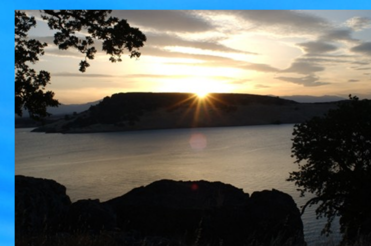
IWR Institute for Water Resources

United Nations Educational, Scientific and Cultural Organization

International Center for Integrated Water Resources Management under the auspices of UNESCO

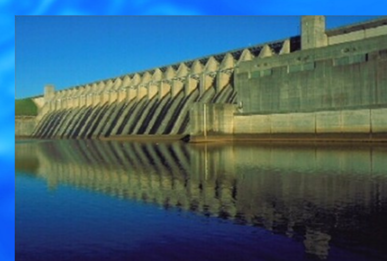
December 2014

Aspects of Governing Water Allocation in the U.S.



Report Prepared for

Agência Nacional de Águas



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2014-R-04

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The Institute has several satellite centers: The Hydrologic Engineering Center (HEC), located in Davis, CA which specializes in the development, documentation, training, and application of hydrologic engineering and hydrologic models; Navigation and Civil Works Decision Support Center (NDC) and its Waterborne Commerce Statistical Center (WCSC) in New Orleans, LA, which is the Corps data collection organization for waterborne commerce, vessel characteristics, port facilities, dredging information, and information on navigation locks; and the Risk Management Center (RMC) located in Denver, CO and Pittsburgh, PA whose mission is to manage and assess risks for dams and levee systems across USACE, to support dam and levee safety activities throughout USACE, and to develop policies, methods, tools, and systems to enhance those activities. Two other enterprise centers at the Institute's NCR office include the Conflict Resolution and Public Participation Center of Expertise (CPCX) which focuses on both the processes associated with conflict resolution and the integration of public participation techniques with decision support and technical modeling and the International Center for Integrated Water Resources Management (ICIWaRM).

ICIWaRM

ICIWaRM, under the auspices of UNESCO, was established by IWR in 2007 in collaboration with U.S. institutions, various Universities, and non-Government organizations sharing an interest in the advancement of the science and practice of integrated water resources management (IWRM) to address water security and other water-related challenges around the world by regional and global action, through new knowledge, innovative technologies, collaborative interdisciplinary scientific research, networking, training and capacity development."

ICIWaRM was formalized as a United Nations Educational, Scientific and Cultural Organization (UNESCO) Category 2 water center in October 2009 with the signing of an agreement between the U.S. Government and UNESCO. The designation greatly facilitates ICIWaRM's ability to engage the UNESCO water family, serving as a focal point for increasing U.S. contributions to the International Hydrological Programme (IHP).

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Institute for Water Resources

Water Allocation in the U.S.

Report Prepared for Agencia Nacional de Aguas

in accordance with a 2013 ANA-USACE Agreement Component,

Regulatory Aspects, Task 4, Document 4.1, Technical Report

with emphasis on "Water Rights as a Commodity"

Edited by Maria T. Lantz, Elizabeth C. Bourget, and Joe D. Manous, Jr., PhD

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Disclaimer

The description of the laws and issues contained in this report are for informational purposes only and do not reflect the formal position or legal determination of the United States with respect to any matter discussed herein. USACE intends that the select information provided in this report will promote and facilitate education and communication regarding the challenges of water management. Nothing in this report, however, is intended to represent any position of the Federal government in any administrative, judicial or other proceeding to evidence any legal or policy interpretation. As such, statements contained in this report do not, and shall not, represent a legal position or interpretation by the U.S. Federal government.

Contents

Acknowledgements and Authorship

This report was prepared under the auspices of the U.S. Army Corps of Engineers, Institute for Water Resources (IWR)**.** Special thanks are due to the following invited authors:

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The report was prepared in English units of measurement. Approximate metric conversions have been added to provide a sense of scale for the intended international audience, but in all instances the English units are authoritative.

Preface

The country of Brazil is confronting significant and increasing water resources challenges. Decreasing water availability and competing demands on water are placing increased pressures on state and national governments to more effectively manage available water resources.

An agency charged with management and sustainable use of water resources at the national level is the Agência Nacional de Aguas (ANA). Created in 2000 to help implement a new national water policy and system of water resources management, ANA continues to investigate ways to improve the planning, monitoring, allocation, and regulation of Brazil's water resources. As part of that effort, ANA requested assistance from the U.S. Army Corps of Engineers (USACE) through a government-to-government agreement on several water resources planning and management topics.

One of these requests was a summary of U.S. water allocation policies. USACE’s Mobile District, as project manager of ANA’s request for USACE assistance, passed this request to the Institute for Water Resources (IWR) to develop a response. The following report is the result.

Since surface and ground water allocation in the U.S. is managed at the state level, the methods used in the U.S. vary between each state and territory. As a result, the following report does not attempt to provide a holistic report or assessment of U.S. water allocation policies, but rather describes the two dominant philosophies guiding U.S. water allocation: riparianism and prior appropriation. Using these philosophies, individual state water allocation practices (e.g., monitoring, allocation, regulation, etc.) within watersheds of interest to ANA were reviewed to provide notable water allocation examples from different parts of the country.

While the examples selected for this report were chosen to address situations of likely interest to Brazil, the substance of the report is not specific to Brazil, and as such may be of interest to others experiencing challenges in water allocation. For this reason, this report is being made available to the broader international community through IWR’s UNESCO-affiliated International Center for Integrated Water Resources Management (ICIWaRM).

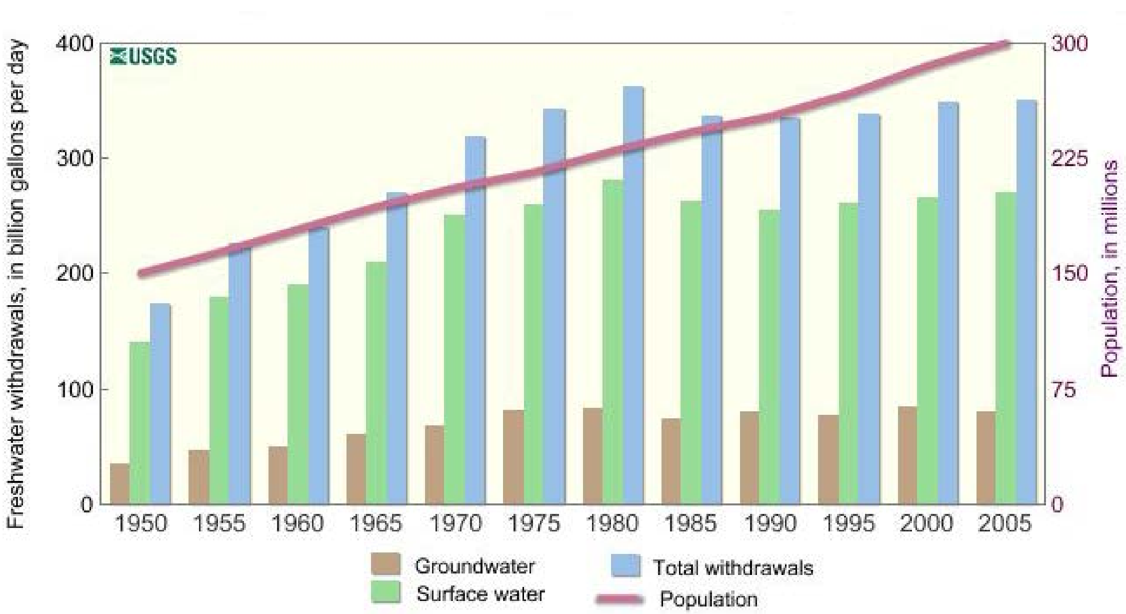
1. INTRODUCTION

1.1 Overview and U.S. Facts and Figures

In the United States, water availability and demand are becoming increasingly important issues. Responding to changes in the nation's demographic, economic, and political landscapes, water resources managers are adjusting water management practices in ways that address changed priorities, physical conditions, consumption rates, and allocations. These changed practices are underscored by an evolving set of legal, institutional, and technological conditions.

In 1950, the federal government began to regularly compile data on freshwater withdrawals. These records indicate that, between 1950 and 1980, withdrawals increased with national population size; however, despite steady population growth after 1980, water withdrawals have remained relatively stable (see Figure 1). This stabilization has been attributed to more efficient uses of water resources.

Figure 1 Water Use in the United States, 1950-2005[1]



Source: U.S. Department of the Interior (2013).

Today's U.S. population is approximately 317,941,000 (U.S. Census Bureau, 2014), and the mean center of population continues to shift south and west (U.S. Census Bureau, 2010) toward the country's more arid regions. As of 2005, approximately 349 billion gallons per day [approximately 1.32 million ML/day] of fresh water are withdrawn (Kenny et al., 2009); major uses include thermoelectric power generation (primarily for once-through cooling at power

[1] Available online at http://water.usgs.gov/edu/wateruse-trends.html, along with other U.S. information.

plants), 41%; irrigation, 37%; and public water supply, 13% (Kenny et al., 2009). Fresh surface water sources provide most of the water for public water supplies, irrigation, aquaculture, thermoelectric, and industrial withdrawals, with nearly 30% of total fresh surface-water withdrawals occurring in five states: California, Colorado, Idaho, Illinois, and Texas (Kenny et al., 2009). Most fresh groundwater withdrawals are for irrigation (67%) and public water supply (18%), with more than 50% occurring in six states: Arkansas, California, Florida, Idaho, Nebraska, and Texas (Kenny et al., 2009).

Different levels of government (federal, state, local) all manage U.S. waters, with states having jurisdiction over waters lying entirely within state boundaries. However, several public and private organizations manage water at local levels including municipal water departments, water and sewer districts, levee and flood-control districts, and mutual ditch and irrigation companies. Types of regional water agencies include irrigation, natural resources, conservation, and groundwater districts. Overall, water management is a coordination challenge, given the multitude of differing state approaches, the differing legal frameworks states employ, and the host of governmental and non-governmental entities involved. Even at the federal level, there is no formal coordinating platform, and agencies share information and coordinate through innumerable ad-hoc committees and task forces.

1.2 Report Content and Organization

This report reviews the widely varying and fragmented approach to governing water allocation and reallocation, drawing lessons from diverse experiences and providing references for more detailed consideration. In this report, governance of water allocation refers to a hierarchical legal and administrative system for determining the share of water that each water-using entity (states, federal agencies, tribes, power authorities, farmers, municipalities, industries, environment, etc.) is entitled to, under a variety of conditions. Priorities of use are often determined legally in the event of droughts and other catastrophes – usually giving precedence to municipal water users, irrigators and industry in that order. Once allocation rules have been determined, the administrative arms of government regulate adherence to these rules by monitoring and enforcing the water allocation shares for each sector, both in terms of quantity withdrawn and discharged, as well as quality.

The report was prepared under the auspices of the U.S. Army Corps of Engineers (USACE), Institute for Water Resources, to provide information and observations concerning U.S. water allocation and its regulation for consideration by Brazil’s Agência Nacional de Águas (ANA). It is part of a larger delivery of information and assistance to ANA. The report focuses on aspects of the U.S. water experience that were identified in an agreement and subsequently refined during written exchanges and discussions with ANA staff (see Appendix 1). The report addresses administrative, regulatory, and market-based processes for allocating water especially in times of scarcity and the larger U.S. context in which these processes take place. This report provides a sampling of the U.S. experience at a high level while providing specific examples to demonstrate particular, on-the-ground application.

Section 2 describes U.S. water law and allocation at the federal level. It describes the federal government's interest in water, provides a summary of agencies with a significant role in managing inland water resources, and highlights specific federal agencies with water rights and allocation responsibilities.

Section 3 reviews water law and allocation at the state level. Policies, institutions, and allocation processes within states are described. Two dominant legal systems for water allocation have evolved in the U.S.: one in the more humid eastern half of the continent and the other in the more arid western states. These two legal systems have profoundly affected water rights, use, and allocation. Section 3 describes this bifurcated evolution and explores its implications, including market-based water transfers.

Section 4 examines water allocation among states, a formidable challenge in a country where most major river basins cross one or more state or international boundaries. This section reviews 22 interstate water allocation compacts, examines specific allocation mechanisms and formulas, and considers the specific administrative arrangements established to carry out the compacts. Section 4 also provides lessons and offers recommendations. Important questions to address when designing an interstate water allocation mechanism are included. Appendix 2 summarizes information regarding the various compacts.

The three case studies on the Delaware River Basin, the Colorado River Basin, and the Columbia River Basin were chosen for their diversity, their representation of different levels of water management, and to highlight specific areas of experience relevant to ANA. Two case studies are in the arid west and fall under the doctrine of prior appropriation, while the third is in the more humid east and follows the doctrine of riparian rights. The three case studies provide differing perspectives regarding legal, institutional, and financial water allocation arrangements. Interstate and state-local coordination mechanisms are also described. Two case studies showcase out-of-basin water transfers, and two highlight market-based approaches to reallocating water.

The first case study (Section 5) examines the Delaware River Basin, selected for its eastern (humid) location, court-ordered water allocation formulas, and broad water management focus. The commission responsible for implementing the compact includes federal and state members and provides space to address specifically assigned responsibilities and a forum to address broader communication and coordination issues beyond its mandate. The case study describes the commission's permitting program, designed to avoid substantial impairment or adverse impacts on the basin's water resources, including: groundwater protection, pollution discharge, and wastewater discharges. It also describes a fee-based water supply program that provides a revenue stream to the commission, water conservation initiatives, and a drought management program. It details the circumstances leading to, and management of, large out-of-basin transfers, as well as agreements to revise water allocations to meet a variety of purposes, including water supply and fisheries habitat. Finally, this case study examines the management of the New York City water supply system, which relies on Delaware River Basin water and natural processes to maintain water quality. Specific watershed management approaches, stakeholder relationships, planning considerations, and technical tools to support decision-making are discussed. The case study thus illustrates a large-scale diversion of water out-of-basin and evolving management of that diversion. New large-scale diversions are now much rarer than in the past, given more stringent environmental requirements and numerous other concerns.

The second case study (Section 6) focuses on the Colorado River Basin, an arid region with high and increasing water demands, enormous storage opportunities, and projected water shortages. A long-standing compact (1922) delineates fixed water allocations among upper and lower basin states, and subsequent legal instruments apportion water among states within the upper and lower basin on both fixed and proportional bases. The case study describes the differing circumstances leading to proportional or fixed allocations, examines their relative advantages and disadvantages, and offers observations and insights. Institutional structures and operational practices for various federal-state, interstate, and state-local water management arrangements within the basin are discussed. To address disconnects between water availability and population-driven demand, these institutions have pursued additional water sources through means such as conservation or agricultural-to-urban transfers, interstate water banking through groundwater storage, and trans-basin water allocations. Section 6 also describes the operation of a local water market within a public irrigation district, the district's role in establishing annual availability, and influences on share prices and water value.

The third case study (Section 7) describes how Canada and the United States manage the waters of the Columbia River basin for mutual hydropower and flood control benefits. Dispute resolution mechanisms and environmental impacts are also discussed. The case study examines provisions made to address future changes, potentially to the Columbia River Treaty itself. Detailed planning efforts by both countries consider evolving demographic, economic development, and environmental circumstances, including climate change. The case study also describes how Oregon allocates water. The state has implemented permitting processes that allow for the cancellation, transfer, leasing, or returning (as part of a conserved water program) of water rights. Strategies implemented to address water scarcity, including market-based approaches, are explored.

Section 8 summarizes the important context and evolution of the U.S. experience in allocating and reallocating water. It addresses legal, institutional, and economic implications, and draws out major observations and lessons learned.

Following the Conclusion (Section 9) and References (Section 10), appendices provide additional information on interstate water allocation compacts (supplementing Section 4), a list of acronyms, authorship and acknowledgements, and suggested sources for further reading.

2. WATER LAW AND ALLOCATION AT THE FEDERAL LEVEL

2.1 The Federal and National Perspective

Water in the U.S. is managed differently across all levels of society, from the federal government to regional organizations, to states, to local municipalities, down to the individual. At each level, a unique set of policies, laws, and customs governs how water is managed and shared. Not only is the U.S. system different at each level, it also varies by geographic region due to the history of settlement and economic development and the different climates across the country.

In 1789, the U.S. Constitution established a federal system of government. Power is distributed between national and state governments, as well as to entities within the individual states. Under these specifically delineated relationships, each level of government has a unique responsibility for managing the country's natural resources. Most importantly, the states have the authority and responsibility for managing their water resources. Nonetheless, the U.S. Constitution includes several components that have led to federal involvement in local water resources, specifically, resolving interstate water conflicts, managing interstate waterways, and promoting common environmental standards.

The U.S. Constitution states that the United States Congress shall have the power "To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes."[2] Historically, this constitutional authority has been interpreted to include the management of interstate waterways for the purpose of promoting commerce. Congress may choose to allocate interstate waters directly by statute, although it has almost always deferred to the states to reach a mutual agreement on such issues. Furthermore, Article 1, Section 10, of the Constitution provides that "no state shall enter into an agreement or compact with another state" without the consent of Congress. So, upon completion of successful water negotiations, states must apply to the U.S. Congress for the creation of an Interstate Compact, or treaty, before the agreement becomes binding. Similarly, the creation of standing interstate water management bodies with regulatory authorities, such as interstate river basin commissions, must receive congressional approval.

The federal government is also significantly involved in local water resources through several national environmental statutes, including the National Environmental Policy Act,[3] Clean Water Act,[4] and Endangered Species Act.[5] These and other federal statutes have effectively bounded the water resources decision process by establishing minimum standards for water quality, wetlands protection, protection of endangered species, and other criteria. In particular, the National Environmental Policy Act prescribes a process to evaluate potential environmental harm through an analysis of 1) the environmental impacts of a proposed action; 2) any adverse environmental impacts that cannot be avoided should the proposal be implemented; 3) reasonable alternatives to the proposed action; 4) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and 5)

[2] Article 1, Section 8, Clause 6.
[3] 42 U.S.C. 4321 et seq., signed into law on January 1, 1970, overseen by the Council on Environmental Quality; see http://ceq.hss.doe.gov/welcome.html.
[4] See http://cfpub.epa.gov/npdes/cwa.cfm?program_id=45.
[5] See http://www.fws.gov/ENDANGERED/laws-policies/index.html.

identification of any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

Perhaps due to the diversity in water governance across the country, the United States has never passed a national water policy. However, there are a plethora of national laws, policies and regulations that collectively form the basis of water management in the US. Additionally, various executive and legislative commissions and committees have tried to establish policies to facilitate more effective and efficient water coordination. Current guidance for planning and evaluating water resources projects by the USACE, Bureau of Reclamation (BOR), Tennessee Valley Authority (TVA), and National Resources Conservation Service (NRCS) is provided by the "Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies," established in 1983. Commonly known as the "P&G," this document outlines four "accounts" to consider when evaluating alternatives for water resources projects:

- National Economic Development (NED): beneficial and adverse effects on the national economy in monetary terms[6]
- Environmental Quality (EQ): effects on significant environmental resources and ecological, cultural and esthetic attributes
- Regional Economic Development (RED): distribution of regional economic activity in terms of regional income and employment[7]
- Other Social Effects (OSE): effects on urban and community impacts, life, health, safety factors; displacement, long term productivity, as well as energy requirements and energy conservation

Each account is to be considered during a project's planning phase, but only NED has primacy in the decision process; barring exceptions, a plan recommending federal action is to be the alternative plan with the greatest net economic benefit consistent with protecting the nation's environment.

However, the dominance of National Economic Development in the P&G process, along with social and environmental considerations, led to a call for change in the process. Additionally, some felt that the provisions of the P&G should not be limited to the USACE, BOR, TVA, and NRCS, but should apply to all 12 federal agencies[8] involved with water resources in the United

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[6] Per the 1983 "P&G", beneficial effects in the NED account are increases in the economic value of the national output of goods and services from a plan; the value of output resulting from external economies caused by a plan; and the value associated with the use of otherwise unemployed or under-employed labor resources. Adverse effects in the NED account are the opportunity costs of resources used in implementing a plan. These adverse effects include implementation outlays, associated costs, and other direct costs. Procedures for evaluating NED effects are contained within Chapter 2 of the Guidelines, available at http://planning.usace.army.mil/toolbox/library/Guidance/Principles_Guidelines.pdf .

[7] Per the 1983 "P&G," the regions used for RED analysis are those regions within which the plan will have particularly significant income and employment effects. Effects of a plan not occurring in the significantly affected regions are to be placed in a "rest of nation" category.

[8] Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Department of Homeland Security, Department of Housing and Urban Development, Department of Interior, Department of Transportation, Environmental Protection Agency, General Services Administration, Tennessee Valley Authority, and Department of the Army (USACE); 2010 membership of the Federal Interagency Floodplain Management Task Force (FIFM-TF).

States. Starting in 2007, the executive branch's Council of Environmental Quality began an effort to replace the P&G. While the process is not complete, drafts of a new "Principles and Requirements" document were released for public comment and review by the National Academies in 2013.[9] The proposed replacement is called the Principles and Requirements. The P&R also includes draft guidelines for federal agency implementation – Principles, Requirements, and Guidelines, or PG&R. The P&R is intended to consider a broader range of benefits and costs in addition to economic benefits. One of the key challenges, as with the P&G, is assessing criteria whose benefits and costs are not easily quantified or monetized.

The United States Congress has established many congressional committees that oversee and fund the federal agencies that implement the hundreds of federal laws affecting the nation's water resources. Six federal agencies play a significant role in managing the inland water resources of United States.[10]

2.1.1 Department of Defense, U.S. Army Corps of Engineers[11]

The Civil Works program of the U.S. Army Corps of Engineers (USACE) has primary missions in three water resources areas: inland navigation, flood risk management, and aquatic ecosystem restoration. USACE is involved with a range of peripheral, but important, water resources missions including environmental protection and restoration, hydropower, recreation, emergency management, water storage for water supply, and regulatory enforcement for the protection of wetlands and prevention of obstructions to navigation.

USACE constructs, operates, and maintains single purpose and multipurpose dams. The primary purposes of these dams are navigation and flood damage reduction, and secondary purposes are hydropower, water supply, irrigation, recreation, and providing for in-stream flows. Although the water supply role of USACE is minimal, authorities include the reimbursable inclusion of municipal and industrial water storage in multi-purpose reservoirs, as well as the temporary sale of surplus water for municipal and industrial uses. USACE can provide emergency supplies of clean water to localities in response to contamination threatening public health and may allow temporary water withdrawals from reservoirs during droughts for municipal and industrial use. USACE is authorized to include irrigation as a reimbursable purpose for multi-purpose reservoirs. USACE also undertakes studies and projects for environmental protection and restoration projects, as well as cost-shared beneficial use of dredged material to restore aquatic ecosystems. As a regulatory authority, USACE regulates any construction in navigable waters[12] of the United States and also enforces Section 404 of the Clean Water Act concerning dredged and fill material permit requirements. USACE also participates as a voting member in one interstate water commission (the Delaware River Basin Commission), and it serves as a resource for many commissions and compacts.

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[9]See http://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG.

[10] The following descriptions of U.S. federal agency responsibilities include excerpts from the Congressional Research Service Report, "Selected Federal Water Activities: Agencies, Authorities, and Congressional Committees" (2012). See http://aquadoc.typepad.com/files/crs-federal-water-activities-agencies-authorities-and-congressional-committees.pdf.

[11] See http://www.usace.army.mil/.

[12] The definition of "navigable waters" has changed over time; see http://www.epa.gov/osweroe1/content/spcc/spcc_nov08waters.htm.

2.1.2 Environmental Protection Agency[13]

The Environmental Protection Agency (EPA) implements the Clean Water Act of 1972, regulates surface water, sets standards for drinking water, and protects groundwater. It undertakes extensive water quality planning, studies, and monitoring; focuses on reducing direct and indirect pollutant discharges into waterways; and finances municipal wastewater treatment facilities. Under the National Pollutant Discharge Elimination System (NPDES) permitting program, the EPA regulates discharges to waters of the United States by issuing permits based on specific effluent limitations for the water body. Many states are authorized to administer the NPDES program, assuming permitting authority in lieu of the EPA after obtaining the EPA's approval.[14] The EPA's Water Quality Protection Division issues the NPDES permits and the Water Enforcement Branch ensures that all discharges comply with the permits issued. Discharges include pollutants from municipal and industrial wastewater treatment plants, sewer collection systems, and storm water discharges from industrial facilities and municipalities. The EPA sets limits for contaminants in public drinking water supplies and states enforce these limits. States have the authority to issue grants designed to help achieve EPA's water quality goals by funding community wastewater projects and public drinking water systems, including those on Native American lands. In short, the EPA works to restore, protect, and preserve aquatic ecosystems nationwide, either through its offices or through delegation to states. It also conducts and supports research on the effects of climate change on water resources and the nation's clean water and safe drinking water programs. To reduce water demand, EPA certifies water-efficient consumer and commercial products and provides funds and guidelines for the reuse of wastewater.

2.1.3 Department of the Interior[15]

The *Bureau of Reclamation* (BOR) is the federal agency primarily engaged in water resources development in the 17 states west of the 98th meridian. The BOR was created by the Reclamation Act of 1902 for the purpose of irrigating and settling the arid, western regions of the United States. As a result, the BOR constructs, operates, and maintains dams principally for irrigation, and secondarily for flood damage reduction, navigation, municipal and industrial supply, hydropower, and recreation purposes. Projects of the Bureau of Reclamation provide irrigation supplies based on the ability of the consumer to pay (without charging interest), as well as water for municipal and industrial uses (with interest), generally over an extended repayment period. BOR undertakes a water reclamation and reuse program to augment local water supplies, including groundwater reclamation and recharge, which is cost shared with non-federal sponsors. Moreover, BOR assists water users, states, and other parties with developing water conservation plans, which are required from water and irrigation districts that receive water from BOR projects. To facilitate these water conservation requirements, BOR provides grants for conservation as well as water and energy efficiency projects, including system optimization, advanced water treatment, and water reuse. BOR also conducts research aimed at demonstrating the technical and financial feasibility of desalination. In terms of interagency collaboration, BOR participates as a voting member on one interstate water compact and serves as a resource for many others. Finally, BOR develops scientific information on climate change and provides

[13] See http://www.epa.gov/.
[14] See http://cfpub.epa.gov/npdes/statestribes/astatus.cfm.
[15] See http://www.doi.gov/index.cfm.

grants for climate change research to a range of partners, including universities, nonprofits, and other organizations with water or power delivery.

The *U.S. Geological Survey* (USGS) is responsible at the federal level for monitoring, researching, and modeling U.S. water resources. USGS collects stream flow data (including data related to climate change) from stream gauges throughout the country that are used to address local, state, regional, and national needs. The USGS's Hydrologic Networks and Analysis program provides data and analysis on the quantity and quality of water in streams, lakes, and reservoirs, and these data are widely used for planning, monitoring, and developing the nation's water resources. The Groundwater Resources Program provides information to assess and quantify the nation's groundwater resources, such as groundwater availability in aquifer systems and characterizations of natural and human factors that affect this availability. The Hydrologic Research and Development Program conducts research on complex hydrological problems such as ecological and biochemical processes in the hydrological cycle as well as the movement and availability of subsurface water to inform groundwater management decisions. The National Water-Quality Assessment Program (NAWQA)[16] assesses whether water-quality conditions are getting better or worse over time, and how natural features and human activities affect those conditions. USGS has formed partnerships with local, state, and tribal entities to provide joint monitoring and research capabilities that inform regulatory and management activities. Finally, related to interstate water compacts, the USGS provides administrative support for federal representatives and collects hydrologic data on behalf of 25 interstate compacts.

The *Fish and Wildlife Service* (FWS) works with states, tribes, federal agencies, and private interests to conserve fish and other aquatic resources. The FWS provides technical assistance in the use and development of the nation's land and water resources, including restoration of aquatic species habitat. FWS works with other federal agencies to implement the Endangered Species Act, which requires the conservation of endangered and threatened species. If a federal agency action or project may impact a threatened or endangered species, that federal agency must work with the FWS and share information about the proposed project and the species likely to be affected. If the federal agency action is likely to adversely affect a threatened or endangered species, FWS must prepare a "biological opinion" on whether the proposed activity will jeopardize the continued existence of the species.

2.1.4 Department of Agriculture[17]

The *Natural Resources Conservation Service* (NRCS), formerly the Soil Conservation Service,[18] works with farmers and ranchers to conserve resources on their land. NRCS provides financial and technical assistance to producers and landowners to plan and install structural, vegetative, and land management practices (including water conservation) on agricultural lands to alleviate natural resource problems, including water quality concerns. NRCS provides financial and technical assistance to local project sponsors for small flood damage reduction projects, including dams and reservoirs. For example, NRCS enters into restoration agreements with landowners to protect and restore wetlands. Housed within the administrative structure of the NRCS, the *Risk Management Agency* insures producers against adverse weather, including

[16] See http://water.usgs.gov/nawqa/about.html.
[17] See http://www.usda.gov/wps/portal/usda/usdahome.
[18] See http://www.fs.fed.us/.

droughts and floods, and the *Farm Services Agency* provides emergency funding and technical assistance to farmers to rehabilitate farmland damaged by natural disasters, including implementing emergency water conservation measures in response to severe droughts. The National Water and Climate Center within the NRCS has snow monitoring stations used to estimate snow water equivalents and project snowmelt runoff and spring and summer stream flows. These estimates are critical to water management in the western United States.

The *U.S. Forest Service*[19] has the responsibility to maintain and improve fishery habitat in national forests and grasslands, consistent with overall multiple-use objectives. The USFS also plays a role in preserving designated rivers in their free-flowing condition and directing respective designated federal agencies to administer comprehensive management plans to ensure river protection per the Wild and Scenic Rivers Act. The reservation of land for a federal purpose, such as a national forest, includes accompanying water rights to achieve the purpose of the reservation.

2.1.5 Department of Energy, Federal Energy and Regulatory Commission[20]

The Federal Energy Regulatory Commission (FERC) regulates the interstate transmission of electricity, natural gas, and oil. FERC also licenses the construction and operation of nonfederal hydropower projects. The commission is charged with considering the overall development of a river basin for multiple purposes, including fish passage and other factors, in evaluating and approving license applications. FERC also investigates potential dam safety problems of nonfederal projects and provides owners with resources and expertise to maintain safe dams.

2.1.6 Department of Commerce, National Oceanic and Atmospheric Administration[21]

The National Oceanic and Atmospheric Administration (NOAA) works with federal and state agencies and public and private partners to provide weather and climate information to help predict and prepare for drought, floods and other extreme hydrologic and meteorological events. These services are intended to manage risk and reduce vulnerabilities in order to better protect human life and property, including water-related infrastructure, as well as marine and riverine ecosystems, and coastlines. NOAA’s National Weather Service operates a dozen river forecast centers covering the major river basins in the United States. Flood and drought information and forecasts are coordinated closely with key partners.

The National Marine Fisheries Service (NMFS)[22], a division of NOAA, is responsible for the management, conservation and protection of the nation's living marine resources and their habitat within the United States' Exclusive Economic Zone (ocean up to 200 miles offshore, or approximately 321 kilometers). NMFS assesses and predicts the status of fish stocks, ensures compliance with fisheries regulations, and works to reduce wasteful fishing practices. Under the Marine Mammal Protection Act and the Endangered Species Act, the National Marine Fisheries Service works towards recovery of protected threatened and endangered marine species (i.e., whales, turtles) without unnecessarily impeding economic and recreational opportunities. NOAA's National Marine Fisheries Service works with communities on fishery management

[19] See http://www.fs.fed.us/.
[20] See http://www.ferc.gov/.
[21] See http://www.noaa.gov/.
[22] See http://www.nmfs.noaa.gov/aboutus/aboutus.html.

issues, promotes sustainable practices, and attempts to prevent lost economic potential associated with overfishing, declining species and degraded habitats, striving to balance competing needs.

2.1.7 Coordination across Agencies

While all these federal agencies play a role in water management, there is no formal platform for them to coordinate their work. Instead, they collaborate through ad-hoc committees and task forces. For example, to explicitly address the impacts of climate change, President Barack Obama convened the interagency Climate Change Adaptation Task Force. Many federal agencies worked together on this task force to develop recommendations for how federal agency policies and programs can better address the risks associated with a changing climate. In February 2013, the agencies released their first climate change adaptation plans to ensure smart decisions that protect investments, community health, as well as economies and infrastructure from the impacts of severe weather, rising sea levels, and other changing climate conditions.[23] Coordinating, sharing information and leveraging work across the federal water-related agencies remain an ongoing challenge.

Other examples of federal collaboration include: 1) The White House Office of Science and Technology Policy's Committee on Environment, Natural Resources and Sustainability, Subcommittee on Surface Water Availability and Quality, which provides a formal mechanism for federal interagency coordination; 2) the Federal Interagency Floodplain Management Task Force, which provides a coordinative mechanism for encouraging programs and policies that reduce flood losses and protect the natural environment;[24]and 3) The Federal Emergency Management Agency, as a part of its National Preparedness System, has Five National Planning Frameworks.[25] These frameworks address prevention, protection, mitigation, response, and disaster recovery, and they describe how the whole community (all levels of government) can work together after an emergency, including a flood.

2.2 Federal Reserved Water Rights

Although the U.S. Congress has recognized the primary and exclusive authority of the states to allocate water resources, federal courts have also recognized the federal government's reserved water rights. The federal government may secure rights to the use of waters on federal and tribal lands reserved for specific purposes subject to certain federal laws. This occurs primarily in the western U.S., where the federal government owns significant areas of land. These explicit or implied reserved water rights are held by the federal government - mainly land management agencies - to achieve a specific purpose, such as to support tribal reservations, national forests, national wildlife refuges, military bases, or wild and scenic rivers. Moreover, federal reserved rights usually take priority as they are tied to the date of the reservation under federal law and may take precedence over other non-federal and private water users' rights. In the case of tribal water rights on Native American reservations, numerous court cases have established the rights of tribes and other water users, but some cases have taken decades to resolve and have failed to

[23] See http://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience.
[24] See http://www.fema.gov/floodplain-management/federal-interagency-floodplain-management-task-force.
[25] See http://www.fema.gov/national-planning-frameworks.

provide tribes with resources to develop their water rights. As a result, states and tribes have generally chosen in recent years to negotiate tribal water rights claims that have resulted in congressional approval of many water rights settlement acts since the 1970s.

2.3 U.S. Federal Agencies Primarily Involved in Water Development

Two U.S. federal agencies are primarily involved with water development: the U.S. Army Corps of Engineers and the Bureau of Reclamation. The role of each as it affects water allocation is described below.

2.3.1 U.S. Army Corps of Engineers

States and local municipalities (non-federal entities) have the primary responsibility to develop and manage their water supplies. USACE works cooperatively with these entities in developing water supply storage in conjunction with water resources improvements[26] under certain conditions. This storage may be included in federal navigation, flood control, or multi-purpose projects being considered for construction, modification, operation or maintenance activities. Several laws give USACE the authority for municipal and industrial, surplus, and irrigation water supply storage. Reservoirs cannot be operated for any purpose that has not been authorized by these laws. In addition, these laws give USACE the authority to assist local non-federal entities with their water supply planning and provide emergency water in certain very limited situations, such as temporary assistance due to contaminated water supplies and extreme drought when all other means for securing necessary water supplies have been exhausted. Specific requirements and restrictions exist for each situation.

2.3.1.1 Municipal & Industrial Water Supply

USACE defines Municipal and Industrial (M&I) water supply as uses consistent with the operation of municipal and community waters systems and industrial processes. Under the terms of the 1958 Water Supply Act,[27] USACE can enter into agreements with non-federal entities for water supply storage. These agreements convey the right to store water in the USACE reservoir, but do not convey any rights to the water itself. The non-federal entity must obtain the required water rights, and the agreements do not guarantee either the quality or quantity of the water that will be available for withdrawal. USACE does not sell water, only water supply storage. If water supply storage is included as part of the original authorization of the reservoir, it is considered “original” storage. The cost for original storage varies depending on the date and method of authorization, but typically recoups the total federal investment that corresponds to the requested storage as well as all other costs associated with the water supply function.

[26] Single purpose reservoirs for water supply cannot be proposed for federal construction.

[27] The Water Supply Act of 1958 authorized Army Corps of Engineers to include M&I water storage in planned reservoir projects and to reallocate storage in existing reservoirs for M&I use. In addition, it authorized the Bureau of Reclamation to impound water for present or anticipated future demand or need for municipal or industrial water. These agencies must obtain reasonable assurance that the water supplies will be needed and that users will repay the federal costs within the life of the project.

