anticipated Graduation: 2013
- Major: Watershed Science
- Areas of Interest: Water quality monitoring, snow hydrology, water allocation, climate change, and water-related recreation

“I feel very privileged to have been raised in Routt County and I can definitely see myself living and working in the Yampa River Basin in the future. In 2009 I participated in a Tamarisk removal trip on the Yampa River through Dinosaur National Monument. The trip was very eye opening for me and I would like to do more work, and possibly research, in the fight against invasive species such as Tamarisk and Russian Olive in the Colorado River Basin. After I graduate I plan on joining Engineers Without Borders and traveling around South America to help create better access to safe drinking water and improve sanitation. When I was a sophomore at the Lowell Whiteman School I traveled with the school to Bolivia for my foreign trip. As a service project my group installed a water filter, utilizing rocks, gravel, sand, clay, and silt, to provide safe drinking water to a small village close to Rurrenbaque, Bolivia, in the Amazon



Basin. It was an amazing experience to help these less-fortunate people by providing safe drinking water, and I feel I have an obligation to participate in similar projects in the future, hopefully on a larger scale. I have learned that water-related problems are often times very complex and do not have a simple solution, but require collaboration between many groups and industries. While I am not sure of the exact direction that my career will take, I am very excited about having a career in the water industry.”