MARKET STRATAGIES FOR ADDRESSING WATER SCARCITY: AN INTRODUCTION TO ENVIRONMENTAL WATER TRANSACTIONS IN TEXAS

by

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Market Strategies for Addressing Water Scarcity: *An Introduction to Environmental Water Transactions in Texas*

Executive Summary:

Extreme weather events and trends in population data within Texas over the past 50 years illustrate a relatively recent shift. Texas is experiencing increased climate variability characterized by more erratic and severe weather events during a period of unprecedented population growth. These shifts are a harbinger of the complex challenges Texans will face in managing limited pools of freshwater resources during an increased period of demand and uncertainty. Water scarcity is already a reality across much of the state, where competing demands among water users outpace current supplies, creating conflict between users and often leaving little to no instream water to protect fish and wildlife habitat. Flow depletions are the leading cause of freshwater species imperilment and almost half of all native fishes in Texas are listed for conservation concerns (NFCA 2019).

The current and future challenges associated with freshwater scarcity in Texas will require new and innovative changes in water resources management, and it is essential that these management strategies also consider environmental water needs. Water markets and water transactions are an example of innovative and adaptable means to address scarcity and meet both human and environmental water demands. These tools can create incentivizes for conservation and help redistribute conserved water among users to meet the growing challenge of addressing environmental flow protections.

Over the past 30 years, the state of Texas has responded to address growing concerns of water scarcity with advances in both science and policy. The legislature has recognized the need for environmental flow protections and has provided the legal framework that enables the development of strategies such as water markets and water transactions. Hallmark Texas water legislation including Senate Bill 1 in 1997 establishing the Texas Water Bank and Water Trust, Senate Bill 2 in 2001 adding the Texas Instream Flows Program, and Senate Bill 3 in 2007 providing the Environmental Flows Process are recognition of the commitment our lawmakers have made to addressing water scarcity and developing the science and mechanisms necessary to meet the state's environmental water needs.

However, despite the progressive legislative and regulatory developments that have enabled and supported environmental flow protections, there are still significant challenges to actualizing those instream benefits, including the overallocation of surface-water resources, the limited application of existing environmental flow standards, and barriers to expanding the use of water markets and environmental water transactions for streamflow restoration.

Articulating the function, history and use of water markets and environmental water transactions in the U.S., as well as in Texas, will help illuminate the benefits and challenges to their application and opportunities for addressing water scarcity and environmental demands in Texas. *Market Strategies for Addressing Water Scarcity: An Introduction to Environmental Water Transactions in Texas* accomplishes three goals: 1) provides a review of water markets and environmental flow transactions from historical development in western states to their application in modern-day Texas; 2) presents an evaluation of opportunities for the use of the strategy as a conservation tool; and 3) demonstrates the case for the expansion of the use of the strategy to protect and restore environmental flows.

TABLE OF CONTENTS

Page

Market Strategies for Addressing Water Scarcity: *An Introduction to Environmental Water Transactions in Texas*

Introduction

Context:

The management of water resources under shifting climate conditions and growing scarcity is arguably the greatest challenge facing Texas in the 21st century. Over the next 50 years the population of Texas is expected to grow by more than 70 percent, resulting in a 17 percent increase in water demand, while concurrently experiencing a 10 percent decrease in existing supplies (TWDB 2017). Climate projections suggest Texas will experience more extreme and severe drought periods and rainfall patterns. These shifts in climate combined with increased human demand for water will cause extensive reductions in three important sources of freshwater – the state's aquifer storage, riverine streamflow, and inflows to bays and estuaries (Runkle 2017). These combined factors threaten to further alter the natural flow regimes of our rivers, and provide challenges for meeting environmental flows, i.e., the quantity and pattern of freshwater flows required to support natural processes and native species, into river management. With a projected 4.8 million acre-feet of additional water supply needed by 2020 and with a $73 billion a year cost if those demands are not met, it is essential for the state's water managers to identify and evaluate intervention opportunities that provide water for environmental and economic resilience (TWDB 2017).

Although the state of Texas, through the 2007 Senate Bill 3 process, developed environmental flow standards for most of the river basins in Texas, it also acknowledged that in many cases existing unappropriated flows are not sufficient to meet these environmental flow demands. Further, the Texas legislature recognized through the Texas Water Code, that in basins where the environmental flow standards are not met - "a variety of market approaches, both public and private, for filling the gap must be explored and pursued." (TWC 11.0235(d-3) (2)). In response to these demands, many environmental practitioners in Texas are currently working on the development of water market strategies including environmental water transactions.

Water markets involve the voluntary trading of water rights from willing sellers to willing buyers. By creating the opportunity for open trading, these markets optimize the use of water by encouraging water rights holders to conserve water so that they can then market the unused portion of their rights to other users. These transactions can take many forms and include agreements such as long term or single year lease options, crop fallowing agreements, or permanent water right acquisitions. Under each of these transaction scenarios, water rights acquired can be committed to "instream uses" providing an increase in the quality and quantity of environmental flows.

Research Objectives:

This document evaluates opportunities for the use of water markets and environmental water transactions in Texas. Chapter 1 provides an assessment of enabling conditions, as well as historical and current trends of water market strategies both in Texas and other western states. Chapter 2 reviews the legal and regulatory processes that allow for environmental water transactions and the protection of environmental flows in Texas. Chapter 3 evaluates the processes for identifying, evaluating, prioritizing, executing, and monitoring environmental water transactions. Chapter 4 outlines a means to evaluate and address uncertainties and challenges to capacity building and sustainable funding for transactions.

Methods:

This document provides a review of relevant research, scholarly articles, legal documents, and other published literature concerning water markets and environmental flow transactions in Texas. Academic databases were utilized to identify primary research material, relevant documents used by water transactions professionals and literature published by practitioners working on water market strategies in Texas, including information compiled from the Texas Environmental Flows Initiative (TEFI). The TEFI, formed in 2015, represents a stakeholder collaboration (among The Nature Conservancy, Meadows Center for Water and the Environment, Ducks Unlimited, Harte Research Institute, and National Wildlife Foundation) focused on developing environmental water transactions and water markets in Texas.

Project Significance:

In 2017 The World Economic Forum stated that “Unless current water management practices change significantly, many parts of the world will face growing competition for water between agriculture, energy, industry, and cities” (CEL 2017). In Texas, the competing demands on existing water supplies during times of scarcity are already creating conflict between users. For example, during the 2012 drought, municipal and industrial users petitioned the state to grant them access to water outside of the priority system as their supplies dropped. The state’s subsequent granting of the request, and the redistribution of water granted to cities and power generators under scarce conditions left agricultural water users without their permitted amounts of water in a year in which there were millions of dollars in agricultural losses (Combs 2014). As future scarcity occurs, additional conflicts between water users can be expected, and will likely occur with little consideration for the environmental needs of the rivers of the state. Streamflow depletion is the leading cause of fish species imperilment. As more of these freshwater resources are diverted, the quantity, quality, and timing of flows necessary to sustain freshwater ecosystems are diminished (Walsh 2009). These human driven changes in the historical magnitude, frequency, duration, and timing of freshwater flows are currently one of the most significant threats to the ecological processes of riverine landscapes globally (Poff 1997).

In Texas, over the past 100 years more than 23 million acre-feet of surface water from the rivers and streams have been allocated to competing uses such as agriculture, municipal, and industry. While the state has allocated water rights for the vast majority of its rivers and streams, less than 10% of those water rights specifically consider conditions to preserve environmental flows. Environmental flows are defined as the 'quantity, quality and timing of flows that are necessary to sustain the rivers, estuaries and associated fish and wildlife that rely on these systems' (Arthington 2012). While the passage of Senate Bill 3 (SB3) in 2007 created statutory environmental flow standards for most of the river basins within the state, including the establishment of "set asides" to satisfy the environmental flow standards, these set asides were only to be allocated from "un-appropriated" water. These set asides fail to consider that many of Texas's rivers were over allocated prior to the passing of the legislation. While current statutes limit the issuance of new appropriative rights for instream uses, they do allow for the amendment of existing water rights to change or add instream use for the protection of environmental flows.

As water scarcity continues to threaten western states' ecological integrity and economic stability, water reallocation through market mechanisms is increasing in popularity as a way of meeting demands without the expense of new infrastructure. Many water resource stakeholders in Texas, including the Texas legislature, are considering the viability of these strategies to meet Texas' demands (Texas H.R. 2015). With a finite pool of water, the reallocation of existing surface water supplies through environmental water transactions is a logical approach to balancing the needs of both people and the environment. *Market Strategies for Addressing Water Scarcity: An Introduction to Environmental Water Transactions in Texas*, is intended to inform stakeholders of the existing strategies and opportunities that can accomplish equitable reallocation while simultaneously benefiting environmental flows.

I. Water Markets and Environmental Water Transactions in Texas

a) Water Markets and Environmental Water Transactions:

Markets, whether physical or online, are locations that exist for the purpose of facilitating transactions between willing sellers and buyers. With water markets the commodities being traded are the water rights. These transactions can include permanent transfers, temporary leases, management changes, or efficiency improvements that result in the transfer of conserved water. Environmental water transactions (EWTs) are water market trades in which the intent of the transaction is to provide additional water in the stream, bay, or estuary system for environmental benefit (Aylward 2017).

Some of the benefits of water markets include increasing and promoting water conservation, increasing water availability, improving community flexibility, improving allocation efficiency and accounting, and providing water for environmental flows (Richter 2016). Water conservation is incentivized as users assign a monetary value to the water, and create financial

benefits to saving, selling, or leasing conserved water within the market. Water availability is increased because the market creates opportunities to purchase water supplies from sellers as opposed to building new infrastructure necessary to increase supplies. Community flexibility is increased as water users are allowed to use or trade their water rights and more easily adapt to economic, climatic, and other unforeseen changes that can influence agriculture and/or other forms of production. For example, trading allows irrigators and other water market participants to engage in the market to create new revenue sources when encountering production risks such as periods of drought.