Although USACE is not currently developing new multi-purpose reservoirs, many non-federal entities are still requesting water supply storage in its reservoirs. Where feasible, USACE accommodates those requests through reallocation of existing storage from its present use to M&I water supply. This is considered "reallocated" storage. If a reallocation or addition of storage would have significant impacts to the authorized purposes of the reservoir or would require major structural or operational changes, congressional approval is required. Costs for reallocated storage vary depending on when the reallocation occurred or can be set by legislation. Since 1977, USACE has determined the repayment cost to be the highest of benefits or revenues forgone, replacement cost, or the updated cost of the storage. As with original storage, agreements for reallocated storage detail the exact cost, including all costs associated with the operation and maintenance of the water supply function.

2.3.1.2 Surplus Water Supply

Surplus water is usually water stored in a USACE reservoir that is no longer required because (1) the authorized need for the water never developed, (2) the need was reduced by changes that occurred since the project was authorized or constructed, or (3) M&I water use would be more beneficial than use for the authorized purpose and which when withdrawn would not significantly affect authorized purposes over some specific time period. While original and reallocated storage is considered permanent storage, surplus water storage is not. Section 6 of the 1944 Flood Control Act allows for the development of agreements for surplus water with price and terms deemed reasonable by the Secretary of the Army. This cost is typically determined using methods similar to those for reallocated storage. Currently, USACE is clarifying pricing of surplus water through a rulemaking effort.

2.3.1.3 Irrigation Water Supply

The Reclamation Act of 1902 established the national policy for irrigation in the West (comprised of the 17 contiguous states lying partially or wholly west of the 98th meridian.) In accordance with Section 8 of the 1944 Flood Control Act, USACE reservoirs in those states may include irrigation as an authorized purpose if recommended by the Secretary of the Interior. Section 8 also authorizes the Department of the Interior, Bureau of Reclamation, to provide the irrigation works necessary to make use of the storage and to contract for the storage space in the West. In most cases, Operation & Maintenance costs attributable to irrigation are reimbursable to the U.S. Treasury by arrangements spelled out in each irrigation agreement between the Bureau of Reclamation and the local irrigator. There are, however, a few rare instances where USACE bills the irrigator directly.

2.3.2 Bureau of Reclamation

Established in 1902, The Bureau of Reclamation (BOR) is the federal agency that was charged with the primarily social goal of settling the arid west with small family farms by building major federal water supply facilities in the 17 western states. It controls major storage and conveyance facilities and produced 10 trillion gallons of water for municipal, residential, and industrial use (U.S. Bureau of Reclamation, 2014), as well as for hydropower production, recreational opportunities, and flood control. At the time BOR was established, repaying the federal government for this infrastructure was less important, and thus contracts were established that were interest-free or limited to what the consumer could pay.

BOR is a water wholesaler that generally contracts with water districts, rather than final consumers. BOR requires a water permit from the appropriate state agency, and must apply and secure the water right; water districts must also acquire water rights from the state. Because BOR has long-term contracts for large blocks of water with a small number of districts in the area of the project, re-marketing of supplies between these districts is a viable possibility. In general, irrigators are expected to pay operating costs; the ability to pay is factored into cost-repayment calculations. BOR uses a set of principles to review and approve water transfer requests. Under these principles BOR is directed to facilitate transfer proposals brought to it by interested water users, provided the transfer complies with state law and injures no third parties. Water districts are explicitly allowed to profit from transfers once federal costs are paid to provide them with an economic incentive to facilitate transfers of federally supplied water. Controlling the entrance of potential new water users for BOR facilities differs on a state-by-state basis, as states have primary authority for allocating water use. BOR has the authority to allocate water when it has the water right within project boundaries, and in those instances controlling for potential new water users can also vary on a project-by-project basis within BOR.

BOR policies regarding the cost of water transfers vary by region. Often water is transferred at the federal contract rates; however, there are various exceptions to this. BOR set up a water market during the California drought of 1976-1977, where it placed a limit on the selling price of water. Water in the Colorado-Big Thompson Project is sold at market rates in the Northern Colorado Water Conservation District (described below in the Colorado River Case study). In its banking operations on the Upper Snake River in Idaho, BOR imposes a ceiling on the price of water transferred that is higher than contract costs.

3. WATER LAW AND ALLOCATION AT THE STATE LEVEL

In the U.S. federal system, the states have primary jurisdiction over managing water resources within their boundaries. Over time, different legal systems based on Spanish Water Law and English Common Law evolved to govern the allocation of water resources across much of the country prior to the westward migration. In the western half of the country, where the climate is arid and water is scarce, a legal system developed called "prior appropriation" to govern water allocation. In the eastern half of the country, which is much more humid, states use a legal system called riparian rights. These systems are largely separated by the 98th meridian, which roughly divides the country in half. About a fifth of U.S. states use a hybrid system of the two doctrines, yet there are many additional nuances within states so that no two states have identical forms of water allocation law. To further complicate state water allocation laws vary for surface waters and ground waters. For example, it is not uncommon to find a state with surface water law based on a form of riparian doctrine while the state's groundwater allocation law is based on a form of prior appropriation doctrine. While there are exceptions, prior appropriation generally governs both surface and groundwater allocation in the western U.S. These legal systems dictate the creation and regulation of rights to use water and determine how water is shared among users during normal times as well as times of scarcity.

3.3.1 Riparian Rights & Water Allocation in the East[28]

3.3.1.1 Riparian Doctrine

The doctrine of Riparian Rights is based on ownership of land bordering a water body. The right to water is generally not separated from the riparian land, so inter-basin transfers are not normally permitted. The right to use the water is transferred with the sale of the riparian lands. Under riparian doctrine, land owners do not own water, but they have the right to use water.

The amount of water that is allowed for use by property owners varies depending on the version of riparian doctrine. Theories of Natural Flow, Correlative Rights, and Reasonable Use are the most common theories. Natural Flow theory states each riparian owner is entitled to a stream flow that is not materially diminished or polluted; natural uses include bathing, drinking, gardening, and household stock watering, but not industrial uses. Correlative Rights theory provides for riparian landowners to be assigned a proportional share of the water based on landownership (stream front). Finally, Reasonable Use theory allows riparians to take any amount of water as long as usage does not interfere with the reasonable needs (i.e., absence of injury) of other riparians. Reasonable use is determined in comparison with the uses of other riparians. States typically determine what is reasonable, and approaches differ among states. Some riparian states have special rules to deal with specific problems, including preferences for some types of uses over others. The relative rights of riparians are determined by permit-granting authorities by reference to reasonable use criteria (Getches, 2009).

In most cases, riparian rights are limited by not causing injury to others and by "public rights," such as navigation and recreation, and aesthetics. A recent evolution is to recognize a riparian's right to enjoy the scenic beauty of an adjoining waterway, and several courts have awarded damages to owners based on scenic and recreational values (Getches, 1990). "Reasonable uses"

[28] This section summarizes key points from Getches (1990, 1997, 2009).

are determined based on the purpose and economic and social value of the use, how it harms others, interests of society as a whole, and how the use compares with the uses of other riparians.

In general, a landowner may use the water adjacent to his or her property in any way as long as no one objects. Courts have ruled this objection must happen no later than 7-18 years after the injury began to occur (Cech, 2005). If a landowner feels they have been injured by another riparian, they must prove this injury in court or at a state water agency. A riparian may lose rights to the stream if it is determined that the use of that water is harming others. Governments may also seize water rights to a stream, such as to provide for municipal uses, through the power of eminent domain. This allows a city to condemn private rights for a public purpose if just compensation is paid (Getches, 1990).

As a result of changing water supply and demand, declining aquifers and water quality, expanding water conflicts, and drought, by the mid-1900s many eastern states implemented a permit-based regulatory system to augment the traditional riparian rights doctrine. This evolution of traditional riparian rights protects the public's interest in sustaining reliable supplies of water according to the Correlative Rights Principle and is known as Regulated Riparianism. In 2004 the American Society of Civil Engineers published the Regulated Riparian Model Water Code that sets forth principles followed by many of the 18 states that have adopted regulated riparianism.[29] Regulated riparianism is based on a permit system that allocates surface and ground water based on use, need, percolation rates, and climatic factors. The function of permit programs has been threefold: (1) collect accurate information of water use, (2) allocate water by more definitive criteria, and (3) assert a stronger state interest in water use and management (Tarlock, 2010). Most states require permits only for larger water uses (i.e., diversions, hydropower, municipal use) or for water use in critical areas, such as areas with greater water scarcity or environmental significance. Permits may be issued for water use outside the watershed to non-riparians; however, these permits are sustained only if a riparian does not claim injury and seek a judicial remedy. The Model Code also provides for permit fees based on the value of using the water, yet states' current fee systems are usually a consistent fixed fee for all applicants or fees based on ability to pay.

A primary intent of regulated riparianism is to enable long-term planning to sustain a state's water resources. This is part of the reason permitting agencies require the collection of data from those who receive permits. Once a state has sufficient data to develop a state-wide or regional plan, they can then issue and modify permits in alignment with implementing, or achieving the goals of the plan. One principle of the Model Code that has been widely incorporated is the protection of the biological, chemical, and physical integrity of water resources based on federal and other relevant legal standards (American Society of Civil Engineers, 2004).

Permits are issued, changed, or revoked by the state agencies charged with issuing permits. These officials decide the location, volume, quality, and rate of water that may be used, set any terms and conditions for that use, and decide how much water needs to remain in the stream for environmental or other public purposes. The organization determining such environmental flows varies by state. Permits may be granted in perpetuity or for a fixed term ranging from 10-50

[29] The *Regulated Riparian Model Water Code* of the American Society of Civil Engineers (2004) "provides a complete, comprehensive, and well-integrated statutory scheme for creating or refining a regulated riparian system of water law capable of dealing with the water management problems of the twenty-first century."

years. Several states set priorities for allocating water when there is not enough to serve all permittees (Getches, 1990). [30] Domestic use always ranks highest. States may modify permits in any given year to deal with shortages. The legislation establishing the permit system in a state usually also establishes the criteria officials must use to issue permits or to choose between competing users applying for permits; public notice is typically required in establishing the legislation. These criteria may relate to the type of watercourse, the positive and negative impacts of the use, and the effects on the public. Many eastern states base their criteria, or factors to consider, on the Restatement of Torts. The Restatement of Torts, a four-volume treatise written by the American Law Institute, helps guide the development of tort law in America.[31]

In the nine eastern states that follow the rules of the Restatement of Torts for water issues, courts use these rules as a framework to resolve riparian rights disputes. Specifically, Section 826 uses a balancing test to determine reasonableness of conduct (i.e., whether gravity of harm is greater than actor's utility) (Johnson, 2009). Additionally, courts use factors outlined in Section 850 to compare the interests of the riparian proprietor using the water, of any riparian proprietor harmed by this use, and of society as a whole. These factors allow the court to give weight to the different interests and thus decide if the use is reasonable, if harm has occurred and if/how the harm should be remedied. The factors of reasonable use are as follows: 1) purpose of use, 2) suitability of use to watercourse, 3) economic value of use, 4) social value of use, 5) extent and amount of harm, 6) practicality of avoiding the harm, 7) practicality of adjusting the amount of water used by all users, 8) protection of existing values and investments, and 9) justice of requiring the one causing harm to bear the loss (Getches, 1990). The framework helps the court *compare* the reasonableness of the uses of each riparian rights holder in the dispute, since riparians are often each putting the water to a reasonable use that benefits society.

Some specific examples of how these factors are applied in states are as follows: Maryland's Department of Environmental Quality considers the following factors in judging the reasonableness of a new permit application for groundwater or surface water: whether a requested appropriation and use will have an unreasonable impact on other water users, the financial hardship of requiring a new water user to bear the loss of potential harm to others, and the practicality of avoiding harm by adjusting the proposed use or method of use by the permit applicant or another permittee. The New Jersey Department of Environmental Protection requires applicants for groundwater diversion permits to disclose the diversion's expected impacts on other users of that resource. The Virginia State Water Control Board decides whether a permit should be issued in specific designated management areas using the criteria of relative competing uses of the stream; the number of persons using the stream and the object, extent, and necessity of their withdrawals or uses; and the importance and necessity of the uses. In conditions of drought, Virginia prioritizes human consumption followed by other uses in the order in which the permits have been issued. All of these states periodically review their permits in accordance with these criteria and reserve the right to modify the permit, especially in times of drought. [32]

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[30] Arkansas, Illinois, Iowa, Kentucky, Maryland, Minnesota.

[31] The most relevant sections of the Restatement of Torts (Second Version) for water issues are §821, 826, 850, 855, 856, and 858.

[32] Md. Code Regs. 26.17.06.05D(2) (2008);
N.J Admin. Code §7:19-2.2(c) (2008);

Regulated riparian systems are enforced through criminal penalties, civil penalties, injunctions, administrative orders, and actions for public and private damages (Dellapenna, 2004). While the Model Code includes provisions for alternative dispute resolution and the administrative resolution of disputes between permit holders, most states' water conflict resolution processes are still dependent on judicial processes and lengthy court cases.

3.3.1.1 Water Transfers in the East

Most regulated riparian systems have no provisions for transferring water rights or permits between users. Water transfers are generally restricted in riparian states, but if a state allows a non-riparian to purchase water rights from riparians (which is extremely rare), the new uses must be reasonable compared to uses by other riparians, and this purchase will only be sustained if a riparian does not claim injury. Most market-based transfers in the east are the sale of reclaimed, conserved, or surplus water. These transfers involve a single large seller, typically a large central city or utility company, selling water to numerous large and small suburban cities and water districts and then to individual homes. Sales are necessary to cover the cost of urban water supply acquisition, conveyance, and treatment of the water. The Model Code encourages market transfers of water, but as of the early 2000s, states had not attempted to develop a market to transfer water used under regulated riparian permits to higher-valued uses (Dellapenna, 2004). Introducing market-based transfers into a system of riparian rights or regulated riparianism is challenging and thus unlikely to happen anytime soon in the eastern U.S.

3.3.2 Prior Appropriation & Water Allocation in the West

3.3.2.1 Prior Appropriation Doctrine[33]

The arid nature of the western United States make it ill suited to adherence to the riparian doctrine that had developed in the humid east because very few lands bordered streams and the federal government owned most of the available lands, which prohibited settlers from having riparian rights. Some settlements in the southwest followed local practices of sharing water resources that had been established by the Spanish. (Spanish control of the American southwest ended in 1821, and Mexican control ended in 1848.) Many of the early U.S. western settlements centered on mining operations located far from any streams. Consequently, early settlers sometimes had to divert water from great distances to use in mining operations or to irrigate lands around the towns. Initially, there were no laws allocating mining claims or water use, and many of the prospectors adhered to the mining codes of the places where they had come from, including Central America and South America. Mining law was long established in these countries. It formed the *de facto* basis of the new mining operations in the American West and governed the use of water that these operations required. This set of mining and water use codes stipulated that water for each mining claim was based on a priority system of "first come, first served" (Cech, 2005). By 1853, this set of codes was so widely accepted that the California Supreme Court enshrined them and formally established the doctrine of prior appropriation.

The doctrine of prior appropriation permits non-riparians to divert and use water for beneficial uses based on a priority date. These diversions may occur outside the watershed, and this right to use water, or "water right," is acquired by diverting water from a stream for a beneficial use and

Va. Code Ann. 62.1-248(B)(2006).

[33] This section draws heavily from Getches (1990).

filing a claim for the amount diverted with the local court or state agency. The date that water users file their claims establishes the priority of their water right in a system of prior appropriation. The first person to file a claim has a senior water right; all others have a junior water right in a descending order based on filing date. These rights persist as long as the water continues to be used by the right holder. It is important to note that because water has always been a public resource in the U.S., this water is owned by the state or the public. If a water rights holder ceases to use the water, by laws governing forfeiture and abandonment the water returns to the stream or basin for others to use. The system is thus one of public ownership and private use of the water resource. Water rights perfected or vested by continuous beneficial use under state law can be bought, sold, leased, and bequeathed, and they are protected from takings without just compensation.

In times of scarcity, senior water rights' holders are entitled to receive all of their allotted water, while junior water rights holders only receive water if there is enough left over. The more junior the water right holder is, the less likely it is that the water right holder will receive the full water right, and the person may not receive any water during times of great scarcity. This contrasts greatly with riparian doctrine where all water users share the loss during times of scarcity. While this prior appropriation system governs the initial allocation of water rights across the West, new water rights are established by more complex methods. Since many basins are fully allocated, new users may be required to buy, lease, or otherwise acquire rights to the use of water.

All western states except Colorado use an administrative permit system to provide an orderly method for appropriating water and regulating established water rights (Getches, 1990). A permit is approved if the state engineer or administrative agency finds that there is unappropriated water and that the appropriation is beneficial and not detrimental to the public interest. A claimant must first file for a permit; then the permit is published to allow affected parties to comment or object. If acceptable, the permit will then be issued. [34] The permit will become a water right if all conditions of the permit are met. Written application is required in all permit states, and the time of filing generally becomes the priority date if all later requirements are met. Typically, a notice of filing is published and efforts made to contact affected parties. They have a fixed time period in which to file any objections. The administrative agency usually holds a public hearing, and the state engineer or other appropriate official investigates factual data prior to the agency approving or disapproving the permit application. As noted earlier, the permit can become a water right if all its conditions are met, with applying water to a beneficial use being the act that causes a water right to “vest” so that the priority will then relate back to the time of filing (Getches, 2009). Vesting tied to time of filing, combined with the advantages accruing to more senior water rights holders, offer an incentive to file for a water permit. Permit conditions vary from the basic scenario (diverting and applying the water to a beneficial use within a certain period) to stricter conditions (specifically dictating how the water right is to be exercised). This approval process is becoming more stringent as values change and water scarcity increases; state agencies now have a heavier hand in approving new appropriations and dictating the use preferences for their basins (exemplified by the Oregon case study).

States’ constitutions often dictate what a "beneficial use" is. Usually it is a domestic, municipal, agricultural, or industrial use, although some states may define “beneficial use” differently.

[34] States may use different terms than “permit,” such as “certificate,” to indicate the temporary nature of a use permit prior to its being perfected or vested.

States generally rank domestic or municipal uses first, followed by agricultural and then industrial and mining uses; many states have statues or constitutional provisions that express these preferences. How states enforce these rankings varies from not enforcing them unless in response to a complaint from other water users and keeping with the order of prioritized rights, to enforcing them during times of shortage, to using them to decide which application for new rights to approve (Getches, 1990). States also require that "beneficial use" be "reasonable." Standards for what is reasonable constantly evolve as demand grows, values change, and conservation technology improves. However, findings of unreasonable use and subsequent redefining or reallocating water rights are rare.

State and local agencies enforce the doctrine of prior appropriation, both by enforcing established rights and by regulating how appropriators use their water. States may determine what is a reasonable water duty for specified uses; for example, they may limit a right to a certain amount of water use per acre for seasonal irrigation. There is usually a state engineer who supervises regional engineers or superintendents who oversee commissioners or watermasters responsible for ensuring water is used according to the terms of the water right. The commissioners distribute the water at the authorized time in the authorized amount to the appropriators. The commissioner operates all headgates in order of the priorities of his region. The commissioner or watermaster can be viewed as a “streamside police officer” who manages conflict among users and may in some instances make arrests if necessary (Getches, 1990). In times of drought or lower flow, the commissioner or watermaster closes the gates of those with lowest priority, starting with the latest claim. Some areas have water districts with elected boards that oversee water use. In Colorado, special water courts deal with water controversies (see case study). Commissioners report water use and water issues up the supervisory chain so that they may be managed on a state level. Private water institutions also play a big role in allocating water, and this role varies across the western states. For example, mutual irrigation companies administer water among their shareholders, such as ranchers or farmers. Water users often “self police”, since undue use by one may affect others. External means of resolving conflicts, however, may still be required.

Within the system of prior appropriation, water can be allocated to environmental purposes by two methods: appropriating water for environmental uses or removing water from the appropriation regime and reserving it for the environment. This is done through state action or federal laws. Some states have passed laws that remove certain rivers and lakes from appropriation, protecting them from private withdrawals. Others have reserved water rights for instream flows for fish, wildlife, recreation, and water quality. If a system is fully appropriated, water for the environment must be purchased, or government agencies must use their power of eminent domain to acquire these rights. States determine whether a system is fully appropriated. They may determine that no water remains available for appropriation, either year-round or during specified months. They may adopt a declaration that certain stream systems are fully appropriated, thus precluding acceptance of applications to appropriate unappropriated water.

3.3.2.2 Water Transfers in the West

In most western states, a water transfer may occur by selling, leasing, moving, exchanging, or donating water rights as long as senior water rights are not impacted. A water transfer is a voluntary agreement that temporarily or permanently changes the type, time, or place of use of water and/or a water right. Water transfers can be local or distant, and they can move water among agricultural, municipal, industrial, energy, and environmental uses (Western Governors' Association, 2012). Historically, water transfers most commonly occurred among farmers to obtain water for irrigation, or among farmers, mutual irrigation companies and governmental water districts. For example, many water exchanges and sales occur within mutual irrigation companies. Farmers in these companies (or cooperatives) trade or sell their shares of the total amount of water available to the company. However, this historic custom of transfers within the irrigation sector has begun to shift because of new demands for water in the west.

Heightened demand in the west is the result of economic, industrial, and tourism development, urban population growth, and a new need for water for the environment, such as instream flows for the preservation of natural areas and wildlife. Yet many communities have fully allocated their water resources. There is also an increasing expense and environmental impact of developing new water supplies plus the impacts of climate change. Western water management is moving from developing new supplies to managing demand, and an increasingly important demand management tool is transferring water from agricultural uses to new and often higher valued urban, industrial, and environmental uses.

3.3.2.2.1 Market-based Water Transfers

Market-based water transfers are different than transfers that are donations or transfers as a result of regulatory removal or cancellation. Water marketing is a framework and process for transferring water where there is a buyer and seller. This is the way transfers usually occur and is characterized by voluntary negotiations between the parties over the amount, timing and price of water to be exchanged. The price of water may also be set by the market or by the local government, and the price is influenced by costs associated with the transaction, conveyance, storage, treatment, legal fees, and public agency review, for example. The price naturally influences the ensuing transfers. For example, with lower prices, there are fewer willing sellers and greater demand for water from agricultural users; higher prices encourage sellers but tend to exclude most potential agricultural buyers.

When an appropriator wishes to transfer a water right, the appropriator must apply to, or seek permission from, the state administrative agency such as the office of the state engineer or a state or water court. The decision to permit the water transfer depends on whether the transfer will harm other appropriators, called the "no harm rule," by preventing them from receiving the water to which they are entitled. In some states, if the transfer will harm the "public interest," or have a negative economic, social, or environmental impact on the local community, the authorities can deny the transfer. The burden of proving that no harm will result is on the person seeking the new use or the transfer.

There are various types of market-based transfers, and the type that is chosen depends on the specific needs and constraints faced by the buyers, sellers, and others involved.

3.3.2.2.2 Permanent Transfers

A permanent transfer of water involves the change in ownership of water rights. Permanent transfers are used to meet demands and improve system reliability. Using transferred water can prevent the need for system expansion, which will avoid, or at least delay, economic, social, and environmental impacts associated with construction. The majority of permanent transfers involve the purchase of agricultural water rights by urban entities. The farms are then reverted to dryland agriculture, fallowed, irrigated with lower quality water, or the farms lease the transferred water back during wet years when the urban area does not need the extra water. An example of a permanent water transfer in Arizona is when a developer acquires groundwater rights associated with recently developed, formerly agricultural suburban lands. New Mexico's State Engineer has said that the only way to meet future demands will be through water transfers (Brown, 2013).

3.3.2.2.3 Contingent Transfers/Dry-Year Options/Lease

In many cases, potential buyers of water are less interested in acquiring permanent supplies than in increasing the reliability of their water supply system during times of disruption. For this reason, they prefer a temporary or contingent transfer. The timing and conditions for a contingent transfer agreement will depend on the source of unreliability that the buyer would like to eliminate. Drought-contingent contracts for water are best made with holders of senior water rights since they are the least likely to be shorted during drought, though the increased reliability of water from senior rights tends to raise its market value. Decades-long agreements or contingent contracts allow water-right owners to retain long-term investment flexibility in anticipation of potentially greater future values for water leasing or sale of a water right. Intermediate-term (3-10 years) contingent transfer contracts might be employed to help reduce the susceptibility of the buyer's system during the construction or acquisition of new supplies. Short-term (1-2 year) contingent transfer contracts might be utilized in the midst of a drought by a water agency to replace its depleted storage. Arrangements are also feasible for less than one year.[35]

3.3.2.2.4 Spot Market Transfers & Water Banks

Spot market transfers are typically agreed to and completed within a single water year (October 1 – September 30). They are usually established by some sort of bidding process, often with some of the conditions for transfer being fixed (e.g., price, quantity). However, spot market transfers can arise from negotiations between buyers and sellers. Water banks are a constrained form of spot market operated by a central banker where users with surplus water sell it to the bank for a fixed price and others buy water from the bank at a higher fixed price. The difference in price typically goes to covering the bank's administrative and technical costs. Under most banking arrangements, the original water rights holders retain their permanent water right and only sell to the bank the right to use the water. The California Drought Emergency Water Banks of 1991 and 1992 are examples of water banks or spot markets in which the terms and price of transfer were relatively fixed with the state acting as a banker (Howitt, Moore, and Smith, 1992). These banks were very successful at redistributing water during the drought. Where spot markets or water banks exist, agencies are likely to plan on using them during droughts instead of relying on expensive forms of conventional water supply capacity expansion and urban water conservation.

[35] Oregon offers a voluntary instream leasing program. While leasing water for instream benefits, it provides water users with options that protect their water rights. The program includes provision for split-season leases that allow all or a portion of an existing water right to be used for the existing use and for instream use during the same year, provided that the uses are not concurrent and that the water rights holders measure and report the uses. See http://www.oregon.gov/owrd/pages/mgmt_leases.aspx.

3.3.2.2.5 Transfer of Reclaimed, Conserved, and Surplus Water

Purchasing water made available by reclamation or reductions in water demand is a form of water transfer. Urban water utilities in the eastern United States as well as in the west have become involved in purchasing water back from their retail customers by paying customers or developers to install low-flow plumbing or removing/not using relatively water-intensive forms of landscaping. Urban areas sometimes finance the conservation of irrigation water to make additional water available for urban supplies, primarily by paying irrigation districts to line their canals in exchange for the water this saves. For example, the Metropolitan Water District of Southern California paid the Imperial Irrigation District to line its canals, achieving water savings estimated at 123.3 m^3x10^6 (100,000 acre-ft/yr) from Colorado River water supplies (Gray, 1990).

Water in the western United States is leased and sold primarily in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming. As in the real estate market, water prices follow the country's booms and lulls. One 2010 study attempted to discern trends in sales (permanent transfers) and leases occurring in regions with more established markets to assist appraisers faced with valuing water rights, water infrastructure, water utilities, and other water-related assets.[36] This study found an increase in transactions during the study period 1987 – 2007, and a decrease in average volumes per transaction. Leases seem to be an increasingly popular form of transaction. Sale and lease prices tend to be increasing, though there is a huge variation across the states studied. To get a quick sense of the magnitude of markets in different western states, consider these statistics: the number of sales ranged from 0-120 per year, the total volume sold per year ranged from 0 to 300,000 acre feet (approximately 0 to 370 m^3x10^6), and average sale price ranged from 0-$22,000/acre-foot (approximately $27,000/$m^3x10^3$). For leases, the number per year ranged from 0-160, the total volume leased per year ranged from 0-1.5 million acre-feet (approximately 0-1.8 billion cubic meters), and the average lease prices ranged from $0-$600/acre foot (approximately $740/ m^3x10^3). Another study looked at prices across 12 western states between 1987 and 2008 per volume of committed flow for leases and sales for agriculture-to-agriculture and agriculture-to-urban transactions. The data indicated higher prices for agriculture-to-urban transactions (see Table 1).

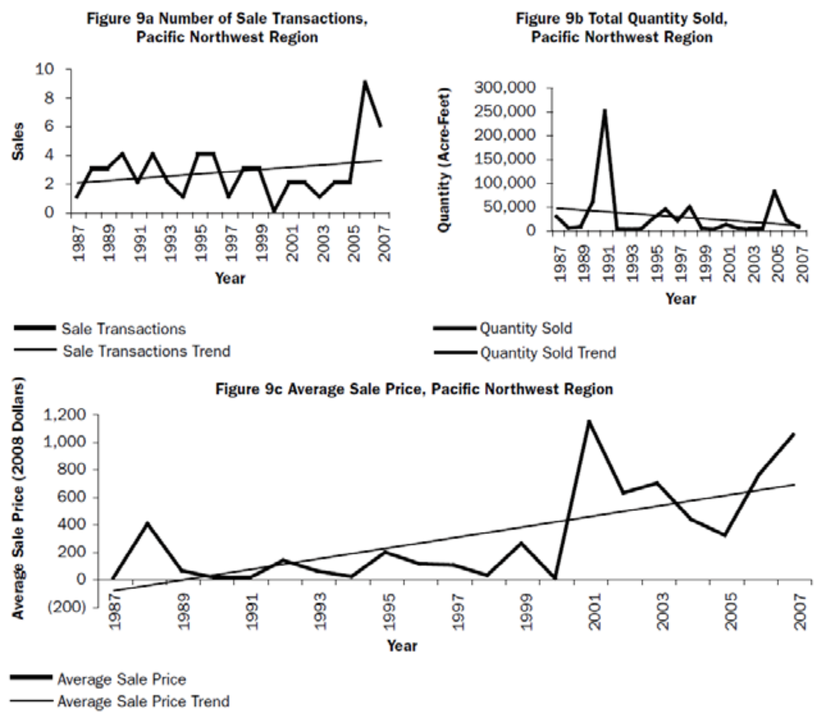
[36] For more details, see Basta and Colby (2010). It examines water market transaction data for 1987 to 2007 in the western United States.

Table 1. Water Transfer Prices by Sector, 1987-2008 (2008 dollars per committed million litres)

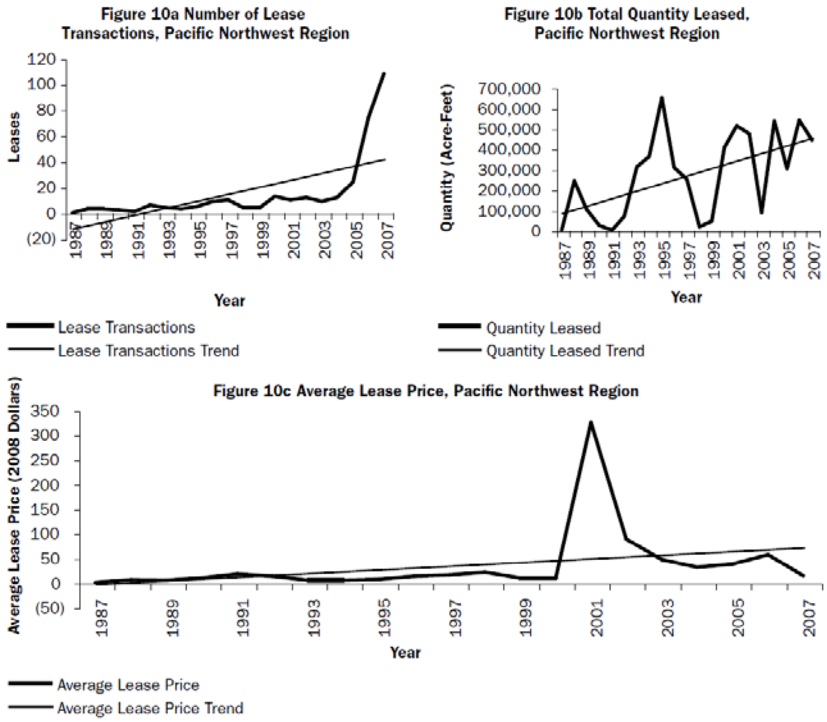
	Agriculture-to-Urban Leases	Agriculture-to-Agriculture Leases	Agriculture-to-Urban Sales	Agriculture-to-Agriculture Sales
Median Price	$60	$15	$239	$117
Mean Price	$154	$45	$354	$199
Number of Observations	229	239	1,140	215

Source: Grafton et al., 2011.

For an example of water sales and leases in one U.S. region (the Pacific Northwest), see Figures 2-7.



Source: Basta & Colby, 2010.



Source: Basta & Colby, 2010.

Drawing conclusions from data in Figures 2-7 is difficult given a lack of oversight at higher regional levels and thus the findings can be incomprehensive or inconsistent. However, it is safe to conclude that water transfers in the west, unlike those in the east, are a viable method to reallocate water and seem to be slowly increasing over time.

3.3.2.2.6 Additional Considerations Regarding Water Transfers

Benefits of water transfers include (1) providing new sources of water to growing cities and for environmental and recreational needs; (2) managing drought; (3) promoting efficient water use (for those receiving the water); (4) encouraging conservation and improved water quality; and (5) providing alternatives to new construction projects intended to augment existing supplies. Water transfers are one of the few ways to increase water supplies in basins that are fully allocated, such as the Deschutes River.

Water transfers are *most successfully* achieved under the following conditions:

1. Water rights are defined clearly.
2. Water transfers have low transaction costs.
3. Water markets consist of multiple buyers and/or sellers.
4. Water is conveyable between willing buyers and sellers.
5. Communication between buyers and sellers is strong and they share certain goals.

The U.S. experience indicates water markets are generally difficult to establish. A fundamental challenge is many water supplies and distribution systems are heavily subsidized, so true transaction costs may be beyond the financial resources of the consumer. Second, a minimum water allocation is considered a public right, so assessing the true transaction costs for water, especially for large numbers of urban consumers, is not socially or politically acceptable. Many of the agricultural interests do not pay full transaction costs for water. This is a legacy from the early settlement of the US, and it is ingrained in the American culture and codified by a variety of laws. As a consequence, these agricultural systems have proven very difficult to modify.

A barrier to water transfers is the externalities of potential impacts on third parties and "area of origin" consequences. Identifying affected parties and adequately mitigating adverse impacts are a challenge. Impacts in areas of origin include reductions in an area's water availability or water quality. These reductions can affect the economy and quality of life and influence employment, personal income, and population. Addressing externalities in any market is a challenging undertaking. The following actions have been taken (see case studies) to address third party and area of origin impacts.[37]

1. Tax transfers to compensate harmed third parties
2. Require transferors to provide additional water for environmental purposes
3. Use state or federal compensation to help economic transitions in water-selling regions
4. Require public review and regulatory and third party approval of transfers
5. Require prior evaluation of third party impacts of transfers, similar to an environmental impact report
6. Require formal monitoring of third party impacts
7. Restrict transfers to "surplus" waters

The proliferation of stakeholders makes a further case for increased oversight. Traditional supply augmentation and demand-management measures can be achieved by a single water agency, but water transfers require coordination between various groups involved in a transfer, including sellers, buyers, and separate entities operating storage and conveyance facilities.

3.3.3 Groundwater Regulation

In the United States, groundwater law was slow to develop and happened mostly after the doctrines of riparianism and prior appropriation were established. Original groundwater law was based on Spanish Law and known as the Rule of Capture. It placed no restrictions on withdrawal since a landowner owned his land including everything below it. As the extent of groundwater pumping grew and started to impact others' groundwater pumping as well as surface water levels, most states applied legal constructs similar to those that they used for their surface water. Some states applied the doctrine of prior appropriations - awarding priority based on first in time, first in right. Others applied the doctrine of riparian rights - based on principles of reasonable use, correlative rights (riparian landowners must share the total flow of water in a stream), and most recently the Restatement approach (using a reasonableness balancing test to permit groundwater withdrawals). States use these doctrines to restrict the withdrawals to a given flow rate from the pump or to a limited number of irrigated acres.

Groundwater marketing is not common in the United States. Most states rely on the above laws to address competing demands. In the east, the riparian doctrine allows a landowner to withdraw

[37] Israel and Lund, pg. 3 (1995).

groundwater with few limitations. When this doctrine interferes with other wells or surface water, the principles of reasonableness and correlative rights and the Restatement approach are applied. In the west, prior appropriation prohibits any interference of senior water rights, and well-spacing requirements reduce the possibility of well-pumping interference. Sales do occur in some states. For example, in Texas, the Rule of Capture is still followed so landowners can sell the water beneath their land. In Colorado, non-Colorado River tributary groundwater can be sold and moved to a willing buyer for an agreed-upon price. In California, groundwater marketing is permitted among pumpers in an adjudicated groundwater basin, but restrictions exist on the transferability of use right (Cech, 2005).

