HUNTING FOR WATER: COMMUNITY WATER TRUST FEASIBILITY IN THE LLANO RIVER BASIN

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Executive Summary

Water scarcity is an increasingly urgent issue around the globe with consequences that impact our most vital natural, social, and economic systems. In the Colorado River basin of Texas, prolonged droughts, over-allocation of surface water, ineffective groundwater management, and increasing municipal water use have contributed to an intensification of regional water scarcity and the subsequent depletion of critical river flows.

As a solution to water scarcity in Texas, The Nature Conservancy is proposing a community water trust (CWT) as a market-based strategy for restoring river health and creating a more sustainable water management system. The overarching purpose of a CWT is to out-right purchase and secure, via investments in water saving strategies, a pool of water-use rights. These acquired water rights can subsequently be re-allocated to serve public benefits and be strategically deployed to promote beneficial water sharing arrangements that ensure the needs of ecosystem values.

In order to evaluate the feasibility of this plan, The Nature Conservancy has partnered with four graduate students in the Department of Urban and Environmental Planning at the University of Virginia School of Architecture to conduct an initial assessment. The study described in this report serves to synthesize and summarize regional water use data, prioritize water rights for acquisition, and gather initial feedback from key project stakeholders.

While the ultimate goal of the investigation phase of the development of the CWT is to assess water use and prioritize water rights for the entire Colorado River Basin, this study used Kimble County in the Llano River basin, a sub-basin of the Colorado River basin, as a case study for developing a replicable methodology for data collection, water right characterization, prioritization, and identification of opportunities for water savings.

Project deliverables for this study include a detailed methodology for data collection, a characterization of water right typologies, recommendations for water saving strategies, a list of priority water rights, and an initial assessment of regional stakeholders and project partners.

Background

Introduction

This report and associated deliverables represent a collaboration between graduate students in the Department of Urban and Environmental Planning at the University of Virginia School of Architecture and The Nature Conservancy's Global Water Program. As part of a Spring 2016 PLAN 6010: Planning Process and Practice (Capstone) course, an independent student planning team comprised of four graduate students worked with staff from The Nature Conservancy to support the development of a community water trust in the Colorado River basin of Texas.

Problem Statement: Water Scarcity in Texas

Water is an increasingly scarce and contentious resource in Texas. Prolonged droughts, over-allocation of surface water, ineffective groundwater management, and rapid population growth are contributing to water scarcity throughout Texas. This problem is exemplified in the Colorado River basin in Central Texas (Figure 1). Forming in the arid western portion of the state, the Colorado River flows 862 miles southeast through the Hill Country, past the state capitol of Austin, and into the Gulf of Mexico. The Colorado River and its tributaries form a watershed of almost 40,000 square miles, approximately 15 percent of the total land area of Texas.

Throughout its course, the Colorado River is diverted, stored, and used for municipal, agricultural, and industrial purposes. The consumptive nature of the water use results in a severely depleted and altered river flow regime. Tributaries run dry on an increasingly regular basis, minimum flow standards set by the State of Texas are not met, and freshwater inflows into the river's estuary are drastically reduced. Beyond simply reducing the amount of water available for downstream users, depleted flows stress freshwater aquatic life, reduce ecosystem productivity, diminish recreational opportunities, and threaten entire economies dependent on a healthy river.

Exacerbating water scarcity in the Colorado River basin are rapidly growing urban communities and the drought-prone nature of the basin. The Austin metro area is consistently ranked among the fastest growing areas of the country and will require additional water for municipal and industrial users. The most recent drought of 2008-

2015 has served a vivid reminder of the vulnerability of the river. As temperature and precipitation patterns change in response to a warming climate, the risk posed by droughts will only increase.