Water accounting and allocation efficiency are increased because transparent and accurate accounting is necessary for transaction valuation and confidence, and the waste or low value use of water is discouraged. Increased efficiency and discouraged waste results in the reallocation of water towards its highest and best use. Markets also open the door to non-traditional water users and market participants such as NGOs and others interested in increased opportunities for environmental flow conservation and restoration. For example, in places such as Texas where environmental flows were not historically protected during the allocation process, conservation organizations and governments can buy water and dedicate those flows to the environment (Richter 2017).

b) Enabling Conditions for Healthy Functioning Water Markets:

When water is scarce and there are multiple competing users for a limited pool of water, water markets are a strategy that can provide significant benefits. However, to establish successful and functioning water markets, four conditions must be met. The four primary enabling conditions essential to developing water markets include: (1) well-defined, secure, and flexible entitlements, (2) scarcity, (3) tradable and transferable entitlements, (4) and a cap on the total number of entitlements in a system.

First, the rights to water use must be clearly defined ad quantified so that each water user understands their water entitlement and allocation. When the volume of each water right is quantified, it creates the possibility of trading (buying, selling, or leasing) that water right in whole or in part (Richter 2017). Water rights and use of the water must be legally defined, monitored, and enforced. Water markets that do not have clearly defined attributes, oversight, and monitoring provide the potential for participants to break the rules and diminish the value of the marketplace. Second, there must be scarcity of the resource to drive the demand for trading among users. Third, the entitlements must be legally transferable among users within the system and be protected once a trade takes place. Fourth, there must be limitations placed on the total volume of water that can be extracted from the water source by all users. Without such limitations or a cap on water consumption, the water source can eventually be depleted to the extent that the certainty or reliability of all water rights is jeopardized—essentially compromising its value and discouraging trade. If these enabling conditions are achieved, the potential for a viable water market capable of providing financial incentives for increasing efficiency, conservation, and productivity could be established (Aylward 2016; Richter 2013).

c) History of Water Markets in Texas:

Texas water markets have a complicated yet evolving history. While water markets have not been fully developed throughout Texas, numerous legislative actions, lawsuits, regulatory decisions, and environmental efforts have combined to create Texas' current water market landscape. Understanding the history and development of water markets in Texas requires briefly reviewing the structure of water rights and their management. The Texas Commission on Environmental Quality (TCEQ) is the agency responsible for the regulation of Texas' surface water. The TCEQ administers water rights to individuals based on their purpose of use, including irrigation, industrial, mining, municipal, recreation, and instream (TCEQ 2018). Each water right granted includes the legal authorization for the use of water at a specified diversion volume, rate, and term. Rights have been historically granted using the prior appropriation doctrine, which follows the "first in time first in right" convention, in which permits granted first are senior in priority to those junior rights granted later. Under this framework, during droughts and times of water shortages, water users with earlier or more senior rights can divert their permitted amount of water from the stream before those with junior rights.

In addition to permitting water rights, the TCEQ is also responsible for ensuring that water right holders operate within their permit requirements, reviewing complaints, and enforcing violations. Watermaster Programs developed in the Guadalupe, San Antonio, Concho, Lower Rio Grande, and Lower Brazos basins, provide daily oversight of streamflow and water use in order to ensure compliance and prevent water from being wasted or excessively used. These programs provide local governance to arbitrate disputes over water use issues and are funded by annual fees paid by the water right holders.

Texas' surface water rights framework, under the prior appropriation doctrine, includes quantified volumes of water, designated use authorizations, a source for oversight and local governance and scarcity of the resource—meeting three of the primary enabling conditions for the development of healthy, well-functioning water markets. However, the fourth enabling condition, a cap or limit on the total extraction of water by users, is not specifically addressed in Texas water law. However, for those basins that are fully appropriated the state cannot grant new water rights, and for those basins with unappropriated water remaining instream, the 2007 SB3 Environmental Flow Standards create a functional limit on the volumes of water that can be extracted. For example, if an entity in a basin applies for a water right that does not meet the SB3 Environmental Flow Standards, they are able to purchase a water right and donate that right to the Texas Water Trust to offset the impact the allocation might have on the SB3 Standards (TAC 298.25(j)). While these basins are not "closed" per se, the limitations that the SB3 standards put on new allocations limits the number of new permits that can be

granted, effectively meeting the fourth primary enabling condition for healthy functioning markets.

While Texas does not have “closed basins” there are river basins that have limits on surface water extractions. For example, the Rio Grande Basin is a river basin with allocation and management restrictions. The 1967 Water Rights Adjudication Act and 1969 Valley Water Suit created the administrative and legal structure for the operation of the Lower Rio Grande water market (Debaere 2016). As a result of years of litigation and legislative actions, Texas water rights within the Middle and Lower Rio Grande basins are managed on a different system of priority, based on type of use and managed correlatively—meaning that in a practical sense agricultural water users could be reduced proportionally. The fact that this basin is managed with a cap on allocations, and that the Rio Grande Water Master program has direct oversight and enforcement of trading within the basin, are the main factors that have allowed it to become the most active surface water market in Texas (TWDB 2003).

Outside of some Groundwater Conservation Districts (GCD), there are no requirements for limitations on pumping or the use of groundwater. Currently the “rule of capture” provides the legal precedence and perspective for how groundwater is managed. However, it provides no use oversight or aquifer withdrawal limitations, indicating that the primary enabling conditions of functioning water markets are not met for Texas groundwater. Even in those GCD’s with set pumping limits, designated permits, and adequate enforcement, the lack of these GCD’s to completely cover an aquifer would leave the potential of external withdrawals creating a barrier to the development of a functional water market (Kelly 2004).

Although the development of a functioning groundwater market is not feasible given the current Texas’ legal framework, one exception is the Edwards Aquifer (EA). The EA is the primary water source for more than 2 million people in central Texas. A lawsuit in the 1990’s, which stemmed from the failure to protect endangered species relying on aquifer-supported spring flows, resulted in a total cap of 450,000 acre-feet/year. A total of 881 groundwater permits equaling 550,000 acre-feet/year were granted to the EA’s historical water users. Because these water right permits granted clear quantities of water to each user, there was strict oversight of pumping within the aquifer due to the endangered species monitoring, and there was a specific cap that limited extractions on the aquifer, a water market quickly developed (Debaere 2014). The City of San Antonio became the largest buyer of water rights in the EA by investing in the purchasing of groundwater rights from irrigators as a more cost-effective method of developing supply. In under a decade, San Antonio’s water utility acquired more than 68,000 acre-feet of water from water-rights making up 10% of its water supply portfolio (Richter 2013).

For decades the Texas legislature has recognized the importance of water markets as a demand side solution flexible enough to meet future water needs and the environmental demands for the state’s rivers, bays, and estuaries. Created in 1993, the Texas Water Bank allows voluntary, either temporary or permanent, water rights transfers. The bank’s primary functions are to act

as a clearinghouse of water marketing, trading, and pricing information as well as a repository for currently available water rights. The Texas Water Development Board (TWDB) administers the program, keeps registries of deposits, lists sellers and buyers online, and posts sales price and terms for trades. The TWDB encourages water users to implement conservation practices and contribute the 'conserved' water to the bank. A fee system to fund the program has been implemented which offsets the operational costs of the bank. Water right owners pay an initial deposit fee of 1% of asking price, maximum $50, upon submitting the right, with an additional transfer fee of 9/10 of 1% at the time the transaction occurs (TWDB 2018). Any water right transfer that requires a change of place, purpose of use, or location of diversion requires review by TCEQ, ultimately giving credence and support to regulatory oversight.

Senate Bill 1 passed in 1997 required TWDB to establish the Texas Water Trust, a component of the Texas Water Bank, to facilitate the donation or lease of water rights either for a term or in perpetuity, to meet environmental needs. The trust does not actively pursue these donations, but rather provides a mechanism for the state to procure and hold instream water rights. TWDB, Texas Parks and Wildlife Department (TPWD) and TCEQ review water rights submitted into the Trust, and fees for these transactions are waived and the rights protected from cancellation for the term they are held in trust.

Despite providing the institutional structure for water transactions, the Texas Water Bank has executed only one transaction in 25 years of operation, and the Texas Water Trust has only received two donations within 20 years. The low activity is the result of several factors including limited public awareness and outreach, a lack of incentives, and existing brokers that operate with lower transaction costs (Landry 2004; Debaere 2016). In addition to the state's water trust, there are also several regional water trusts that have developed to facilitate environmental water transactions, including the Guadalupe-Blanco, Trans-Pecos, San Saba, and Colorado water trusts. While some of these local trusts have been active for more than 15 years, the have had limited success with only a handful of lease agreements executed.

In addition to more traditional transaction programs that include payments to landowners to incentivize a change in water use, the Caddo Flows Project (CFP) established in the Cypress Basin in 2004, demonstrates the use of reservoir reoperations to meet downstream user demands and environmental flow needs. The CFP is a stakeholder driven partnership including Caddo Lake Institute, the US Army Corps, TNC, the Northeast Texas Municipal Water District (NTMWD), and others that used a consensus science-based decision framework to create management recommendations for Lake O' the Pines. These recommendations include environmental flow releases to maintain instream habitats and water quality, high-flow pulses for paddlefish spawning cues, and bank-full events to maintain geomorphology and habitats (Smith 2019). Flow recommendations were formally adopted into the USACE Operations Manual for Lake O' the Pines in 2019.

d) Current Trends in Environmental Water Transactions Across Western States:

Historically, water rights in western states were granted through the prior appropriation system which incentivized the diversion and use of water for economically beneficial purposes. During this time appropriations occurred without regard for recreation, fish and wildlife, or other environmental uses, and ultimately led to greater allocations of water than could be supported by the natural flow of rivers and streams (Szeptycki 2015). The overallocation of western rivers has ultimately led to degraded riverine habitats, especially during the drier summer periods, and created the need for both environmental streamflow protections within future allocations and in many locations the need for flow restoration, including the use of EWTs to meet instream flow needs.

Successful use of EWTs as a flow restoration tool requires that some quantified volume of the traded entitlement be either temporarily or permanently dedicated to benefit streamflow. The dedication of water rights to the environment was made possible in many western states by changes in state water law that recognize instream use as a beneficial use and were essential in protecting water rights against cancellation for the perception of non-use and waste (Richter 2013). The concept of instream flow as a beneficial use for fish and wildlife was first developed in Oregon in 1955, with many of the prior appropriation states following their lead, including Texas in 1985. Texas defines instream use broadly as the beneficial use of instream flow for "…aquatic and riparian wildlife habitat, freshwater inflows for bays and estuaries" (TAC 295). Unfortunately, the vast majority of the water in western states was allocated prior to the adoption of instream use designations, including Texas, which has allocated more water than is physically available in most years.