Arizona's Groundwater Management Act of 1980 is an innovative example of groundwater management. This act created a framework to manage groundwater in the state based on use with the goal of "safe yield" by 2025. The state defines safe yield as when the amount of groundwater withdrawn equals total aquifer recharge.[38] Arizona plans to achieve this goal by reducing or eliminating groundwater withdrawals for agricultural purposes and redirecting some of that water to support its population growth. The act established five "Active Management Areas" where there is a heavy reliance on mined groundwater, as well as two Irrigation Non-Expansion Areas, which have restrictions on increasing their number of irrigated acres. The Arizona Department of Water Resources (ADWR) is in charge of implementing this act. ADWR is the primary agency responsible for administering most state water laws. Its responsibilities include meeting water demands, regulating the use of surface water and groundwater, regulating nonfederal dams, and promoting conservation. This department also represents the state in discussions with members of the Colorado River Compact, described in Section 6 of this report.

[38] See the Arizona Department of Water Resources website at http://www.azwater.gov/AzDWR/WaterManagement/Recharge/default.htm. This site also explains how groundwater and surface water permits are administered in the state. Arizona's administration of permits is an excellent example of how a state water agency manages water in an arid state with many competing demands and few resources.

4. WATER ALLOCATION AT THE INTERSTATE LEVEL[39]

4.1 Introduction

Managing a valuable and often scarce resource such as water is an inherently difficult challenge. It raises a variety of equity and efficiency issues and in a federal system of government, can test the relationships between competing levels of government. Experience with federal systems in the United States, Australia,[40] Canada, and India, among others, offers many lessons for how to approach this challenge. This section focuses on the experience in the United States (U.S.), where every major river basin is international, interstate, and/or sub-state; no basin conforms exactly to the contours of a state boundary. Consequently, multijurisdictional conflicts over water resources administration have been present since the first days of the Republic, especially at the interstate scale, and dozens of "coordination mechanisms" have been proposed and implemented to address the unique management challenges posed by transboundary water resources.[41] Using legal foundation and jurisdictional membership as criteria, seven general types of administrative arrangements in three general categories can be identified: (1) the strictly interstate approaches, which includes interstate compacts (and their *compact commissions*) and *interstate councils*; (2) federal-interstate approaches, which include *basin interagency committees*, *interagency-interstate commissions*, and *federal-interstate compact commissions*; and (3) federal approaches, including the *federal regional agency* and the *single federal administrator* arrangement (Kenney, 1993).

Humid regions of the U.S. contain the most administrative diversity, since the need to allocate water among competing jurisdictions has historically not been required. In the arid American West and Southwest, a formal water allocation has typically served as a precursor to more thoroughly coordinated development and management regimes. In these locales, one approach dominates the institutional landscape: interstate water allocation compacts. In the American

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[39] Much of this summary is derived from Kenney (1996) and related studies prepared for the Alabama-Coosa-Tallapoosa and Apalachicola-Chattahoochee-Flint (ACT/ACF) Comprehensive Study.
[40] See Appendix 5 for a brief introduction to the Murray Darling Basin.
[41] How to best manage interstate water resources is a subject that has attracted a great deal of governmental and scholarly attention over time. The following sources listed in the References are some of the more familiar and influential federal (or federally sponsored) reports: Inland Waterways Commissions (1908); President's Cabinet Committee on Water Flow (1934 National Resources Committee (1935); Hoover Commission (1949, 1955); President's Water Resources Policy Commission (1950); the report of the President's Advisory Committee on Water Resources Policy (1956); the report of the Senate Select Committee on National Water Resources (1961); the report of the Water Resources Council (1967); the Advisory Commission on Intergovernmental Relations (1972, 1991); National Water Commission (1973), as well as the commission's numerous background studies (e.g., see Muys, 1971; Hart, 1971; and Ingram, 1971); and the General Accounting Office (1981). Among the more worthwhile studies emerging from the academic community include those by Powell (1890); Martin et al. (1960); Selznick (1966); Teclaff (1967); Voight (1972); Derthick and Bombardier (1974); Hill (1974); Dworsky and Allee (1981); Grant (1983); Foster (1984); Donahue (1987); Simms, Rolfs, and Spronk (1988); Dworsky, Allee, and North (1991); Matthews (1994); McCormick (1994); and Muys, Sherk, and O'Leary (2007).

West, 21 compacts provide a quantitative allocation formula between states. They are:

1. Arkansas River Compact of 1948
2. Arkansas River Compact of 1965
3. Arkansas River Compact of 1970
4. Bear River Compact of 1955 (amended 1978)
5. Belle Fourche River Compact of 1943
6. Big Blue River Compact of 1971
7. Canadian River Compact of 1950
8. Colorado River Compact of 1922
9. Costilla Creek Compact of 1944 (amended 1963)
10. Klamath River Compact of 1957
11. La Plata River Compact of 1922
12. Pecos River Compact of 1948
13. Red River Compact of 1978
14. Republican River Compact of 1942
15. Rio Grande Compact of 1938
16. Sabine River Compact of 1953
17. Snake River Compact of 1949
18. South Platte River Compact of 1923
19. Upper Colorado River Compact of 1948
20. Upper Niobrara River Compact of 1962
21. Yellowstone River Compact of 1950[42]

Many of these compacts follow the same conventions and patterns. All feature two salient qualities. First, all 21 compacts are negotiated agreements between states that became law only upon ratification by the participating state legislatures and then by the U.S. Congress (the federal legislature).[43] Second, all are anchored by a mathematical formula that provides a quantitative allocation of water among the competing states. Once water is allocated among states via the compact, intrastate allocation to specific end-users (e.g., cities and farms) is accomplished by other rules established and administered under state law, with minimal federal involvement. Likewise, any reallocation of water within states through market transactions is also controlled by the states. While marketing across state lines is arguably not prohibited by the compacts, it is not specifically authorized, it is not generally assumed to be a viable option, and (except in the

[42] This list only includes compacts where adopting a quantified allocation between states is the primary focus. Interstate water compacts addressing other management purposes, such as pollution abatement or flood control, also exist but are omitted here if they do not also provide a formal allocation. See Muys (1971) for a general discussion of interstate water compacts.

[43] Typically, the negotiation and approval of interstate compacts have followed a 5-step process: (1) Congress authorizes the states to negotiate a compact, (2) state legislatures appoint commissioners, (3) the commissioners meet, usually aided by a federal chairman, to negotiate and sign the agreement, (4) the state legislatures ratify the compact, and (5) Congress ratifies the compact. The Department of the Interior typically required states to resolve interstate water allocation disputes prior to commencing federally funded river basin developments.

Lower Colorado River Basin, noted below in the case study), does not occur in any meaningful way. Treating water as a marketable commodity is an idea that is well established within the western states, but it is not accepted at interstate scales.

Water allocation compacts are the dominant mechanism for interstate allocation in the United States and are the primary focus of this summary, the special case of the Delaware River is also worth noting. The Delaware is an eastern (i.e., humid region) river, initially allocated through the second[44] interstate allocation mechanism provided by the U.S. federal system, the federal judiciary. Specifically, disputes between states rise to the Supreme Court—the highest court in the country—and on many occasions, the Court has been asked to address issues of water allocation. Typically, in such cases, the Court urges the states to negotiate a solution (via a compact),[45] but in a few celebrated examples, the Court has used the highly flexible doctrine of "equitable apportionment" (the water law doctrine that governs the U.S. Supreme Court's allocation of interstate rivers between or among states) to craft interstate allocations based on its assessment of equity and need. The initial use of equitable apportionment was on the Arkansas River between Colorado and Kansas in 1907.[46] The most celebrated case, decided in 1931, concerned an eastern river, the Delaware River.[47] States generally prefer compacts to equitable apportionment proceedings since, in the former, they retain control over the dispute resolution process, the terms of the ultimate agreement, and implementation arrangements. Compacts also allow allocations to occur long before needs materialize, which can greatly aid long-term planning and management programs. Partly due to these features and the desire to broaden management efforts away from the singular issue of allocation, the states of the Delaware Basin rolled the Court's allocation agreement into a compact in 1961. Thus, the Delaware Compact is different from the western compacts in three notable ways. First, the allocation formula originated with the Supreme Court rather than through interstate negotiations. Second, the Delaware Compact has a stronger focus on water management than the western agreements. Third, the Delaware Compact is a so-called "federal-interstate" agreement, which means the federal government is included as a signatory and equal participant in the agreement and in the corresponding compact commission (General Accounting Office, 1981). These are salient differences that make the Delaware case worth including in our survey of interstate allocation

[44] Arguably, a third strategy also exists, but it is far from common: congressional apportionment. This approach is not included here because it has only been observed in one, highly unusual situation, and is generally not expected to emerge again as a means for interstate apportionment. The case in question involved allocation of the Lower Colorado River among Arizona, California, and Nevada, something that Congress effectively did (according to a later court decision) in the Boulder Canyon Project Act of 1928 (Getches, 1990).

[45] For example, see: *Colorado v. Kansas*, 320 U.S. 383, at 392 (1943).

[46] *Kansas v. Colorado*, 206 U.S. 46 (1907).

[47] *New Jersey v. New York*, 283 U.S. 336 (1931). A key feature of equitable apportionments is that they can be changed later by the Supreme Court should conditions change. This was done on the Delaware in 1954 (New Jersey v. New York, 347 U.S. 995 (1954). *Also see* Lord and Kenney (1995).

approaches, and expanding upon in a case study below. Thus, a 22nd compact, the Delaware River Basin Compact of 1961, is described here.[48]

22. Delaware River Basin Compact of 1961

In this section, the interstate water allocation formulas and administrative arrangements of these 22 agreements are summarized, lessons are identified, and recommendations are offered regarding how best to use interstate water allocation formulas in situations where that approach is preferable. It should be noted that the assessment primarily speaks to issues of *execution* of the water allocation compact approach, but an equally important consideration is the inherent limitations of the *model*. Although the water allocation certainty offered by the compact approach can be very desirable, it can come at the expense of flexibility. Unlike a Supreme Court ordered equitable apportionment that can be independently revised by the Court should conditions change, the unanimous consent of the signatory states is required to modify compacts, something that is unlikely to occur since any such adjustment is inherently zero-sum. Additionally, while water allocation can be a useful or even essential precursor to the development of more broadly focused management regimes, any effort that essentially divides up a river into discrete allocations can run counter to notions that rivers should be viewed and managed as multi-faceted systems of integrated processes. Particularly in areas not experiencing water scarcity, it remains debatable whether or not imposing an interstate allocation is a necessary or desirable action. What is clear from the U.S. experience is that, should an allocation be pursued, the execution of the effort is critically important. However, the advice offered in this report is most relevant to the design of allocation formulas and the associated administrative arrangements.

4.2 Interstate Water Allocation Formulas

The key element in interstate water allocation compacts is the mathematical formula used to apportion flows. The treatment of two related variables best explains the different approaches seen in allocation formulas: (1) the type of hydrologic standards used and (2) the time scale over which the hydrologic variables are measured:

- **Hydrologic Standards**: Four general approaches can be identified pertaining to the type of hydrologic standards used: (1) systems based on maintaining minimum flows at state lines (or other useful gauging stations), (2) approaches based on reservoir storage, (3) formulas allocating fixed or percentage-based rights to consumption or diversion, and (4)

[48] Another “eastern” effort at an interstate water apportionment is worth mentioning. The ACT/ACF is the moniker given to a complex array of two, largely parallel, rivers originating in north Georgia: the Alabama-Coosa-Tallapoosa (ACT) system, which travels into Alabama before reaching the ocean at Mobile, and the Apalachicola-Chattahoochee-Flint (ACF) basin, which includes parts of Alabama and its terminus in the Florida panhandle. After a lengthy dispute, compacts were established for each basin in 1997 to apportion the rivers. Unlike the “western style” of allocation compacts, these compacts did not feature a quantitative apportionment. Commissions undertook this central task. Those efforts failed, the compacts expired in 2003, and the courts resumed the central role. There have been many decisions and appeals since 2009.

a requirement for upstream states to deliver downstream a minimum *volume* (rather than a constant *flow* rate) over a lengthy time period.

- **Time Scale**: Four general approaches can be identified pertaining to the time scales employed in operation of the allocation formula: (1) constant requirements (same standard in effect at all times); (2) seasonal requirements, (3) annual requirements (i.e., typically a "water year" standard); and (4) a multi-year requirement.

4.2.1 Hydrologic Standards

The most obvious way to distinguish among the different formulas is by the type of hydrologic standard used. Minimum flow standards, typically measured in cubic-feet per second (cfs), can be used in a variety of situations, and are especially useful in situations featuring important instream flow uses. This approach is also frequently used due to relative ease of monitoring, something that can often be done using existing stream gauging stations.[49] An often simpler-to-administer approach is based on reservoir storage. This approach generally limits the amount of water that can be stored by a given party or simply limits the amount of "reservoir storage capacity" that can be constructed. A more complicated but common category of approaches is allocating rights to consume (or divert) given quantities of the river to the various parties. Typically, this can be done using a percentage system or by specifying fixed quantities. Finally, some approaches specify a delivery requirement, which is similar to a flow standard except that delivery requirements are volume-based, whereas a flow standard is rate-based. Some allocation schemes use more than one of these hydrologic standards.[50] Examples of each of these four general approaches are given below:

- **Minimum Flow.** The formula for the Big Blue River between Nebraska and Kansas calls for Nebraska (the upstream state) to regulate water uses in order to "maintain minimum mean daily flows at the state-line gaging stations" during the summer months. Standards range from 45 cfs [approximately 1.27 m^3/s] in May to 90 cfs [approximately 2.55 m^3/s] in August.

- **Reservoir Storage.** The Canadian River Compact (between New Mexico, Texas, and Oklahoma) places an upper limit on how much water New Mexico and Texas (the upstream states) can store. Specifically, New Mexico is limited to 200,000 acre-feet [approximately 247 m^3x10^6] of storage, while Texas is limited to 500,000 acre-feet [approximately 617 m^3x10^6]. An acre-foot of water is that amount necessary to cover an acre of land to a depth of one foot. No restrictions are placed on the amount of storage (or water consumption) that can occur in Oklahoma (the downstream state), although the compact specifies that once Oklahoma builds more than 300,000 acre-feet [approximately 370 m^3x10^6] of storage, Texas's storage limit is raised accordingly.

[49] State-line standards are particularly well suited to situations in which the river crosses but does not form the state line. This is the typical situation in western compacts, a reflection of how the western states were established following lines of latitude and longitude, rather than along hydrologic features. Those few western U.S. rivers that do act as state lines are often not subject to interstate water allocation formulas. Prominent examples include the Columbia River between Washington and Oregon, and the Snake River between Idaho and Oregon. In the Midwest and East, it is much more common for rivers to form state lines, but allocation formulas are much rarer.
[50] In Appendix 2, Table 1, the compacts are classified according to the type of approach that best describes the overall philosophy of the compact and not necessarily how it affects each party.

- **Rights of Consumption/Diversion.** The Belle Fourche formula allocates 10 percent of all unappropriated waters in the basin to Wyoming (the upstream state) and the remaining 90 percent to South Dakota (the downstream state).[51]

- **Delivery Requirements.** The Colorado River Compact requires the states of the Upper Basin (Wyoming, Colorado, Utah, and New Mexico) to deliver to the states of the Lower Basin (Nevada, Arizona, and California) a minimum of 75 million acre-feet (maf) [approximately 92.5 $m^3 x 10^9$] over all ten year periods.[52]

Appendix 2, Table 1 presents the water allocation formulas featured in the 22 U.S. compacts. The "accounting based" approaches that allocate rights of consumption/diversion are, by far, the most common approach, followed by schemes based on reservoir storage, minimum flows, and delivery requirements. "Accounting based" strategies - with their measurement and record-keeping complexities - are among the most complicated and administratively difficult formulas.

4.2.2 Time Scale

The second variable, after hydrologic standards, that can be used to distinguish among different approaches is the time scale. Some standards, such as flow minimums and/or storage maximums, generally are in effect at all times. Approaches based on consumption and/or deliveries (e.g., from upper to lower basins) often feature longer time scales, usually either annual or multi-year requirements. In regions where water is primarily valued for irrigation (a common situation in western basins), standards sometimes vary to reflect growing seasons.

Not surprisingly, there are some general correlations between the hydrologic parameters used and the time scales over which these parameters are measured. Standards based on minimum flows tend to be defined on a constant (or daily) basis, whereas approaches that allocate rights of consumption/diversion tend to be defined using annual time scales. Similarly, approaches that rely primarily on delivery requirements often feature annual or multi-year time scales. Approaches that rely on reservoir storage standards show the greatest variety in their use of time scales.

4.3 Administrative Arrangements

The administrative burden of interstate allocation can vary significantly based on the structure of the formula. Some formulas require daily measurements or calculations; others require this information periodically or under special circumstances; still others—such as those limiting the construction of storage capacity—do not require any field monitoring. Additionally, some require fairly simple tasks—e.g., reading a stream gauge—while others require complex and data intensive calculations, such as estimating consumptive use or precisely estimating annual virgin water flows (from which to calculate consumption percentages). Presumably, compact

[51] The term "appropriated water" is common in the compacts. Most western states internally use a system of "prior appropriation" to allow specific end-users to acquire rights to consume water. Water that is unappropriated is water that has not yet been assigned to a particular end-user through the state process.

[52] The Compact actually does not specify a "delivery obligation" but requires the Upper Basin to allow the specified amount of water to flow downstream. Whether or not this is different from a delivery obligation is a contested matter. See Robison and Kenney (2013).

negotiators will consider the availability of administrative resources when designing allocation formulas.

In many cases, interstate water allocation compacts create new administrative bodies for this purpose. As shown in Appendix 2, Table 2, 18 of the 22 compacts either established, or provided for the establishment of, a new compact commission (or "Authority") to implement, or coordinate the implementation of, the apportionment. Compacts that do not establish commissions generally empower high-level administrative officials in the participating states to create the necessary administrative rules, and sometimes empower the states to later establish commissions—something that has been done in the La Plata, Republican, and South Platte River Basins. In practice, an unstaffed (and unbudgeted) interstate "commission" is not often significantly different from a cooperative arrangement that provides mechanisms for state engineers to routinely communicate and coordinate their actions.

The federal government has been delegated or has assumed major responsibilities in all interstate watercourses. Consequently, most compact commissions (15 of 18) feature federal membership. The federal member typically serves as the chair in non-voting capacity; only the Upper Colorado and Delaware River Commissions provide for voting federal members. Despite the common federal presence, in most cases the responsibility for implementing the allocation is clearly placed on the shoulders of state actors (acting either through a commission or through a more informal administrative arrangement), although coordination with federal actors—particularly the U.S. Geological Survey (USGS)—is often specified. Only in a few cases, such as the River Master system used in the Delaware Basin and the Lower Colorado Basin's reliance on the Secretary of the Interior, do federal officials play the lead role in these activities.[53]

4.4 Lessons from Problematic Interstate Allocation Formulas

A successful water allocation coordination mechanism provides an element of certainty, stability, and civility in interstate water issues. When the allocation formulas prove to be problematic, however, none of these goals is achieved, and litigation is the typical result. Some examples include compacts for the Arkansas, Canadian, Colorado, La Plata, Pecos, Red, Republican, and Yellowstone basins.[54] A detailed review of all relevant disputes is not provided in this report but rather lessons distilled from selected experience:

- **Clearly Defining Terms is Essential**. Most statutes governing water allocations define key terms, but some confusion over the exact meaning of language has led to litigation. One example is the Canadian River Compact, which includes the innocuous term "reservoir storage capacity." In this dispute, Oklahoma and Texas argued the term

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[53] In both of these basins, Supreme Court decisions empower a federal actor to take primary responsibility for implementation of allocation formulas. In the Colorado Basin, the Secretary of the Interior manages the interstate allocation in accordance with several federal statutes (including two interstate compacts) and the decree associated with the *Arizona v. California* (1963) decision. In the Delaware Basin, this responsibility falls to a court-appointed River Master (typically, a USGS official) pursuant to the New Jersey v. New York (1954) decree. The Delaware situation is further complicated by rules that allow the Delaware River Basin Commission to temporarily modify the judicially established allocation formulas during drought emergencies.

[54] Problems with court-imposed allocation formulas, such as those on the North Platte and Delaware River Basins, have also occurred, but are not reviewed here given the emphasis on compacts. See Kenney (1996) for a more detailed review of several compact-related disputes.

referred to the actual physical limit of a structure; New Mexico (successfully) countered that the term meant the actual value of water that could be practicably stored given reservoir operating rules accounting for issues such as flood control and dam safety.[55] Other terms that have been (or may soon be) featured in compact disputes include consumption, depletion, delivery, natural, and tributary.

- **Excessive Administrative Complexity is Risky**. While some compacts opt for simplicity in the design of formulas—such as the aforementioned Canadian River Compact which features a reservoir storage limit—others seek to dynamically account for the natural variability in the hydrologic cycle. One example is the Pecos River Compact, which utilizes an "inflow-outflow method" that links downstream flow standards to natural inflows upstream. While simple (and progressive) in concept, the formula in practice has been administratively difficult. It requires Commissioners to precisely measure natural inflows—a particular challenge in flood years—and to estimate all sources of human and natural depletions.[56] Requiring unanimous agreement among Commissioners on matters of professional judgment is a recipe for conflict.

- **Changes in Physical Conditions are Inevitable**. As noted earlier, an allocation compact entails a trade-off between certainty and flexibility. In basins where physical conditions change, formulas can become unworkable. For example, Rio Grande flooding caused severe channel erosion, which in turn led to increased conveyance losses that made compact obligations impractical. In the Colorado River Basin, a delivery obligation formula was based on a period of flow estimates that proved to be unrepresentative of "normal" conditions (Robison and Kenney, 2013). Changes in hydrologic cycles attributable to climate change—such as changes in the timing or quantity of natural flows—are likely to cause additional concerns.[57]

- **It is Impossible to Anticipate all Relevant Societal Changes.** In recent decades, no subject has been the source of more compact disputes than the failure of compact negotiators to anticipate that groundwater usage would impact downstream surface water flows, a trend enabled by the advent of improved pumping technology. The Kansas v. Colorado[58] litigation on the Arkansas River is perhaps most illustrative of this issue, but the Pecos, Republican, and Yellowstone disputes are other examples. Unanticipated changes are often the result of agricultural expansion. The water demands of energy development are a key stressor in the Yellowstone Basin. Other issues related to the environment and Native American communities are also much more widely recognized today than in earlier decades. Some of these compact "omissions" likely to be most problematic in the future are summarized in Appendix 2, Table 3.[59]

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57 Several compacts (including those for the Arkansas, Bear, Costilla Creek, Rio Grande, Snake, South Platte, Upper Colorado, Upper Niobrara, and Yellowstone) define apportionment periods, in part, using calendar dates chosen to reflect traditional water use cycles—spring dates corresponding to the start of the irrigation season and/or fall dates to indicate the start of a storage season. In an era of climate change, these dates will become increasingly out of synch with actual hydrologic conditions (Kenney et al., 2008).

59 This table is adapted from Kenney et al. (2008).

If there is an overarching lesson to be drawn from these problems identified in water allocation compacts, it is that mechanisms (short of Supreme Court litigation) must be put in place to efficiently address implementation disputes. Whenever one party to a compact feels that another party fails to take (or restrict) required actions, procedures must be in place to gather facts, make findings, and implement remedies. Commissions, when they exist, are normally expected to tackle these challenges. However, the mere presence of a commission is often insufficient to resolve conflicts. In some cases, the commissioners are deadlocked and cannot make a decision, a problem most typical of two-state commissions and those that employ the unanimity decision-rule. Most commissions are not designed to deal with this situation, and litigation frequently ensues. Those that do address this issue do so by providing for arbitration or by empowering a federal party to cast a tiebreaking vote. Arbitration, either voluntary or mandatory, is provided for in four of the compacts: Arkansas (1949), Arkansas (1970), Klamath (1957), and Sabine (1953). In the Arkansas compacts, arbitration is not compulsory; the Klamath compact calls for mandatory arbitration. Arbitration in the Sabine is not mandatory; however, legal actions cannot be initiated on issues until they are first addressed by an arbitration board. In the Snake (1949) and Yellowstone (1950) compacts, the federal actors most involved in the joint administration of the formula (officials in the U.S. Geological Survey) are empowered to cast a tiebreaking vote when the states cannot reach agreement.[60]

Even when a decision is made by a commission (by whatever procedure), participating states normally reserve the right to have the decision reviewed in "agencies or courts of competent jurisdiction." Some compacts specify that rulings (if any) made by the commission will constitute *primae facie* evidence. This means that "findings of fact" made by the commission are generally assumed to be accurate; challenges should therefore be based on procedural grounds or other related factors, in essence empowering the commission to decide technical (factual) matters while allowing the courts to rule on other issues not requiring water management expertise.

A different type of compact dispute occurs when parties challenge a compact allocation formula on the grounds that the formula is inequitable (and therefore violates the doctrine of equitable apportionment), unconstitutional, or otherwise invalid on grounds not relating to a specific implementation issue. For example, the allocation formula in the Colorado River Compact could potentially be challenged as a "mutual mistake" (a contract law concept) since the scheme is based on virgin flow estimates that are now widely acknowledged to be inaccurate (Robison and Kenney, 2013). Similarly, formulas made inequitable or unworkable due to shifting climatic regimes are likely to provoke future challenges to compacts. Addressing problems of this type may be beyond the reach of any existing compact commission.[61] A few compacts explicitly call upon the commissions to periodically review these agreements and recommend changes to the appropriate legislatures. For example, after waiting periods of five and twenty-five years, respectively, the Big Blue (1971) and Arkansas (1965) commissions are permitted (whenever desired) to systematically review the provisions of these compacts and recommend changes,

[60] It is quite likely, however, that the federal official would be hesitant to take such action, as it might jeopardize the "neutral third-party" position of the federal commissioner.

[61] Temporary modifications in allocations may be within the scope of some commissions. For example, while the allocation formula in the Delaware Basin is permanent, the compact empowers the commission to declare temporary water emergencies and then to develop and enforce new allocation rules during the crisis situation (Lord and Kenney, 1995).

while the Bear (1978) compact empowers the commission to propose amendments "at intervals not exceeding twenty years."[62]

Changing allocation formulas is difficult but not impossible.[63] Many compacts specify that the allocation formula can be changed (or terminated) through a repeat of the compact negotiation process. Many compacts also contain language, added by Congress, reserving the right of the federal government to independently modify the agreement,[64] although this is not something Congress has shown an interest in doing. Congress is much more likely to act if its role is to consent to a revision negotiated and unanimously accepted by the participating states. But this occurrence is unlikely. Any deviation from the original formula is likely to favor some states at the expense of others. Opportunities for a win-win revision are limited. The unanimity requirement can be bypassed by appealing directly to the Supreme Court; however, the Court's role in modifying compacts has historically been limited to disputes regarding implementation and interpretation. It has not attempted to fundamentally restructure agreements. The Supreme Court is more likely to revisit an allocation formula of its own creation from an equitable apportionment case, as occurred in the Delaware Basin.[65]

4.5 Conclusions and Recommendations

Water allocation compacts in the American West have been effectively used to resolve (and preempt) dozens of interstate water conflicts. This is a significant accomplishment and suggests an ongoing need for compacts.[66] Yet it is important to realize the limitations of the compact approach. Many compacts are problematic, and few attempt to achieve anything resembling truly integrated management at the basin scale.[67] Compacts aggressively addressing issues such as water quality management, flood control and planning, and project integration are relatively common and generally confined to the Midwest and East. These compacts are distinct from the western agreements focused on allocation (Muys, 1971). Only in the East - specifically, in the Delaware and Susquehanna Basins - do federal-interstate compacts (that include the federal government as a signatory and equal partner) exist. And compact commissions, where they exist, are usually very modest organizations with narrow functions and authorities. Although interstate water allocation compacts could be a stepping-stone to more integrated and sophisticated

[62] For example, see the Bear River Compact, 1978; Article 14.
[63] Minor amendments (not affecting the basic apportionment) have been made to the Bear River and Costilla Creek compacts.
[64] The original draft of the Bear River Compact empowered the commission to change the allocation of storage rights, subject to ratification by the state legislatures. Congress, however, added an amendment to the ratified version requiring congressional consent. As a practical matter, with or without such language, congressional consent is likely required to change any compact.
[65] New Jersey v. New York, 347 U.S. 995 (1954) amends the formula provided by the court in *New Jersey v. New York*, 283 U.S. 336 (1931). The 1961 compact affirms this updated formula for the duration of the compact – a minimum of 100 years. The compact is significant in that it locks the formula into place for a long time period, something that is not guaranteed by a judicial decree.
[66] To guide such efforts, a model interstate water compact was developed by the Utton Transboundary Resources Center, University of New Mexico (*see*: Muys, Sherk, and O'Leary, 2007).
[67] In part, this is a reflection of the circumstances and era in which most of the compacts were negotiated; most were enacted to clear the way for dam-building projects, and all but 2 were enacted before the enactment of most federal environmental laws.

regional water management regimes, this has not typically happened in practice.[68] If additional agreements are crafted in the future, it would be reasonable to demand a little more ambition from their negotiators.

Many of the observed problems with interstate water allocation compacts can be avoided in new mechanisms by basing apportionments on percentages (rather than absolute values) and utilizing good scientific data and easily measured hydrologic parameters, providing a strong commission and related means of administration and dispute resolution, and broadening the scope of the agreement to include related topics influencing, and influenced by the apportionment. The necessity of allocating some fraction of the available water to environmental purposes (i.e., to the stream itself) is particularly important and something that has been notably absent in U.S. efforts.[69] All these efforts should be done in the context of the special physical and institutional characteristics that make each basin unique.[70] While there is no single "right" approach to the development of allocation formulas, it is evident that considering the demands of administration and dispute resolution should be central concerns, not merely technical exercise. Simultaneously achieving all these design objectives is a difficult task, but addressing these concerns represents a good investment of time and resources given the notoriously high costs of resolving interstate water disputes.

Any effort to design an interstate water allocation mechanism should take into account these questions:

- What types of water facilities exist in the basin—namely, what is the system of stream gauges, reservoirs, and diversion facilities? What opportunities and constraints are provided by these existing facilities in the design and administration of an interstate water allocation formula?[71]

- What information is most readily available? Is it reliable? Is the historic record of stream flows sufficiently long and technically accurate to be relied upon in the design of an

[68] Again, the only obvious exception is in the Delaware Basin, where the compact built upon, rather than established, the apportionment.
[69] Typically, interstate compacts assign a specific quantity of water to each participating state; each state then decides what it does with the water allocated, including consideration of water for environmental purposes. It would be possible, however, to allocate a percentage of basin flows for environmental purposes as part of the compact framework itself, which would both increase the certainty of water for that purpose and alleviate any potential concerns regarding one state possibly not withdrawing its full allocation to the benefit of another state that may not be similarly inclined.
[70] For example, most U.S. water allocation compacts deal with rivers that cross state lines but do not actually form the border, a reflection of how the western states—unlike those in the Midwest and East—were established following lines of latitude and longitude, rather than along hydrologic features. In these situations, state-line flow standards are an obvious option that may prove impractical for other basins. Many western U.S. rivers that do act as state lines are often not subject to interstate water allocation formulas (e.g., the Columbia River between Washington and Oregon, and the Snake River between Idaho and Oregon); notable exceptions are the Colorado, Red, Rio Grande, and Sabine.
[71] As a general rule, the more storage capacity in a basin—especially in the upper reaches—the more flexibility that exists in designing formulas.

allocation formula? What methods (e.g., stochastic approaches, hydropaleontology) might be used to supplement the historic record and provide additional information about potential extreme conditions? Can hydrologic stationarity be assumed? Would projections from General Circulation Models be of value? Is the surface water/groundwater connection well understood?

- What hydrologic parameter is most relevant to the needs of the parties? What types of guarantees do water users need?[72]

- Do the needs of major water-users in the basin (including environmental concerns) fluctuate over the course of a year? Is an allocation formula needed that features variable standards?

- Is an allocation formula needed to address all water resources in the basin at all times, or is it necessary only to consider a particular sub-basin and/or a particular time of year or event (e.g., drought)?

- What parties must be at the negotiation table to ensure agreements are legitimate and enforceable?

After considering these issues, it should be possible to tentatively begin constructing water allocation formulas and their associated administrative arrangements. As proposals are developed, they should be evaluated in the context of the following criteria and questions:

- Is it always clear what the hydrologic standards are?[73]
- Is the commission (or other administrative body) expected to make determinations that require "judgment calls" or the use of incomplete or poor information? If yes, can this potential problem be minimized? Have efforts been made to base the allocation formula on easily measured parameters?
- Have all potential “complicating factors" been addressed? Some common examples include:
    - the surface water-groundwater connection
    - potential changes to the physical system
    - new water developments and uses, or changes in the use of existing facilities
    - situations in which water quality influences water supply
    - natural depletions (e.g., seepage losses, evaporation, etc.)
    - interbasin transfers
    - climate variability (including droughts and floods) and climate change

[72] For example, if the primary uses are off-stream, then standards based on consumption (or diversion) or storage may be most appropriate; however, if the primary uses are in-stream, then flow standards may be more relevant.
[73] This is especially an issue for formulas that feature variable hydrologic standards.

- Does the proposed formula and administrative structure create any special demands or problems for state or federal water administrators?[74] Have the relevant federal-state issues been addressed, and provisions made for cooperative interagency partnerships (regarding monitoring or other activities)?

- Does the allocation formula allocate the risk of shortages in an acceptable manner?

- Does the commission (or similar administrative body) have the necessary authorities and resources to accomplish its goals? Has the commission been given the flexibility to modify administrative arrangements, as needed, to efficiently accomplish its goals?

- Do procedures exist to enforce the allocation? Is a system of penalties and remedies specified? Has a system of credits and debits (regarding water deliveries) been considered?

- Do the decision-making rules (in the commission or similar body) provide procedures and incentives to resolve conflicts? Have dispute resolution devices been considered?

- Have all terms been defined in a precise manner?

- Does the formula satisfy norms of fairness and political acceptance?

The U.S. experience suggests that formulas that can be favorably evaluated against these criteria and questions are ones with a high probability of success. However, the experience also shows that achieving this level of quality is a formidable challenge.

[74] For example, regulation and permitting of surface and/or groundwater withdrawals.

5. THE DELAWARE RIVER BASIN COMMISSION AND NEW YORK CITY CASE STUDY[75]

The Delaware River basin offers a model for federal-state collaboration on integrated regional water management, addressing in-basin management needs while accommodating substantial out-of-basin diversions. A Commission allows for coordination among its federal-state members and with key partners, and supplies an effective alternative to resolving conflicts in court. Broad powers allow for consideration of multiple purposes including water allocation, surface-groundwater interaction, pollutant and wastewater discharges, environmental needs, and flood and drought management (including advance measures). A water supply charging program offers institutional stability while providing pricing distinctions (and thus incentives) between consumptive and non-consumptive uses. Extreme hydrologic conditions have tested the framework and even called into question the viability of some previously-established requirements; however, strong working relationships, a system orientation, and investment in continued operational improvements have enabled those in the basin to meet water management needs to date and provide a strong basis for tackling possibly more extreme challenges in the future.

5.1 The Delaware River Basin Commission

5.1.1 Introduction to the Delaware River Basin[76]

The Delaware is the longest un-dammed river in the United States east of the Mississippi, extending 330 miles [approximately 531 km] from the Catskill Mountains in New York State to the mouth of the Delaware Bay where it enters the Atlantic Ocean; approximately one-third of its length is tidal. In all, the basin contains 13,539 square miles [approximately 35,066 km^2]; draining water from parts of Pennsylvania, New Jersey, New York, and Delaware (see Figure 2.)

The landscape of the Delaware River Basin is very diverse. Nearly 50% of the basin is forested, including large portions of the upper watershed, which is important for water supply and water quality. Fifteen percent of the basin is developed, mostly centered near the tidal portion of the river. Farms and grasslands account for 26% of the basin; 10% is water and wetlands.

Over 15 million people (approximately five percent of the nation's population) rely on the waters of the Delaware River Basin, including approximately 7 million outside the basin in New York

[75] The description of the laws and issues involved in the operation and management of the Delaware River contained in this summary are for informational purposes only and do not reflect the formal position or legal determination of the United States with respect to any matter discussed herein. The Corps intends that the overview provided herein will promote and facilitate education and communication regarding the challenges of water management. Nothing in this paper, however, is intended to represent any position of the Federal government in any administrative, judicial, or other proceeding to evidence any legal or policy interpretation with respect to the Delaware River. As such, statements contained in this summary do not, and shall not, represent a legal position or interpretation by the Federal government as it relates to water management of the Delaware River.

[76] For additional information on the Delaware River Basin, see http://www.nj.gov/drbc/basin/.

City and northern New Jersey. However, the watershed is small, draining only 0.4% of the total continental U.S. land area.