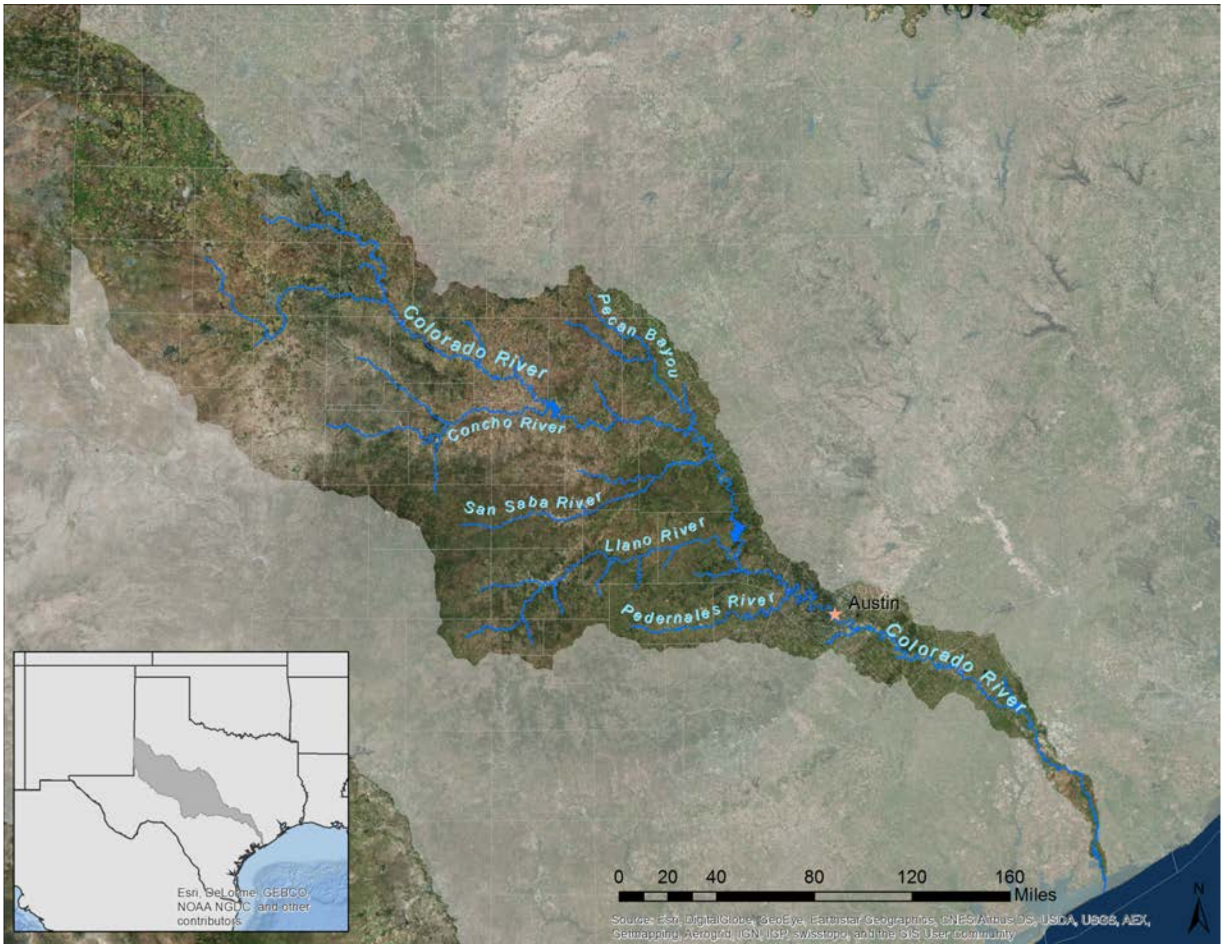


Figure 1. The Colorado River basin of Central Texas.

Proposing a Solution: What is a Community Water Trust?

Traditional water trusts have been in existence for many years. Similar to land trusts, they acquire water through philanthropic donations primarily for the purpose of fulfilling environmental objectives. A community water trust (CWT) (Figure 2) expands upon this scope by using investment capital to acquire a larger portfolio of water rights and reallocating those rights to support a variety of public interests, such as ensuring the needs of the ecosystem and underserved communities are better met, and providing water to other water-use sectors such as municipal and industrial users in need of additional water supplies. An innovative feature of the CWT is the use of impact investment funds, a type of investment where beneficial social or environmental returns are included with financial returns. The funds provide the necessary capital for the CWT to acquire water rights through a variety of mechanisms including fee simple purchase, investing in municipal water infrastructure enhancements, or implementing water conservation measures in agricultural production. Acquired water is returned to the river system or offered for sale or lease to downstream users, generating environmental and financial returns for investors. At its core, the CWT seeks to create a robust water rights trading system that allocates what limited water is available more efficiently and balances economic, environmental, and social values necessary to responsibly manage water.