Over the past 30 years, the western prior appropriation states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming) have all developed laws that allow for water rights to be transferred or dedicated for purposes of enhancing or protecting fish and wildlife habitat and recreation uses. While these protections allow EWTs to be used as a mechanism to protect water instream against other uses, the laws and regulations that govern these transactions vary by state, which has a significant impact on the transaction activity in each state.

Water transactions among users in the western US have developed into a $385 million-dollar market annually (WWR 2018). These water right transactions emerged to meet the growing demands of many large-scale water users such as municipalities, industrial users, and farmers who have identified the trading of water rights as an economical alternative to constructing new water supply projects. While agricultural and municipal water users still represent the largest market participants by number and volume of trades, environmental user groups have also identified markets as a strategy to meet increasing environmental water demands. Of the major demand sectors, EWTs represent 25% of the total volume of trades over the last decade. California, Idaho, and Oregon alone account for more than 850,000 acre-feet leased annually for environmental use representing more than $67 million dollars (WWR 2018; Malloch 2015). As a result of increasing demands among users, drought induced water shortages, and

increasing interest and development of EWT programs across western states, the quantity of trading by the environmental sector is anticipated to increase.

While many western states share the challenge of managing over appropriated water resources under scarce conditions, specific water governance and regulatory mechanisms vary state to state, which results in unique challenges for the development and execution of EWTs. While Oregon, Washington, and Colorado each differ in approach, they also have each established water markets and environmental water transaction programs. While a review of each western states and their respective water transaction activities is beyond this document's scope, the following critical analysis will provide a brief overview of the developmental drivers underlying Oregon's, Washington's, and Colorado's EWT programs, the regulatory structures enabling them, and each programs current status.

Oregon:

Oregon is a pioneer in the development of water markets and environmental water transactions. The Oregon legislature adopted minimum streamflow standards in 1955, and in 1987 enacted the Instream Water Rights Act that put in place a mechanism for converting existing senior water rights to instream flow. This allowed for public or private entities to lease, purchase or receive donations of existing water rights and convert them to enforceable instream flow rights at the full authorized amount and original priority date. The state also adopted the Allocation of Conserved Water Statute, which rewards investment in conservation and efficiency by returning 75% of the conserved water back to the user for re-use, lease, or sale, with 25% dedicated back to the state for instream flow protection (OWRD 2018, Malloch 2015).

Historically there have been numerous entities working throughout different Oregon river basins implementing EWT strategies such as The Freshwater Trust (a merged coalition of Oregon Trout est. 1983 and Oregon Water Trust est. 1993), the Klamath Water Bank, and the Deschutes River Conservancy. The Oregon Water Trust, established in 1993, was the first water trust in the United States and is the oldest dedicated non-governmental practitioner of environmental water transactions in the country. After merging into The Freshwater Trust in 2009 it became instrumental in shaping and implementing the Columbia Basin Water Transaction Program (CBWTP) (Neuman 2004). In 2002, the Bonneville Power Administration (BPA) established a partnership with the National Fish and Wildlife Foundation, in cooperation with the Northwest Power and Conservation Council, to launch the CBWTP. The BPA supports CBWTP as an important part of its fish and wildlife program helping the agency meet commitments under both the Endangered Species Act (ESA) and the Northwest Power Act. Instream flow augmentation is an essential function of the habitat recovery program for endangered species, and the transactions are targeted in areas where flow is a limiting factor. CBWTP provides funding through a competitive grant program offering financial and technical support for conservation groups, state agencies, and tribes, to develop water transactions throughout the Columbia River Basin. Through 2017, CBWTP has protected more than 1.6

million acre-feet of water, restoring water instream to thousands of river miles within the Columbia (CBWTP 2017).

In 2001, severe drought conditions coupled with the enforcement of the ESA for three endangered fish species resulted in a major reduction of irrigation water to farmers within one of the oldest irrigation projects developed by the Bureau of Reclamation (BOR), the Klamath Reclamation Project. The resulting fallout surrounding the economic and social impacts to farmers and rural communities pushed stakeholders to develop strategies for meeting environmental flow demands for ESA impacted species while limiting impacts to these communities. In response, the BOR created the Klamath Water Bank in 2003 to purchase 50,000 acre-feet of water from willing sellers on a temporary basis to meet ESA needs in the basin with the goal of scaling up to 100,000 acre-feet by 2005 (Burke 2004). The BOR used strategies such as source switching from surface to groundwater, fallowing agreements, and direct discharge of groundwater to the river to meet its acquisition targets (Malloch 2015). The BOR continued to operate the water bank through 2007 ultimately deploying $30 million in funds for flow restoration activities. In 2008 the BOR transitioned the water bank to the Klamath Water and Power Agency (KWAPA), awarding $11.25 million to continue fallowing agreements and source switching activities. While KWAPA ceased operation in 2016, as of September 2015 $28 million was spent directly on compensating irrigators (DOI 2016).

Deschutes River Conservancy (DRC), established in 1989, started as a collaboration of stakeholders focused on the management of federally owned land, and water quantity and quality problems with irrigated agriculture. The group focuses on market-based incentives with both private and governmental representation. Most of DRC's projects involve ecosystem restoration work on wetlands, riparian corridors, and stream channels. For the water transactions, DRC primarily focuses on improving efficiency and promoting transactions through the Deschutes Water Exchange. Efficiency projects use Oregon's Allocation of Conserved Water statute where improvements in irrigation systems, usually replacing leaky ditches and gravity systems with pressurized piping and sprinklers, resulting in reduced diversions with some or all of the conserved water dedicated to instream flows. The DWE also provides several transaction opportunities, including annual leasing, transaction consulting services, and a groundwater mitigation credit bank (Malloch 2015). The leasing program is well established, with more than 20 years of agreements resulting in significant flow restoration within dewatered sections of the Deschutes river and smaller tributaries. Over the past 30 years between conservation efficiency projects, leasing agreements, and permanent transactions, the DRC has restored more than 200 cfs annually in the Deschutes River Basin (DRC 2018).

Washington:

Following the prior appropriation doctrine, Washington established an administrative water rights system in 1917, with no provision for protecting instream or environmental flows. In 1949 the state legislature approved and recognized fish and wildlife protection as a beneficial use, and in 1976 due to pressure and federal requirements for salmon and steelhead fisheries

restoration under the ESA, began establishing minimum streamflow standards. To meet identified environmental flow demands in the 1980's the Washington Department of Ecology (WDOE), the agency that administers water rights, developed the Trust Water Rights Program that allowed for water rights to be held and protected for enhanced streamflow within priority basins.

In Washington, EWTs are primarily targeted at flow restoration for anadromous fish species listed under the ESA. The Yakima River Basin Water Enhancement Project , the CBWTP, Washington Water Trust (WWT), as well as the state's own Washington Water Acquisitions Program (WWAP) developed in 2000, are all actively developing, supporting, and completing transactions including purchase, lease, donation, and net water savings from irrigation efficiency. Funding for transactions and support comes from multiple sources including the Bonneville Power Administration through the CBWTP, the BOR, and the state of Washington (Malloch 2015). The WDOE administers a voluntary partnership with the WWAP and the WWT, which involves an incentive-based program designed to encourage water right holders to sell, lease, or donate some or all of their water rights to increase instream flows for the purpose of salmon restoration. As of 2018, the program has funded more that $84 Million in temporary, permanent, and conservation transactions, representing more than 811,000 acre-feet of water in basins where flow levels have been identified as critically low for threatened or endangered fish species (Lovrich 2004; WDOE 2018). The WWT, founded in 1998 on the Oregon Water Trust model uses a voluntary, market-based transactions including purchase and lease agreements, source and crop switching, and efficiency projects to temporarily or permanently to leave water instream and improve and protect flows for imperiled salmon and steelhead. In 2001, WWT began working with funding through the WWAP developing transactions with local landowners and acting as an intermediary between water right holders and the state agency (WWT 2018).

Colorado:

In the early 1970's as Colorado's urban water needs were increasing and putting growing pressure on the state's rivers, streams, and fish and wildlife resources, the state began to evaluate strategies for keeping water instream for the environment. In 1973, the Colorado legislature recognized the need to "correlate the activities of mankind with some reasonable preservation of the natural environment" and passed Senate Bill 97 creating the state's Instream Flow Program (Merriman 2005). This program, one of the first of its kind, vested the Colorado Water Conservation Board (CWCB) with exclusive authority to protect streamflow through a reach of stream rather than just at a point, and to protect levels in natural lakes. Until this law was passed, all appropriations of water in Colorado were required to divert water from its natural course in the stream. SB 97 removed the diversion requirement for the CWCB to appropriate water "instream". In 1986, the state expanded the program to allow the CWCB to convert existing senior water rights acquired by purchase or donation to instream use (Merriman 2005). Since 1973, the CWCB has appropriated instream flow water rights on more

than 1,700 stream segments covering more than 9,700 miles and 480 natural lakes. The CWCB has completed more than 35 voluntary water acquisition transactions (CWCB 2018).

While Colorado's instream flow regulations gave the CWCB the authority to make new appropriations for instream flows in the minimum amount necessary to maintain the environment to a reasonable degree, the program was limited in protecting over appropriated streams. The state eventually expanded the program to allow CWCB to accept temporary loans or leases of senior water rights for instream flows. However, the program appropriated no funding for acquisitions, requiring all senior rights to be donated. While Colorado's cities have been most active in donating water rights for instream flows, donations by the private sector have been made, including The Nature Conservancy and the Colorado Water Trust. Due to Colorado's relative high bar for no-injury analysis to other water right holders, and engineering and biological justification and requirements for instream conversions, donations have been rejected by the CWCB. Due to these challenges, there have been only 27 permanent environmental water transactions, leading conservation groups and others to continue to work towards transactions that protect instream flow through temporary means in addition to other strategies such as dry year lease agreements that are less complicated and expensive, as they do not require going through CWCB's instream right conversion process (Szeptycki 2015; Malloch 2005).

e) Opportunities for Developing Water Market Strategies in Texas:

Growing water scarcity, population growth, increasing capital costs, and the regulatory burdens of new water supply projects have increased the interest and activity in demand side solutions that can successfully reallocate existing water supplies among Texas water users. However, market transactions are not being used broadly across the state because of the lack of market visibility, regulatory burdens that restrict water transfers between regions, and limitations of infrastructure to move water among users. Despite the nascent use of market strategies, Texas does meet the primary conditions for healthy functioning water markets including well-defined, secure, and flexible entitlements, scarcity, tradable and transferable entitlements, and a functional cap on new allocations. These conditions alone provide significant opportunities for the expansion of market strategies and the use of EWTs for flow restoration.