Figure 2. Map of the Delaware River Basin

More than 8 billion gallons [approximately 30,000 ML] of water is withdrawn from the basin every day, with the largest water use sectors[77] being power generation (~71%), public water supply (~10%), industry (~8%), and out-of- basin transfers (~7%). Other uses include domestic/home wells (~1.5%), agriculture (~1%), and mining (~0.5%).

5.1.2 The Formation of the Delaware River Basin Commission

The Delaware River Basin Commission (DRBC or Commission) was formed in 1961 when President Kennedy and the governors of Delaware, New Jersey, Pennsylvania, and New York signed concurrent compact legislation—the Delaware River Basin Compact—into law, creating a regional body with the force of law to oversee a unified approach to managing a river system without regard to political boundaries. The Compact's signing marked the first time that the federal government and a group of states joined as equal partners in a river basin planning, development, and regulatory agency, and the DRBC is the first federal-interstate river basin commission in the U.S..

The Commission was formed as a response to major water resource problems requiring regional solutions. These problems included water supply shortages; disputes over the apportionment of the basin's waters; poor water quality, especially in the tidal reaches of the river's urban centers; and the devastating flood of August 1955 (still considered the Delaware River's Flood of Record). There was a lack of coordination and cooperation amongst state, interstate, and federal agencies, and these entities realized that regional organization was needed to properly and effectively manage the basin's water resources.

5.1.3 About the Delaware River Basin Commission

Although the Delaware River Basin Compact created an agency with broad powers, those powers are not unilateral. The Commission is neither above the states nor the federal government; rather, it serves as a forum for the states and the federal government to jointly address the region's watershed management issues in an integrated, non-duplicative, and adaptive manner. [78]

The current Commission members are the four basin state governors and the commander of the North Atlantic Division of the U.S. Army Corps of Engineers (USACE), who represents the federal government. [79] The five members appoint alternate commissioners, with the governors selecting high-ranking officials from their state environmental agencies. The cities of Philadelphia and New York are advisors to their respective states. Annual elections are held for Commission chair, vice chair, and second vice chair based on a rotation of the five signatory parties. Each commissioner has one vote of equal power, with a majority vote needed to decide most issues. Exceptions are votes on the Commission's annual budget and drought emergency declarations, which require unanimity.

The Commission has its own Executive Director and approximately 40 employees.[80] The Commission's technical arm is divided into three branches: Planning and Information

[77] For more information on basin water use, see http://www.nj.gov/drbc/programs/supply/policies/wateruse.html.
[78] For more information on the Delaware River Basin Commission, see its web site at www.drbc.net
[79] For the current commissioner listing, see http://www.nj.gov/drbc/about/commissioners/.
[80] For the current staff listing, see http://www.nj.gov/drbc/about/staff/.

Technology, Water Resources Management (flow management and regulatory functions), and Modeling, Monitoring, and Assessment. Commission programs include water quality protection, water supply allocation, regulatory review, drought management, flood loss reduction, watershed planning, water conservation initiatives, and recreation.

The Compact stipulates that the five signatory parties agree to financially support the Commission's annual current expense budget. In 1988, the Commission members reached a tacit agreement to apportion their contributions at the following percentages: Pennsylvania (25%), New Jersey (25%), federal government (20%), New York (17.5%), and Delaware (12.5%).[81] In addition to signatory funding, the DRBC is supported by its project review fees, water use charges, and penalties as well as federal, state, and private grants. For the fiscal year 2014 (July 1, 2013 to June 30, 2014), DRBC's current expense budget is $5,647,550.

The Commission serves federal, state, and local interests by providing comprehensive, proactive water resources management for the Delaware River Basin that adheres to the doctrine of riparian rights, which all states in the basin follow. The Commission holds regular business meetings and public hearings on policy matters, rule changes, and water resource projects under regulatory review. These sessions, along with meetings of the Commission's various advisory committees, are all open to the public. Every Commission decision is made at a public meeting.

5.1.4 DRBC Regulations and Authorities[82]

The Delaware River Basin Compact describes the powers and authorities of the Commission and its relationship to its signatory members. Its duration was initially set for 100 years, and it can be continued for additional periods of 100 years, as long as none of its signatory members choose to terminate through legislative action. The Compact promotes interstate comity, removes causes of present and future controversy, and provides for cooperative planning by the signatory parties. The Compact directs the Commission to coordinate the activities of both state and federal agencies working in the basin, while specifying that the functions, powers, and duties of these agencies are to be preserved and utilized when possible.

Notably, the Compact provides that no project having a substantial effect on the water resources of the Delaware River Basin shall be undertaken unless it has been first submitted to and approved by the Commission (Compact, §3.8). This gives DRBC the authority to review projects in the basin that withdraw from, or discharge to, the basin's waters over certain thresholds. The Compact also authorizes the commission to manage water supply and adopt water quality regulations.

The Compact directs the commission to develop and periodically update a Comprehensive Plan for the immediate and long range development and use of the water resources of the basin. The commission also annually adopts a Water Resources Program based on the Comprehensive Plan. This program consists of the projects and facilities that are proposed to be undertaken by the commission or other authorized agencies and organizations during a set time period.

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[81] For more information on the commission's budget, see http://www.nj.gov/drbc/about/budget.html.

[82] To view and/or download the Delaware River Basin Compact and other DRBC regulatory documents, see http://www.nj.gov/drbc/about/regulations/.

DRBC's Rules of Practice and Procedure (RPP) govern the adoption and revision of the Comprehensive Plan, the Water Resources Program, and the exercise of the commission's authority pursuant to the provisions mandated or authorized by the Compact. The RPP also directs the Executive Director to enter into cooperative administrative agreements with its signatory parties to facilitate the submission and review of projects and avoid unnecessary duplication of staff functions. Other commission regulatory purviews are set forth in its Water Code, Water Quality Regulations, Water Supply Charges (further discussed in Section 5.1.7), and Flood Plain Regulations.

5.1.5 Dispute Resolution in the Delaware River Basin

In the Delaware Basin, the commission is the forum to address and resolve water management issues, avoiding the courts and lengthy, costly litigation. Part of the commission's success is rooted in its adherence to the following tenets of integrated water resources management:

- Water does not respect political boundaries and should be managed on a holistic, watershed basis that takes into account surface and groundwater, as well as stormwater and wastewater;
- What happens on the land affects the water and what happens upstream affects downstream users;
- Water management is collaborative; all levels of government—including federal, state, interstate, and municipal, as well as local stakeholders—must be engaged in the process; and
- Water management must be adaptive to changing conditions, new science and technology, and the changing of regional priorities.

5.1.6 DRBC's Permitting Program (Project Review)[83]

According to Section 3.8 of the Compact, the commission is required to approve a project whenever it finds and determines that the project would not substantially impair or adversely impact the water resources of the basin. Docket and permit applications are reviewed by the DRBC Water Resources Management and Modeling, Monitoring, and Assessment branches. The commission's RPP provides instructions on the procedure of submission, review, public input, and consideration of projects pursuant to Section 3.8.

In the Delaware River Basin, DRBC's review threshold for water withdrawal projects is for an average withdrawal—be it from ground or surface water or diversion or transfer in or out of the basin—of more than 100,000 gallons per day (gpd) [approximately 378,500 L/day] during any consecutive 30-day period. The exception is withdrawals located within the Southeastern Pennsylvania Groundwater Protected Area (GWPA), which is an area of known groundwater

[83] For additional information on DRBC's permitting program, see http://www.nj.gov/drbc/programs/project/application/.

stress due to intense development pressures. [84] In this area, more stringent regulations apply to groundwater withdrawals. New or expanded well projects involving an average withdrawal of more than 10,000 gpd [approximately 37,850 L/day] during any consecutive 30-day period are required to obtain a DRBC Protected Area Permit.

The main goal of the GWPA is to prevent the depletion of groundwater. Lowered water tables in the GWPA have reduced flows in some streams and dried up others. This reduction in base flows affects downstream water uses, negatively impacts aquatic life, and can reduce the capacity of waterways in the region to assimilate pollutants. Other goals of the GWPA include protecting the interests and rights of lawful users of the same water source, as well as balancing and reconciling alternative and conflicting uses of limited water resources in the region.

The commission also regulates the discharge of pollutants into the ground or surface waters of the Delaware River Basin. Discharges over 50,000 gpd [approximately 189,300 L/day] during any consecutive 30-day period require DRBC's approval, be it from wastewater treatment facilities or the importation or exportation of wastewater. DRBC approval of wastewater projects is contingent upon the determination that the discharge meets treatment standards and does not adversely affect established water quality criteria for the basin's waters.

Wastewater discharges are more closely regulated in DRBC's Special Protection Waters (SPW) program, which includes the entire non-tidal Delaware River and the watershed that drains to it.[85] In these waters, commission approval is needed for discharges over 10,000 gpd [approximately 37,850 L/day], because water quality exceeds standards and there is a common interest to not let the water quality degrade. To obtain DRBC approval, new discharges and substantial alterations and additions to existing discharges within the drainage area to waters classified as SPW must (1) demonstrate no measurable change to existing water quality as defined by the regulations, (2) use best demonstrable technology for wastewater treatment, and (3) submit a non-point source pollution control plan to limit non-point source pollutant loadings from the project.

The commission collects fees on the projects it reviews, and these fees directly support the permitting program. DRBC's review responsibilities cover new projects, renewals, or increases in allocations previously approved by the commission. When necessary, projects in the Delaware River Basin may also need separate approval from the states in which they are located. DRBC works with the basin states to ensure that there is not unnecessary duplication of effort in approving projects. And, if DRBC and the respective state's regulations differ with respect to criteria values that must be met, the general rule is that the stricter of the two applies within the basin's boundaries.

[84] To view more details on the GWPA, see http://www.nj.gov/drbc/programs/project/southeast/.
[85] For more information on DRBC's SPW program, see http://www.nj.gov/drbc/programs/quality/spw.html.

Section 3.3 of the Compact states that the commission shall allocate the waters of the basin to and among the states in accordance with the doctrine of equitable apportionment. This means that during normal hydrologic conditions (non-drought), the Commission's permitting program does not prioritize one water use sector over another when allocating the basin's water resources. The one exception to this is during times of drought emergency. Section 2.5.2 of the commission's Water Code states the following:

> During drought emergencies, the commission…will give first priority to those uses which sustain human life, health and safety, and second priority to water needed to sustain livestock. Thereafter, based on the doctrine of equitable apportionment, the remaining water will be allocated among producers of goods and services, food and fibers, and environmental quality in a manner designed to sustain the general welfare of the basin and its employment at the highest practical level. [86]

To be prepared for times of drought and the possibility of water curtailments, large water users docketed by DRBC are required to have conservation plans in place.[87] Some power companies have established alternative water sources to use during times of drought to replace water lost to evaporation during power generation. More information on DRBC's drought management program appears in Section 5.1.9.

The commission's project application requirements are detailed and its review process thorough, which is crucial since both elements help determine whether the project being applied for will adversely impact the water resources of the basin and whether the stated need is justified. Commission dockets and permits include specific requirements and conditions that must be met, as well as explain the procedures necessary to make changes to the docket decision(s). DRBC dockets and permits must be renewed regularly, and the commission's RPP provides for appeals and hearing requests, as well as a method to assess penalties if compliance with docket conditions is not being met.

5.1.7 Water Supply Charging Program[88]

Between 1964 and 1974, the Commission authorized a system of water supply charges applicable to surface water uses to cover all the costs associated with making the basin water

[86] To view the Water Code, see http://www.nj.gov/drbc/library/documents/watercode.pdf.

[87] Water conservation plans are submitted by large water users (e.g., public water supply purveyors) as part of their project applications. These plans describe the various programs adopted by the purveyor to achieve maximum feasible efficiency in the use of water. At minimum, they describe how they accomplish source metering, service metering, and leak detection and repair. In addition to DRBC review and approval, the state in which the system is located also reviews and approves the conservation plan. These plans do not require the establishment of measures specifically associated with the basin drought triggers. These plans are not available online; however, more information about water conservation can be found in Section 2.1 of the Water Code at http://www.nj.gov/drbc/library/documents/watercode.pdf , and resolutions passed by DRBC pertaining to water conservation can be found at http://www.nj.gov/drbc/programs/supply/policies/.

[88] Full details on the DRBC Water Charging Program can be found at http://www.nj.gov/drbc/programs/supply/charging/.

supply available and maintaining its continued availability in adequate quantity and quality over time. Groundwater withdrawn from the basin is currently exempt from the Commission’s water charging program.

Surface water charges provide the revenue stream the Commission needs to repay the debt service as well as operations and maintenance costs for its water supply storage in two USACE-owned multi-purpose reservoirs, Beltzville and Blue Marsh. Storage in these reservoirs is utilized in the Commission's lower basin drought operating plan (more below in Section 5.1.9). Water charges also support the Commission’s administrative and staff costs related to the protection and preservation of the basin's water quantity and quality.

Any person, corporation, organization, or agency that uses, withdraws, or diverts surface waters from the basin pays water charges in accordance with the Commission’s program. The Commission sets separate rates for consumptive use and non-consumptive use; consumptive use is defined as water that is withdrawn but not returned to the surface waters of the basin. The surface water rates currently in effect (as of January 2011):

- Consumptive Use: $80 per million gallons [approximately $21 per ML]
- Non-Consumptive Use: $.80 per million gallons [approximately $0.21 per ML]

DRBC exempts charging a facility for the amount of water taken from a surface water source if it has been taking that water since before the creation of the Commission. These facilities receive certificates of entitlement (COE) that specify the amount of water that is exempt from charges; however, any amount of water they withdrawal over the amount listed on the COE is subject to water charges.

DRBC also exempts certain uses from its water charging program:

- Non-consumptive uses of less than 1,000 gallons [approximately 3,785 L] during any day, and less than 100,000 gallons [approximately 378,540 L] during any quarter;
- Water taken, withdrawn, or diverted above Montague, N.J. and below the mouth of the Cohansey River, N.J.; and
- Ballast water for shipping purposes.

The water charging program also has a reporting component. Entities are required to report their water use quarterly (post-1961 industries, water suppliers, and power companies) or annually (ski resorts, golf courses, and pre-1961 entitlement holders). Starting in 2013, the Commission implemented an electronic reporting system to enable users in the water charging program to submit their reports and calculate their payments (if required) online.

5.1.8 DRBC Water Conservation Initiatives[89]

DRBC has long recognized the importance and value of saving water at all times, not just during times of drought. The Commission's water conservation program incorporates a wide range of elements including, but not limited to: requirements for metering, leak detection and repair programs, water conservation plans, and water conservation performance standards for plumbing fixtures. Most recently, in 2009, the Commission passed a water audit requirement that requires water purveyors to track how effectively water is moved from its source to customers' taps using a new reporting program. Based on methodology proposed by the American Water Works Association (AWWA), this approach reflects the latest thinking in the field of water efficiency, helping improve the way that public water supply systems quantify and account for their water losses. The new rule requires water suppliers to submit annual reports to the Commission by utilizing AWWA's free water audit software program.

5.1.9 DRBC Drought Management Program[90]

The Commission's drought management program was adopted in the early 1980s and is designed to manage regional storage through the regulation of river flows and reservoir releases in the basin. The plan coordinates interstate reservoir operations during times of drought while balancing cutbacks in out-of-basin diversions and river flow objectives against conservation releases for water supply, recreational, and fishery benefits.

DRBC drought operating plans are implemented either basin-wide or for the lower basin (south of Montague, N.J.) and are automatically invoked when reservoir storage levels fall below specific thresholds. Lower basin operations are controlled by basin-wide or lower basin storage triggers, with the most limiting restrictions controlling. The Commission's program complements the basin states' drought plans, while DRBC's program has a regional focus; state drought plans look at local water supply conditions, such as precipitation amounts, soil moisture, stream flows, groundwater levels, and local reservoir storage.

The DRBC basin-wide drought operating program is triggered by low levels of combined storage in three water supply reservoirs owned by New York City (Cannonsville, Pepacton, and Neversink) in the headwaters of the Delaware River. A storage-based rule curve for the Cannonsville, Pepacton, and Neversink reservoirs was developed with activation levels for Normal, Drought Warning, and Drought (see Figure 3[91]). Drought Warning is divided into equal

[89] For more information on the commission's water conservation policies, see http://www.nj.gov/drbc/programs/supply/policies/.

[90] For additional details on DRBC's Flow and Drought Management Program, see http://www.nj.gov/drbc/programs/flow/.

[91] Figure 3 is taken from page 8 of the Delaware River Basin Water Code: http://www.nj.gov/drbc/library/documents/watercode.pdf.

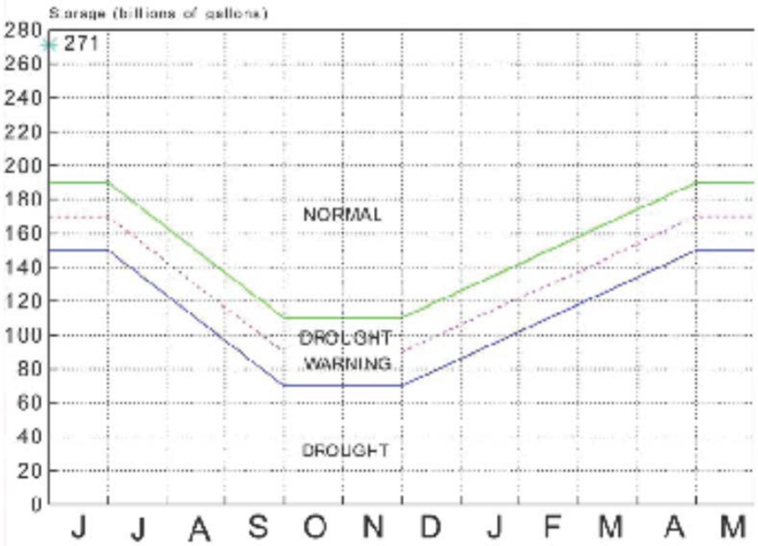

Figure 3. Operation Curves for Cannonsville, Pepacton, and Neversink Reservoirs

upper and lower sections. As water levels in the reservoirs decline, there is a fixed schedule of phased reductions in releases, diversions to New York City and New Jersey, and stream flow objectives for Montague, N.J., and Trenton, N.J., that goes into effect to help conserve the basin's water resources (see Tables 1 and 2 and also Section 5.2). [92] The reductions set forth are numbers, not percentages, and were negotiated and unanimously agreed upon by the decree parties. The negotiations and ultimate agreement were based on their assessment of potential drought impacts using DRB-specific models for daily water balance and flow and for water quality impacts of salinity intrusion in the river's estuary. More details about the decree parties appear in Section 5.2.

Table 1: Flow Objectives for Salinity Control During Drought Periods

NYC storage condition	NYC Div. (Mgd) [ML/day]+	NJ Div. (Mgd) [ML/day] +	Montague flow objective (cfs) [m3/s] +	Trenton flow objective (cfs) [m3/s] +
Normal	800 [3,000]	100 [380]	1,750 [50]	3,000 [85]
Upper Half-Drought Warning	680 [2,570]	85 [320]	1,655 [47]	2,700 [76]
Lower Half-Drought Warning	580 [2,200]	70 [265]	1,550 [44]	2,700 [76]
Drought	520[1,970]	65 [246]	1,100-1,650* [31-47]	2,500-2,900* [71-82]
Severe Drought (to be negotiated based on conditions)				
*Varies with time of year and location of salt front as shown in Table 2				
+Approximate metric value				

Table 2: Flow Objectives for Salinity Control During Drought Periods

Flow objective, cubic feet per second [m3/s] + at:						
	Montague, NJ			Trenton, NJ		
7-day average location of "Salt Front," River-mile*	Dec-Apr.	May-Aug.	Sept-Nov.	Dec-Apr.	May-Aug.	Sept-Nov
Upstream of R.M. 92.5	1,600 [45]	1,650 [47]	1,650 [47]	2,700 [76]	2,900 [82]	2,900 [82]
Between R.M. 87.0 and R.M. 92.5	1,350 [38]	1,600 [45]	1,500 [42]	2,700 [76]	2,700 [76]	2,700 [76]
Between R.M. 82.9 and R.M. 87.0	1,350 [38]	1,600 [45]	1,500 [42]	2,500 [71]	2,500 [71]	2,500 [71]
Downstream of R.M. 82.9	1,100 [31]	1,100 [31]	1,100 [31]	2,500 [71]	2,500 [71]	2,500 [71]
*Measured in statute miles along the navigation channel from the mouth of Delaware Bay						
+Approximate metric value						

Reductions tied to Drought Warning are automatically implemented when storage declines into that zone and remains there for five consecutive days; they do not require additional resolutions or DRBC action. Declaring a Drought Emergency (i.e., when storage falls below the Drought trigger and remains there for five consecutive days), however, requires a unanimous vote by the DRBC members. This is one of the built-in checks and balances, because in Drought Emergency, the DRBC is given authority to call for an additional 69 billion gallons [approximately 3,785 ML] of storage and releases from private, state, and federally owned reservoirs (see Figure 4) in the basin.

There are times when the lower basin experiences drought conditions, but the upper basin does not. When this is the case, the Commission's lower basin drought management plan goes into effect. The primary focus of this plan is to control the upstream migration of salty water (referred to as the "salt front") from the Atlantic Ocean into the tidal river in times of drought.

While the salt front's location normally fluctuates along the tidal Delaware River as freshwater inflows increase or decrease in response to hydrologic conditions (thereby diluting or concentrating chlorides in the river), it is important to limit its upstream migration to protect the drinking water intakes in the urban areas of Philadelphia and Camden, N.J. As part of the drought management program, the establishment of a flow target of 3,000 cubic feet per second (cfs) [approximately 85 m^3/s] at the river's head-of-tide at Trenton, N.J., helped to better ensure a base flow of freshwater from the non-tidal river. In times of low flow, DRBC can direct releases from the Blue Marsh and Beltzville reservoirs, located on upstream tributaries, to meet the Trenton flow target. Water supply storage in these two lower basin reservoirs—both owned by USACE—is financed by surface water users under a water charging program implemented by the DRBC (see Section 5.1.7).

Similar to how declining storage in the New York City Delaware Basin Reservoirs triggers drought operations in the basin-wide program, declining storage in the Blue Marsh and Beltzville reservoirs is used to trigger drought warning and drought operations in the lower basin program. This allows for reductions in the Trenton flow target and the New Jersey diversion when lower basin conditions are drier than in the upper part of the basin.

Merrill Creek Reservoir, a pumped storage facility located near Phillipsburg in Warren County, N.J., releases water to replace evaporative water losses caused by power generation when the basin is under DRBC-declared drought operations. Owned and operated by a consortium of power companies, the reservoir stores water for the utilities to release to compensate for their consumptive water use, reducing their likelihood of facing mandatory water cut-backs during times of drought. Releases are made during both basin-wide and lower basin drought warnings and drought emergencies whenever the Trenton flow target is not met for at least two consecutive days.

The DRBC's drought operating program focuses on managing the surface water resources of the entire basin during times of drought. It is then up to the states or other entities to enact plans on how to manage and allocate water resources to their residents and consumers. See Section 5.3 for information on how New York City manages its system and apportions its water supply.

5.2 DRBC's Relationship with New York City, per the 1954 U.S. Supreme Court Decree

Today, New York City (NYC) exports water out of the Delaware River Basin as part of its drinking water supply. The city is allowed to export up to 800 million gallons per day (mgd) [approximately 3,000 ML/day], on average, from reservoirs it owns on tributaries to the Delaware's headwaters; this allocation stems from a U.S. Supreme Court decree that dates back over 50 years.

5.2.1 New York City and the Delaware River Basin

New York City, which is not located in the Delaware River Basin, realized in the 1920s that it needed to look upstate for additional water supply to accommodate its increasing demand. One potential source was the waters of the Catskill Mountains that drain to the Delaware River. While New York State supported New York City's plan to divert water out of the Delaware Basin, New Jersey did not. Concerned about whether down-basin needs could be met after an up-basin diversion, New Jersey sued the State of New York and the City of New York. Pennsylvania later intervened on the side of New Jersey.

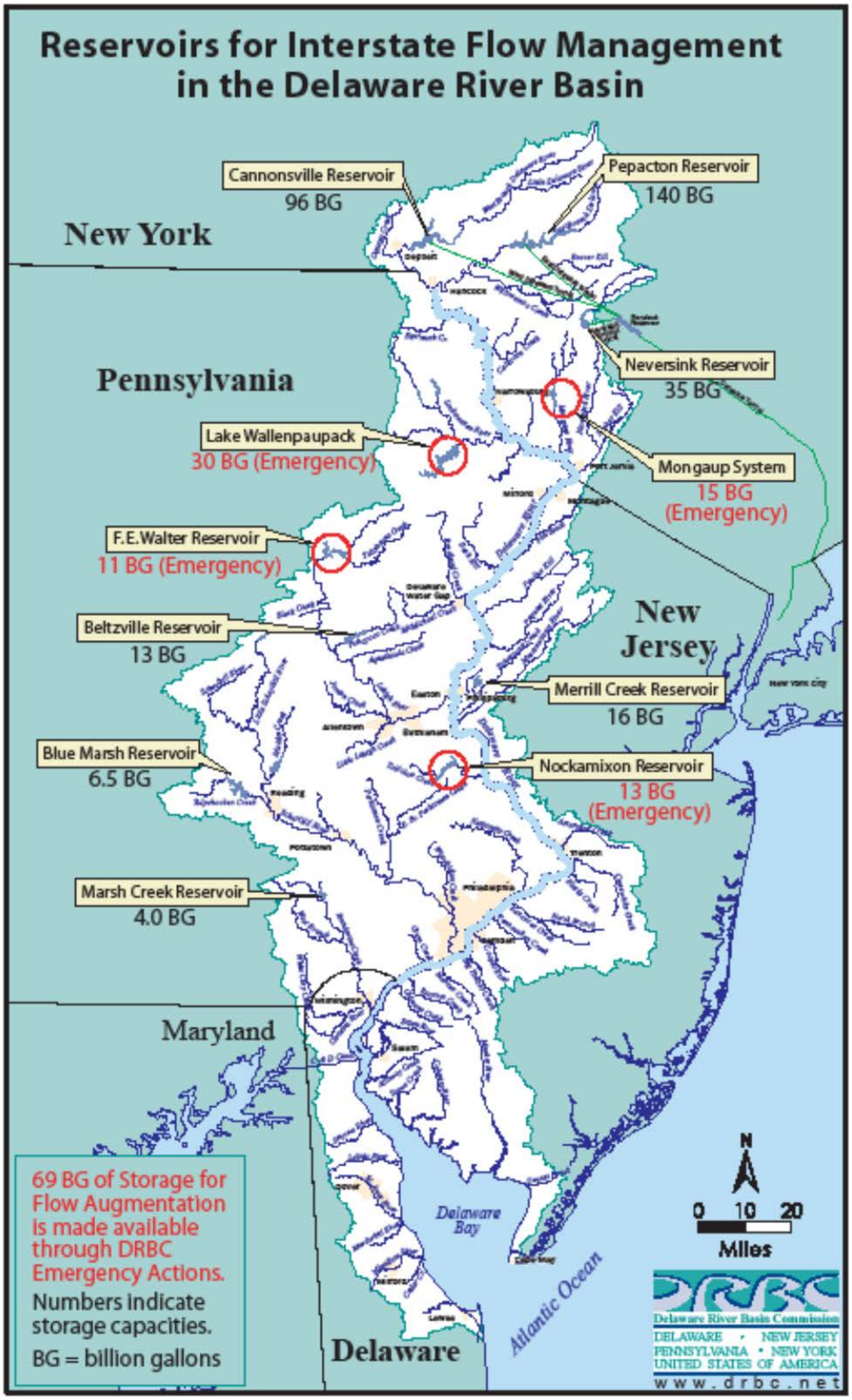

Figure 4. Reservoirs for Interstate Flow Management in the Delaware River Basin

5.2.2 The Case before the U.S. Supreme Court

In May 1931, the United States Supreme Court issued a decree to settle the case of the State of New Jersey v. the State of New York and the City of New York. The decision authorized New York City to divert an average of up to 440 mgd [approximately 1,670 ML/day] from two reservoirs the City planned to build on headwater tributaries of the Delaware River to its water supply system in the Hudson River Basin. The reservoirs—Neversink on the Neversink River and Pepacton on the East Branch of the Delaware River—became fully operational in late summer of 1955. The decree also required that New York City release sufficient water from its Delaware River Basin reservoirs to maintain a specified flow in the Delaware River at Port Jervis, N.Y.

In 1952, New York City sought to increase its diversion from the Delaware Basin, citing the need for additional water supply. This resulted in the five decree parties—the States of Delaware, New Jersey, New York, and Pennsylvania, along with the City of New York—returning to the U.S. Supreme Court, which issued an amended decree on June 7, 1954[93]. The amended decree permitted New York City to divert to up to 800 mgd [approximately 3,000 ML/day], on average, from the Delaware Basin, contingent upon the City's construction of a third headwaters reservoir, the Cannonsville Reservoir on the West Branch of the Delaware River, which was completed in 1967 (see Figure 5).

Other conditions of the 1954 decree include:

- the requirement that New York City must make compensating releases from its three reservoirs to maintain a minimum flow objective of 1,750 cfs [approximately 50 m^3/s] in the Delaware River at Montague, N.J. (the Montague flow target);
- the authorization allowing the State of New Jersey to divert an average of up to 100 mgd [approximately 380 ML/day] out of the Delaware River Basin to the Raritan River Basin through the Delaware and Raritan Canal; and
- the establishment of the Office of the Delaware River Master, a position within the U.S. Geological Survey (USGS). [94]

The River Master's job is to ensure that the provisions of the 1954 U.S. Supreme Court Decree are met in an impartial manner. The daily operations of the River Master are conducted by the Deputy River Master through a USGS field office in Pennsylvania. The Deputy River Master reports to the River Master, whose office is located at USGS Headquarters. The River Master has administered the provisions of the amended decree for a period of almost 60 years, and this

[93] To view the text of the 1954 U.S. Supreme Court Decree, see http://water.usgs.gov/osw/odrm/decree.html.
[94] To learn more about the Office of the Delaware River Master, see its web site at http://water.usgs.gov/osw/odrm/index.html.

Figure 5. The Location of the NYC Delaware Basin Reservoirs

success is directly attributable to the neutrality of the position and the ability of the River Master to engage the decree parties cooperatively and proactively.

5.2.3 The Difference between the DRBC and the Decree Parties

The DRBC was not yet formed when the 1954 U.S. Supreme Court Decree was put into place. While the 1961 Delaware River Basin Compact gave the Commission broad powers to plan, develop, conserve, regulate, allocate, and manage water resources in the basin, it included an important limitation. Sections 3.3 and 3.5 of the Compact prohibit the Commission from adversely affecting the releases or diversions provided in the 1954 decree without the unanimous consent of the decree parties. Commission members are the four basin states and the federal government, and the decree parties are the four basin states and New York City; while four of the five parties are the same, this is a significant distinction to remember.

5.2.4 Modifications to the 1954 U.S. Supreme Court Decree

The decree included a condition that allowed for modifications to the decree formulae upon the unanimous consent of the five decree parties. Additionally, the Delaware River Basin Compact specifies that the Commission cannot make changes to the diversions and releases put forth in the 1954 decree without first obtaining the consent of each party to the decree. Over the years, the Commission has worked successfully with the decree parties and the River Master, serving as a facilitator and arbiter in enforcing the provisions of the decree, as well as securing their unanimous consent for multiple decree modifications pertaining to times of drought and improving in-stream flow needs.

It became obvious from the 1961-1967 drought of record that New York City could not divert its full 800 mgd [approximately 3,000 ML/day] allowed by the decree and still have enough water to meet the Montague flow target. A new operating regime was needed to better conserve storage in the NYC Delaware Basin Reservoirs and ensure adequate flow augmentation during the next drought of record. Negotiations amongst the decree parties culminated in a set of consensus recommendations known as the Good Faith Recommendations in the early 1980s. [95] Drought management aspects of the Good Faith Recommendations—consisting of phased reductions in diversions, releases, and flow objectives based upon reservoir storage curves—were codified in DRBC's Water Code as the Commission's drought management program (see Section 5.1.9). The Commission's drought operating plans have been invoked numerous times since their adoption and have helped conserve the basin's water resources during times of drought.

Other modifications to the 1954 decree have been unanimously approved by the parties and incorporated by DRBC. Specifically, these changes addressed the need for minimum flows to sustain aquatic life, a need not originally recognized by the U.S. Supreme Court. Conservation releases from the NYC Delaware Basin Reservoirs for the protection of fisheries were established in DRBC docket D-77-20 CP and subsequent related resolutions and revisions.[96]

Three serious main-stem Delaware River floods between September 2004 and June 2006 added yet another important management issue for consideration: the potential use of the NYC Delaware Basin Reservoirs, which are designed specifically for water supply, to enhance flood mitigation. Accordingly, the decree parties became engaged in a complex, collaborative effort to flesh out how to incorporate flood mitigation into the already delicate balance of multiple, sometimes competing uses of NYC's Delaware Basin Reservoirs, while continuing to recognize

[95] To download the Good Faith Recommendations, see http://www.nj.gov/drbc/library/documents/regs/GoodFaithRec.pdf.
[96] For a complete listing, see http://www.nj.gov/drbc/programs/flow/resolutions.html.

the rights established by the 1954 decree. Decree party negotiations were undertaken by appointed representatives of the decree party entities; this workgroup met regularly, whether in person or via teleconference, to discuss potential options to further modify the decree. DRBC staff, along with the Office of the Delaware River Master, assisted in this process, providing a forum of support and expertise to the decree parties and their workgroup members.

In September 2007, this effort resulted in the creation of a Flexible Flow Management Program (FFMP), which was unanimously agreed upon by the five decree parties. The FFMP is designed to provide an adaptive framework which allows increased flexibility for program modifications and adjustments compared to the previous operating regime. The FFMP is intended to meet water supply demands, protect fisheries habitats downstream of the NYC Delaware Basin reservoirs, assist with flood mitigation, and repel the upstream movement of salt water in the Delaware Estuary. The flood mitigation component of the FFMP is based upon the conditional storage objective (CSO), which defines—depending on reservoir storage levels and the time of year—how much water is able to be released to allow space to capture runoff, reducing the likelihood of reservoir spills. The general goal of the flood mitigation component of the FFMP is to maximize releases when reservoir levels and refill probability are high, therefore limiting risk to water storage.

The original FFMP was amended in December 2008 and implemented through May 31, 2011. The decree parties then signed an agreement for a new interim FFMP, which was initially in effect June 1, 2011 through May 31, 2012, and then renewed twice. The last FFMP agreement was in effect through May 31, 2014. [97]

The FFMP Agreement and its revisions and extensions have not been subject to the Commission's regulatory process to become part of its Water Code. Codification of the FFMP remains a long-term goal of the Commission. Commission staff continues to help the River Master coordinate and facilitate discussion among the decree parties—who continue to meet on a semi-regular basis—concerning the substance of the FFMP. The five decree parties continue to further evaluate the FFMP and use the experience they've gained since its inception to help guide ongoing negotiations to develop future multi-year agreements.

5.3 New York City's Water Supply

5.3.1 New York City's Department of Environmental Protection and the Regulatory Environment

The Bureau of Water Supply (BWS) of the New York City Department of Environmental Protection (NYCDEP) is the local government entity responsible for maintaining and operating New York City's water supply system. NYCDEP has over 6000 employees, 865 of which work

[97] Download the current FFMP at http://water.usgs.gov/osw/odrm/documents/FFMP_2013_Agreement.pdf. Other FFMP-related agreements can be found linked from http://water.usgs.gov/osw/odrm/index.html.

for the BWS, which operates on an annual budget of over $250 million (for the current fiscal year). NYCDEP must operate the system so that the city can reliably provide sufficient water to meet consumers' demand and for other uses, as well as ensuring that the water meets all federal water quality standards.

In terms of providing sufficient water, the city must meet its obligations under the 1954 Supreme Court Decree that governs the sharing of water from Delaware River Basins with other states (see Section 5.2), while simultaneously providing water to its consumers. There are no DRBC regulations controlling the provision of water to the city's consumers. Rather, the city has been able to meet consumer demands by expertly managing the water supply system. The DRBC provides a forum for the other parties to work with the city on water issues of mutual concern. The relationship between DRBC and NYCDEP is amiable, although disagreements inevitably arise.