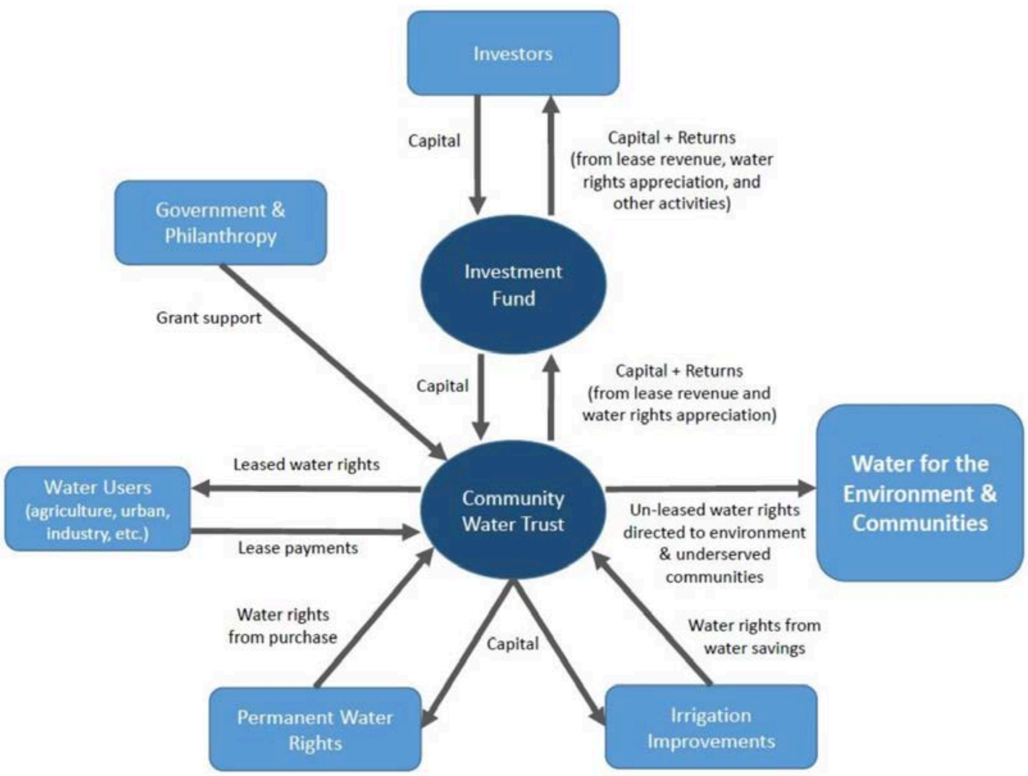


Figure 2. Community Water Trust Schematic.

Benefits of a Community Water Trust:

1. **Environmental Flow Restoration**

As previously explained, a CWT seeks to acquire a portfolio of water rights in order to reallocate water in support of a variety of public interests, such as ensuring the needs of the ecosystem. One such environmental imperative is the need to restore adequate stream flow. Texas Senate Bill 3 (SB3) establishes environmental flow standards for rivers across Texas. These standards set minimum flow regimes that support a sound ecological environment. In the Colorado River basin, there are 15 existing USGS river gauges that have SB3 environmental flow standards set. When comparing environmental flow standards to measured flow at these gauges, the degradation of the river becomes readily apparent. Looking back 20 years, river flows at all 15 gauges failed to meet the standards at some point during most years, and often several times throughout the year. The flow deficit is greatest in the upper reaches of the Colorado River and its tributaries and during drier summer months (Figures 3 and 4). As such, the CWT will focus on restoring river flows in these areas first as a way of prioritizing water rights acquisition.