While Texas does not permit the appropriation of new water rights for instream uses, it does let instream use amendments retain their original priority date, accepts any party to hold instream flow water rights, and specifically grants transfers of conserved water to instream use. In addition, Texas water law lets water right holders to combine or "stack" instream uses on water rights that concurrently maintain other, diversionary uses. For example, according to TCEQ's Active Water Rights Database, of the 36 rights that have instream use, all of them include some other use including irrigation, industrial, municipal etc. This "stacking" of multiple uses on an individual permit enhances the flexibility for water rights holders by affording them the option to choose and market the uses that they will exercise in a given year or season (Szeptycki 2015).

When the appropriate conditions are met, water markets are an effective tool in addressing scarcity among competing users and providing the opportunity to secure environmental water allocations through EWT. Over the past 30 years successful water markets and EWT programs have developed demonstrating the value of these transactions as a conservation tool. The surface water rights system in Texas includes the primary enabling conditions for water markets and the legal framework for water rights to be transferred or dedicated for environmental protection. The following section explores the origin and processes of the legal and regulatory frameworks that support Texas EWTs.

II. Legal and Regulatory Processes Supporting Environmental Water Transactions

This section presents a historical overview of major legislation addressing instream uses as well as relevant statutes that have molded Texas' EWT's regulatory and legal processes. Further it reviews how laws made it possible to enforce and protect environmental flows. Throughout the section the risks, limitations, and uncertainties associated with these laws and subsequent processes are discussed.

a) Texas Surface Water Law and Instream as a Beneficial Use:

Texas surface water law is entrenched in the state's historical governance structures, specifically common rule, Spanish rule, Mexican rule, and English Common Law. These early influences embedded the concepts of common use and riparian rights that stated that ownership of land riparian to a stream includes the right to use water from that stream (Jarvis 2018). The state's adoption of the prior appropriation framework stems from the unique conditions under which the Republic of Texas joined the United States in 1845. When Texas joined the union, it retained its public debts, obligations, and lands. The lack of federal lands, existing debts, and political pressure for economic growth, immigration, and agricultural development to support the state's population spurred the first water laws in Texas, including the Irrigation Acts of 1852 and 1889. The Act of 1852 provided counties the authority to develop and regulate reservoirs and irrigation works to support the further development of agriculture. The Irrigation Act of 1889 established unappropriated waters as waters of the state, and the prior appropriation doctrine of "first in time first in right". This later act was primarily intended to establish rules by which irrigation companies would acquire water rights, it also recognized and protected the rights of landowners who owned property adjacent the stream to divert water for domestic use. This was the first acknowledgement by the legislature of a dual system of water laws, prior appropriation and riparian, which although it has undergone many modifications over the past century, is still the prevailing water law framework that exists in Texas to date (Sansom 2008).

While Texas surface water law was historically based on a combination of common-law riparian rights and appropriative rights, several court cases and the Water Rights Adjudication Act of 1967 attempted to untangle this management structure. The 1967 Water Rights Adjudication

Act was an attempt to unify the dual system of water law and to inventory and quantify the number of and volume of water appropriations (Jarvis 2018). The act required an adjudication process in which all claims for water rights were reviewed by the courts and re-certified based on their historical beneficial use. To establish a consistent and manageable water rights system, the adjudication process included a review of riparian claims and assigned them time priorities, effectively converting them into appropriative rights, other than those for domestic and livestock uses which were specifically excluded from the act likely due to their primacy in the state's Spanish, Mexican, and English Common law legacy.

The prior appropriation doctrine requires that anyone wanting to use surface water must file for a water right, and the first person to receive a permit and put that water to beneficial use is senior to all other users. This "first in time first in right" system ensures that during times of water shortage, the senior water rights holders receive their full entitlement prior to any junior water right holder. In Texas, surface water is defined in statute "water under ordinary flow, underflow and tides of every flowing river, natural stream, lake, bay, arm of the Gulf of Mexico, and storm water, floodwater or rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state is the property of the state" (TWC 11.021a). A right to use surface water, or water right permit, does not transfer ownership of the water from the state but rather grants the water right holder a "usufructuary right", or right to put the water to beneficial use. The surface water is still owned in trust and regulated by the state through the TCEQ, which permits water rights to water users, and handles all permit amendments, changes of ownership, and disputes over permit conditions.

The definitions of beneficial uses have changed over time, and while Texas has always considered domestic, municipal, agricultural, and industrial uses as beneficial, the state has only recently recognized the importance of environmental flows with the addition of "instream use" as a beneficial use in 1993 (Wells 2018). TCEQ describes beneficial use as "the amount of water which is economically necessary for a purpose authorized by law, when reasonable intelligence and reasonable diligence are used in applying the water to that purpose" (TWC 11.002). Texas Water Code further and more specifically defines the purposes for which water may be appropriated, including: domestic and municipal uses; agricultural uses and industrial uses; mining and recovery of minerals; hydroelectric power; navigation; recreation and pleasure; public parks; and game preserves; or any other beneficial use (TWC 11.024). While not specifically mentioned within that list of beneficial uses in the Texas Water Code, TCEQ rules define instream use broadly as the "beneficial use of instream flows for such purposes including, but not limited to, navigation, recreation, hydropower, fisheries, game preserves, stock raising, park purposes, aesthetics, water quality protection, aquatic and riparian wildlife habitat, freshwater inflows for bays and estuaries, and any other instream use recognized by law" (TAC 297.1). It is important to note that while instream use is an acknowledged beneficial use, new permits may not be granted for instream purposes.

In 2000 the San Marcos River Foundation (SMRF) filed a new water right application for 1.3 million acre-feet annually within the Guadalupe Basin for the sole purpose of instream use to provide freshwater inflows to the Guadalupe and San Antonio Bay systems. SMRF intended to transfer the water right to Texas Parks and Wildlife Department (TPWD) for deposit into the Texas Water Trust (Kelly 2012; Wells 2018). The water right application was the first requesting a significant quantity of water for the sole purpose of protecting environmental flows, and both the filing of the application and subsequent draft permit issued by TCEQ in 2002 creating a substantial amount of debate and legal challenges. Questions were raised as to whether the commission had the authority to grant such applications due to the lack of expressly defined statutory recognition of "instream use" as a beneficial use. The passage of SB 1639, in 2003, added Texas Water Code 11.0235, clarifying that "the legislature has not expressly authorized granting water rights exclusively for: instream flows dedicated to environmental needs or inflows to the state's bay and estuary systems"(Kelly 2012). Although the SMRF application was not subject to the new statute, as it was filed and administratively complete prior to adoption, TCEQ took the adoption of the statute as guidance and dismissed the application. Around that same period similar applications for environmental flow appropriations amounting to millions of acre-feet had been file by groups such as the Caddo Lake Institute, Matagorda Bay Foundation, and the Galveston Bay Foundation, and were all denied by TCEQ, citing that it had no express authority to issue new appropriations for instream use.

While SB 1639 codified the commissions limited authority to grant new appropriations for instream uses, it also added TWC 11.0237 which provided that while "the commission may not issue a new permit for instream flows dedicated to environmental needs or bay and estuary inflows. The commission may approve an application to amend an existing permit or certificate of adjudication to change the use to or add a use for instream flows dedicated to environmental needs or bay and estuary inflows". The bill also established the Environmental Flows Study Commission with the intent to make recommendations on addressing environmental flows to the legislature during the interim (SB 1374; SB1639; Kelly 2012).

b) Environmental Flows Process 2001 – Present:

In 2001, Senate Bill 2 (SB2) under TWC 16.059 directed the TCEQ, TPWD, and TWDB to "jointly establish and continuously maintain an instream flow data collection and evaluation program". In addition, the legislation directed the agencies to "conduct studies and analyses to determine appropriate methodologies for determining flow conditions in the state rivers and streams necessary to support a sound ecological environment" (TIFP 2008; TWC 16.059). The agencies responded by establishing the Texas Instream Flow Program (TIFP) as an instream flow data collection and evaluation program jointly administered by the TCEQ, TPWD and TWDB. The group identified priority study areas and sub-basins for these instream flow studies based on potential water development projects, water rights permitting issues, and other factors. Study areas include: Lower Sabine River, Middle and Lower Brazos River, Lower San Antonio River and Cibolo Creek, lower Guadalupe River and middle Trinity (TWDB 2018). TIFP was intended to be

a transparent state driven process that would make recommendation to meet a “sound ecological environment” defined as a resilient, functioning ecosystem characterized by intact, natural processes and a balanced, integrated, and adaptive community of organisms comparable to that of the natural habitat of a region (TIFP 2008). Of the study areas identified, the Brazos and Lower San Antonio Basin have been completed, and studies in the Guadalupe and Trinity are on-going, and the Lower Sabine has been discontinued.

In 2007, SB3 passed, and included several provisions relating to environmental flows, including the development of a new process for ensuring quality science and full participation of local and regional stakeholders in setting environmental flow targets and desired flow regimes. While SB2 was a multi-year effort to collect the scientific data necessary to identify appropriate flow regimes that conserve fish and wildlife resources while also providing sustained benefits for other human uses of water resources, SB3 requires that environmental flow standards be predicated upon the best science and data currently available; and it is intended that adaptive management be employed to refine the flow standards in the future (TWDB 2018).