The city's water supply must meet water quality regulations set by the United States Environmental Protection Agency (EPA), including the U.S. Safe Drinking Water Act.[98]Under the federal Surface Water Treatment Rule[99]—designed to limit turbidity and prevent waterborne diseases caused by microbes—a water supply system may qualify for Filtration Avoidance if it meets certain criteria without filtration. [100] A water supplier must apply for and receive a Filtration Avoidance Determination (FAD) by demonstrating to the EPA that it meets all required criteria. Criteria include not only water quality data, but evidence that an effective watershed control program has been implemented, including the identification, monitoring, and control of activities in the watershed that potentially threaten water quality, thus ensuring that natural processes in the watershed will continue to maintain water quality. The city has been required to apply for, and so far has received, a FAD renewal at five-year intervals. The city meets the criteria at considerable expense and by employing considerable expertise. Approximately $40 million of the BWS budget is used specifically to address the FAD.[101] However, it is generally agreed that this option is more cost effective than building, operating, and maintaining a filtration plant, which is estimated to cost $6-10 Billion to build and hundreds of millions of dollars per year to operate and maintain. [102]

5.3.2 New York City Water Supply System Background

New York City’s water supply system is comprised of nineteen reservoirs and three controlled lakes with a total capacity of 580 billion gallons [approximately 2.2 million ML], which includes three reservoirs in the Delaware River Basin. This system delivers an average of more than one billion gallons per day to consumers, including over 8 million city dwellers and another million residents of nearby communities. This is the largest unfiltered water supply in the U.S. (only a

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[98] See http://water.epa.gov/lawsregs/rulesregs/sdwa/
[99] See http://water.epa.gov/lawsregs/rulesregs/sdwa/swtr/
[100] See http://www.epa.gov/region2/water/nycshed/filtad.htm
[101] See http://www.nyc.gov/html/dep/pdf/reports/9._administration_annual-report_09-13.pdf
[102] See http://www.ibo.nyc.ny.us/iboreports/catskills1209.pdf

small portion of the supply is currently filtered); as such, natural processes in the watersheds are largely responsible for maintaining water quality. Water delivery is almost completely gravity fed by the elevation gradient between the reservoirs and city.

The majority of the water used by New York City comes from the mostly forested basins of the Catskill Mountains over 100 miles [approximately 160 km] north of the city on the west side of the Hudson River (West of Hudson, or WOH, system; see Figure 6). The WOH system consists of eastern Catskills basins (the Catskills system) that drain into the Hudson River and western Catskills basins (the Delaware system) that drain into the upper branches of the Delaware River. Water quality in both basins is excellent, but water from the Delaware basin is considered the highest quality. Catskill system basins are steep with clay soils; as a result, turbidity from erosion in the streams poses the most significant water quality challenge. In Delaware system basins, which are shared with the states of Delaware, New Jersey and Pennsylvania, eutrophication associated with agricultural runoff in the Cannonsville watershed is the more problematic water quality issue. The remaining portion of the municipal water supply comes from the smaller, and less pristine, system east of the Hudson River (the Croton system), where population densities are greater and non-point sources of pollution are more significant. The Delaware system is used to meet 60-70% of New York City's demand. The total WOH watershed area is over 1600 square miles [4000 square kilometers], while the Croton watershed is approximately 20% as large. In many ways, the New York City water supply system has features that make it more robust than most systems due to its spatial extent (so that on any day, problems in one basin are not likely to occur in all basins), the many reservoirs connected in series (allowing them to act as settling basins), and the connectivity (allowing operators to vary the source water on an ongoing basis).

The relationship between the city, watershed communities, and other stakeholders is intimately linked with management of the system and has evolved in recent years. Starting early on, an antagonistic relationship developed between the city and watershed residents. Many settlements in the Catskills region were in valleys ideal for water impoundment. As a result, New York City forcibly evacuated towns and dismantled communities for dam construction during the 19th and 20th centuries. It is estimated that over 7,000 inhabitants were displaced by WOH reservoirs.[103] There were legal and political battles not only over the legality of the City's use of eminent domain, but over the remuneration, widely believed to be inadequate, paid to local residents, farmers, and business owners. These sorts of disputes caused by the city's one-sided approach resulted in distrust and antipathy towards the city that is still evident today. However, this situation is being ameliorated by a new relationship that is developing between the city and watershed communities as a result of events during the 1990s.

[103] Donna Steffens, Time and the Valley Museum, pers. Communication March 30, 2014, and http://www.cwconline.org/linked/watershedtimeline.pdf

5.3.3 The Memorandum of Agreement (MOA)

The series of events marking a turning point in the relationship between the city and watershed communities began in 1989 and led to the Memorandum of Agreement (MOA) in 1997. [104] As a result of amendments to the U.S. Safe Drinking Water Act in 1986, the EPA instructed the city to either take satisfactory precautions to protect water quality in the reservoirs or filtration would be required. [105] Because a filtration system to handle the WOH system is prohibitively expensive in comparison with watershed protection, the city decided on a set of water protection measures that would be enforced within watershed boundaries. These measures were declared unilaterally, without consulting watershed communities, leading to uproar and a series of political and legal battles between the city, watershed communities, and other interested parties, that eventually led to the signing of the MOA. In the MOA, the city agreed to provide support to upstate communities in return for the establishment of practices to protect the water supply while, to the extent possible, allowing productive and economic activities in the region. The MOA provides for three major programs funded by the city: (1) a Land Acquisition Program, under which the city may purchase key vacant properties in the watershed from willing sellers at fair market prices; (2) a regulatory program—under which the city reviews and approves proposed new development projects in the watershed—to ensure the protection of water quality; and (3) a series of partnership programs in which the city funds a variety of programs to improve water quality such as the installation, upgrading, and operation of wastewater treatment facilities. As part of the MOA, an entity called the Catskill Watershed Corporation (CWC) was created to develop and implement some of the mandated programs. [106] CWC's mission is to serve as a local development corporation to protect water quality in the WOH; to preserve and strengthen communities in the region; and to increase awareness and understanding of the importance of the water system. A critical aspect of CWC is that it serves as a voice of the watershed communities, despite funding from NYCDEP (a majority of the CWC Board of Directors is comprised of local elected officials who represent towns in the watershed). Similarly, the Watershed Agricultural Council (WAC) works with farm and forest owners to protect water quality through

[104] See http://www.epa.gov/region2/water/nycshed/nycmoa.htm
[105] The primary federal law to ensure drinking water quality across the U.S. (http://water.epa.gov/lawsregs/rulesregs/sdwa/)
[106] See http://www.cwconline.org/

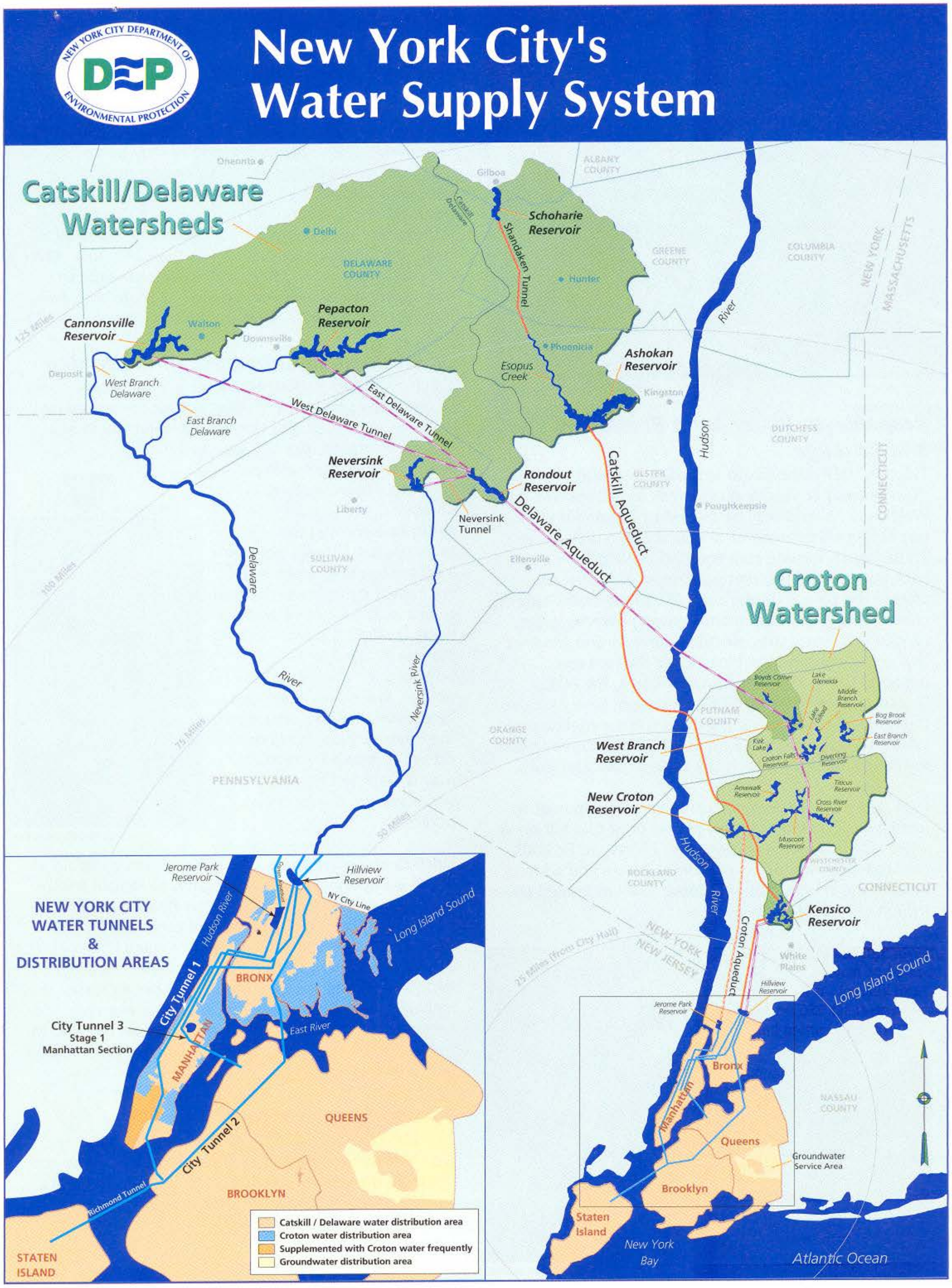

Figure 6. New York City's Water Supply System (New York City Department of Environmental Protection)

implementation of farm programs, forest management plans, and conservation easements. [107] A critical aspect of these measures is that participation by watershed residents is less by compulsion and more by choice. The city must continually monitor water quality and evaluate these programs and regularly apply for Filtration Avoidance Determinations (FAD), which have so far been successful. As a result of the MOA and associated programs, NYCDEP now works more closely, and more in partnership, with upstate stakeholders.

5.3.4 NYCDEP Relationship to stakeholders and optimizing multiple demands

Since the MOA, the communication between NYCDEP and watershed stakeholders, elected officials, non-governmental and community organizations and their leaders has been more open. Above and beyond what is mandated by the MOA, issues important to watershed residents and other water supply users are considered and accommodated if the water supply is not adversely affected. The Deputy Commissioner of the Bureau of Water Supply has regular conversations and meetings with stakeholders, including the leadership of watershed town coalitions, town supervisors, and county executives. Lower-level NYCDEP staff also work regularly with watershed residents. The human capital in the watershed is now a critical part of the green infrastructure that maintains the city's water quality, and investment in that human capital is considered essential.

For example, as a result of planned infrastructure upgrades and associated flow interruptions over the next few years, some water supply users will be affected. In support of those affected towns, the city is funding studies to find new supplies even though such support is not mandated by the MOA or any other legal instrument. Also, many of the city's watershed employees are local residents. Such employees may tend to understand both the city's and the local points of view, and local communities often appreciate the employment opportunities. Employing locals benefits the city as well because they serve as local contacts during emergencies. For example, during recent floods, partially by virtue of local residents working for the city, the city was able to identify critical situations and provide resources quickly, well before state and federal resources started flowing.

Nevertheless, conflicts do arise. For example, during large stream flow events, turbidity in the Catskill system typically increases due to the mobilization of sediment from stream channels. In order to protect water quality and improve downstream flood protection, turbid water is occasionally released from the Ashokan reservoir, which can affect fishing, boating, swimming, and agriculture. Such events have occurred in recent years, leading to either threatened or actual legal action.

Other differences between watershed communities and the city involve more long-term policy issues. One example involves a degree of unhappiness among a small group of stakeholders about the way the city has implemented parts of the stream program by contracting directly with

[107] See http://www.nycwatershed.org/

agencies and individuals rather than contracting through the CWC, as they feel was the intention specified in the MOA. The contractors, which include government entities such as the Soil and Water Conservation Districts, are usually well received, liked, and respected by watershed residents. However, under this arrangement, the city rather than the CWC is controlling the work that is performed. As a result, certain residents sometimes feel that their community's interests are not always adequately represented. There may be limited or no legal recourse in such cases, but complaints may garner media attention and impair the working relationship between the city and local residents.

Despite specific disputes, the perception among watershed communities is that, in a general sense, the city is working well with upstate communities, and the level of distrust of the city on the part of local residents, while still evident, is much less than prior to the MOA. Most local residents share the view that the natural attributes of the watershed area are so valuable that they should be protected. Conflicts are more frequently resolved by cooperation, and the expected trend is closer cooperation in the future.

5.3.5 Management of the NYC Water Supply System through Green Infrastructure, Engineering Solutions, Demand Side Tools, and *Water for the Future*

Management of the water supply to ensure reliable quantity and quality includes a combination of green infrastructure, innovative engineering solutions, and demand-side technical and economic tools. Green Infrastructure entails the maintenance of water quality through the use of natural and managed landscapes allowing ecosystem functions to benefit the human population, thus minimizing the need for "hard" engineering solutions. As a result of the MOA, the city operates the WOH system in this way to the extent possible. Engineering solutions include development of, long term planning for, and maintenance of infrastructure. Demand side tools include incentives for customers to use less water. All of these strategies have been used in the past. Currently, the city's *Water for the Future* program combines all of these into a coherent vision for ensuring a reliable water supply well into the 21^{st} century.

5.3.5.1 Green Infrastructure

In many respects, the Catskills/Delaware watershed management program may be considered a large-scale green infrastructure project, in which long-term challenges arising from human development—including the impacts from diversions and spills—must be considered in concert with environmental changes. In order to meet the Federal Surface Water Treatment Rules, "soft" measures are employed by NYCDEP whenever possible. [108] For example, in the early 1990s fecal coliform was identified as a problem in the Kensico reservoir (located east of the Hudson River). NYCDEP scientists, in collaboration with others, identified the local bird population as the source, and devised a bird harassment program to make noise in order to scare the birds away

[108] The primary federal rule designed to prevent waterborne diseases caused by microbes (http://water.epa.gov/lawsregs/rulesregs/sdwa/swtr/)

from critical areas such as intake valves. The locations are sufficiently far away from residential areas, and the noise is sufficiently intermittent, so as not to affect local residents. This program continues to successfully prevent a recurrence of the problem. More recently, as a result of voluntary farm programs implemented by NYCDEP, nutrient input to the reservoirs as well as the risk of cryptosporidium have been dramatically reduced. These programs—including practices such as proper manure handling, separation of calves, and grazing cattle away from streams—either benefit farmers directly and/or farmers are compensated.

5.3.5.2 Engineering Solutions

Ongoing "hard" infrastructure projects include several large projects. A third tunnel (to be completed before 2020) is being built to distribute water within the city, which will allow the two existing tunnels, which are aging, to be shut down for inspection and maintenance. A new UV disinfection facility, the largest of its kind in the world, was completed in 2013. It provides more efficient protection against cryptosporidium and other cysts in addition to chlorination, and is considered an important step in ensuring water quality into the future. A filtration plant for the Croton system has been completed, is currently in testing mode, and is expected to come on line in 2014.

5.3.5.3 Demand Side Tools

Demand side tools have been successfully implemented in the past to address short-term droughts, many of which were experienced in the 1980s as a result of increasing demands during the previous twenty years. Prior to that time, consumers did not pay for water. Starting in the 1990s, water metering and charging, in conjunction with requirements for low-flow fixtures, successfully decreased demand from almost 1.5 billion gallons per day (BGD) [approximately 5,700 ML/day] to less than 1.1 BGD [approximately 4,200 ML/day]. While only commercial users are subject to regulatory oversight, both commercial and residential consumers must pay for water.[109] Water and sewage rates are specified by a rate schedule that is updated annually.[110] Some residential customers pay rates proportional to property frontage area and size, while others pay according to metered usage.

5.3.5.4 Water for the Future

NYCDEP's *Water for the Future* is a $1.5B program designed to ensure the long-term reliability of the water supply system. [111] This program is motivated by the need to repair the Delaware aqueduct, which conveys more than half of the water supply to New York City. The aqueduct is leaking in two places due to small cracks in the tunnels. While the total amount of water lost to leaks (15-35 MGD) [approximately 57-130 ML/day] is small compared to the total amount conveyed by the tunnel (500 MGD) [approximately 1,900 ML/day], it is still significant.

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109 See http://www.nyc.gov/html/dep/html/customer_services/amr_about.shtml
110 See http://www.nyc.gov/html/nycwaterboard/html/rate_schedule/index.shtml
111 See http://www.nyc.gov/html/waterforthefuture/index.shtml

Furthermore, the leaks result in water flowing to the surface, causing hardship and expenses for residents and friction between residents and the city. In response to this problem, the city is embarking on another long-term, complex engineering project. The largest portion of the project involves the construction of a three-mile bypass tunnel to replace the portion of the tunnel that contains the largest leak. Construction is expected to result in a period of 6-12 months around the year 2021 during which water from the Delaware system will be unavailable.

To ensure minimum impact on the city's water supply resulting from the Delaware Aqueduct shutdown, *Water for the Future* includes a number of infrastructure and conservation measures. First, the Croton system will come online, providing up to 290 MGD [approximately 1,098 ML/day]. Second, the Catskill Aqueduct, which has accumulated a biofilm on the walls of the tunnels over the last several decades, will be cleaned using chemical means. Removal of the biofilm will reduce friction between flowing water and the tunnel wall, resulting in an expected increased capacity from its current 595 MGD [approximately 2,250 ML/day] to 640 MGD [approximately 2,420 ML/day] (compared to its historic peak of 660 MGD [approximately 2,500 ML/day]). In addition to removing biofilm, the project will replace aging valves and other components of the infrastructure to ensure reliability, especially during the Delaware shutdown. Third, a groundwater source located within the city's boundary that has not been used regularly for several decades will be resurrected. In addition, conservation measures—including a municipal efficiency program affecting city-owned structures and incentives for residential low-flow toilets—are targeted to reduce consumption by an additional 5% over conservation measures introduced in the 1990s. These efforts will allow the city to function for a short time without water from the Delaware System. After the repairs are complete, the city will resume using Delaware water, considered the purest in the system.

5.3.6 Operating the New York City Water Supply System: The Operations Support Tool

NYCDEP operates the city's water supply system to ensure reliability with regard to water quantity, water quality, and meeting environmental objectives. Operation of the water supply involves daily decisions on how much water to deliver, release, or spill from each reservoir, and how much water to transfer between reservoirs. Operational decisions are complicated by the variety of sometimes competing demands on the system. These include municipal supply quantity and quality requirements, downstream ecological and human demands, flood control, drought prevention, outage planning, and emergency management. NYCDEP has recently developed and implemented a state-of-the-art computer management tool called the Operations Support Tool (OST), at a cost of $8 million, which is designed to maximize system reliability and strengthen the city's ability to make objective, risk-based daily operational decisions.[112] OST links a series of models that were previously run independently, including reservoir water quality models and an operational water supply system model. In addition, the new system includes access to real-time and near-real-time data and stream flow forecasts, and a software

[112] See http://www.nyc.gov/html/dep/pdf/reports/ost_white_paper.pdf

platform providing access to this tool to a variety of users with different technical skills. OST components allow operators to optimize diversions and releases to simultaneously maximize water quality for consumers and downstream ecological health while minimizing flood risk, and to account for all known constraints on system operations (such as reservoir and aqueduct capacities).

OST runs on a hardware platform that allows operators to quickly and efficiently incorporate real-time observations as well as forecasts, and then produce output promptly, which allows operators to test several hydrological and decision-option scenarios. The previous system took approximately 30 hours to run. Water supply simulations can now be run in approximately 5 minutes, and water quality simulations in approximately 30 minutes. Each simulation provides forecasts for up to a year, with the first fourteen days driven by meteorological forecasts, fourteen-day to nine-month forecasts driven by large-scale atmospheric circulation patterns, and the final three months forecasted using climatological values.

OST is still relatively new, and the operational team is still learning how to use it most efficiently. NYCDEP currently has a staff of five who manage OST operations, operate the software system, evaluate simulation results, administer the database, contribute to model development and evaluation, and participate in scientific research. An additional staff member monitors and maintains the NYCDEP meteorological station network. (These staff requirements are in addition to the Water Supply Control Center staff that controls the actual water supply system.) On a typical day, a number of water supply simulations are performed. In the morning, the operator will parameterize the model according to current conditions (such as reflecting limited flow capacity because of construction). Then OST is run a number of times with different values for an important operational decision (e.g., the release rate from the Ashokan Reservoir). OST automatically incorporates up-to-date monitoring data and forecasts and then provides probabilistic forecasts for all system parameters (e.g., storage in the Ashokan Reservoir) in the future for each scenario. Operations team leaders review all scenarios, compare parameter forecasts to target values, and make operational decisions; the team may include modelers, engineers, field operators, or water quality monitoring staff. If the potential consequences of any decision are deemed to be of sufficient consequence, higher level NYCDEP personnel may be called in to participate in the decision making process. Improvements to all aspects of this procedure will continue to be made based on changing needs, OST software improvements, and the experience of the OST staff. OST allows operators to test different operational changes in a virtual setting, and understand their outcomes, so that daily decisions are made with the best available information. OST can help operators understand the relevant system dynamics, and to predict the potential impacts of different events, decisions, and system changes.

5.3.7 Adapting to Changes

Adapting water supply management to changing environments involves a number of ongoing projects that contribute to the resiliency of the water supply system and test the flexibility of

OST. During the most recent decade or so, this region has experienced an increased frequency of extreme hydrological events that caused unprecedented flooding. Such extreme events are known to be responsible for a significant portion of the annual sediment load into reservoirs, which cause water quality (i.e., turbidity) problems. In response to these events, the city has an ongoing program to identify specific sites in streams that contribute significant sediment loads, and to subsequently evaluate, plan, and implement stream restoration projects to reduce sediment release in the future. Water quality management programs funded through the MOA, as well as ongoing infrastructure improvements, fall under this category as well.

NYCDEP is also investing in the evaluation of the potential impact of climate change on the water supply system during the 21st century. This project involves a significant effort in data analysis, climate model evaluation, and the development of improved hydrological, terrestrial biogeochemical, and water quality models. These models are then used in combination with OST to try to foresee potential problems that may arise under changing climatic conditions in conjunction with changing demographics and regulatory environments. According to climate models, the total water availability in the region will most likely not be diminished, but the seasonal hydrological cycle and mean temperatures may be dramatically altered. These changes have potential to pose challenges to maintaining water quality standards in the future.

5.4 Reflections and Lessons Learned

The value of a river basin commission is that it provides the forum for its signatory members to cooperatively set priorities and adapt management schemes as new science emerges, new management tools are developed, and water demands change. Since its formation, the DRBC has provided leadership in restoring the Delaware River and protecting water quality, resolving interstate water disputes without costly litigation, allocating and conserving water, managing river flow, and providing numerous other services to the signatory parties. These successes are rooted in the Delaware River Basin Compact’s chief canon: that the waters and related resources of the basin are regional assets vested with local, state, and national interests that all share a joint responsibility to maintain and protect.

The Delaware River is an interstate river; when you stand on one of its banks, you are always looking across at another state. In forming the DRBC, each basin state and the federal government relinquished a portion of their sovereign authority to come together as one agency to coordinate the management of the river’s water resources on a watershed basis. For over 50 years, this collaborative effort has made sense economically and environmentally, proving to be a model for transboundary water management, a wise leveraging of public dollars, and an effective way to work together towards the common goal of protecting the Delaware River for present and future generations.

6. COLORADO RIVER BASIN WATER MANAGEMENT CASE STUDY[113]

The physical, institutional, and legal framework that has evolved within the Colorado River basin largely meets current water needs within the basin, albeit with some discomfort during prolonged dry periods, notwithstanding possibly over-generous historical assumptions regarding normal water availability. Constructed infrastructure offers significant water management flexibility, legal arrangements provide for inter-state allocations within a larger basin framework and changes over time, and institutional arrangements provide for cooperation among the various levels of government recognizing appropriate roles. However, the water management approach was put in place with limited contemplation of environmental considerations, tribal and international obligations, and changing physical and societal conditions that will likely place even greater stress on a system already stretched during times of drought. Basin water managers have successfully implemented temporary measures that address current demand/supply inequities, gaining benefits through coordination and system-oriented operations, but greater and potentially more controversial changes will likely be needed to address anticipated future pressures. Similarly, a water market provides a successful reallocation mechanism within a conservation district, but establishing inter-basin or inter-state water markets would be a considerably more complex undertaking.

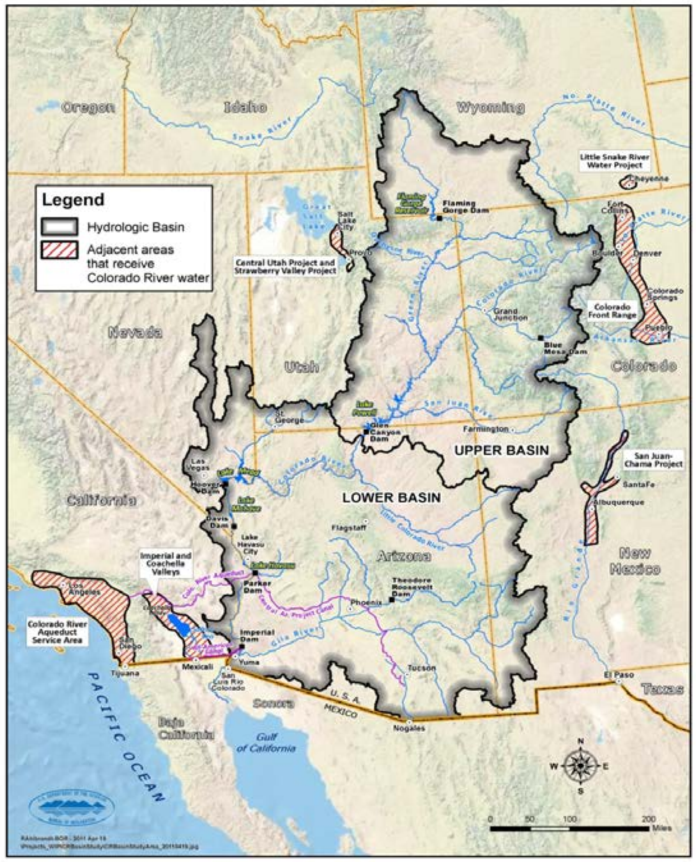

Figure 7. Colorado River Basin, Consumptive Use Outside the Basin Highlighted (Cohen, 2011)

[113] The description of the laws and issues involved in the operation and management of the Colorado River contained in this summary are for informational purposes only and do not reflect the formal position or legal determination of the United States government with respect to any matter discussed herein. The Corps intends that the overview provided herein will promote and facilitate education and communication regarding the challenges of water management. Nothing in this paper, however, is intended to represent any position of the Federal government in any administrative, judicial, or other proceeding to evidence any legal or policy interpretation with respect to the Law of the Colorado River. As such, statements contained in this summary do not, and shall not, represent a legal position or interpretation by the Federal government as it relates to the Law of the River.

6.1 Introduction

The Colorado River and its tributaries emerge out of the iconic Rocky Mountains, draining approximately 244,000 square miles [approximately 632,000 km^2] before ending up in the Gulf of California just across the Mexico border. Along the way, the river and its tributaries provide water for nearly 40 million people, effectively support irrigation on 5.5 million acres [approximately 2,226,000 ha] of land and can generate 4,200 megawatts of hydroelectricity (Bureau of Reclamation, 2012(a)). [114] Despite being an arid region with a relatively low amount of runoff, these extensive demands have been sustained, in part, by the enormous storage capabilities of the Colorado River. Lakes Powell and Mead alone can hold approximately 50 million acre-feet (MAF) [approximately 62 billion m^3], equivalent to almost four years of average historic flow at Lee Ferry, in northern Arizona.

The seven Basin states and the federal government adopted the Colorado River Compact of 1922 to establish the basis under which the waters of the river would be allocated. In doing so, it divided the Basin into two sub-basins. The Upper Basin is that portion of the river basin which rises upstream of Lee Ferry, a point one mile below the confluence of the Paria and Colorado Rivers (16 miles downstream of present day Glen Canyon Dam). The Upper Basin includes areas of the states of Colorado, New Mexico, Utah, and Wyoming; a small portion of Arizona is also located in the Upper Basin. The Lower Basin is that portion of the river basin that drains into the mainstem downstream of Lee Ferry. The Lower Basin includes areas of Arizona, California, and Nevada; small portions of Utah (the Virgin River drainage) and New Mexico (the Gila River drainage) are also located in the Lower Basin. However, although these seven states are all partly located within the physical Basin itself, approximately 70 percent of the urban deliveries of Colorado River water occur outside the Basin (Cohen, 2011). Figure 7 highlights the trans-basin diversions supplying water to prominent urban areas such as the Front Range in Colorado, the Wasatch Front in Utah, and Los Angeles and San Diego in Southern California. [115]

There are several reasons why the 1922 Compact came to be (Hundley, 2009). First, the Upper Basin states were concerned about losing the ability to develop water rights in the future, as the Lower Basin states were growing and establishing water rights at a much quicker pace (Tyler, 2003). A then-recent Supreme Court decision had found that the legal system of water rights in the Western United States—the doctrine of prior appropriation (explained above)—operated across state lines (Getches, 1997). [116] As a result, water rights established in the Lower Basin states could potentially impact how much water could be developed in the Upper Basin. Second, in order for the Lower Basin states to take advantage of the Colorado River, they recognized the need for large infrastructure projects to help control, store, and transport water to where demand

[114] This is the effective number of irrigated acres (both in the hydrologic basin and outside the basin through exports) that are supported at least in part by the Colorado River and its tributaries.
[115] Western water law allows for diversions out of a hydrologic basin, so long as they do not negatively impact users with more senior water rights.
[116] *Wyoming v. Colorado*, 259 U.S. 419, 42 S.Ct. 552 (1922)

was increasing significantly, most notably in Southern California (Reisner, 1993). Not wanting to interfere with interstate comity, however, the federal government's assistance in building a large infrastructure project was made contingent on a Basin-wide agreement amongst the seven Basin states. Thus, because of the need to preserve the capacity for future development and the need to obtain federal support for large projects, both the Upper Basin and Lower Basin states had incentives to negotiate an interstate compact allocating the waters of the Colorado River.

6.2 Allocation of the Colorado River: the Law of the River[117]

The Colorado River Compact of 1922 apportioned 7.5 million acre-feet (MAF) [approximately 9.3 billion m^3] annually to both the Upper and Lower Basin states for future consumptive use. [118] While both Basins are technically apportioned 7.5 MAF [approximately 9.3 billion m^3], these apportionments are further combined into a management regime that requires the Upper Basin to "not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75,000,000 acre-feet [approximately 93 billion m^3] for any period of ten consecutive years."[119] In other words, the Upper Basin has an obligation to deliver 75 MAF [approximately 93 billion m^3] over ten years on a rolling average to the Lower Basin (Hundley, 2009). [120][121]

It is important to note that the 1922 Compact was the first effort to manage and allocate the waters of the Colorado River through an interstate process with all seven Basin states. As such, it cannot be expected that the Compact be "perfect" or done the "right" way, but instead should be viewed as having created a foundation upon which future policies may incrementally build upon and address the ambiguities or omissions in the original Compact. Further, inherent to any such first effort, there were issues that needed to be addressed following the adoption of the Compact. Issues such as each state's specific allocations, obligations to Mexico and Native Americans, changing physical and societal conditions, and environmental concerns are topics not specifically addressed in the original Compact, but they have been, and will continue to be, addressed as necessary (Hundley, 2009). The continued negotiations, acts, settlements, compacts, and decisions since the Compact was established collectively comprise what is known as the "Law of the River."

[117] For summaries and copies of each constituent part of the Law of the River, see http://www.usbr.gov/lc/region/g1000/lawofrvr.html. For additional information and related reports, decrees, resolutions, meeting minutes, etc., see http://www.onthecolorado.com/resources.cfm?mode=section&id=Reports
[118] Colorado River Compact of 1922, 45 Stat. 1057.
[119] Colorado River Compact of 1922, Article III (d).
[120] As the language in Article III (d) suggests, the Compact does not specify a "delivery obligation" per se, but does require the Upper Basin to not deplete the flows at Lee Ferry below a certain amount. Whether or not this should be interpreted as a de facto delivery obligation is a contested matter (Robison and Kenney, 2013).
[121] While the Upper Basin was legally apportioned 7.5 MAF [approximately 93 billion m^3]for consumptive use, it has become evident that the average flows on the Colorado River are insufficient to provide this quantity to the Upper Basin and still provide the Lower Basin's allocation at Lee Ferry. Therefore, the Upper Basin is limited in its ability to develop additional Colorado River water by the obligation to not deplete flows at Lee Ferry below the Lower Basin apportionment.

The Boulder Canyon Project Act of 1928 allocated specific quantities of Colorado River water to each of the Lower Basin states. [122] These allocations were "fixed"'—as opposed to proportional—in that they specified a quantity of water that each state could consumptively divert and use. A fixed allocation scheme for the Lower Basin seemed appropriate, as there was some certainty in annual water availability due to the Upper Basin's delivery obligation to the Lower Basin. Specifically, California was allocated 4.4 MAF/year [approximately 5.4 billion m^3/year], Arizona was allocated 2.8 MAF/year [approximately 3.5 billion m^3/year], and Nevada was allocated 0.3 MAF/year [approximately 0.4 billion m^3/year].

The Upper Colorado River Basin Compact of 1948 apportioned the Upper Basin states' shares of Colorado River water under the 1922 Compact. [123] Using a different approach than the Lower Basin, the Upper Basin Compact utilized a proportional allocation scheme. As opposed to allocating fixed quantities of water, each state was allocated a proportion of the Upper Basin's water supply. This arrangement was selected because the Upper Basin states recognized there could be variability in the availability of water, and a fixed allocation might not be available each year (Kuhn 2007). As such, the states were apportioned a percentage of the available supply each year: Colorado – 51.75%, Utah – 23%, New Mexico – 11.25%, and Wyoming – 14%.

Further additions to the Law of the River have been implemented since the original Compact, but these initial allocations to the Upper and Lower Basins, as well as among the states within each basin, continue to provide the basic framework for how the Colorado River Basin is managed. [124]

6.3 Insights and Observations from the Law of the River

A close examination of the development and implementation of the Law of the River yields a number of useful lessons. Some of the relevant issues illustrated by this history include the differing consequences of the types of allocations, the omission of certain topics from the original Compact, and the lack of an explicit mechanism to reallocate water as physical and social conditions vary. These insights are especially salient today as it has been recognized that original 1922 Compact and subsequent allocations within and between the Upper and Lower

[122] Boulder Canyon Project Act, 45 Stat 1057 (1928).
[123] Upper Colorado River Basin Compact of 1948, 63 Stat. 31. (1949).
[124] For example: in 1970, the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (P.L. 90-537) was established to provide annual operating plans to the seven Basin states and Mexico for how the major reservoirs would be operated. Further, it established an annual objective minimum release from Glen Canyon Dam of 8.23 MAF [approximately 10 billion m^3]. This annual objective release provides for the Lower Basin allocation of 75 MAF over ten year rolling averages, in addition to 750,000 AF [approximately 925 million m^3] of the 1.5 MAF [approximately 1.9 billion m^3] Mexico allocation (minus the downstream inflow of the Paria River of approximately 20,000 AF [approximately 25 million m^3]). The other half of the Mexico allocation would come from the Lower Basin. As discussed in more detail in this Section, this 8.23 MAF [approximately 10 billion m^3] objective release was scheduled to be reduced in Water Year 2014 for the first time since it was established.

Basins were based on flow records and estimates that were unusually wet and unrepresentative of longer term trends in hydrology (Robison and Kenney, 2013).[125]

The allocations utilized by the Upper and Lower Basins highlight two prominent types of allocations schemes in water management: fixed and proportional allocations. The positive and negative attributes for each depend on the context in which they are implemented. Fixed allocations provide greater certainty for users in that it is explicitly clear what their water apportionment is each year, such as the case in the Lower Basin. This arrangement is, of course, dependent on reliable storage and subsequent deliveries upstream from the fixed allocation. Inherent in fixed allocations, however, is the inflexibility to reallocate water should hydrologic or societal conditions change (Schlager and Heikkila, 2011). For example, in the Boulder Canyon Project Act of 1928, Nevada was only allocated 0.3 MAF [approximately 0.4 billion m^3] from the 7.5 MAF [approximately 9.3 billion m^3] available to the Lower Basin. This was because when the allocations were being negotiated, Nevada was relatively unpopulated with little prospects for substantial growth (Hundley, 2009). Throughout the 20th century, however, Las Vegas has emerged as one of the fastest growing cities in the country with resultant significant increases in demand for Colorado River water (Bureau of Reclamation, 2012(b)). This highlights the inability to accurately predict the future, which is problematic if the allocation cannot be adjusted to reflect these changes.

Proportional allocations have greater capacity to respond to hydrologic changes because they are dependent on the hydrologic conditions and availability of supply, as opposed to a static quantity each year (Schlager and Heikkila, 2011). In other words, those users involved in the proportional allocations are subject to increases and decreases in available deliveries as hydrologic conditions warrant. This is evident in both year-to-year conditions and longer-term decadal trends in hydrology. This flexibility can be beneficial in responding to changing hydrologic conditions, but may reduce the certainty users have in the availability of developing new supplies. For example, since water to the Upper Basin states is proportionally allocated, it is unclear how much each state’s water demands can be reliably increased before potentially creating risks such that the Upper Basin would be unable to comply with the 1922 Compact. Despite being able to adapt to hydrologic changes, however, proportional allocations face similar challenges to fixed allocations in responding to societal changes (e.g., population growth).

As mentioned earlier, there are several issues that the Compact did not specifically address, including environmental concerns, obligations to Mexico, and Native American water rights. The Compact did, however, provide the framework for the Basin states and the federal government to address these issues as development of the Colorado River continued. For example, the United States and Mexico signed a treaty in 1944 requiring an annual delivery to Mexico of 1.5 MAF

[125] Also, see Figure 8 that shows the “wet” period during which the compacts were negotiated.

[approximately 1.9 billion m^3].[126] Additionally, there have been numerous tribal water negotiations,[127] as well as modifications to reservoir operations to reduce negative impacts to the Colorado River ecosystems.[128] Rather than attempting to decide how to resolve many of these concerns during negotiations of the original Compact, which would have proven extremely difficult or impossible, the Compact provided the framework for more incremental changes in Basin policy as the various issues and concerns have required attention. Providing this framework for how the waters of the Colorado River were to be allocated among the seven Basin states allowed for these incremental changes in that they could be built upon the existing agreement. Thus, any additional issue or concern did not require renegotiating the basic tenets of the original Compact.

Despite this inherent flexibility for incremental changes in policy, however, the basic framework for allocating the Colorado River to the seven Basin states is inflexible and does not prescribe if —and how—allocations should be modified as a result of future changes. This lack of a specific procedure to allow for a policy mechanism to reallocate the water (e.g., water marketing) limits the ability of the Basin states to respond to variability in, or substantial changes in, social and hydrologic conditions. For example, prolonged drought and climate change are expected to decrease the amount of Colorado River water available in the coming decades (Overpeck and Udall, 2010), but the Compact does not specifically allow for a reallocation among the Basin states, either on a voluntary or mandatory basis (e.g., Bjornlund, 2003).

6.4 Current Colorado River Basin Management

The Colorado River continues to be managed under the Law of the River. In the Upper Basin, states have plans to develop additional Colorado River supplies, but there is some uncertainty as to exactly how much water is physically and legally available.[129] The Upper Basin states currently use approximately 4.4 MAF [approximately 5.4 billion m^3] annually, but that number varies each year depending on the availability of surface water supplies (Bureau of Reclamation, 2013). The Upper Colorado River Commission,[130] which was created by the Upper Colorado River Basin Compact of 1948, is responsible for a variety of Upper Basin issues, including ensuring compliance with the Law of the River through tracking Upper Basin water use, quantifying deliveries to the Lower Basin, and determining any potential curtailments to ensure

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[126] Treaty Relating to the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande, U.S.-Mex, Feb. 3, 1944, 59 Stat. 1219.

[127] See, for example, the Navajo Nation Water Rights Settlement negotiations: http://www.ose.state.nm.us/legal_ose_proposed_settlements_sj.html

[128] For example, the Grand Canyon Protection Act of 1992, Pub. L. 102-575, title XVIII, 1992, 106 Stat. 4669

[129] See the Colorado Water Conservation Board's 2012 Colorado River Water Availability Study Report. Available online: http://cwcb.state.co.us/technical-resources/colorado-river-water-availability-study/Pages/CRWASSupportingDocuments.aspx

[130] The Commission does not have its own website, but see the Upper Colorado River Commission section of this website for further information: http://www.onthecolorado.com/resources.cfm?mode=section&id=Reports

Compact compliance.[131] A representative from each of the four Upper Basin states and one representative from the federal government with various other support staff comprise the Commission. Meetings with the entire Commission are held several times throughout the year and are open to the public. The Commission is also required to submit an annual report to the federal government summarizing the Upper Basin reservoir operations, hydrology, deliveries, and any related activities, including relevant programs, court cases, legislation, or resolutions. The Commission's $300,000-400,000 annual budget is paid for proportionately by the four Upper Basin states based on their water allocation percentages in the 1948 Compact.

The Lower Basin has fully developed its Colorado River apportionments, but each of the three states is projected to increase its demands as populations continue to grow. To meet these increased demands, these states are pursuing a variety of additional water sources such as conservation, conjunctive groundwater management, increased supply from outside the hydrologic Basin, and agriculture-to-urban transfers (Bureau of Reclamation, 2012(b)). While each state has some autonomy within the Law of the River, there is substantial federal involvement in managing the Lower Basin. The Bureau of Reclamation operates the major reservoirs—most notably Lake Mead—and contracts with water users to allocate Colorado River water. The Boulder Canyon Project Act of 1928, in addition to apportioning the Lower Basin's 7.5 MAF [approximately 9.3 billion m^3] among the three states, also authorized and directed the Secretary of the Interior (federal agency overseeing the Bureau of Reclamation) to function as the "water master" in the Lower Basin and contractually allocate Colorado River water to the Lower Basin states and users.[132]

In addition to these intra-Basin issues, the entirety of the Colorado River Basin has experienced a prolonged drought for approximately the last 14 years. Despite a few wet years with above average flows, the major reservoirs have declined in storage with reduced runoff due in part to the drought. [133] Concurrent with this prolonged drought, there is a long-term trend of average demands equaling, and in some years exceeding, average available supplies. Figure 8 demonstrates this long-term trend and the projected increase in this supply and demand gap.

In response to the drought and increasing demands, the seven Basin states and the Bureau of Reclamation negotiated the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead.[134] These Guidelines add to the growing body of the Law of the River, and coordinate the operations of Lake Powell and Lake Mead, requiring different releases depending on the elevations in each reservoir. In addition to coordinating operations between the two reservoirs, the Interim Guidelines also prescribe how and when shortages will be addressed in the Lower Basin, again based on elevation levels in

[131] To date, there have not been any curtailments as a result of Compact compliance, so the exact process for Compact curtailments is uncertain.
[132] See, for example, the California Seven Party Agreement: http://www.usbr.gov/lc/region/pao/pdfiles/ca7pty.pdf
[133]See http://www.usbr.gov/lc/region/g4000/hourly/rivops.html
[134] See http://www.usbr.gov/lc/region/programs/strategies.html

each reservoir (Jerla and Prairie, 2009). Should Lake Mead reach certain elevation levels, specified shortages to the Lower Basin states will be implemented. For example, if Lake Mead falls below an elevation of 1,075 feet [approximately 328 meters], Arizona, Nevada, and Mexico would see reductions in their annual apportionment of 320,000 AF, 13,000 AF, and 50,000 AF respectively [approximately 395 million m^3, 16 million m^3, and 62 million m^3, respectively] (California would still receive its full apportionment). If Lake Mead falls below an elevation of 1,025 feet [approximately 312 meters], the shortages increase to 480,000 AF, 20,000 AF, and 125,000 AF, again respectively [approximately 592 million m^3, 25 million m^3, and 154 million m^3, respectively]. These predetermined shortages were developed in the Interim Guidelines and allow for the Lower Basin states to anticipate and plan for potential shortages during prolonged droughts. Within each state, the specific users who would be curtailed under these shortages are based on the priority of each user. In Arizona, for example, the lowest priority of users from the Central Arizona Project (which delivers Colorado River water to the state) would be primarily agricultural and underground storage users.[135] An important aspect of these new Guidelines is that they are not permanent changes to the Law of the River, but rather a temporary modification to operations in order for the Bureau of Reclamation and Basin states to gain experience with coordinated operations. The Guidelines are in place through 2026 when they can be extended, modified, or revert to pre-2007 operational procedures.

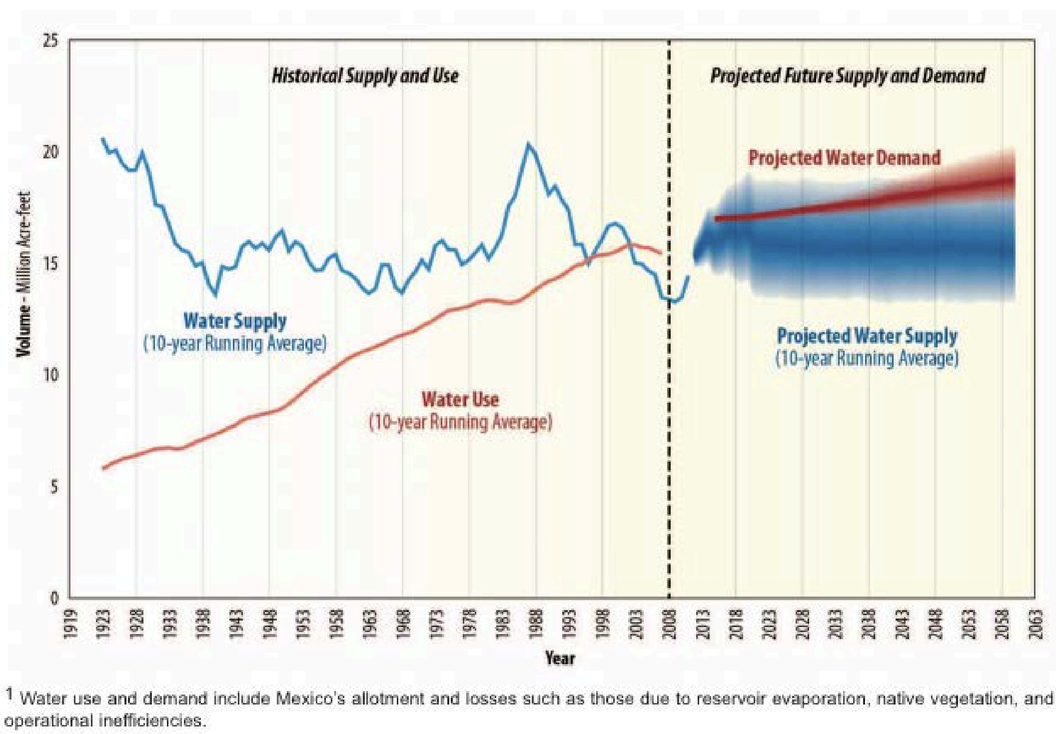

Figure 8. Historical and projected supplies and demands of the Colorado River Basin (Bureau of Reclamation 2012(a))

[135] For additional information on CAP and the Interim Guidelines, see http://www.cap-az.com/documents/planning/State_of_the_River_2014.pdf

Based on these Interim Guidelines, and the reservoir levels for Lakes Powell and Mead, the Bureau of Reclamation announced in the summer of 2013 that deliveries from Lake Powell will be reduced from 8.23 MAF [approximately 10.2 billion m^3] to 7.48 MAF [9.23 billion m^3] for the first time in history for Water Year 2014.[136] Deliveries from Lake Powell have historically been a minimum of 8.23 MAF [approximately 10.2 billion m^3], and fluctuate depending on each year's hydrology as outlined in the Bureau of Reclamation's Annual Operating Plans.[137] Further, with these reduced releases from Lake Powell, continued declines in Lake Mead could trigger the first ever official Lower Basin shortage as early as 2016, again as prescribed in the Interim Guidelines and discussed above. [138] The reduced releases from Lake Powell and the potential shortages to the Lower Basin states are integral parts of the Interim Guidelines and are intended to reduce overall vulnerabilities throughout the entirety of the Basin. These Interim Guidelines are an example of how uncertainties and potential shortages can be agreed upon ahead of time before they become unavoidable conflicts requiring costly lawsuits and litigation among the Basin states.

In addition to the Interim Guidelines, there have been some examples of interstate agreements to manage and utilize the Colorado River in the Lower Basin. For example, Arizona and Nevada created a water bank system in which Nevada can pay Arizona to "store," in Arizona's groundwater aquifers, any Colorado River water saved from Nevada's apportionment.[139] When this banked water is needed by Nevada, the water can be "recovered" through Nevada utilizing some of Arizona's allocation from Lake Mead while Arizona withdraws that same amount from the stored groundwater aquifers. This banking arrangement allows for Nevada to store Colorado River water in wet years, and draw upon the bank during dry years.[140]

In 2013, the Bureau of Reclamation and the seven Basin states released the multi-year Colorado River Basin Water Supply and Demand Study ("Basin Study").[141] The Basin Study is the most comprehensive study to date, quantifying projected supplies and demands in each of the seven Basin states. Multiple demand scenarios were utilized and included both high- and low-demand growth scenarios. Supply projections included a variety of scenarios, including a reduced overall supply due to climate change and a repeat of the hydrology seen in the 20th century. Ultimately, the Basin Study concluded that while a range of futures is possible, the supply and demand imbalance is expected to continue to increase to as much as 3.2 MAF [approximately 3.9 billion m^3] by 2060 (Bureau of Reclamation, 2012(a)). In addition to quantifying future scenarios, the Basin Study examined potential options and reforms to reduce this imbalance. Options were solicited from a variety of stakeholders (including the general public), and included municipal

[136] See http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=44245
[137] See http://www.usbr.gov/uc/water/rsvrs/ops/aop/
[138] Shortages in the Upper Basin due to inadequate surface water availability are regular occurrences, but to date there has not been official or declared shortages to Lower Basin users from Bureau of Reclamation contracts.
[139] See http://www.snwa.com/ws/future_banking_arizona.html
[140] In 2013, however, Nevada announced that it would be temporarily putting the water bank on hold due to cost and the availability of alternative supplies elsewhere in the state.
[141] See http://www.usbr.gov/lc/region/programs/crbstudy.html

and agricultural conservation, watershed management (e.g., invasive plant removal), supply augmentation (e.g., desalination), and modifying system operations. While not a decision document—in contrast to the 2007 Interim Guidelines—the Basin Study provided a platform for the Basin states, Bureau of Reclamation, and other stakeholders to come together and discuss potential options for solving the projected supply and demand imbalances. The Basin states, Bureau of Reclamation, and a wide range of basin interests continue to discuss the identified options and the potential for implementing some options where physically, politically, and legally possible.[142]

As mentioned earlier, concerns for Colorado River ecosystems were not included in the original 1922 Compact. Building upon the Law of the River more recently, however, there have been several programs and operational changes to reduce overall impacts on Colorado River ecosystems and endangered species. For example, operations undertaken pursuant to the Grand Canyon Protection Act of 1992 limit fluctuations in daily releases (for hydropower demands) from Lake Powell to reduce negative impacts on ecosystems and native species in the Grand Canyon. [143] This does not modify the total annual deliveries from the Upper Basin to the Lower Basin, but does attempt to better mimic pre-dam hydrology through modified dam operations. Other programs include the Upper Colorado River Endangered Fish Recovery Program,[144] the Lower Colorado River Multi-Species Conservation Program,[145] and most recently Minute 319 of the 1944 Treaty between the United States and Mexico. [146] This Minute to the original treaty covers—for a five year period—a variety of international Colorado River issues, but also includes a joint effort by the two countries to intentionally create conserved water through various conservation measures. This conserved water would then be used to send a springtime "pulse flow" of water to the Colorado River Delta in the Sea of Cortez for environmental benefits. This would better mimic more natural Colorado River hydrology and in theory help the Delta ecosystem restore some of its natural environment. The first pulse flow began in late March of 2014 and will be extensively monitored and studied to understand the responses of the ecosystem.[147]

6.5 State of Colorado

The state of Colorado has developed its own water supplies within the Colorado River Compact of 1922 and the Upper Colorado River Basin Compact of 1948. Pursuant to the 1948 Compact, Colorado is allocated 51.75% of the Upper Basin's share of the Colorado River. Currently, total Upper Basin use is in the range of 4.5-5 MAF [approximately 5.6-6.2 billion m^3] and Colorado's

[142] See the Basin Study "Next Steps", available online at http://www.usbr.gov/lc/region/programs/crbstudy/MovingForward/index.html
[143] Grand Canyon Protection Act of 1992, Pub. L. 102-575, title XVIII, 1992, 106 Stat. 4669
[144] See http://www.coloradoriverrecovery.org/
[145] See http://www.lcrmscp.gov/
[146] See http://www.ibwc.gov/Files/Minutes/Minute_319.pdf
[147] See http://newswatch.nationalgeographic.com/2013/12/12/scientists-plan-for-grand-experiment-in-the-colorado-river-delta/

total use is approximately 2.2 MAF [approximately 2.7 billion m^3] (Bureau of Reclamation, 2013). These numbers fluctuate each year as the Upper Basin lacks sufficient reservoir storage in locations usable for deliveries to water users, and thus the Upper Basin states are reliant on each year's hydrologic conditions and required deliveries to the Lower Basin.

In Colorado, water is allocated based on the doctrine of prior appropriation and the amount of water available each year from surface and groundwater sources. Colorado faces what is known as the "80/20 problem" – 80 percent of the population lives on the east side of the continental divide, where only 20 percent of the available surface water is located.[148] To deal with this problem, water users on the east side have built and secured water rights to numerous trans-basin diversions. Going forward, additional diversions are being proposed but are to be included in a more holistic state water plan that addresses concerns on both sides of the divide (discussed in more detail below).

Water management in Colorado is typically administered at the local level—e.g., individual division engineers, water courts, and irrigation districts—but is guided by several state authorities involved in managing water in Colorado. The Colorado Water Conservation Board (CWCB) is a prominent authority in overseeing water issues and is responsible for the state's water supply planning, flood protection, intrastate management, stream and lake protection, and water conservation and drought planning. [149] The CWCB is also responsible for managing interstate and federal issues, and participates in the Upper Colorado River Commission discussed in the previous section.

The Colorado Division of Water Resources,[150] also known as the Office of the State Engineer, is the agency responsible for administering specific water rights that have been determined in the water court system.[151] The state is divided into seven "water divisions" that are defined by the seven river basins. Within each division, a Water Commissioner allocates water rights—based on the prior appropriation system—determined in the courts, in compliance with local, state, and federal laws, and has the legal authority to curtail junior users if the water rights of senior users are not being met. During times of shortage or drought, the Water Commissioners allocate water rights based on this seniority. Disputes among water right holders, should they occur, are resolved in the water courts within each division.

Demand is projected to continue to grow in Colorado—particularly in the "Front Range" of Colorado where a majority of the state's population is located—but the state faces some uncertainty in what can legally be developed and consumptively used under the Law of the River

[148] See, for example, page 6 of Colorado Water Conservation Board Presentation to the Colorado Foundation for Water Education Legislative Lunch, available online at http://cwcb.state.co.us/water-management/water-supply-planning/Documents/LegislativeUpdateCOWaterSupplyFuture.pdf
[149] See http://cwcb.state.co.us/about-us/about-the-cwcb/Pages/main.aspx
[150] See http://water.state.co.us/Home/Pages/default.aspx
[151] Colorado is somewhat unique compared to other western states in that all water rights are determined in a court system, rather than solely through a state engineer or state water board.

(Colorado Water Conservation Board 2012). This is due to a variety of reasons, including less total Colorado River water being available than previously assumed, different viewpoints in interpretation of the Law of the River, and potential climate change impacts. For example, the Colorado River Water Availability Study conducted by the CWCB in 2012 found that there is a significant range in the total amount of new Colorado River water the state could conceivably develop (Colorado Water Conservation Board 2012).

In response to these growing demands and related uncertainties, the Governor of Colorado issued an executive order in 2013 directing the CWCB to create a first-ever "State Water Plan."[152] The process for developing the State Water Plan is a "bottom-up" approach that incorporates public participation through the state's individual seven river basins' "Basin Roundtables."[153] This Plan has yet to be completed, but initial efforts to date have focused on identifying additional agricultural and municipal conservation, agriculture-to-urban transfers that are flexible and temporary, and the state's support for water supply projects that meet a predetermined set of criteria deemed important in the Plan. The ultimate goal is to have a statewide, comprehensive plan to address future water uncertainties that was developed in an interactive, stakeholder-driven process. The Plan is expected to be complete by the end of 2015.

6.6 Northern Colorado Water Conservancy District

Within each of the divisions described above, there are a variety of service and supply organizations that actually own and manage the water rights and how they are delivered to users. These organizations can be public or private, and include entities such as utilities, mutual water companies, ditch companies, municipalities, and irrigation districts. One example of a public irrigation district is the Northern Colorado Water Conservancy District ("Northern").[154] Located in northeast Colorado, Northern was created in 1937 to help build and operate the Colorado-Big Thompson Project (trans-basin diversion from the headwaters of the Colorado River through the continental divide). The Colorado-Big Thompson (CBT) water is brought across the divide for municipal, agricultural, domestic, and industrial uses. Within Northern's boundaries, users can voluntarily buy and sell water "shares" each year in a water market (Howe and Goemans, 2003; Howe 2011).[155] Once a "share" is purchased or owned, Northern announces in April each year the quota of each share that will be available, depending on that year's hydrologic conditions and the expected amount of available surface water. If the quota is 100%, then one share is equal to one acre-foot [approximately 1,230 m^3] of water.[156] In addition to market shares, there is an active "rental" (or lease) market from which shareholders can temporarily sell surplus water in a given year.

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[152] See http://coloradowaterplan.com/
[153] See http://cwcb.state.co.us/water-management/basin-roundtables/Pages/main.aspx
[154] See http://www.northernwater.org/default.aspx
[155] For further information on Northern's water market, see http://www.northernwater.org/AllotteeInformation/AllotteeInformation.aspx
[156] See http://www.northernwater.org/AllotteeInformation/C-BTQuota.aspx

A variety of factors contribute to determine the price of each share and ultimately the value of the CBT water. Type of user (e.g., irrigator versus municipality), time of year (e.g., growing season), and that year's given hydrologic conditions can all influence the price for each share. Because of the influence of these values, in addition to other market forces such as historic supply and demand, the price can vary quite substantially from year to year (e.g., the price for one share fluctuated between \$9,500 and \$18,500 during the 2013 water year).[157] Users pay for each share and then are charged by Northern a small amount per acre-foot delivered to the user (e.g., \$3.50/acre-foot for irrigators). As for the rental/lease market, price is determined by the time within the growing season, as well as the hydrologic conditions. In addition to annual variability of these prices, the price of shares has been increasing in recent years due to market demand by municipalities for agricultural users' shares. As municipalities' demands within Northern's boundaries have continued to increase, agricultural water is often considered a "low-hanging fruit" for municipalities to purchase and secure additional supplies.

Ultimately the price of this water is driven partially by traditional supply and demand forces, but also by the type of the user, quantity used, and whether the share is permanently bought or temporarily leased. This is an example of an active water market in the Colorado River Basin, although only users within the water district are allowed to participate. Water users cannot buy or sell water rights outside of the district. Northern's policies illustrate how a water market can operate in the Basin, but because it is located within a single water district with one governing authority, it does not have to address many of the legal and political issues that would have to be confronted in the context of an inter-state or inter-basin water market.

[157] See http://www.denverpost.com/ci_23616554/cost-water-share-nearly-doubles-northern-colorado

7. COLUMBIA RIVER TREATY CASE STUDY[158]

The Columbia River basin provides an excellent working example of transboundary cooperation to achieve—and share—multiple benefits. It also serves as an example of how water can be governed at different scales to manage the resource for multiple purposes amidst scarcity and competing uses. At the international level, the Columbia River Treaty was developed primarily for hydropower and flood control benefits. However, it can address other considerations subject to mutual agreement, and the overall basin framework accommodates complementary arrangements for addressing non-hydropower and non-flood control issues, including fish and wildlife concerns. Strong working relationships among water managers in the basin have limited the need for accessing the tiered levels of the treaty's dispute resolution provisions. At the state and sub-basin level, the examples of water allocation and a successful water market within a portion of the Columbia River basin in Oregon illustrate approaches for limiting scarcity, encouraging conservation, regulating groundwater, and incentivizing water suppliers to enter the market.

7.1 Columbia River Treaty

7.1.1 History & Background

The Columbia River basin (CRB) is an international basin shared between the United States and Canada. Seven states and one Canadian province have land within the basin, which covers an area of 259,500 mi^2 [approximately 668,000 km^2] (Hearns, 2008). The average annual flow of the Columbia River at its mouth is 198 million acre-feet (MAF) [approximately 244 billion m^3] (J. Hyde, 2010). In 1948, severe flooding hit the Columbia River Basin, causing multiple deaths and extensive property damage in both Canada and the United States. In response to this and other flood events, as well as to foster hydroelectric development, the U.S. and Canada ratified the Columbia River Treaty (CRT) in 1964. The intent

Figure 9: Map showing the dams in the Columbia River Basin (U.S. Army Corps of Engineers (c) ESRI 2013; USGS; NASA image)

[158] The description of the laws and issues involved in the operatic contained in this summary are for informational purposes only and do not reflect the formal position or legal determination of the United States government with respect to any matter discussed herein. The Corps intends that the overview provided herein will promote and facilitate education and communication regarding the challenges of water management. Nothing in this paper, however, is intended to represent any position of the Federal government in any administrative, judicial, or other proceeding to evidence any legal or policy interpretation with respect to the Columbia River. As such, statements contained in this summary do not, and shall not, represent a legal position or interpretation by the Federal government as it relates to water management of the Columbia River.

was to maximize flood control and hydropower benefits received on both sides of the U.S.-Canada border (Hearns, 2008). The CRT authorized construction of four dams: Mica Dam, Hugh Keenleyside Dam, and Duncan Dam in Canada as well as Libby Dam in the U.S. (Montana) (Figure 9). To ensure equal sharing of downstream benefits, the U.S. paid Canada $64.4 million at treaty ratification for assured flood control for expected avoidance of flood damages through 2024. Each year the U.S. also returns to Canada 50% of the downstream power benefits, known as the Canadian Entitlement, in the form of energy and capacity (Hearns, 2008; Hyde, 2010). These downstream power benefits are "the difference in the hydroelectric power capable of being generated in the United States of America with and without the use of Canadian storage" (CRT Article VII). The value of the Canadian Entitlement is estimated to range from $100 to $300 million per year (Hearns, 2008).

7.1.2 Treaty Operations

The CRT established the U.S. and Canadian Entities as organizations to implement the CRT (Table 3). Appointed by their respective governments, Bonneville Power Administration (BPA) and the U.S. Army Corps of Engineers (USACE) serve as the U.S. Entity and BC Hydro serves as the Canadian Entity (Hyde, 2010). Together the Canadian and U.S. Entities implement the CRT through two committees: the Hydro-Meteorological Committee and the Operating Committee, which develop a number of plans to operate the treaty which build upon and refine one another (Table 4). As part of the U.S. Entity, USACE—specifically the Water Management Division of the Northwestern Division—plays a large role in the CRT by conducting studies required for developing the various treaty operating plans.

In addition to the dams authorized by the CRT, there are numerous other private and public dams on the Columbia River and its tributaries. In the U.S., these dams are authorized to operate for a variety of purposes in addition to hydropower and flood risk management, such as navigation, irrigation, and recreation. [159] These dams make up the Coordinated Columbia River System and are operated under regulations and requirements in addition to the CRT, including:

- Pacific Northwest Coordination Agreement (PNCA)[160] – An agreement between federal project operators and hydroelectric generating facilities in the Pacific Northwest (private and public). It establishes processes that coordinate the use of planned Canadian storage operations with U.S. project operations in order to optimize system reliability and power production after giving priority to non-power objectives on a day-to-day basis. The current agreement expires in 2024. The PNCA Coordinating Group (BPA, USACE, Reclamation, and public and private utilities in the U.S. Pacific Northwest and western

[159] Depending on the owner of the dam, its purpose, and its location, the dam requires authorization from the state and/or federal government. Authorization from the state and/or federal government dictates for what purposes (e.g., irrigation, flood control, etc.) a dam can be operated.
[160] For a copy of the PNCA see http://www.crt2014-2024review.gov/Files/97PNCA_ConformedCopy.pdf

Canada) is the group that implements the agreement using a number of rule curves for reservoir operations developed by the Northwest Power Pool Study Group each year.

- Environmental and fish and wildlife statutes – Most notably, the federal Endangered Species Act (ESA), which requires alterations to operations such as increased spill, reservoir drawdowns, and increased/altered timing of flows under a Biological Opinion issued for endangered salmon species. To implement the ESA Biological Opinion, USACE works as part of the National Marine Fisheries Service (NMFS) Regional Implementation Forum—an avenue for regional dialogue for determining the operations of the Federal Columbia River Power System (FCRPS, which is made up of the 31 federally owned dams on the Columbia River and its tributaries) for a variety of purposes. The Regional Implementation Forum includes an Executive Committee and Implementation Team that are supported by the Technical Management Team (TMT), Water Quality Team (WQT), System Configuration Team (SCT), and others. [161] The TMT is an inter-agency technical group that makes recommendations on dam and reservoir operations for the Coordinated Columbia River System in order to improve passage conditions for adult and juvenile anadromous fish. Chaired by USACE, the TMT includes representatives from the NMFS, U.S. Fish and Wildlife Service (FWS), Bureau of Reclamation (BOR), Bonneville Power Administration (BPA), the Environmental Protection Agency (EPA), National Weather Service (NWS), state agencies, and Native American Tribes (Bonneville Power Administration et al., 2001). The WQT works to lower total dissolved gas levels and water temperatures, which can be harmful to fish and wildlife. The SCT considers how to improve the physical structures in the hydroelectric system for optimal performance and fish and wildlife concerns (Bonneville Power Administration et al., 2001).

- Operating requirements – Specific requirements for dams and reservoirs, such as minimum instantaneous discharge, minimum daily discharge, maximum hourly and daily rates of change for project flows, downstream water surface elevations, and maximum hourly and daily rates of change for reservoir elevations. Requirements may be system-wide (applying to multiple dams/projects) or site specific (applying to only one project or one location). These requirements are defined when a project is designed and/or authorized, in the authorizing legislation (for federal projects) or in the Federal Energy Regulatory Commission (FERC) operating license (for non-federal projects). Requirements can also be changed or added later (Bonneville Power Administration et al., 2001).[162]

[161] For more information about the TMT visit its website at http://www.nwd-wc.usace.army.mil/tmt/

[162] A great reference that explains the coordination of operations on the Columbia River is available at https://www.bpa.gov/power/pg/columbia_river_inside_story.pdf

Table 3. CRT roles (compiled from CRT, 1964; Hearns, 2008; Hyde 2010)

Organization	Description	Members
Entities	• Established by CRT Article XIV to implement treaty on behalf of Canada and U.S.	• U.S. Entity is appointed by the President by Executive Order (Administrator of BPA[163] and the USACE Northwestern Division Engineer[164]) • Canadian Entity is appointed by the Province of BC (BC Hydro[165])
Permanent Engineering Board (PEB)[166]	• Established by CRT Article XV • Reviews reports and other efforts associated with treaty implementation to ensure CRT objectives are met • Assists in reconciling differences between Entities on technical or operational issues • Reports annually to the U.S. and Canada on Treaty implementation	• Two members, two alternates, and one secretary from each country • In the U.S., the Secretary of the Army and Secretary of Energy each appoint one member and one alternate • In Canada, the federal government of Canada and provincial government of BC each appoint one member and one alternate
PEB Committee	• Established by PEB to assist with technical aspects of CRT operations	• Appointed by PEB with representatives from both countries
Operating Committee	• Created by the Entities to help with CRT implementation • Develops a number of plans and other documents for operating the various projects in the Columbia River System	• Appointed by two Entities
Hydro-Meteorology Committee[167]	• Formed by the Entities to help with CRT implementation • Provides assistance to the Entities on issues related to hydro-meteorological and water supply forecasting and plans/monitors operation of data facilities	• Appointed by two Entities

163 For more information see http://www.bpa.gov/Projects/Initiatives/Pages/Columbia-River-Treaty.aspx
164 For more information see http://www.nwd.usace.army.mil/Missions/WaterManagement/ColumbiaRiverBasin.aspx
165 For more information see http://www.bchydro.com/
166 For more information see http://www.nwd-wc.usace.army.mil/PB/PEB_08/peb.htm
167 For more information see http://www.westernsnowconference.org/sites/westernsnowconference.org/PDFs/2008Smith.pdf; for the Hydro-Meteorology annual reports see http://www.nwd-wc.usace.army.mil/PB/PEB_08/docHMC.htm

Table 4: CRT operating plans and agreements (compiled from Hyde, 2010; Canadian and U.S. Entity, 2010; Northwestern Division USACE, 2004)

Plan/Agreement	Description	Timing
Flood Control Operating Plan (FCOP)[168]	A plan developed by the U.S. in consultation with Canada that specifies maximum reservoir levels for the four treaty dams at different times of the year in order to minimize flooding in both countries.	Updated as needed
Principles and Procedures (POP)[169]	The documents that guides the preparation and use of hydroelectric operating plans for Canadian storage (e.g., AOP and DOP, described below).	Updated as needed
Assured Operating Plan (AOP)[170]	A plan that lays out dam operating criteria, which include: 1) a series of rule curves that direct reservoir operation for flood control, optimum power generation, and reservoir refill in average and better water years; 2) critical rule curves for reservoir operation for ensuring firm power in low flow conditions; 3) operating criteria (e.g., minimum and maximum flows, procedures for target flows) for Mica and Arrow dams that optimize Canadian power generation.	Developed annually for the sixth successive year
Determination of Downstream Power Benefits (DDPB)[171]	A report that calculates the Canadian Entitlement (amount and delivery) based on the AOP.	Developed annually for the sixth successive year
Detailed Operating Plan (DOP)[172]	A plan based on the AOP that presents operating alternatives to increase benefits from river flows or consider non-power and/or non-flood control issues. Both Entities must agree to the DOP; otherwise, the Entities operate according to the AOP.	Annually
Treaty Storage Regulation (TSR)	Studies that report monthly operation plans and storage in the Canadian dams using actual inflows, forecasted stream flows, and current reservoir levels	Bi-monthly
Supplementary agreements[173]	Agreements on non-power and/or non-flood control issues that can be implemented if accepted by both Entities.	As needed
Treaty flow agreement	Agreements that determine the actual operation of the dams and storage facilities based on the TSR, supplemental agreements, and/or flood control requirements	Conducted weekly via conference call

[168] The 2003 FCOP is available at http://www.crt2014-2024review.gov/Files/FCOP2003.pdf
[169] This is the common name used for the plan. The full name for the document is the "Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans for Canadian Storage." The 1991 POP is available at http://crtlibrary.cbt.org/items/show/130
[170] For the current and past AOPs, see http://www.nwd-wc.usace.army.mil/PB/PEB_08/docAOP.htm
[171] For current and past versions of this report, see http://www.nwd-wc.usace.army.mil/PB/PEB_08/docAOP.htm
[172] For current and past DOPs see http://www.nwd-wc.usace.army.mil/PB/PEB_08/docDOP.htm
[173] The Non-Treaty Storage Agreement (NTSA) is an example of a supplemental agreement. More information about the NTSA can be found at http://www.bpa.gov/Projects/Initiatives/Non-Treaty-Storage-Agreement/Pages/default.aspx

As stated above, the CRT operations (DOP and those plans subsequent to it) can include consideration of non-power and non-flood control issues. However, in order to do so, the U.S. and Canadian Entities must agree on their inclusion. Typically, the operating plans incorporate those additional benefits or issues only if they are mutually beneficial for the two countries. To meet ESA and other requirements, the U.S. alters the river's flows after they cross the border from Canada. For example, the ESA Biological Opinion issued for several salmon species in the river requires increased spill at dams, reducing power generation. Even if power generation decreases due to these changes in operations, the U.S. must still return the value of the Canadian Entitlement calculated from the AOP in the DDPB report.