SB3 was designed to be an accelerated, stakeholder-driven, scientific and consensus-based process to establish environmental flow recommendations from which the TCEQ could set environmental flow standards. The bill created a framework of local river basin stakeholders and expert science teams that convened to develop recommendations (Figure 1). The groups were tasked with answering three primary questions: (1) How much water is needed to sustain a sound ecological environment in the state's rivers and estuaries? (2) What are the strategies can be employed to protect these flows?; (3) What is the appropriate balance between water needed to sustain a sound ecological environment and water needed for human or other uses? (TWDB 2018). The expert science teams developed environmental flow regime recommendations that were intended to protect a “sound ecological environment”, while the stakeholder groups considered the information from the science teams, in addition to future water needs and provided a recommendation for TCEQ to consider in adopting standards. Throughout the development and implementation of Senate Bill 3 there was recognition of the need for voluntary market mechanisms to help secure and protect instream and environmental flows, including statutory requirements that the Environmental Flows Advisory Group study public policy implications of granting permits for instream flows dedicated to environmental needs or bay and estuary inflows, use of the Texas Water Trust, and address appropriate methods to encourage persons voluntarily to convert reasonable amounts of existing water rights to use for environmental flow protection. (TWC 11.0236 (i))

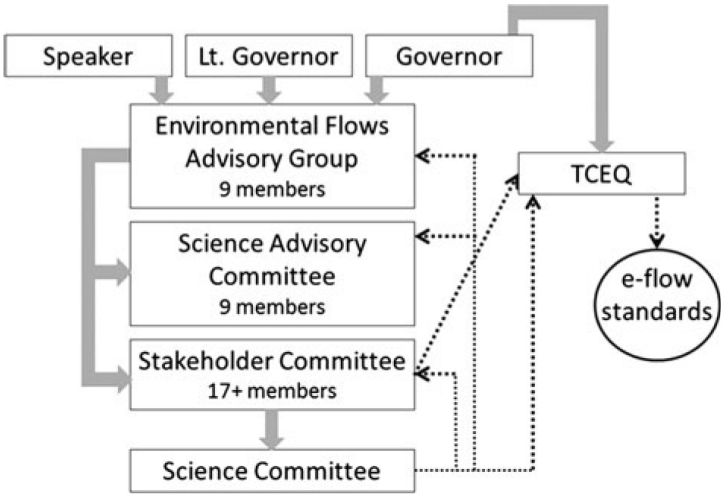

Figure 1. Senate Bill 3 Framework (Roach 2013)

c) Conveyance of Water Rights and Due Diligence:

While surface water within Texas's streams and rivers are owned by the state, the state allocates water right certificates and permits to provide usufructuary authorizations for those waters. While the water right holder does not own the water itself, if the water right is put to beneficial use, or perfected, it is considered a vested property right (McCarthy 2018). These water rights under the prior appropriation system provide the owner a senior property right to use, sell, or lease their water. These water rights represent the legal, regulatory, and administrative process for the transfer and transaction of water among user groups. The characteristics of each individual water right including the priority date, authorized annual diversion amount and rate, authorized use, location, term (temporary or permanent), any special conditions or restrictions are all factors that influence the marketability and price of a water right.

While water transactions and the specific water rights themselves will always be unique, the due diligence process for water rights transactions should always assess a few key elements, including: (1) whether the subject water right will provide the necessary quantity, quality, and reliability for the intended use, (2) whether permit amendments will be necessary to apply the water right to the intended use, including changes of ownership, and; (3) whether the rights are legally marketable. Title reviews and evaluating historical use assessments and compliance with TCEQ reporting requirements and fees can ensure water rights are protected from cancellation and are marketable by the owner (McCarthy 2018).

In response to the passage of HB 1964 in the 86th legislative session in 2019, some amendment applications, such as those requesting the addition of instream use, are processed without public notice and the need for public hearings. Water right amendments that may impact other

water right holders require public notice. For example, those that impact other water right holders, or change use from non-consumptive to consumptive, trigger procedural actions and can result in significant time, cost, and uncertainty to the transaction. Some examples of amendments that can extend the complexity of a transaction include those that require the movement of a diversion point. Under these amendments, in addition to the public notice and opportunity for contested case hearing, a technical review is necessary to assess whether special conditions are necessary to mitigate impacts to other water right holders. Other potential permitting requirements that must be considered include the need for bed and banks authorizations to convey purchased water (from storage/ground water) downstream, or the need for interbasin transfer, or the movement from one basin to another, which if authorized, results in the subject water right becoming junior to all other water rights in the basin of origin, which can diminish the value of the water right.

In addition to these primary considerations for water rights and EWTs, it is also important that the due diligence process identify any unintended consequences, ecological or economic, that might occur due to the result of these transactions. EWTs that are permanent transfers of water rights away from agriculture can undermine the long-term economic viability of rural communities and in the case of irrigation rights, could result in negative ecological impacts to both aquatic and terrestrial species.

Mitigating unintended impacts requires fully understanding the water budget for a potential project in advance. In places where irrigation rights are fully converted to instream flow, the historical benefits of that agricultural production including the secondary services supported in the agriculturally economy, such as farm labor, seed and fertilizer sales, etc., could be impacted. Rural economic indicators can be used to assess effects of EWTs on irrigation-dependent communities. Specifically, they can evaluate changes in economic productivity and labor demands of irrigated cropland. Solutions that result in neutral or positive trends such as temporary transfers, efficiency investments, or crop switching to higher value commodities can help to maintain the support of rural communities for EWT programs (Kendy 2018).

In addition to rural impacts, some EWT strategies that increase efficiency and dedicate conserved water to instream and environmental flow can actually have unintended impacts of reducing stream flow. For example, if inefficient irrigation sprinklers are converted to high efficiency equipment reducing the quantity of water put on a field to grow the same crop, the excess water that historically ran off the field and into the river may be reduced causing a decrease in streamflow. A full understanding of the water budget not only helps in determining the strategies that will result in the desired conservation benefits, it also allows for informed negotiating of the terms necessary to achieve those benefits.

d) Types of Transactions and Regulatory Review:

While the majority of water transactions that occur in Texas fall under traditional sale or lease agreements, EWTs include any voluntary agreement in which users change their water use to

protect or restore environmental flows; including donations, forbearance agreements, dry-year options, deficit irrigation, water conservation agreements, crop conversion/substitution, split-season leases, infrastructure construction and reoperation, groundwater recharge and storage, and use of alternate sources. Because the majority of water withdrawn and consumed in the west is allocated toward irrigation uses it is logical that senior irrigation water rights are the primary source for market transactions (Kendy 2018).

Purchase agreements that include the permanent transfer of water rights require a change of ownership that must be filed with TCEQ and executed to convey a surface water right. These will also include any other necessary due-diligence and amendments that are necessary when executing water transactions. However, lease agreements with individual water right holders that are not classified as wholesale water suppliers, can be executed for the lease and use of water rights as long as the water rights have been amended for the authorized purpose of use and location. In comparison, a fallowing agreement or dry-year option agreement with an irrigator that requires the forbearance, or non-use, of a water right does not need a water right amendment for the addition of instream use but would effectively provide the same instream benefit at the diversion point, however would not protect the right from cancellation as the right would not be put to a recognized beneficial use under the permit.

Transaction types that result in improved instream flow can be classified by their impact as either having reductions in consumptive water use or changing water management (Aylward 2013). For example, water management interventions that include reservoir reoperations, changing the timing of flow releases, or conjunctive management agreements that provide for switching from surface to groundwater, could provide the desired ecological benefit of an increase in the quantity and timing of instream flows, but not increase in the quantity of water in the system overall. In comparison, strategies and interventions such as switching to lower water use crops, or fallowing agreements reduce the quantity of water consumed can increase the net quantity of water in a system impacting the consumptive use.

e) Transaction Enforcement and Risk:

Despite precedence that has been set in water transactions both within Texas, as well as other western states, there still exists some risk and uncertainty associated with the use of EWT as a tool to protect instream and environmental flows. If EWTs are to be truly effective as a conservation tool, the transactions must result in tangible and physical increases in streamflow. This incorporates having certainty in the transfer of the water right through an agreement, including the protection of those transferred rights for instream use. Whether they are real or perceived, due to the nascent nature of water markets and EWTs in Texas, there still exist a number of uncertainties that are risks to the use of EWTs as a conservation strategy.

Despite the number of water rights that currently have instream flow authorizations, to date there have been no priority calls for instream use to verify the processes required by TCEQ for enforcement. While it can be assumed that they would be processed as any other priority call,

without precedent it remains unclear. This adds risk to the ability of these transactions to meet their intended flow protection. While it is clear that an instream water right can only be protected at its diversion point and is subject to diversion by even junior water right holders once its passes that point, there are often unknown risks such as the impact of domestic and livestock uses and groundwater pumping that can reduce or negate the ability of these EWTs to provide instream flow benefits, which must be acknowledged and assessed early on during the prioritization and due diligence process.

The dual system of prior appropriation doctrine and riparian rights that exists in Texas today can be linked back to policies in place more than 300 years ago. While this system has changed significantly over time, Texas has always recognized the importance of water uses such as domestic and agriculture. It has only been in the past 30 years that the state has truly recognized the importance of environmental flows. Over the past 30 years state lawmakers passed major legislation to identify the needs of Texas rivers, bays and estuaries, and developed programs to support voluntary transfers of water rights to meet these demands. While water markets are established and currently being utilized, EWTs are still a nascent strategy and demonstration of successful transactions are vital in proving their worth as a valuable conservation tool.

III. Transaction Processes

This section outlines the steps of executing an environmental water transaction. This includes the process and tools for identifying flow needs, setting targeted quantities for acquisition, evaluation and ranking water rights to meet those goals, and how to monitor and evaluate the success of a transaction. Various transaction scenarios are discussed, in addition to providing an overview of the regulatory application processes for changing ownership of and amending a water right for environmental protection.

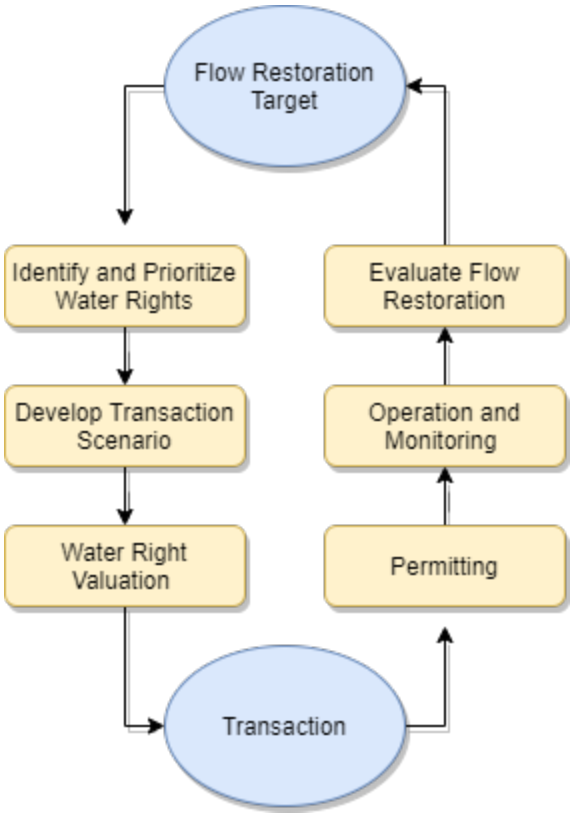

Figure 2. Environmental Flow Transactions Process

a) Identifying and Setting Environmental Flow Targets:

The use of EWTs as a flow restoration tool is founded on the premise that changes in the management of water allocations can result in some beneficial ecological response. As predicting or evaluating the direct ecological response of aquatic species and ecosystems is resource intensive, the flow regime is often used as a representative proxy (Kendy 2018). Texas benefits from the research and science developed through the SB2 and SB3 processes, these studies published flow ecology relationships for many indicator species, made flow regime recommendations, and resulted in adopted environmental flow standards for many streamflow gages. Hydrograph analyses and use of TCEQ's water availability models, that provide a simulation of streamflow under various conditions, can be used to determine the attainment frequency of recommended flow targets. These outputs can then be used to inform the degree of hydrologic alteration and help to quantify the volume of water needed for flow restoration.