The CRT is primarily focused on shaping river flows to maximize certain benefits from the river, not on allocation of water. Each nation is allowed to divert water for consumptive uses, which are defined in the treaty as "water for domestic, municipal, stock-water, irrigation, mining or industrial purposes" (CRT, 1964). Canada is also allowed to divert flows from Kootenay River in different amounts at different times. Specifically it is allowed to (1) divert 1.5 MAF [approximately 1.9 billion m^3] from the Kootenay River into the Columbia River, and (2) divert all Kootenay River flows post-2024 as long as it does not cause Columbia River flows to drop below 2500 cfs [approximately 71 m^3/s] at the border, and 3) divert all Kootenay River flows post-2044 as long as it does not cause Columbia River flows to drop below 1000 cfs [approximately 28 m^3/s] at the border (Northwestern Division USACE, 2004).

7.1.3 How Disputes are Resolved

Article XVI of the CRT lays out how the two nations are to settle differences in treaty implementation (CRT, 1964). First, the two nations should attempt to resolve the difference themselves through the Entities, the PEB, or an exchange of notes. If they are unable to do so, they may refer the issue to the International Joint Commission (IJC) for a decision. [174] If, after three months, the IJC has not made a decision, then either nation may request arbitration by a tribunal consisting of three members (one appointed by Canada, one appointed by the U.S., and one jointly appointed by both nations).[175] To date, no request has been made to the IJC (Hyde, 2010). The Entities have resolved all disputes on their own or with assistance from the PEB, and on rare occasion, the British Columbia government, the Canadian Ministry of Foreign Affairs and Trade, and the U.S. Departments of State, Army, and Energy. Those larger disputes requiring assistance from outside the Entities centered on three issues: (1) non-treaty storage, (2) operation of dams for fish and wildlife objectives with power and other impacts, and (3) methods for calculating the amount and delivery of the Canadian Entitlement. Central to addressing disputes out of court is a strong working relationship between the U.S. and Canadian Entities and a concerted effort to focus on win-win strategies in negotiation, sharing technical information and analysis, developing creative alternatives, and avoiding legal disputes (Hyde, 2010).[176]

[174] Learn more about the IJC at its website http://www.ijc.org/en_/. A report for UNESCO provides a history of the IJC's involvement in the Columbia River Basin prior to the CRT (available at http://crtlibrary.cbt.org/archive/files/d8fa5899fa5bfaf04b2871cf34d4bf26.pdf)

[175] If they are unable to form this tribunal within six weeks, either Canada or the U.S. may request the President of the International Court of Justice to appoint the members.

[176] In his report on the past, present, and future of the CRT, Hyde (2010) describes several conflicts and their resolutions. His report is available at http://www.crt2014-2024review.gov/files/10aug_hyde_treatypastfuture_finalrev.pdf.

One dispute in the implementation of the CRT was over how to calculate Capacity Credit Limit, or the maximum for the capacity component for the Canadian Entitlement (Hyde, 2010). The CRT states that the Capacity Credit Limit will not exceed "the difference between the capability of the base system without Canadian storage and the maximum feasible capability of the base system with Canadian storage, to supply firm load during the critical stream flow periods" (Columbia River Treaty, 1964). Put more simply, it determines the maximum capacity owed to Canada based on the dependable hydroelectric capacity to be credited to Canadian storage (Hyde, 2010). The issue was first raised in 1981, and the U.S. and Canadian Entities developed a method for the calculation that was rejected by the PEB. Additional investigations were conducted in the 1990s to explore the technical aspects of the issue, as well as the intent of the CRT on this issue. This issue was never fully resolved, but the matter is partially addressed in the 2003 POP, which assumes all hydroelectric power generated is usable for meeting peak loads (specifically the 1-hour peak capability).[177] The Capacity Credit Limit has never limited the amount of the Canadian Entitlement but may in the future (Canadian and U.S. Entity, 2010; Hyde, 2010). Lessons learned from this dispute include: (1) the importance of clearly defining policies and procedures in order to avoid differing interpretations (as well as documenting the negotiation process to understand the intent of a legal agreement), (2) how a good working relationship helps sustain a collaborative partnership even through disagreements, and (3) the benefit of checks and balances to ensure that the sovereign parties of the CRT agree with the technical staff's implementation.

7.1.4 Upcoming and Potential Changes to the CRT

While the Treaty continues indefinitely, some of its flood control provisions will expire in 2024 and others will come into effect. First, flood control operations shift from assured flood control for 8.95 MAF [approximately 11 billion m^3] of storage in Canada to "Called Upon" flood control through which the U.S. can request and pay for emergency storage to prevent flooding after it has utilized its own storage. Second, both nations can choose to unilaterally terminate the treaty with ten years' advance notice. Therefore, if either nation wanted to terminate the CRT in 2024 (the earliest date to do so), the U.S. or Canada would need to give notice of its intent in 2014 (Canadian and United States Entities, 2010; Hearns, 2008). This "deadline" provided both nations with the opportunity to consider a change in governance of the Columbia River. The USACE and BPA led the U.S. CRT 2014/2024 Review process to develop a recommendation to the Department of State. The Province of BC's Ministry of Energy and Mines conducted its own investigation in order to provide a recommendation to the Canadian Department of Foreign Affairs, Trade, and Development. The U.S. Entity delivered its recommendation to the Department of State in December 2013. [178] The Province of BC delivered its final recommendation in March 2014. [179] Both recommend continuing with the CRT and modifying it. However, the two differ upon what issues should be considered in modifying the CRT. For example, the U.S. Entity's recommendation advocates that ecosystem-based function be included

[177] An example calculation of the Capacity Credit Limit is available in Appendix A of the CRT 2014/2024 Review Phase 1 Studies at http://www.bpa.gov/news/pubs/GeneralPublications/crt-Phase-1-Report-Appendices-July-2010.pdf

[178] The U.S. Entity Regional Recommendation is available at http://www.crt2014-2024review.gov/RegionalDraft.aspx

[179] The BC position is available at http://blog.gov.bc.ca/columbiarivertreaty/files/2012/03/BC_Decision_on_Columbia_River_Treaty.pdf

as a primary operating purpose of the Treaty, in addition to existing hydropower and flood risk management purposes. The BC recommendation states that ecosystem considerations are already made and may not merit formal inclusion in the CRT. The two also differ on how benefit sharing should continue under the Treaty, with the U.S. Entity arguing for changes in the calculation of the Canadian Entitlement that would reduce its value while the Province of BC argues that the Canadian Entitlement should consider other benefits resulting from the CRT beyond flood control and hydropower (which would maintain or increase the value). Despite these differences, both recommendations acknowledge the importance of incorporating climate change into future CRT implementation, as well as state that flood control efforts should be flexible and adaptive while also set at a fixed duration that provides certainty in river operations.

7.2 Oregon and its State Water Law

Oregon is one of several U.S. states located within the CRB. The Columbia River forms Oregon's northern border with the state of Washington, and several of the Columbia's tributaries originate in or flow through Oregon. The following section describes Oregon water law, how it works in conjunction with the CRT, and how Oregon is addressing water scarcity.

7.2.1 Oregon Water Code

Each year in Oregon, water users divert approximately nine million acre feet [approximately 11 billion m^3] of water for out-of-stream uses such as agriculture, municipal use, industry, and domestic use. In Oregon, one use of water is not prioritized over another. Like most states in the western U.S., Oregon follows the Prior Appropriation Doctrine for allocating water. Prior appropriation was codified into law in the 1909 Oregon Water Code. All water in Oregon is owned by the public and managed by the state as part of the Public Trust. The Oregon Water Resources Department (OWRD) manages the allocation of water on behalf of the state. [180] A separate state agency, the Oregon Department of Environmental Quality (ORDEQ), manages water quality. [181] The primary goals of OWRD are "to directly address Oregon's water supply needs, and to restore and protect stream flows and watersheds in order to ensure the long-term sustainability of Oregon's ecosystems, economy, and quality of life" (Oregon Water Resources Department, 2014). This agency employs approximately 144 full-time employees, and for 2011-2013 it operated with a budget of $51,679, 079 (including state and federal funds) (Ward, 2013). [182] Its regulating authority comes from the Oregon Water Code (State of Oregon, 2011). The Oregon Water Resources Commission (WRC), a body established by statute with seven members appointed by the Oregon Governor and confirmed by the state Senate, oversees the activities of OWRD (State of Oregon, 2011).

In most cases, those who wish to use surface or ground water must obtain a permit from the OWRD via an application and review process (Figure 10). ORWD also issues permits for storing water in reservoirs or ponds. To use stored water, users must apply for a second use permit. There are four fundamental provisions of the Oregon Water Code:

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[180] More information about OWRD is available at http://www.oregon.gov/owrd/Pages/index.aspx
[181] More information about ORDEQ is available at http://www.oregon.gov/DEQ/Pages/index.aspx
[182] In Oregon, the state legislature passes a budget every two years. The Governor of Oregon has requested $65,971,911 for the 2013-2015 budget and would like to increase the department staffing to the equivalent of approximately 160 full time employees (available at http://www.oregon.gov/gov/priorities/Documents/GBB_Complete.pdf)

1. Priority – Those rights with earlier dates have a higher priority in receiving water. In times of shortage, junior water rights may not receive all or any water in their water right (Oregon Water Resources Department, 2009).

2. Appurtenance – A water right is attached to the land listed in the water right. When the land is sold the water right is sold with it (Oregon Water Resources Department, 2009).

3. Beneficial use without waste – A water right must be used for one of the specific beneficial uses designated in Oregon. Beneficial uses in the state include (but are not limited to) irrigation, stock water, forest management, mining, industry, human consumption, municipal use, stormwater management, pollution abatement, wildlife, recreation, and aquatic life. In addition to being used for a particular beneficial use, water use must be done without waste. In Oregon, "waste" is considered to be the diversion of more water than is needed for the beneficial use listed on the permit (Oregon Water Resources Department, 2009, 2012a). [183] Inefficient use or application of water is not necessarily considered waste if a permit, for example, states that the beneficial use is flood irrigation.

4. Use or lose – A water right must be used at least once every five years or it may be cancelled and water forfeited. The only exception to this is for municipalities, who may obtain rights for future growth and development and not risk losing the right if it is not used every five years (Oregon Water Resources Department, 2009).

7.2.2 How Oregon's Water Code and the CRT Integrate

Within the United States, the right to allocate water is reserved to the states. As such, the CRT and Oregon's Water Code operate independently of one another. As part of the U.S., Oregon has the right to withdraw water for consumptive use as laid out by the Treaty, but the Treaty does not dictate how much or when those withdrawals can occur (CRT, 1964). However, the CRT and Oregon's Water Code do intersect in that dam operations dictated through the CRT alter the timing and availability for water in Oregon. As a result of Treaty operations, the hydrograph of the Columbia River (which forms Oregon's northern border) has changed, with water shifted from the April-July months to the winter months. As a result, there are lower summer flows in the river, decreasing the water available at that time. However, at the same time, the flows are also more reliable through the coordinated operation of the dams on the river, providing more certainty on what water rights will be met each year (Hatcher & Jones, 2013).

[183] Prior to issuing a permit the state calculates how much water is needed for the intended beneficial use.

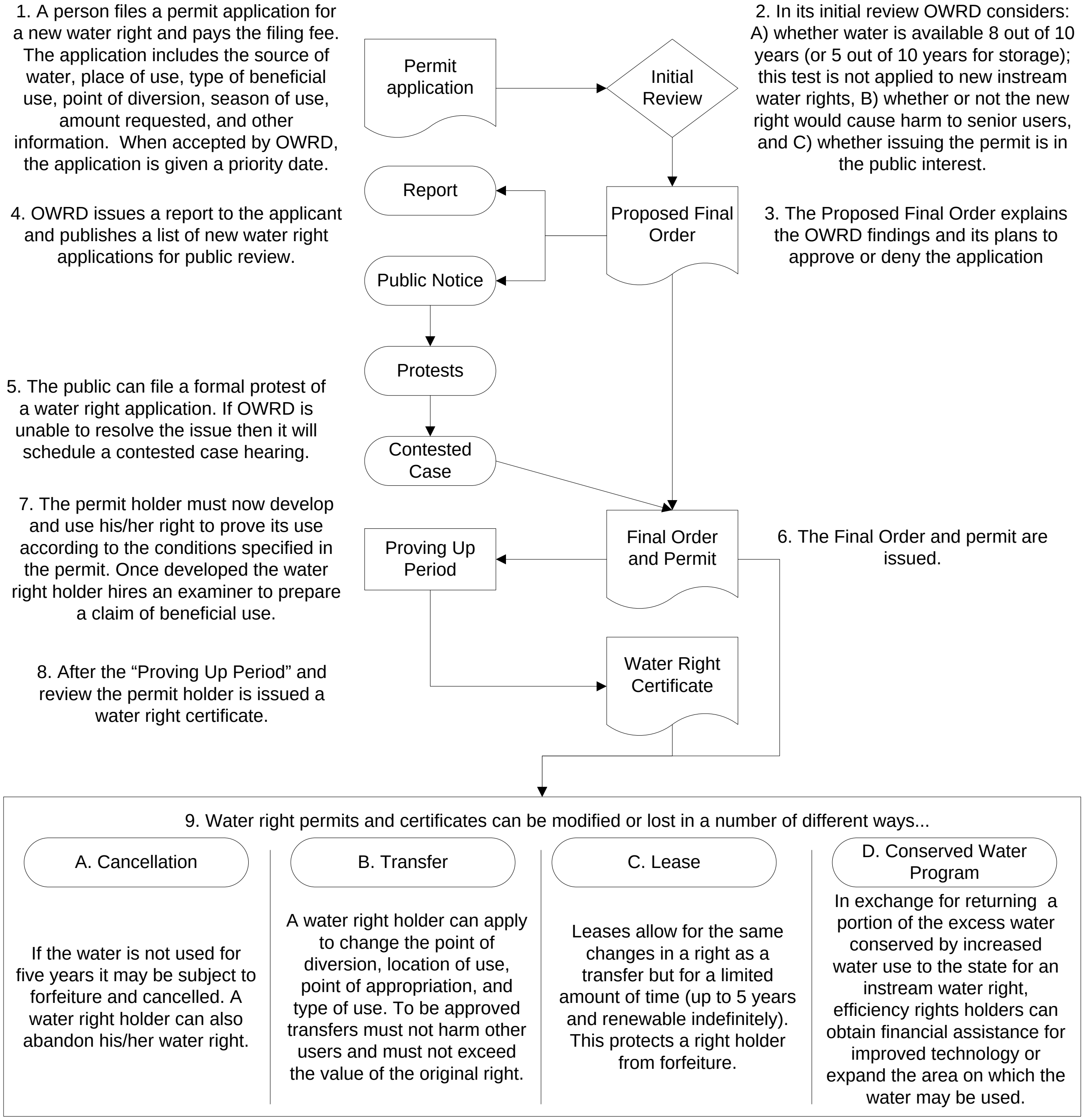

Figure 10. Oregon's surface water rights acquisition process (adapted from Oregon Water Resources Department, 2009, 2012a, 2012b)[184]

7.2.3 Sharing Basins between States

Oregon shares river basins with its three neighboring states: Washington, Idaho, and California. How Oregon shares water with each of those states differs. The U.S. states within the Columbia River Basin do not have a compact that governs water allocation once the river crosses the U.S.-

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[184] A good summary of Oregon water law is available at http://www.oregon.gov/owrd/pages/pubs/aquabook.aspx

Canadian border. One was developed but was not formally adopted by all states in the basin (Meyer, 2010). One of the few formal agreements Oregon has with another state regarding the sharing of a transboundary river is the Klamath River Basin Compact governing the Klamath River Basin shared by Oregon and California.

Ratified in 1957, the Compact addresses water supply and pollution and is administered by the three-member Klamath River Compact Commission (a voting representative from the California Department of Water Resources, a voting representative from the Oregon WRC and a non-voting federal representative who serves as chair). The agreement itself does not allocate water between the two states. Rather, regarding water supply, the Compact includes prohibitions against out-of-basin transfers of water, conditions for diversions by Oregon and California, and recognition of existing rights. The Compact also describes that in the case when there is not enough water for all water right applications, each state is allowed to grant rights to higher uses (i.e., domestic and irrigation use) over lower uses (recreational use including use for fish and wildlife, industrial use, generation of hydroelectric power, and all other uses). To address pollution issues, the Commission is to work with state and federal agencies to develop laws and regulations for pollution abatement, including minimum water quality standards, as well as disseminate information on pollution abatement to the public (Klamath River Basin Compact, 1957). The conflict resolution mechanism for the Compact is that when there is a split decision, the representative from each state will appoint another person and then together appoint a third person. These three new members act as an arbitration forum and will present a decision on the issue at hand (Klamath River Basin Compact, 1957). Despite a long history, the Compact was not sufficient to address the severe drought and resulting heated conflict in the basin in the early 2000s, when Endangered Species Act requirements led the Bureau of Reclamation to shut off water to irrigation projects (superseding the Klamath agreement which historically gave preference to irrigation rights.) This is an example of how the federal government's mandate to enforce federal laws can change water allocation at local levels.

7.2.4 Dealing with Scarcity

Oregon has adopted a number of strategies to address scarcity due to drought and instances when demand exceeds supply. One method is to limit scarcity by only issuing new water right permits based on model predictions and state water availability calculations.[185] New water rights for consumptive use of water will only be issued when state calculations predict water will be available eight out of ten years, and new rights for storage will only be issued if water is predicted to be available five out of ten years. However, a challenge still remains in many basins in Oregon where there is a discrepancy between the amount allocated in a water right (called "paper water") and water that is physically available in any given year (called "wet water"). This means that even though a water right is issued, that water may not exist in the river in a particular

[185] More information on how surface water availability is calculated in Oregon is available at http://www.oregon.gov/owrd/wr/docs/sw02-002.pdf

year (Garrick et al. 2011). Another effort to deal with scarcity is promoting increased efficiency of water application. As mentioned earlier, inefficient use of water (e.g., flood irrigation) is not necessarily considered waste. To promote increased efficiency of water use and to meet future out-of-stream and instream needs, Oregon passed the Conserved Water Statute. Through the program, water rights holders who improve their water use efficiency can "spread," sell, or lease, a portion of their water to a different piece of land (which is otherwise unlawful), receive financial assistance with project costs, and/or sell/lease the water in exchange for returning a portion of the water right to the state for instream use (Oregon Water Resources Department, 2006). Oregon also promotes collaborative efforts to resolve potential disputes over water. For example, local Watershed Councils provide the opportunity for local evaluation and management of a watershed along with the potential for partnerships between residents, local, state and federal agency staff to restore or enhance the conditions of a river through collaboration (Davis, 2001).[186] Location-specific collaborations, such as the Columbia River-Umatilla Solutions Taskforce (CRUST), are also used to address conflicts on water quality and quantity (Center for Agricultural and Environmental Policy, University of Oregon School of Law, & Oregon Water Resources Department, 2014).[187]

7.3 Water Markets in Oregon

The following section describes how the state is employing market-based approaches to deal with water scarcity, paying specific attention to a successful market in the Deschutes Basin.

7.3.1 Overview

Oregon uses a number of different market-based approaches to address issues of water quality, water quantity, and habitat (Table 5). Programs across the state are at various stages (i.e., under development, pilot programs, active programs). This case study focuses on the Deschutes Water Alliance Water Bank as an example of a water market in Oregon due to its success in meeting demands for multiple uses, longer history, and the way in which it addresses both surface water and ground water scarcity.

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[186] A map of and contact information for Oregon Watershed Councils is available at http://www.oregon.gov/OWEB/pages/watershed_council_contacts.aspx

[187] More information about CRU.S.T is available at http://orsolutions.org/osproject/crustaskforce

Table 5. Water markets in Oregon (adapted from Institute for Water and Watersheds & Institute for Natural Resources, 2012)

Name	Type	Status
Clean Water Services[188]	Temperature	Active
City of Ashland[189]	Temperature	Under Development
Cities of Eugene and Springfield[190]	Temperature	Under Development
City of Medford[191]	Temperature	Active
Columbia Basin Water Transactions Program[192]	Water quantity and habitat	Active
Deschutes Water Alliance Bank[193]	Water quantity and habitat	Active
Deschutes River Conservancy Groundwater Mitigation Bank[194]	Groundwater flow and surface water interaction, water quantity	Active
Deschutes River Conservancy Whychus Creek[195]	Water quantity	Under Development
Gales Creek[196]	Temperature and habitat	Pilot
Half-Mile Lane[197]	Temperature and habitat	Active
Mohwak Creek[198]	Temperature and habitat	Pilot
Klamath Basin Rangeland Trust Water Transaction Program[199]	Water quantity and habitat	Under Development
Klamath Tracking and Accounting Program[200]	Water quality and watershed enhancement	Under Development
Walla Walla Lease Bank[201]	Water quantity	Active
Water Users Mitigation Program (Klamath Basin)[202]	Groundwater flow, fish and wildlife protection	Active

188 For more information see http://www.deq.state.or.us/wq/wqpermit/cwspermit.htmand http://www.deq.state.or.us/wq/trading/docs/wqtradingcasestudy.pdf

189 For more information see http://www.ashland.or.us/Page.asp?NavID=8925 http://www.ashland.or.us/Files/WWTP%20Contract.pdf

190 For more information see http://www.mwmcpartners.org/AboutMWMC/Documents/MWMC_ReuseStudy_FinalReport.pdf

191 For more information see http://www.deq.state.or.us/wq/trading/docs/MedfordThermalTrading.pdf

192 For more information see http://www.cbwtp.org/jsp/cbwtp/program.jsp

193 For more information see http://www.deschutesriver.org/what-we-do/water-banking/deschutes-water-alliance-bank/

194 For more information see http://www.deschutesriver.org/what-we-do/water-banking/groundwater-mitigation-bank/

195 For more information see http://www.deschutesriver.org/Whychus-Water-Bank-Feasibility-Study.pdf

196 For more information see http://willamettepartnership.org/ecosystem-credit-accounting/pilot-project-descriptions/Gales%20Creek%20Enhancement.pdf

197 For more information see http://willamettepartnership.org/ecosystem-credit-accounting/pilot-project-descriptions/Half%20Mile%20Lane%20Pilot.pdf and http://www.watways.com/half-mile-lane-mitigation-bank

198 For more information see http://willamettepartnership.org/ecosystem-credit-accounting/pilot-project-descriptions/Mohwak%20Creek%20Pilot.pdf

199 For more information see http://www.oregon.gov/owrd/law/docs/GrantApp/GC0013_09_WTPFinal_June2011_OWRD.pdf

200 For more information see http://www.klamathpartnership.org/KTAP.html

201 For more information see http://www.ecy.wa.gov/programs/wr/instream-flows/Images/pdfs/WaterLeasingReview2003.pdf

202 For more information see http://www.ecy.wa.gov/programs/wr/instream-flows/Images/pdfs/WaterLeasingReview2003.pdf

7.3.2 Deschutes River Basin and the Deschutes Water Alliance Water Bank

The Deschutes River Basin is a sub-basin of the Columbia River Basin located entirely within the state of Oregon. Water rights holders in the basin include Native American Tribes, irrigators (often grouped by irrigation district), municipalities, federal agencies, and state agencies holding rights for instream flows. The Deschutes River and its tributaries are fully appropriated, and therefore OWRD will not authorize any new water rights. To meet increasing water demand, water users in the basin turned to groundwater. A direct connection between groundwater and surface water was determined in 1998 (Oregon Water Resources Department, 2007). Therefore, under Oregon water law, groundwater is regulated as part of the surface water rights structure and 2,267 of the 9,043 water rights in the basin are groundwater rights (Cole, 2006). Based on the direct surface water and groundwater connection, OWRD put a moratorium on groundwater rights in the basin. To further complicate matters, other laws, including the federal ESA,[203] the Oregon Scenic Waterways Act,[204] and the Oregon Instream Water Rights Act added requirements that water is left instream for ecosystem and aesthetic purposes (Whitman, 2013).[205]

A number of programs were established to address current and future water scarcity in the basin. One effort to allow municipalities to drill wells to meet increasing demand for water was the creation of the Deschutes Ground Water Mitigation Program, which sought to find a way to allow new groundwater uses while maintaining a scenic waterway and instream water right flows in the Deschutes Basin (Whitman, 2013). [206] Under this program, new groundwater rights can be obtained from OWRD if the right holder obtained mitigation credits for the right on a "bucket for bucket" basis. In this case, mitigation entails efforts to keep water instream. In the Deschutes Basin, there is a strong correlation between groundwater withdrawals and surface water levels. As one withdraws groundwater, one decreases surface water flows downstream. Therefore, in order to withdraw groundwater and still meet instream flow requirements, one must obtain credits to offset the groundwater withdrawals. The Deschutes Water Alliance (DWA) was formed by the Deschutes Basin Board of Control (DBBC),[207] The Confederated Tribes of Warm Springs, the Central Oregon Cities Organization (COCO), and the Deschutes River Conservancy (DRC, which administers the bank) with a U.S. Bureau of Reclamation (BOR) Water 2025

[203] An overview of the ESA is available at http://www.fws.gov/ENDANGERED/laws-policies/index.html
[204] Additional information about the Oregon Scenic Waterways Act is available at http://www.oregon.gov/oprd/RULES/pages/waterways.aspx and http://www.oregon.gov/oprd/rules/docs/sww_log.pdf
[205] Background information on the Oregon Instream Water Rights Act is available at http://www.dfw.state.or.us/fish/water/docs/BKGWaterRights.pdf
[206] A brief overview of the program is available at: http://www.deschutesriver.org/Deschutes-Groundwater-Mitigation-Program.pdf and the references cited include a number of additional references on the program.
[207] The DWA's website provides additional information about the organization. See http://www.deschutesriver.org/what-we-do/partnerships/deschutes-water-alliance/

Challenge Grant in 2004 (Newton Consultants Inc., 2013).[208] As per the Deschutes Basin Mitigation Bank and Mitigation Credit Rules (Oregon Division 521), the DWA Water Bank developed a mitigation bank charter with OWRD that was approved by the WRC. This charter lays out what types of mitigation credits the bank can market, as well as how credit transactions are conducted and reported to OWRD. The bank must also submit an annual report to OWRD (Oregon Water Resources Department, 2008).

At its core, the DWA seeks to balance and meet agricultural, municipal, and ecosystem water needs. As such the DWA has three goals: “[1] move stream flows toward a more natural hydrograph while securing and maintaining improved instream flows and water quality to support fish and wildlife, [2] secure and maintain a reliable and affordable supply of water to sustain agriculture, and [3] secure a safe, affordable, and high quality water supply for urban communities” (Tillman, 2008). The DWA Water Bank provides a forum through which buyers may purchase either temporary or permanent mitigation credits.[209] Excess water from irrigation districts and other water rights holders is brought into the bank through increased efficiency in irrigation practices, piping of irrigation canals to reduce water loss during diversion, and land exiting agriculture (as urbanized land requires less water). To further incentivize suppliers of water to enter the market, the DRC coordinates the payment of irrigation district assessment and/or exit fees in exchange for their excess water. The bank then matches buyers with water based on the quantity and timing of their need. Water marketed through the bank can be used for: (1) permanent and temporary mitigation credits, which municipalities and agricultural users may need to mitigate their groundwater use; and (2) instream flow restoration via temporary instream leases and permanent instream transfers. In 2014, the members of the DWA Water Bank are the DRC, Central Oregon Irrigation District, Swalley Irrigation District, City of Bend, City of Redmond, and Avion Water Company (Deschutes River Conservancy, 2014).

Success of the DWA Water Bank can be attributed to a number of factors, including: (1) a crisis to motivate action (specifically in this case, the moratorium on new rights and regulations provided incentives to proactively mitigate groundwater withdrawals), (2) quantified water needs in the basin, (3) accurate knowledge of who held rights (knowing who has rights and therefore can participate in the program), (4) development of shared goals and definitions of success by

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[208] Through this program, BOR awarded 50/50 cost-share grants through a competitive process to projects that pursued creation or implementation of one of four tools identified in the initiative: (1) conservation, efficiency, and markets; (2) collaboration; (3) technology; and (4) removal of institutional barriers and increases in interagency cooperation. These grants were available to local government, municipal and private irrigation districts, water associations, and tribes. Particular emphasis was placed on projects focused on increasing efficient water use and creating water markets (Bureau of Reclamation, 2005; Department of Interior & Bureau of Reclamation, 2003). In addition to funding the pilot program for the DWA, this grant also funded five planning studies and a synthesis document to better understand current water practices, management, and future needs. The Water 2025 Program no longer exists, but a summary description is available at http://biodiversity.ca.gov/Meetings/archive/water03/water2025.pdf. BOR now issues similar grants through its WaterSMART Program; see http://www.usbr.gov/WaterSMART/.

[209] More information is available at http://www.deschutesriver.org/what-we-do/water-banking/deschutes-water-alliance-bank/

water users, (5) forward thinking individuals who championed the cause and used their influence to educate others about the program, and (6) an understanding of the interdependence of different water users in order to meet future needs (Table 6) (Center for Agricultural and Environmental Policy et al., 2014; Whitman, 2013). Challenges the DWA Water Bank has faced include (1) high transaction costs which provide a disincentive for participants to enter the market (Garrick, Lane-miller, & Mccoy, 2011; Neuman, 2004), and (2) resistance to what some water rights holders perceived as giving up a property right (Center for Agricultural and Environmental Policy et. al., 2014). To overcome the first challenge, the DWA Water Bank capitalized on a federal grant program (Water2025) to lower the initial transaction costs. To address the issue of resistance to entering the market because of cultural beliefs, the DWA Water Bank has relied on leaders in the community to use their relationships to foster understanding about the benefits of market and encourage participation (Center for Agricultural and Environmental Policy et. al., 2014).

7.4 Conclusion/Summary/Synthesis

The CRT is lauded as a premier example of international cooperation in river management. The U.S. and Canada have successfully managed the river for flood control and hydropower benefits for 50 years. Factors that contribute to the success of the CRT include: (1) its focus on benefit sharing, (2) the inclusion of a conflict resolution process for addressing disputes, (3) a commitment to sharing information, and (4) extensive coordination between the two nations through technical staff as well as higher level officials (Barton, 2010; J. M. Hyde, 2010; Ketchum & Barroso, 2006; Muckleston, 2003). To address these other values in water management, the U.S. has utilized other domestic management schemes such as the PNCA, ESA, and project operating requirements after the CRT shapes river flows. The U.S. CRT 2014/2024 Treaty Review provided a timely effort to review to see if management of the river under the CRT matches current values or if it should address additional factors, such as climate change or ecosystem health.

As a state within the Columbia River Basin, Oregon has primacy over the federal government in the allocation of water. As demand grows and supply changes with climate change, Oregon has pursued a number of efforts to address past, present, and future water scarcity, including the use of water markets such as DWA.

Table 6. Reasons for success of DWA Water Bank (compiled in part from Center for Agricultural and Environmental Policy et. al., 2014)

Contributing factor	How it contributed to success in the Deschutes River Basin
A crisis to motivate action	The moratorium on new water rights and regulations favoring instream water use meant that if the basin wanted to continue to grow, it needed to find a creative way to find additional water to use. Therefore the crisis provided incentive to mitigate groundwater withdrawals in order to meet growing demand for water.
Quantified water needs in the basin	The Water 2025 grant allowed the basin to collect data and model water needs, which was previously unknown. All interests in the basin agreed to study findings giving it greater legitimacy. By knowing the current and future water needs for a variety of water uses (e.g., fish, irrigation, municipalities, etc.), those in the basin were able to better define the problem. With a well-defined problem, the DWA Water Bank knew what it needed to work on addressing.
Accurate knowledge of who held rights	Adjudication of the basin (i.e., the legal proceedings to formally determine who held water rights in the basin) allowed those in the basin to identify who can participate in the program.
Development of shared goals and definitions of success by water users	By developing goals and definitions of success together, water users became invested in the success of the program because it was (1) something they helped create, and (2) their interests and concerns were represented in the program.
Forward thinking individuals serving as champions	Select leaders in the basin realized that in order to address water scarcity in the Deschutes, the water rights holders in the basin had to change their behaviors to meet growing demand and ensure the economic and environmental health of the region. These individuals championed the cause and used their reputation and relationships in the community to educate others about the program.
An understanding of the interdependence of different water users	Environmental, development, and irrigation interests all understood that in order meet their individual water needs, they had to work together. The interdependence fostered collaboration and a willingness to work with others who they may have considered to be adversaries in the past.

8. LESSONS LEARNED

Innovation in inter-sector water transfers and allocations is occurring slowly in the United States as the diverse regimes of state laws and regulations have proven impediments to change. Because the country continues to evolve from an unexplored country, to agrarian society, and finally urban communities, the established philosophies and rules for water allocation are becoming increasingly difficult to reconcile with changes in demand and supply. New concepts and mechanisms for allocating or reallocating water are being applied in some cases, but established water rights are difficult to alter. Especially in the west, U.S. water rights are not based on equity, but on legal precepts that protect historical claims regardless of demographic, economic, or climate changes.

In times of emergency, special rules can be applied to federal or state managed waters, but these are temporary measures. Permanent change may emerge through legislated or judicial action, but "fair market value" compensation will probably be required. While U.S. water law has a strong historical precedent, a social sense for an individual's right to water for personal use does exist. However, this concept of a minimum "personal use" water right is not consistently codified, though it is part of the American character.

While changes in water allocations have not kept pace with population growth or industrial changes, there are signs of evolution in state water allocation law. Progress in instituting Regulated Riparianism and movements to shift prior appropriation allocations from agriculture and mining to municipal purposes are occurring, influenced as much by market forces as by changes in law. Changes in the regulation of U.S. water allocation are occurring, but slowly.

8.1 Legal Frameworks and Regulation

To remain relevant, water allocation processes (laws, policies, and regulations) must evolve in response to changes in demographics, economics, climate, etc.

U.S. water demand is starting to move away from agricultural and industrial consumption toward greater municipal consumption. As a result, U.S. water allocation processes are receiving scrutiny.

In the east, there are instances where riparianism is being modified through permitting to create withdrawal limits lower than those previously allowed under "reasonable use" policies. A consequence of the Regulated Riparianism approach is the need for greater governmental involvement to ensure monitoring and enforcement of permits occur.

It is interesting to note that the success of the existing U.S. water allocation systems results directly from a fundamental element of the American experience - compliance with applicable laws and regulations. In a market-based society, blind compliance with regulation is not typical, but *the U.S. system works because adherence to the numerous water related regulations is* *effectively monitored and enforced*. While there are many instances of individuals failing to comply through ignorance or deceit, these are the exceptions and they are sought out and addressed. As a result, even with the complex nature of U.S. water law and regulation, or perhaps in spite of such complexities, the U.S. approach enables the majority of water needs to be met.

In the west, water laws based on prior appropriation are difficult to amend. In many cases, water shortages currently exist and junior appropriators may already not receive the allocation of water they feel they need. Reallocations under these conditions of shortage result in immediate economic or environmental impacts. For waters (rivers, lakes, and groundwater) that are not fully allocated, state agencies increasingly view the permitting process for new water rights as a way to refine the definition of "beneficial use." However, such redefining does not directly impact the vast majority of allocated water.

As the U.S. looks forward, there are two pathways with the potential to make significant changes to western water allocation practices. The first is market forces, which may economically incentivize senior appropriators to sell their water to new users or junior appropriators for a profit greater than what the water current generates. The second pathway is the application of political pressure to change the formulas for Federal subsidies to collect and distribute water from Federal reservoirs. Increasing, the supply cost of water - actual costs to produce and deliver - may force senior appropriators to sell their water for new uses, especially if the revenues from current water uses can no longer support actual water costs.

At the interstate and state levels, agencies continue to refine criteria for what constitutes reasonable use (in the east) or beneficial use (in the west). Some examples of criteria for permitting new water rights can be found in the Restatement of Torts and the Regulated Riparian Model Water Code. These criteria can help allocate water across competing uses while addressing scarcity and change. Factors affecting changes in allowable water use include environmental impacts, impacts on other users, and adjustments to predictions of water availability.

An important regulatory tool is aligning permitting criteria to specific geographic areas of risk, as exemplified by DRBC's Special Protection Waters or Virginia's designated management areas. However, to make these permitting programs more politically acceptable they often apply to new users only and exempt those using the water resource before the program was established.

Laws, policies, and regulations can establish rights, economic dependencies, and societal expectations that are difficult to revise when future conditions change.

When water is allocated according to an agreement, such as an interstate compact or international treaty, the framing of the agreement can help avert later confusion and conflict. Section 4.5 offers key considerations when framing such an agreement. Clearly defining agreement terms can help avoid confusion over interpretation, while simple and clear administrative approaches can avoid disagreement over measurement and implementation details. Since changes in water supply and demand over time are inevitable, it is critical to design agreements that accommodate evolving physical and societal conditions and values and provide procedures for dispute resolution.