There are a number of existing and developing decision support tools to help identify priority conservation areas and set flow targets for flow restoration including Texas Parks & Wildlife's Environmental Flow Information Toolkit (EFIT). Completed for the Great Plains Landscape Conservation Cooperative in 2020 and in development for the entire state, EFIT is an online web mapping decision support tool for the assessment and evaluation of hydrologic alteration

and various interventions and strategies for restoration and protection on environmental and instream flows. The tool uses USGS gage data to assess hydrologic alteration, fish species collections, and statistical relationships to inform flow ecology relationships, reach-based stream flow recommendations, and historical water use and water right reliability to determine the prioritization and benefit of various acquisition scenarios.

b) Identifying and Prioritizing Water Rights:

Once a priority reach and flow restoration target have been identified it is possible to evaluate the reality of using EWTs as a tool for meeting those targets. The total number of water rights and their collective volume above a priority reach is used to determine the feasibility of meeting the target restoration goals. After a group of water rights have been identified that could meet the restoration goals of the subject reach, decisions on the preferred transaction scenarios should be developed and their relative cost assessed to determine next steps. Prioritization of water rights are primarily be based on their position to the conservation area, reliability, priority date, volume, diversion rate and pattern of use.

During the Texas Environmental Flows Initiative pilot project the Geospatial Water Rights Tool was developed to link the various data sets of TCEQ water rights information in a geospatial platform. This tool provides users the ability to identify water rights, rapidly assess their proximity to priority conservation areas, and evaluate their unique characteristics including; priority date, volume, diversion rate, and modeled WAM reliability. This tool served as the primary screening platform to help TEFI practitioners in identifying and prioritizing water rights for acquisition.

c) Transaction Strategies:

Preferred transaction strategies and scenarios will always be dependent on the flow restoration targets and the characteristics of the prioritized water rights. If the flow target and restoration goals are specific to a season, i.e. restoring or protecting summer critical low flows, it may be adequate to enter into dry-year lease options for an individual or small number of run-of-river water rights. If the restoration goals include improving freshwater inflow into a bay and estuary and are tied to critical salinity levels, it may be necessary to acquire several water rights that can be permanently dedicated, potentially with agreements for releases from storage.

For example, the TEFI pilot focused on transactions that had the ability to benefit coastal systems. This broad coastal focus created significant challenges, specifically that it takes a large volume of freshwater inflow to influence estuarine systems. These challenges led TEFI practitioners to evaluate the purchase of large water rights in excess of 10,000 acre-feet, and often involved water stored in reservoirs that could provide managed releases to meet the desired conservation benefits. Due to the large quantities of firm water supply, and reservoir infrastructure necessary to create these managed releases, the TEFI identified large institutional water right holders, such as river authorities and navigation districts, that have firm water supplies that could be called upon even in dry years. On account of the wholesale water

supply relationship these entities have with their customers, negotiating the permanent acquisition of these water rights was not feasible. However, those large institutional water right holders commonly lease water under long-term agreements for municipal supply contracts, and those contracts provided a framework and deal structure for negotiations.

In addition to these projects TEFI also worked on the development of dry year lease, forbearance, and conjunctive use agreements. A dry year lease agreement could be a 5-year contract in which the irrigator is paid an annual reserve payment for 4 of those years, and in one of the years under some pre-determined operations triggers such as low flow at a gage, would be compensated at a higher rate to forgo irrigation. Those forbearance agreements consider the lost commodity cost in the single year, but also consider the reduced labor and pumping cost to reach justified payment agreements. Conjunctive use agreements are similar to those dry year lease agreements, in that they provide payment to the irrigator at a base rate but would require the temporary switch from surface to groundwater during a dry year to create the maximum amount of water instream during those low flow years. In addition to these lease agreements, The Nature Conservancy (TNC) has also done a significant amount of work to evaluate incentives for producers to switch from high water demand crop types, such as alfalfa, to low water demand crops. These "crop switching" agreements reduce the total consumptive water use on farm, and if valued appropriately, can potentially increase revenues for producers while also increasing instream flow.

d) Water Right Valuation and Transaction Costs:

While ultimately the value of a water right is exactly what the seller is willing to agree to, there are few methods for assessing accurate valuation estimates to inform negotiations, including; sales comparison, income capitalization, land differential and cost replacement. The sales comparison approach compares the subject water right with similar water resources that have been sold or leased to determine market value. Due to the unique nature of water rights one of the primary challenges to using this approach is identifying the appropriate adjustments that should be applied to account for differences in the physical and legal characteristics of the underlying rights such as their reliability and priority date. This method also requires a reasonable number of transactions to make accurate comparisons. While this is the preferred valuation methodology when there are sufficient transaction data available and may provide regional benchmarks for price entering into negotiations, due to the limited market activity the implementation of a traditional sales comparison approach in Texas can be particularly challenging.

The income capitalization approach estimates the value of a water source according to the contribution that water provides to the net income for a business. For example, water that a farmer is using to irrigate commodity crops would be compensated based on expectations of future revenue of the commodity. When applied to permanent transactions this valuation method can be complicated by speculative uses, such as future sales of water for municipal use.

However, this approach is often applied to short-term water leases to arrive at a capitalized value.

The land price differential approach is a hedonic price analysis which estimates the value of the subject water rights based on comparative values of property with water rights to property without water rights. This method uses the difference in the property's value with and without access to water to estimate the contribution that water availability provides to the overall sale price. Proper implementation of the approach is data and time-intensive and similar to sales comparison approach relies on an appropriate number of transactions for accurate results. The cost replacement approach is used when cost of developing alternative water supplies similar to that provided by the subject water resource can be used to establish value. This approach requires specific knowledge about the range of opportunities and costs associated with water supply development alternatives and require the analyst to consider the subject water right in context with the available alternatives.

In addition to the use of these methods to assign value there are other characteristics of the individual water right such as its priority date and reliability, location, designated use, and special conditions that must be considered. There are also deal characteristics such as the size of the transaction, regional water demands, and infrastructure for delivery that must be considered and will require adjustments to the unit price of water being transacted. For example, while a right that designates storage in a reservoir will provide more reliable water and generally have a greater value than a run-of-river based water right, the acquisition of a water right that authorizes an impoundment will require the reservoir be operated and maintained, which requires ongoing infrastructure expenditures that must be factored into the transaction.

Depending on the complexity of the transaction there will be varying costs associated with the transfer of the water right. Lease agreements that do not require a regulatory change in a water right will have low transaction costs, and permanent acquisitions that require more detailed appraisals, negotiation of pricing, changes or amendments to the permit etc., will require more legal review and associated transaction cost. Due to the lack of publicly available transaction data it may be necessary to have a formal appraisal of the water rights done in advance of the transaction. While rural land appraisers are certified to provide these services, depending on the scenario, it may be necessary to contract with a firm that specializes in water rights appraisals. Regardless of the transaction, before entering into negotiations or attempting seller outreach it is important to understand the underlying water rights, the type of seller and their motivations, and have an informed market perspective.

e) Permitting Processes:

The timing required for any permit amendments and the associated costs should be identified at the point of making an offer on a water right. Any letter of intent submitted for the purchase a water right should include provisions for executing due diligence. This may include; evaluating

ownership, regulatory review, and potentially even requiring the current owner to submit the amendment application for the change of use etc. to expedite the ability of the transaction to have immediate conservation value once transferred. For example, during the TEFI pilot TNC requested a 90 day due diligence period within which all potential sellers were required to submit applications to TCEQ to add instream use to the subject water rights to ensure that at time of transfer TNC would be able to put those rights to beneficial use as intended. While use additions are administrative in nature and have relatively short timelines for processing, permits which require moving diversion points, addition of bed and banks authorizations, or contemplate new appropriations of water can take months if not years to execute.

After determining the necessary permit amendments outreach to TCEQ for a pre-application meeting should be requested. These meetings with TCEQ staff provide an opportunity to ask specific questions about changes to the permit and receive a determination of feasibility and timelines for review and processing. Having these conversations in advance of making an offer can be useful in setting timelines for due diligence.

f) Monitoring & Operations:

Providing accountability to stakeholders, including funders, that are supporting EWTs as a flow restoration tool is essential to the continued success of the strategy. Quantifying and documenting the resulting changes in water management, including oversight of the agreement to ensure that implementation is carried out as agreed, and assessing the efficacy of the transaction in providing the desired ecological results are paramount.

The established western water transactions programs have all developed specific accounting framework that define metrics to measure progress based on their individual focal species and habitat. While individual projects may have different metrics, all monitoring and accounting frameworks should answer these primary questions: Are the terms of the agreement for the transaction being met? Can the increase in flow be accounted for instream? Are there flow-habitat changes that can be measured as a result of the transaction? What are the changes in the biological community as a result of the transaction? These questions can be evaluated and structured within an accounting framework. For example, the framework used in Oregon and Washington with the CBWTP includes multiple tiers including Contractual Compliance, Flow Accounting, Habitat Response, and Biological Communities (Figure. 2) (Aylward 2013).