As consensus-based or unanimity decision processes can often result in a deadlock, the inclusion of resolution mechanisms, such as arbitration or tiebreaking votes by an impartial party, may be prudent in an agreement. Such mechanisms may provide a disincentive to cede decision-making to a third party and encourage finding agreement at lower levels. At the same time, a system of checks and balances (e.g., Delaware River Basin Commission and the Columbia River Treaty) can ensure decisions are verifiable, which is important when multiple entities are involved. Regardless of the method, the U.S. experience strongly indicates effective coordination, collaboration, and dispute resolution mechanisms are useful components of a successful inter-jurisdictional water allocation process.

Allocating water on an absolute basis (e.g., specific minimum flow at a border) provides quantifiable certainty but may not be achievable in times of reduced precipitation or increased demand. Such situations require a clear identification of who holds senior and junior water rights. Alternatively, allocating water by a percentage of flow may provide all users a portion of water, but may still be insufficient to sustain economic viability in a community or region. In short, allocation methods alone are not sufficient to meet expected, and especially unexpected, changes in water supply or demand. The inclusion of provisions for stakeholder review and modification of water allocation agreements and for resolution of unexpected changes in water supply and demand may be difficult to incorporate, but are essential in a successful agreement.

8.2 Institutional Structures

Appropriate institutional frameworks and administrative mechanisms are needed for coordinating and implementing transboundary water allocations.

Permitting systems require an investment in institutional infrastructure to be effective. Similarly, institutional mechanisms are required to implement cross-jurisdictional agreements, such as interstate compacts. Regardless of form, state or local agency, federal-state commission, or other arrangement, an institution must have long-term viability and sufficient resources to carry out its work effectively. This includes capital investments as well as operations and maintenance funds, as highlighted in the Delaware Basin case study.

Commissions provide a unique mechanism for inter-jurisdictional collaboration and have been commonly included in interstate water allocation compacts. They offer a forum where a broad perspective, such as entire watershed, can be considered. This can help promote more holistic management structures such as Integrated Water Resources Management (IWRM). Successful commissions also establish credible technical staff that can provide expert perspectives on an entire river basin and are often seen as a resource for all stakeholders. In some instances, such as the Delaware River Basin, the commission serves as a forum for convening parties to discuss water resources issues and help strengthen a network that can be helpful in times of crisis such as drought or flood.

The benefits of successful institutional structures extend beyond commissions to state-level organizations and local watershed councils. Maintaining forums to address water issues at various scales is an important lesson derived from the U.S. experience. Such forums promote strong working relationships, a willingness to share information for mutual advantage, and the development of creative alternatives that focus on win-win solutions. These elements of success have been highlighted throughout this report. Procedures for gathering facts, drawing conclusions, and implementing remedies in a collective manner have proven useful in helping to avoid legal disputes.

For a particular water allocation approach to be successful, provisions are needed for enforcement that includes measurements, inspections, penalties, and remedies. These remedies may include systems of credits and debits for water deliveries. The Delaware River Basin case study highlighted the utility of involving affected watershed communities in establishing new practices and requirements, as well as creating institutional mechanisms for implementing those practices and giving a voice to affected communities.

8.3 Water Transfers and Diversions

Water transfers may be technically feasible, economically attractive, and socially acceptable at local levels, but out-of-basin transfers are legally complicated and politically difficult.

Market-based water transfers are slowly increasing in the American West. They most frequently originate from agricultural users and flow to urban users, (where water is more highly valued) with a small portion of flow going to environmental needs. Given the scale of water for agriculture in the U.S., small percentage reallocations to nonagricultural uses could meet water demands for decades. These sources have been coveted by urban water managers, but legal precedent supports historical water claims. Nationwide, the number of market-based water transfers remains small, with the sale or lease of water barely exceeding 100 instances in any given year.

Given the conditions required for success and the methods to address area-of-origin or third-party impacts, water transfers are more likely successful at a local level. Interstate or inter-basin markets are more difficult to coordinate and implement. Northern Colorado Water Conservancy District’s policies illustrate how a water market can operate, but because this market is located within a single water district with one governing authority, it does not have to address many of the legal and political issues confronted in the context of an interstate or inter-basin water market.

In reality, transfers in the U.S. beyond natural system boundaries, such as large inter-basin transfers, are rare. Significant inter-basin transfers do exist, such as those to supply New York City (Delaware River Basin), Denver (Colorado River Basin), and Los Angeles (Sacramento and San Joaquin River Basins). These large, inter-basin transfers were established early in the nation's development and before much of the agricultural, industrial, and municipal demand in the areas-of-origin were established. However, states have taken a strong stance to minimize political and legal controversies caused by these transfers, as well as the potential for detrimental effects on the economy, ecology, culture, lifestyle, and potential future growth in the originating basins. Today, most states have established area-of-origin protection requirements, creating statutory barriers to extra-basin transfers. In the future, water transfers are most likely to be local and small, occurring within or adjacent to areas-of-origin.

8.4 System considerations

Water allocations should be based on long-term projections of water availability and future water demands.

In the West, water allocation tended to reflect a relatively short-term view of water availability. Knowing the volume of water available requires measurements over time, suitable procedures for making extrapolations from limited data, and consideration of possible long-term trends. On the Colorado River, allocation requirements were based on a period of flow estimates that, ultimately, were unrepresentative of normal conditions. Consequently, demand based on population growth was vastly underestimated. Long-term stream gauging and other record-keeping can help build a robust information base that will best support water allocation decisions.

Groundwater is often treated separately from surface water in terms of the law, even though physically, groundwater and surface water may be interconnected. To make better decisions on water use, the U.S. is collecting more information about groundwater resources to improve understanding of these crucial interconnections.

When water is fully allocated within a system, accommodating newly-recognized uses poses particular challenges. New uses now considered in permitting decisions include environmental impacts, water quantity-water quality connections, and the need for instream flows. Under prior appropriation water is being appropriated for environmental uses or removed from the appropriation regime. In some cases, purchases of existing water rights or use of eminent domain to establish claim to water rights are required. A decision on whether the Columbia River Treaty should be modified to include ecosystem-based functions as a primary operating purpose (in addition to its hydropower and flood control focus) remains unresolved.

Considering the water system as a whole offers many advantages, widens the range of options available, and provides greater protection of all stakeholders involved.

Considering the system as a whole can offer previously unseen advantages. For example, water managers recognized the potential to use existing Delaware Basin Reservoirs as a means of mitigating flood damages in addition to their original purpose for water supply. In 2007, a flexible flow management plan that addressed flood and drought issues was implemented. Similarly, Delaware River water flows are now managed during drought to prevent the Atlantic Ocean salt front from migrating upstream and contaminating drinking water intakes for urban areas.

Sometimes system-wide advantages can be obtained through cooperation. For example, the 2007 negotiation of interim guidelines for the Colorado River coordinated the operations of two reservoirs in response to drought and increased demand. Successful cooperation is often technically grounded. Collaborative modeling approaches such as Shared Vision Planning can lead to comprehensive solutions. This approach integrates water resources planning, structured public participation, and collaborative computer modeling to facilitate a common understanding of a system and provide a forum for identifying tradeoffs and new management options. Collaborative computer models make it easier to investigate possible scenarios and approaches; structured public participation can build the relationships, trust, and understanding needed to implement lasting solutions. The Operations Support Tool used to manage New York City's water supply system exemplifies how technological underpinning can improve system-oriented operations. The Operations Support Tool quickly incorporates real-time data and assists in analyzing a variety of system components and uses.

8.5 Decision making

Effective and informed decision making requires organizational structures and timely, accurate information to address inevitable changes in water supplies and demand.

While some changes are anticipated, new information often calls into question previously held assumptions. As an example, new data on climate non-stationarity may raise questions about the typical range of future flows from a previously accepted period of flow records. In this and other situations, the evolution of data gathering and technical tools can improve analyses, leading to more informed decisions. New knowledge is essential to illuminate less-understood needs and open doors to new approaches.

An ability to adapt to unforeseen conditions can also be accomplished through carefully crafted legal frameworks combined with periodic stakeholder reviews and updates to water allocation agreements. While no U.S. water allocation agreement or organization is without its faults, the Colorado "Law of the River" and tiered agreements that address increasingly stringent needs over time, such as the Southeast Pennsylvania Groundwater Protected Area and Special Water Protection in the Delaware River Basin, provide valuable teaching points.

U.S. institutions are regularly tested in their ability to adapt to changing external conditions. As an example, New York City continues to make adjustments to climate change and an associated increase in frequency of extreme hydrological events. One technique, adaptive management, can be a useful approach in such situations by applying an iterative cycle of long-term monitoring, modeling, and assessment to develop improved responses. Decisions and projects can be reviewed and revised as new information becomes available or external conditions change. Investing in data collection and analytical tools is a critical component of prediction and adaptation.

9. CONCLUSION

The United States has adopted a variety of approaches for governing the allocation of water resources, predominantly divided between those used in eastern versus western states. The lack of a centralized, water management philosophy or program complicates and creates inefficiency in these processes. While this arrangement is not the most efficient, it does uphold a fundamental concept of the American form of government; only the minimum essential authorities are reserved for the national government. The framers of the U.S. Constitution made certain monopolistic power would not evolve within the United States by distributing real governmental powers to the individual states. An element of this power was the management of natural resources, such as water.

The result of these efforts was an effective, representative form of government that may have inefficiencies in water management, but *created an environment where monitoring and regulation of water allocations are sufficiently effective* so as to ensure water supplies are available to those in need. Perhaps the important lesson from a review of American water allocation systems is not that the U.S. has superior technical, hierarchical, legal, or regulatory systems, but that *less than perfect systems that are well executed and managed can produce satisfactory results*.

As the U.S. moves forward in the twenty-first century, new challenges in water resources are emerging and the negative impacts of known challenges are becoming more acute. The population across the U.S. continues to grow, placing increasing demands for water in areas of relative scarcity such as the southwest and creating shortages in historical areas of water abundance such as the southeast. Additionally, climate variability raises questions regarding how changes in regional temperatures and precipitation will affect the timing and amount of precipitation, while climate non-stationarity questions using historical flows as a basis for water allocation agreements.

While U.S. water management is fragmented, it does effectively account for differences in climate, topography, and water use across the fifty states and four territories. The adoption of riparianism, prior appropriation, or a combination of the two doctrines effectively incorporates regional cultures and natural environments. The challenge is amending or updating these legal systems that have strong legal, economic, societal, and political underpinnings and support. Changes in water allocation are occurring and will continue, but the pace is slow and less than amicable among stakeholders. However, the same government system that enabled the success of the American water management system thus far is sufficiently adaptable to incorporate needed future changes – over time. Changes resulting from demographic or economic shifts, environmental concerns, climate variability, and societal values are the future of water resources management worldwide. The case studies included in this report shed light on how water can be allocated and reallocated to address these changes in the U.S.

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Appendix 1: Report Focus

The report focuses on certain aspects of the U.S. water experience as identified in an agreement between ANA and USACE and subsequently refined during written exchanges and discussions between USACE and ANA staff.

Agreement between ANA and USACE:

USACE shall provide a Subject Matter Expert (SME11) in the areas of water rights to produce Document USACE 4.1, with emphasis towards "Water Rights as a Commodity." The area of U.S. water rights is exhaustive. Therefore the intent of this task is to provide to ANA a broad-based document in regards to U.S. water law and policy. The document shall cover topics including, but not limited to purchase, sale, transfer, ownership, regulation, and enforcement throughout the U.S. The document shall highlight the various legal aspects for both surface and groundwater rights within federal, state, and local regions, including the doctrines of riparian and prior appropriation. The document shall address the legality and challenges of water rights within the U.S. and dispute resolution regarding usage for multipurpose projects. The document may incorporate as necessary various needs such as public, private, municipal, recreational, hydropower, navigation, flood control, drought, environmental, industrial, agricultural, and inter-basin transfer to explain overall policy and dispute resolution. The document shall briefly provide information on federal (i.e., USACE, FERC, USGS, EPA, etc.), state, and local agency roles in regards to water rights. The SME11 shall complete the final report in the U.S. within 16 weeks in English and translate the document to Portuguese. The SME11 shall conclude this task by presentation of the document to ANA during a one-day briefing in the U.S. within the Technical Visit 4.1 (Subtask 4.b).

As refined by subsequent written exchanges:

1. At which scale do water allocation systems occur in the U.S.?
2. Federal, State, Region, basin?
3. How does it work in scarcity conditions?
4. Are there specific rules, instruments or laws?
5. Is there any legal instrument that has been applied due to Climate Change concerning water allocation?
6. Are the rights to use the water commercialized? If yes:
    a. Is it a permanent or a temporary practice? What are the adopted criteria to define the temporary cases?
    b. Are they commercialized in specific geographic settings (e.g.: specific river basins), or on a specific State basis? If in specific basins, who defines it and what are the criteria adopted?
    c. Is the "water market" defined by the regulatory authority? What are the available legal instruments used? Are there transaction limits?

d. How is the trading process regulated? Are there permits to be issued before and after the trading process? How is the regulatory authority informed by traders about the process?
e. When a commercial allocation of water is done, is it for a specific period? What criteria are used to define the established period? If this is the case, when the specific period ends, are the original conditions reestablished?
f. Are the regulatory conditions and effectuated transactions publicized? How is it publicized to society?
g. How does the water market work on rivers shared by states? How does the regulatory authority act in these cases?
h. Is there any difference related to the origin of water, if underground or superficial?
i. Where the water market works, which instruments are used to organize the basin, and what are the related economic, social and environmental arrangements?
j. Who are the traders? Explain who is authorized to trade and how the trading relations between public and private sectors take place.
k. How is the trading value of water established between the traders? Is it defined only by the traders, or there are minimum and maximum values to be respected? Are any costs of transaction and enforcement established and shared?
l. Are there fiscal issues concerning these transactions?
m. Does the seasonal variation of water offered in a basin affect the trading value? Do any other factors affect the price?
n. In times of scarcity, are there compensations to traders/water users? Is trade allowed during times of scarcity?
o. Are there instruments that allow public authority to supersede trade arrangements, and in what cases they can be applied?

<u>As refined by subsequent discussions</u>:

1. How are economics and other values considered in water allocation processes?
2. Who controls the water use, who issues the water permits, and what are the institutional arrangements supporting allocation processes?
3. How is water quality considered when allocating water? Are there markets for water quality?
4. Is there any legal instrument that has been applied due to climate change concerning water allocation?
5. What is the process of trading water permits in the U.S.? Why does it only happen in some areas of the country?

Appendix 2: Annotated Tables and Interstate Compacts

Appendix Table 1. Water Allocation Compacts in the U.S.: Allocation Formulas

Compact			Hydrologic Standard Used				Time Scale of the Hydrologic Standard			
Basin (*see descriptive notes below*)	Signatory States	Year	Minimum Flows	Reservoir Storage	Consumptive Amount	Delivery Volume (annual or longer)	Constant	Seasonal	Annual	Multi-Year
Arkansas[1]	CO, KS	1948		X				X		
Arkansas[2]	KS, OK	1965		X			X			
Arkansas[3]	AR, OK	1970			X				X	
Bear[4]	ID, UT, WY	1955		X	X		X			
Belle Fourche[5]	WY, SD	1943			X		X			
Big Blue[6]	NE, KS	1971	X	X			X	X		
Canadian[7]	NM, TX, OK	1950		X			X			
Colorado[8]	WY, CO, UT, NM, NW, AZ, CA	1922				X				X
Costilla Creek[9]	CO, NM	1944			X			X		
Delaware[10]	NY, PA, NJ, DE	1961	X		X		X		X	
Klamath[11]	OR, CA	1957			X		X			
La Plata[12]	CO, NM	1922	X				X	X		
Pecos[13]	NM, TX	1948	X		X					X
Red[14]	TX, OK, AR, LA	1978			X				X	
Republican[15]	CO, NE, KS	1942			X				X	
Rio Grande[16]	CO, NM, TX	1938				X			X	
Sabine[17]	TX, LA	1953	X		X		X		X	
Snake[18]	WY, ID	1949			X				X	
South Platte[19]	CO, NE	1923	X				X	X		
Upper Colorado[20]	WY, CO, UT, NM	1948			X				X	
Upper Niobrara[21]	WY, NE	1962		X					X	
Yellowstone[22]	WY, MT, ND	1950			X				X	

(1) The design of the allocation formula, found in the 1949 compact, was largely influenced by Supreme Court decisions in 1902, 1907 and 1943, and by a variety of “executive agreements” between the two states regarding the operation of the John Martin Reservoir in Colorado, a Corps of Engineers facility. The formula specifies the months and conditions under which water will be stored (separate rules for winter and summer), and the reservoir conditions under which either state can request releases (up to specified limits). The formula also specifies the need to maintain historic flows, but no specific standards are provided. Problems associated with implementation of the formula were the cause of yet another Supreme Court case, decided in 1995.

(2) In this formula, limits are placed on the amount of reservoir storage capacity that can be constructed in Kansas (the upstream state). When storage is constructed downstream in Oklahoma, the storage limit in Kansas is increased by the same amount. The formula sets specific limits in each of five sub-basins.

(3) For each shared sub-basin, the upstream state (usually Arkansas) is granted the right to deplete the annual yield by a specified percentage. The Commission must determine each year how much water is available.

(4) This is a very complicated allocation formula, largely because the bulk of the basin is near the Idaho-Utah-Wyoming border regions. The formula primarily establishes consumption levels for each state, defined in terms of percentages in specific sub-regions. Rights to existing and future reservoir storage are also addressed. The allocation formula is primarily designed for drought conditions; during normal conditions, the formula is largely irrelevant.

(5) South Dakota is allocated 90% of the unappropriated water, with the remaining 10% allocated to Wyoming with the exception that Wyoming's domestic and stock uses are not counted against Wyoming's entitlement. The amount of “apportioned” water can be determined at any time of the year by taking the sum of the cumulative stream flow measured at the state line (since January 1st) and the amount of storage in upstream reservoirs.

(6) The formula requires specific flows in cfs (cubic feet per second) to be maintained daily at the state-line gaging stations. Each summer month features a different flow standard. Limits on storage capacity are also provided. Periodic stream gauge measurements are required.

(7)This is a very simple compact; the formula places limits on the storage capacity of new reservoirs.

(8) This is one of the most unusual and controversial of all interstate water allocation formulas. The compact calls for the four states of the upper basin to deliver 75 maf (million acre-feet) [approximately 93 billion m^3] of water to the three states of the lower basin over all ten-year periods, regardless of the virgin flow during that period. The ten-year moving average is used to “even out” the wet and dry years, since the upper basin states are theoretically allowed to deliver high volumes in wet years and low volumes in dry years. As a practical matter, other considerations—notably hydropower generation—encourage a constant annual compact delivery of 7.5 maf [approximately 9 billion m^3].

(9) This is one of the most complicated allocation formulas seen, in large part because it explains in detail how the existing network of irrigation ditches and related facilities are to be utilized. The compact allocates specific quantities of water available for diversion (and consumption) from the irrigation ditches, while water in storage is allocated by percentage. The formula is largely based on

(and affirms) existing prior appropriation rights. The formula provides requirements for the "irrigation season" (May 16 to September 30) and the "storage season" (October 1 to May 15). The Commission must estimate the annual safe yield of water available during the summer irrigation season.

(10) The so-called "Montague release formula" crafted by the Supreme Court provides restrictions on how New York City can utilize the reservoir system in upstate New York, where the river originates. New York City may divert up to 800 mgd (million gallons/day) [approximately 3,000 ML/day] (following completion of the East Branch and Cannonsville reservoirs) out of the basin as long as compensating releases are made downstream to maintain a flow of 1,750 cfs [approximately 50 m^3/s] at the Montague gauging station. Significantly smaller out-of-basin diversions are also permitted by New Jersey (under certain conditions) without requiring compensating releases. Flow standards are to be maintained on a constant basis; however, the diversion maximums are measured on an annual basis (June 1 to May 31).

(11) This is a highly unusual allocation formula, since it does not deal with the rights of states, but with the rights of individual water users. Rights to consume water are allocated to specific users in accordance with the principles of prior appropriation without respect to state lines. In times of shortage, principles of "first in time, first in right" apply.

(12) This is one of the simplest interstate water allocation formulas (although it is difficult to categorize). There are no requirements or limits (regarding water use) on either state when flow at the interstate border exceeds 100 cfs [approximately 2.8 m^3/s]. If summer flows fall below that amount, the upstream state (Colorado) is obligated to take actions to maintain a daily flow at the interstate gauging station of at least one-half the flow recorded the previous day at the upstream gauging station (near Hesperus, Colorado). The formula is not in effect during the winter.

(13) Although the compact mentions "flow levels," the allocation scheme primarily is a tool for allocating the consumptive use of waters in excess of a specified minimum. Essentially, the compact formula does not restrict upstream water consumption in New Mexico as long as the flow at the interstate border does not drop below the pre-compact level—described as the "1947 condition." This determination is to be made through use of a specified inflow-outflow model. Any water "salvaged" (i.e., developed) from new water project construction upstream is allocated to the two states using a percentage system: 57% to New Mexico, 43% to Texas. Flood waters are shared equally. All hydrologic variables (including depletions, state-line flows, quantities of water salvaged, and quantities of flood waters) are determined based on three-year intervals.

(14) Generally, the formula allocates rights to consume given quantities of water, using both percentages and fixed quantities, for five "reaches" of the river. In a few cases, the right to consume water upstream is based on the existence of minimum flows downstream; however, upstream states are not required to maintain downstream flows. For the most part, the major calculations (of consumption) are to be performed on an annual basis, unless otherwise determined by the Commission.

(15) Although the Compact provides fixed quantitative allocations, as a practical matter those numbers are used to establish fixed percentages, which are the real basis for annual water allocation. This approach partially addresses some of the ongoing administrative challenges of implementing Article 3 of the Compact, which states that if the actual virgin water supply is found to deviate by

more than 10 percent from the estimates used in the Compact, then the allocation is to be proportionally adjusted. The Compact allocates water on an annual basis based on the year's virgin water flow, which is proving to be highly problematic since demands are on a seasonal basis and the virgin flow cannot be accurately determined until the end of the water year.

(16) The upstream states are required to annually deliver to the downstream states a quantity (i.e., volume) of water that is proportional to the quantity measured that year on upstream tributaries (i.e., virgin flow). At the end of each year, debits and credits are calculated, and releases from storage can be required if possible (and desired) to rectify any imbalances. In a few elements of the allocation formula, specific seasonal requirements are provided; however, in general, obligations are calculated on an annual basis.

(17) Each state is entitled to half of the flow of water in the “interstate reach,” which is that part of the river that forms the interstate border. (This reach is approximately the last 180 miles [approximately 209 km] of the river.) The upper reaches of the river are in Texas, which is required to restrict any new uses which will deplete the flow at the state line below a fixed minimum standard of 36 cfs [approximately 1 m^3/s]. Thus, the approach relies on both a state line minimum flow standard (a constant requirement) and an allocation of consumptive use (tabulated on an annual basis).

(18) This Compact only deals with the upper portion of the river between Wyoming and Idaho; downstream Oregon is not a party. Flows in the upper reaches are allocated 96 percent to Idaho and 4 percent to Wyoming.

(19) Colorado (the upstream state) is required to take certain actions to maintain a constant minimum flow at the state line of 120 cfs [approximately 3.4 m^3/s] between April 15 and October 1. The Compact provides limits, however, on the actions Colorado must take in order to reach this goal.

(20) The compact allocates “consumptive use” rights among the four Upper Basin states using a percentage system: 51.25% to Colorado; 23% to Utah; 14% to Wyoming; and 11.25% to New Mexico. A small, fixed amount (50,000 acre-feet [approximately 62 million m^3]) is also allocated to the lower basin state of Arizona. Note that this allocation system is “nested” within the overall allocation scheme provided by the Colorado River Compact of 1922. Similarly, the Animas-La Plata Compact (Colorado-New Mexico, 1968) calls for the use of that river system to conform to the scheme provided in the Upper Colorado River Basin Compact.

(21) Restrictions exist limiting the amount of water that can be stored upstream by Wyoming. The Compact also specifies the dates during which water may and may not be stored. All other water allocation decisions are made in accordance with the principles of prior appropriation, without respect to the state lines. The Compact also calls for studies leading to an allocation of groundwater. The basic scheme provides storage requirements that are measured on an annual basis. However, some facilities can only store water in certain seasons, and prior appropriation rights often are defined using a variety of time periods. Thus, a variety of time frames are relevant.

(22) The Compact allocates the right to consume water in four major sub-basins/tributaries of the river system. Water is allocated among Wyoming and Montana using a percentage system. No effort is made to allocate that portion of the river system flowing between Montana and North Dakota.

Appendix Table 2. Water Allocation Compacts in the U.S.: Administrative Arrangements						
Compact			Commission Exists		Federal Member	
Basin (*see notes*)	States	Year	Yes	No	Yes	No
Arkansas[1]	CO, KS	1948	X		X	
Arkansas	KS, OK	1965	X		X	
Arkansas[2]	AR, OK	1970	X		X	
Bear[3]	ID, UT, WY	1955	X		X	
Belle Fourche	WY, SD	1943		X		No commission
Big Blue	NE, KS	1971	X		X	
Canadian	NM, TX, OK	1950	X		X	
Colorado[4]	WY, CO, UT, NM, NW, AZ, CA	1922		X		No commission
Costilla Creek[5]	CO, NM	1944	X			X
Delaware[6]	NY, PA, NJ, DE	1961	X		X	
Klamath[7]	OR, CA	1957	X		X	
La Plata[8]	CO, NM	1922	X			X
Pecos	NM, TX	1948	X		X	
Red[9]	TX, OK, AR, LA	1978	X		X	
Republican[10]	CO, NE, KS	1942	X		X	
Rio Grande	CO, NM, TX	1938	X		X	
Sabine[11]	TX, LA	1953	X		X	
Snake[12]	WY, ID	1949		X		No commission
South Platte[13]	CO, NE	1923	X			X
Upper Colorado[14]	WY, CO, UT, NM	1948	X		X	
Upper Niobrara	WY, NE	1962		X		No commission
Yellowstone[15]	WY, MT, ND	1950	X		X	

(1) If the Commissioners cannot reach an agreement regarding a possible violation, the commissioners can (through unanimous agreement) consent to binding arbitration. This has never been done.

(2) Voluntary arbitration is called for by the Compact.

(3) Note that unanimity is not the decision-rule in this Compact, so the Commission can make a ruling without unanimous agreement—an unusual arrangement.

(4) Based largely on the Supreme Court decision in Arizona v. California (1963), the Secretary of the Interior is empowered to implement the formula. Representatives of the basin states (and other interested parties) can provide input to the Secretary through the "AOP (Annual Operating Plan) Committee." Reservoir operating plans are adjusted each year, as necessary, to correspond to changes in storage levels, natural flows, and demands, and as provided for in the 2007 Interim Guidelines. The Secretary of the Interior has been instructed by the Court to interpret and enforce many of the most controversial elements of the formula. As is true of administrative decision-making in general, the actions taken by the Secretary can potentially be subject to judicial review.

(5)The USGS is asked to cooperate with the Commission as needed.

(6) Administering the interstate water allocation is the primary responsibility of a court-appointed River Master (typically a USGS official), who acts in cooperation with the Commission and New York State water managers. In water emergencies, the responsibility for temporarily modifying allocations is held by the Commission. The Delaware Compact (1961) is among the most comprehensive in existence, and empowers the Commission to exercise authorities in a broad range of subject areas, including water quality.

(7) Binding arbitration is mandatory when the commissioners are deadlocked.

(8) The Compact did not establish the Commission, but did provide language which allowed the parties to establish an administrative body known as the La Plata River Compact Commission.

(9) Unanimity is not the decision-rule in this compact, so the Commission can make a ruling without unanimous agreement.

(10) The Compact did not establish the Commission, but did provide language which allowed the parties to establish an administrative body known as the Republican River Compact Administration. Although not mentioned in (or required by) the Compact, the three states employed a mediation firm in order to help them address current areas of conflict.

(11) Arbitration is required before legal action can be taken.

(12) If the two states cannot agree on an action, the USGS is requested to provide a federal representative who will cast the necessary tie-breaking vote.

(13) The Compact did not establish the Commission, but did provide language which allowed the parties to establish an administrative body known as the South Platte River Compact Commission. The state of Colorado is responsible for making the necessary releases (and prohibiting, as necessary, upstream diversions).

(14) Unanimity is not the decision-rule in this Compact, so the Commission can make a ruling without unanimous agreement.

(15) If the state commissioners are deadlocked, the federal member (who is normally the non-voting chairman of the Commission) is empowered to cast a deciding vote.

Appendix Table 3. Water Allocation Compacts in the U.S.: Inclusions and Omissions								
Compact			The following terms (and their variants) appear in the text					
Basin	States	Year	Ground-water	Native American Rights	Environ-ment	Fish & Wildlife	Water Quality	Drought
Arkansas	CO, KS	1948						
Arkansas	KS, OK	1965					X	
Arkansas	AR, OK	1970					X	
Bear	ID, UT, WY	1955	X					
Belle Fourche	WY, SD	1943						
Big Blue	NE, KS	1971				X	X	
Canadian	NM, TX, OK	1950		X				
Colorado	WY, CO, UT, NM, NW, AZ, CA	1922		X				
Costilla Creek	CO, NM	1944						
Delaware	NY, PA, NJ, DE	1961	X			X	X	X
Klamath	OR, CA	1957	X	X		X	X	
La Plata	CO, NM	1922						
Pecos	NM, TX	1948						
Red	TX, OK, AR, LA	1978			X	X	X	
Republican	CO, NE, KS	1942						
Rio Grande	CO, NM, TX	1938		X				
Sabine	TX, LA	1953						
Snake	WY, ID	1949		X		X		
South Platte	CO, NE	1923						
Upper Colorado	WY, CO, UT, NM	1948		X				X
Upper Niobrara	WY, NE	1962	X	X				
Yellowstone	WY, MT, ND	1950		X				

Among the 21 western allocation compacts (e.g., excluding Delaware), most mentions of the terms listed are cursory. References to groundwater are normally either to define groundwater as outside the scope of the agreement, or to postpone action on groundwater to a later date. No agreement provides for a coordinated management and accounting of surface water and groundwater. Similarly, mentions of Native American water interests defer such issues, rather than attempt to quantify or include tribal rights in the apportionment scheme. The singular reference to environment (in the Red River Compact) is merely to acknowledge the issue as a concern; similarly, the few mentions of fish and wildlife do not correspond to any attempt to integrate fish and wildlife needs into the apportionment. Of these compacts that mention water quality, most make no effort to integrate the apportionment agreement into a regulatory regime. Surprisingly, only one agreement (in the Upper Colorado) mentions drought, and then only to instruct the commission to make "findings of fact" during such periods. Given the age of the agreements, it is not surprising that none mention climate change.

The Delaware Compact is much more modern, is much broader in its scope, and establishes the most powerful commission. Consequently, it features fewer omissions. References to groundwater are extensive, and empower the Commission to conduct research and establish standards to protect the resource from depletion or pollution. Likewise, the topics of "fish and wildlife" protection and water quality ("pollution control") are also given serious attention, as is the topic of "drought" management. The omission of the word "environment" in this compact is thus misleading, as the scope of the agreement provides for a coordinated program of management.

Interstate Compacts

Arkansas River Compact of 1949, 63 Stat. 145.

Arkansas River Basin Compact of 1965, 80 Stat. 1409.

Arkansas River Compact of 1970, 87 Stat. 569.

Bear River Compact of 1955, 72 Stat. 38; amended 94 Stat. 4 (1980).

Belle Fourche River Compact of 1943, 58 Stat. 94.

Big Blue River Compact of 1971, 86 Stat. 193.

Canadian River Compact of 1950, 66 Stat. 74.

Colorado River Compact of 1922, 45 Stat. 1057.

Costilla Creek Compact of 1944, 60 Stat. 246; amended 77 Stat. 350 (1963).

Delaware River Basin Compact of 1961, 75 Stat. 688.

Klamath River Basin Compact of 1956, 71 Stat. 497.

La Plata River Compact of 1922, 43 Stat. 796.

Pecos River Compact of 1949, 63 Stat. 159.

Red River Compact of 1978, 94 Stat. 3305.

Republican River Compact of 1943, 57 Stat. 86.

Rio Grande River Compact of 1938, 53 Stat. 785.

Sabine River Compact of 1953, 68 Stat. 690.

Snake River Basin Compact of 1949, 64 Stat. 29.

South Platte River Basin Compact of 1923, 44 Stat. 195.

Upper Colorado River Basin Compact of 1948, 63 Stat. 31.

Upper Niobrara River Basin Compact of 1962, 83 Stat. 86.

Yellowstone River Basin Compact of 1950, 65 Stat. 663.

Appendix 4: Acronyms

ADWR	Arizona Department of Water Resources
ANA	Agência Nacional de Águas
ASCE	American Society of Civil Engineers
AOP	Assured Operating Plan
AWWA	American Water Works Association
BC	British Columbia
BC Hydro	British Columbia Hydro and Power Authority
BGD	Billion Gallons per Day
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
BWS	Bureau of Water Supply
CBT	Colorado-Big Thompson
COCO	Central Oregon Cities Organization
COE	Certificates of Entitlement
Corps	Army Corps of Engineers
CRB	Columbia River Basin
CRT	Columbia River Treaty
CRUST	Columbia River-Umatilla Solutions Taskforce
CSO	Conditional Storage Objective
CWA	Clean Water Act
CWC	Catskill Watershed Corporation
CWCB	Colorado Water Conservation Board
DBBC	Deschutes Basin Board of Control
DDPB	Determination of Downstream Power Benefits
DOP	Detailed Operating Plan
DRBC	Delaware River Basin Commission
DRC	Deschutes River Conservancy
DWA	Deschutes Water Alliance
EPA	Environmental Protection Agency
EQ	Environmental Quality
ESA	Endangered Species Act
FAD	Filtration Avoidance Determination
FCOP	Flood Control Operating Plan
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FFMP	Flexible Flow Management Program
FNC	Federal Navigation Channel
FWS	U.S. Fish and Wildlife Service
GWPA	Groundwater Protected Area
IJC	International Joint Commission
IWRM	Integrated Water Resources Management
IWRS	Oregon's Integrated Water Resources Strategy
IWW	Oregon's Institute for Water and Watersheds
M&I	Municipal and Industrial

MAF	Million Acre Feet
MGD	Million Gallons per Day
MOA	Memorandum of Agreement
NAWQA	National Water-Quality Assessment Program
NED	National Economic Development
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
NTSA	Non-Treaty Storage Agreement
NWS	National Weather Service
NYC	New York City
NYCDEP	New York City Department of Environmental Protection
ORDEQ	Oregon Department of Environmental Quality
OSE	Other Social Effects
OST	Operations Support Tool
OWRD	Oregon Water Resources Department
P&G	Economic and Environmental Principles and Guidelines for Water and Land Related Resources Implementation Studies
PG&R	Principles, Requirements, and Guidelines
PEB	Permanent Engineering Board
PNCA	Pacific Northwest Coordination Agreement
POP	Principles and Procedures
RED	Regional Economic Development
RPP	Rules of Practice and Procedure
SCT	System Configuration Team
SPW	Special Protection Waters
SWAQ	Surface Water Availability and Quality
TMT	Technical Management Team
TSR	Treaty Storage Regulations
TVA	Tennessee Valley Authority
U.S.	United States
USACE	U.S. Army Corps of Engineers
U.S.EPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
WAC	Watershed Agricultural Council
WQT	Water Quality Team
WRC	Water Resources Commission

Appendix 5: Suggested Further Reading

Regarding U.S. Water Law and Water Markets:

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Hundley, N. Jr. (2009). *Water and the West: The Colorado River Compact and the Politics of Water in the American West.* University of California Press.

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Hooper, B., Ph.D. (2006). Key Performance Indicators of River Basin Organizations. Retrieved from http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/2006-VSP-01.pdf.

Regarding the Murray Darling Basin

The U.S. experience is not the only one with lessons to offer. For example, the Murray-Darling Basin Commission is responsible for managing the Murray River in southeastern Australia, an area that includes approximately 50% of the country's cropland and 10% of its population. This commission distributes the river's water among three states, New South Wales, Victoria, and South Australia. Originally, costs for the water were subsidized by the state. Later, states phased in prices to cover the cost of delivering water; Victoria now collects full operation costs, and New South Wales implemented a charge to preserve instream flows ($1.35/megalitre in 1995). In the 1980s, water shortages and salinity became severe and specific water allocations were introduced along with temporary trading of water rights within irrigation districts. In the 1990s water rights were trading for up to $70/megaliter.[210] The Murray-Darling Basin Commission is often cited as an innovative water market.

[210] This description comes from a case study included in Cech 2005 (pg 387).

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