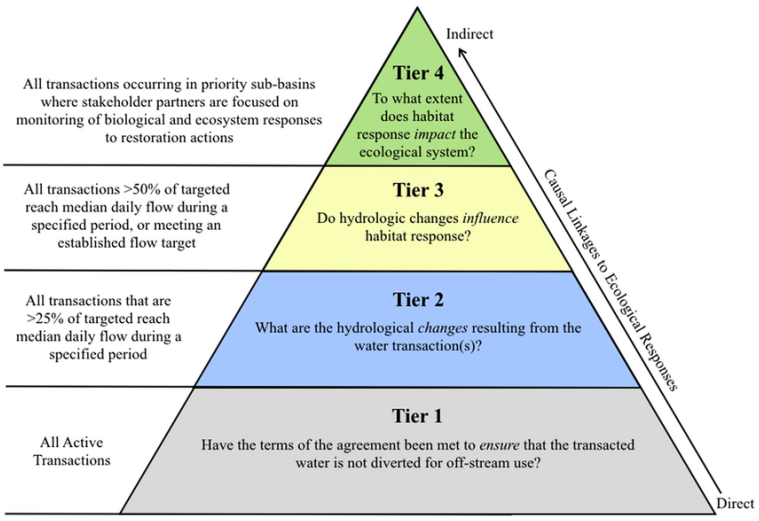

Figure 3: Flow Restoration Accounting Framework: Columbia Basin Transactions Program (CBWTP) (McCoy 2018).

In addition to accounting, in some cases an EWT requires that the water rights acquired be exercised in a specific way to deliver water and meet the intended conservation goals. To do this, the advanced development of an operations plan helps to set the framework and triggers for when and how those actions take place. Decision support tools based on factor such as hydrology and climate data, or other related variables, are often necessary to determine when the deliveries of fresh water are needed or when a forbearance option should be executed. Having these plans developed early in evaluation of the transactions not only helps to inform the negotiations but can also help to justify for funders that the transactions have been evaluated appropriately from a technical and scientific perspective.

For example, one of the transaction scenarios under the TEFI pilot focused on purchases of stored water and direct delivery of water into wetland and marsh environments during dry periods to mitigate elevated salinity levels. The operations plan developed under this transaction used the U.S. Drought Monitor drought forecasts, USGS streamflow gages, salinity sensors, and nearby precipitation gages to provide data for informing decision making. The proposed operations plan monitored for signs of developing drought conditions and identified specific thresholds for when onsite salinity monitoring would occur, and ultimately when the delivery of fresh water to the project site would be initiated and a call for targeted deliveries of water would be made.

Environmental water transactions begin with identification of conservation objectives and are completed with monitoring and assessment of the benefit provided through the change in water management. While this process can be challenging, DSTs such as EFIT can be used to assist in setting flow restoration targets, prioritizing water rights and can even evaluate the benefit of various transaction scenarios. While having a robust accounting framework provides clear methods for evaluating the benefit of individual transactions, a successful transaction is

always dependent on accurate understandings of the science, economics, and regulatory limitations of each deal.

IV. Building the Case, Capacity and Funding

a) Building the Case:

While there are only a handful of practitioners and organizations working to advance EWTs as a conservation strategy in Texas, the current impediment to bringing the strategy to scale is not necessarily capacity but normalization of the strategy among the conservation, resource, and funder communities. To bring the strategy to scale it is first necessary to build the case for EWTs by bringing forward meaningful transactions that provide tangible conservation benefits that can then be used as demonstrations of conservation successes and replicated across geographies. For example, during the TEFI pilot, the group applied for water transactions funding from the Gulf Environmental Benefit Fund (GEBF). The GEBF fund was created as a result of settlement agreements in response to the 2010 Deepwater Horizon explosion and oil spill. The agreements directed more than $2.5 billion to fund projects benefiting the natural resources of the Gulf Coast that were impacted by the spill. Feedback received from the resource agencies on proposed projects demonstrated the need to further refine the messaging and arguments being made for protection of inflow to benefit spill effected species. The initial and primary focus for TNC and other organizations focused on EWTs as a strategy should be first to engage and educate those that can enable EWTs at scale within the state including the resource agencies and funders.

b) Capacity:

Not unlike the land trust movement in Texas, once EWTs as a strategy has been demonstrated as a beneficial conservation practice, it will be necessary to expand the number of participating organizations and practitioners that are utilizing EWT to support their conservation goals and priorities. Regional land trusts and watershed groups have the benefit of established relationships with local landowners and stakeholders that can help to more rapidly identify and execute transactions. While these groups will be essential in identifying and cultivating the relationships necessary to execute the transactions, it will likely be necessary for groups such as TNC and others to play a role in the development and execution of the transactions, including monitoring and protection to ensure they are achieving the intended conservation outcomes.

TNC in partnership with other conservation organizations has already reached out to many of the Texas land trusts working on conservation easements and land transactions that also identify water resources as part of their conservation priorities. Initial discussions with these groups have primarily focused on evaluations of their current assets to determine whether water rights exist within their portfolios, and if so, identifying opportunities for amendments to those rights for instream use, and helping them to identify other opportunities for using EWTs

strategy to meet their conservation objectives. TNC has developed landowner outreach materials to assist in engagement with water right holders, and is facilitating presentations and workshops to expand outreach efforts to conservation groups interested in EWT as a conservation tool.

c) Funding Opportunities

Effectively expanding the use of EWTs as a tool in Texas will require long term and continuous funding. Much like land transactions, funds are necessary for acquisition and transaction support, including technical, administrative, and legal assistance necessary to evaluate, negotiate, and execute the transactions. In western states with relatively active water transactions programs, there have traditionally been four categories of funding including state and federal government, private/philanthropic foundations, mitigation funds, and private corporations (Aylward 2013).

Water transaction programs that have access to federal funds for ESA recovery such as the CBWTP through BPA have been successful at deploying up to $5.7 Million a year (CBWTP 2018) to projects that improve habitat for endangered fish species. While this is the most direct example of funds passed through for transactions, the NRCS through its Water Smart program provide funds for irrigation and infrastructure projects that reduce water use. Even federal funds developed for water protection, including those administered by the State's such as the Clean Water State Revolving Fund (CWSRF) administered by TWDB could potentially be used to fund land and water transactions that reduce water quality impairments. For example, Ohio as well as other states have implemented land acquisition strategies for water quality protection. In Texas, the CWSRF—which in 2018 will make as much as $525 million in available loan capital—has the potential to similarly amplify land and water protection. These funds could potentially be adapted for use in funding other water quality strategies, such as environmental flows transactions with landowners to keep water in stream, helping to dilute nonpoint source pollution and improve water quality impairments such as dissolved oxygen, temperature and total dissolved solids.

Mitigation funds are also viable sources of long-term funding for EWTs. In a response to settlements agreements between the U.S. Department of Justice and BP and Transocean for the 2010 Deep Water Horizon oil spill in the Gulf of Mexico, BP agreed to pay $2.394 billion and Transocean agreed to pay $150 million in criminal penalties to the National Fish and Wildlife Foundation (NFWF). To distribute those funds NFWF established the GEBF to provide restoration funding for the five Gulf States, including $203 million for restoration projects in Texas. Though the 5-year cycle of the fund has expired as of 2018, there is still approximately $30 million remaining for projects in Texas. In addition to GEBF funds, BP has also worked with the trustee agencies to develop a $1 Billion-dollar Natural Resource Damage Assessment (NRDA) fund of which Texas will receive $238 Million. One of the challenges of sourcing these mitigation funds has been the requirements for proving permanent uplift to the spill effected species. During the TEFI pilot, the group met with the GEBF Trustee Agencies to discuss the

EWT strategy as it related to these funds, while significant progress was made in socializing the strategy among those decision makers and the scientist evaluating projects for funding, it is still clear there is work to do in framing water transactions and their relative ecological benefit so that they are not compared directly to land acquisition.

While philanthropic giving has been essential in the development of these strategies especially in Texas with over 2.5 million invested in the TEFI alone, long term giving to support transactions programs will not be adequate to bring the strategy to scale. However, there are a number of opportunities to engage with beverage companies and other corporations that have sustainability or corporate responsibility goals to reduce or offset water use. These funders will often support "replenishment projects" that serve as a gallon to gallon offset, or acre-ft of water right protected credits them with an acre-ft offset. However, in those relationships it is often important to have a portfolio of projects ready for funding to help facilitate funds quickly from corporate partners to on the ground projects and measurable conservation benefits. This is often a challenge as it is always risky to begin discussions with water right holders about lease agreements or permanent acquisition in advance of secure funding.

One of the current challenges within philanthropy is figuring out how to increase private investment in environmental and social causes or "impact investing". Impact investing is a relatively new and innovative strategy that includes philanthropic program related investments in mission related projects such as sustainable water management. TNC has been working in Texas on the development of an impact investing project that includes agricultural land investment, water efficiency upgrades, and crop conversion. This effort would deploy private capital to finance improvements in agricultural water use, resulting in water savings and modernized farming operations. These improvements could involve conversion to higher-value or lower-water-use crops, with water savings reallocated to other needs, including the environment. This project would both prove the effectiveness of on-farm improvements to benefit streamflow in water scarce regions of Texas, as well as prove the benefits and potential of advancing impact investing to unlock more funding resources to meet conservation goals.

While it is necessary to expand the number of practitioners capable of executing transactions to increase the effectiveness of EWT as a flow restoration tool, normalization of the strategy among the conservation, resource, and funder communities is the beginning of the process. There are multiple long-term funding sources that can be utilized for EWT though it is vital in the near term to execute transactions that prove the conservation benefit of EWT to unlock those funds and expand the recognition of the conservation strategy.

IV. Conclusion

With one of the fastest growing populations in the nation putting increasing pressure on Texas's already fully allocated rivers and streams, there is a clear need for the development of strategies that can meet the needs of both people and the environment. Mechanisms such as

environmental water transactions have proven an effective strategy for meeting flow protection and restoration goals in other western states for decades. With a clearly defined water rights system, scarcity of water resources, regulatory oversight of tradable entitlements, and a functional cap on future allocations, Texas meets all the enabling conditions for healthy functioning water markets. Although a nascent strategy in Texas, the use of EWTs to meet flow protection and restoration goals in the state appears a viable one. Although there are challenges in the development of any new strategy in a state as large as Texas, the primary limitations to the expansion of EWTs currently include potential regulatory limitations in the protection of instream use under priority calls, the lack of institutional capacity for developing transactions, and the need to identify long-term sustainable funding sources for transactions.

TEFI's pilot utilized the academic and institutional expertise of its member groups to make significant progress towards the use of EWTs as a viable tool for restoring freshwater flows in Texas. While the lack of a completed transaction prevented the group from testing the regulatory framework for instream protection, the group did make significant advances in the science and tools necessary for prioritizing and identifying ecological benefits. Further, work by the group socialized the strategy in the regulatory community, created an interest from the broader conservation community, and created opportunities to secure future funding including corporate, private investment, mitigation, and philanthropic dollars, in addition to federal and state funds.

In order to build on the advances made by TEFI and to fully demonstrate the potential value of EWTs there is a critical need to develop representative transactions and expand the knowledge gained through the pilot to other practitioners. TNC is currently working on a number of transactions at different stages of development and anticipates that these initial transactions will both provide a test of the regulatory structure and increase awareness of the EWTs as a conservation tool within the non-profit and land trust community. To expand capacity of the number of organizations and practitioners working on EWTs, in the near future, this research, and materials developed by the TEFI, will be developed into communication and outreach materials and a number of regional workshops will be held across the state to continue socializing and expanding the strategy to potential transactors. These efforts are the essential next steps towards advancing EWTs to address the water scarcity challenge facing Texas in the 21st century.

ACRONYMS

BAP	Bonneville Power Administration
CBWTP	Columbia Water Transactions Program
CWSRF	Clean Water State Revolving Fund
DU	Ducks Unlimited
EA	Edwards Aquifer
EWTs	Environmental Water Transactions
GEBF	Gulf Environmental Benefit Fund
HRI	Harte Research Institute
NFWF	National Fish and Wildlife Foundation
NRCS	Natural Resource Conservation Service
NRDA	Natural Resource Damage Assessment
NWF	National Wildlife Federation
OWT	Oregon Water Trust
TCEQ	Texas Commission on Environmental Quality
TEFI	Texas Environmental Flows Initiative
TNC	The Nature Conservancy
TPWD	Texas Parks & Wildlife Department
TWC	Texas Water Code
TWDB	Texas Water Development Board
USGS	United States Geological Survey
WWAP	Washington Water Acquisition Program
WWT	Washington Water Trust

References:

11 Tex. Admin. Code §295

11 Tex. Admin. Code §297.1

Arthington, Angela H. 2012. Environmental Flows: Saving Rivers in the Third Millennium. Freshwater Ecology Series 4. Berkeley: University of California Press.

Aylward, Bruce "Measuring Cost-Effectiveness of Environmental Water Transactions, Bend, OR: Ecosystem Economics" 2017

Aylward, Bruce. Aylward "Environmental Water Transactions: A Practitioner's Handbook. Bend, OR: Ecosystem Economics" 2013

Burke, Susan M., Richard M. Adams, and Wesley W. Wallender. 2004. "Water Banks and Environmental Water Demands: Case of the Klamath Project" Water Resources Research 40 (9). https://doi.org/10.1029/2003WR002832.

Canadian Electronic Library (CEL). 2017. The Global Risks Report 2017. http://www.deslibris.ca/ID/10090180.

Colorado Water Conservation Board (CWCB). n.d. Accessed December 10, 2018. http://cwcb.state.co.us/environment/instream-flow-program/Pages/main.aspx.

Combs, Susan, Texas Comptroller of Public Accounts "Texas Water Report: Going Deeper for the Solution." 2014, Publication# 96-1746

Debaere, Peter, Brian D. Richter, Kyle Frankel Davis, Melissa S. Duvall, Jessica Ann Gephart, Clark E. O'Bannon, Carolyn Pelnik, Emily Maynard Powell, and Tyler William Smith. 2014. "Water Markets as a Response to Scarcity." Water Policy 16 (4): 625-49. https://doi.org/10.2166/wp.2014.165.

Debaere, Peter, Li Tianshu, "The Effects of Water Markets: Evidence from the Rio Grande" Draft 2016

Department of the Interior, Office of the Inspector General: Final Report -Audit of the Bureau of Reclamation's Klamath Basin Water User Mitigation Program Report No. 2015-WR-080. 2018

Deschutes River Conservancy | Streamflow Restoration in Central Oregon. n.d. Accessed December 10, 2018. https://www.deschutesriver.org/

Jarvis, Glen "Historical Development of Texas Surface Water Law", in Essentials of Texas Water Resources ch. 4 (Mary K. Sahs ed., 5th ed. 2018)

Kelly, Mary E. "A Powerful Thirst: Water Marketing in Texas". 2004

Kelly, Mary E. "Water for the Environment: Updating Texas Water Law,". 2012

Kendy, Eloise, Bruce Aylward, Laura S. Ziemer, Brian D. Richter, Bonnie G. Colby, Theodore E. Grantham, Leslie Sanchez, et al. 2018. "Water Transactions for Streamflow Restoration, Water Supply Reliability, and Rural Economic Vitality in the Western United States." JAWRA Journal of the American Water Resources Association 54 (2): 487-504. https://doi.org/10.1111/1752-1688.12619.

Landry et al., "An Analysis of Water Banks for the Western States" 2004

Lovrich, Nicholas P. n.d. "Of Water and Trust: A Review of the Washington Water Acquisition Program," 38.

Malloch, Steven "Liquid Assets: Protecting and Restoring the West's Rivers and Wetlands through Environmental Water Transactions". Arlington, VA: Trout Unlimited, Inc. TU. 2015

McCarthy, Edmond, Sherman, Lynn Ray, Seal, Derek “Surface Water Rights Transactions”, in Essentials of Texas Water Resources ch.15 (Mary K. Sahs ed., 5th ed. 2018)

McCoy, Amy L., S. Rankin Holmes, and Brett A. Boisjolie. 2018. "Flow Restoration in the Columbia River Basin: An Evaluation of a Flow Restoration Accounting Framework." Environmental Management 61 (3): 506-19. https://doi.org/10.1007/s00267-017-0926-0.

Merriman, Dan, Anne M. Janicki, Colorado's Instream Flow Program: How it Works and Why It's Good for Colorado" 2005

Neuman, Janet, "The Good, The Bad, and The Ugly: The First Ten Years of the Oregon Water Trust" 83 Neb. L. Rev. 2004

National Fish and Wildlife Foundation, and Bonneville Power Administration (BPA), Portland, OR. 2017. "Columbia Basin Water Transactions Program; National Fish and Wildlife Foundation, Annual Report 2017."

Poff, Leroy N., Brian D. Richter, J. David Allan, James R. Karr, Julie C. Stromberg, Karen L. Prestegaard, Mark B. Bain and Richard E. Sparks. 1997. "The Natural Flow Regime." BioScience 47 (11): 769-84. https://doi.org/10.2307/1313099.

Richter, B.D., D Abell, E Bacha, K Brauman, S Calos, A Cohn, C Disla, S Friedlander O'Brien, D Hodges, S Kaiser, M Loughran, C Mestre, M Reardon, and E Siegfried. 2013. Tapped out: how can cities secure their water future? Water Policy 15 (2013) 335-363.

Richter, Brian D. 2014. Chasing Water: A Guide for Moving from Scarcity to Sustainability. Washington?: Covelo?: London: Island Press. Richter, 2016

Richter, Brian D., James D. Brown, Rachel DiBenedetto, Adrianna Gorsky, Emily Keenan, Chantal Madray, Martha Morris, Devin Rowell, and Susan Ryu. 2017. "Opportunities for Saving and Reallocating Agricultural Water to Alleviate Water Scarcity." Water Policy 19 (5): 886-907. https://doi.org/10.2166/wp.2017.143.

Roach, Katherine A. 2013. "Texas Water Wars: How Politics and Scientific Uncertainty Influence Environmental Flow Decision-Making in the Lone Star State." Biodiversity and Conservation 22 (3): 545-65. https://doi.org/10.1007/s10531-013-0443-2.

Runkle, J., K. Kunkel, J. Nielsen-Gammon, R. Frankson, S. Champion, B. Stewart, L. Romolo, and W. Sweet, 2017: Texas State Climate Summary. NOAA Technical Report NESDIS 149-TX, 4 pp. http://stateclimatesummaries.globalchange.gov

S.B. 1639, 82 Leg. (2002) (enacted)

Sansom, Andrew, Emily R. Armitano, and Tom Wassenich. 2008. Water in Texas: An Introduction. 1st ed. Texas Natural History Guides. Austin: University of Texas Press.

S.B. 1374, 82 Leg. (2002) (enacted)

Szeptycki, Leon F.; Forgie, Julia; Hook, Elizabeth; Lorick, Kori; and Womble, Philip, "Environmental Water Rights Transfers: A Review of State Laws" (2015). All In-Stream Flows Material. Paper 3.

Tex. Water Code Ann. §11.021 (Vernon 1997).

Tex. Water Code Ann. §11.023 (Vernon 1997).

Tex. Water Code Ann. §11.024 (Vernon 1997).

Tex. Water Code Ann. §16.059 (Vernon 1997).

Texas House of Representatives: Interim Charges 85th Legislature. 2015

Texas Instream Flow Program | Texas Water Development Board. n.d. Accessed December 10, 2018. http://www.twdb.texas.gov/surfacewater/flows/instream/index.asp.

Texas Instream Flow Studies: Technical Overview. [Austin, Tex.: Texas Water Development Board, 2008] Web.. https://lccn.loc.gov/2008412266.

Texas Water Development Board. 2016. Water for Texas: 2017 State Water Plan. http://www.twdb.texas.gov/waterplanning/swp/2017/index.asp (Accessed January 26, 2018)

Texas Water Development Board. 2003. A Texan's Guide to Water & Water Rights Marketing. Texas Water Development Board

Walsh, Stephen J., Howard L. Jelks, and Noel M. Burkhead. 2009. "The Decline of North American Freshwater Fishes." Action Bioscience.http://pubs.er.usgs.gov/publication/70003605.

Washington State Department of Ecology - Water Acquisition. n.d. Accessed December 10, 2018. https://ecology.wa.gov/Water-Shorelines/Water-supply/Water-rights/Trust-water-rights/Water-acquisition.

Water Rights: Permits - TCEQ - Www.Tceq.Texas.Gov. n.d. Accessed December 10, 2018. https://www.tceq.texas.gov/permitting/water_rights/wr-permitting.

“Washington Water Trust.” n.d. Accessed December 10, 2018. http://www.washingtonwatertrust.org/home.

Wells, Hope, Bradsby, Colette “Environmental Flows” in Essentials of Texas Water Resources ch. 11 (Mary K. Sahs ed., 5th ed. 2018)

WestWater Research | Market Insight. n.d. Accessed December 10, 2018. http://www.waterexchange.com/market-insight