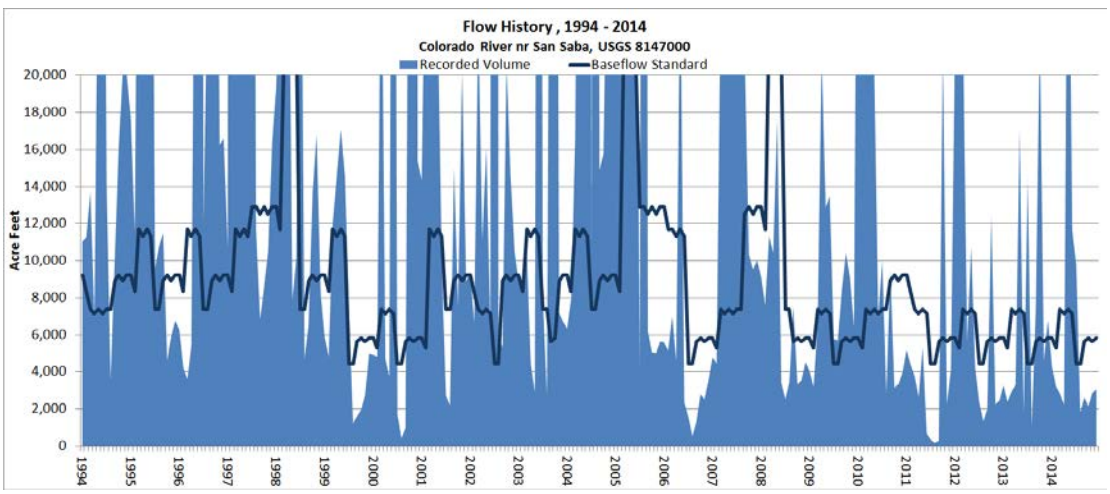


Figure 3. Flow history of the Colorado River near its confluence with the San Saba River.

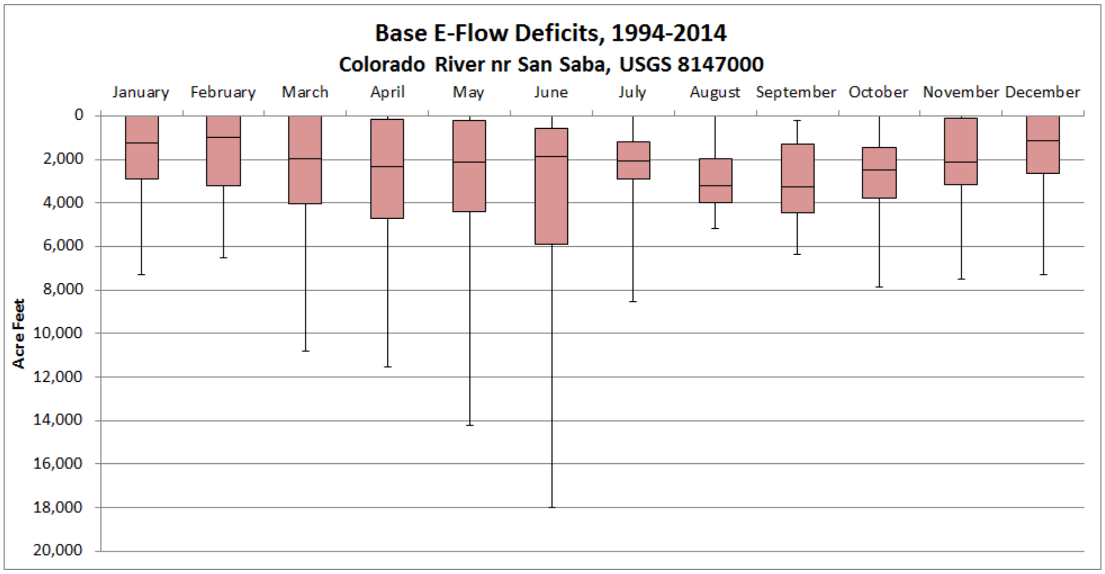


Figure 4. Average flow deficits on the Colorado River near its confluence with the San Saba River.

2. Meeting Downstream Water Demands

By increasing river flows, the CWT also makes more water available for downstream users. Municipal water use is growing in the Colorado River basin (Figure 5). The city of Austin, for example, can purchase or lease water from the CWT's portfolio of acquired water rights to meet their growing demands, while also providing a mechanism of generating returns to investors and ensuring the CWT remains solvent. Making use of the existing storage reservoirs along the Colorado River, known as the Highland Lakes, allows for increased flows that help meet environmental and social goals to be captured and stored downstream for use by willing buyers. In an area of Texas where water rights trading is virtually non-existent, the CWT provides a mechanism for increased trading and a valuable alternative for water use sectors to increase supplies without investing in expensive and contentious new water infrastructure.

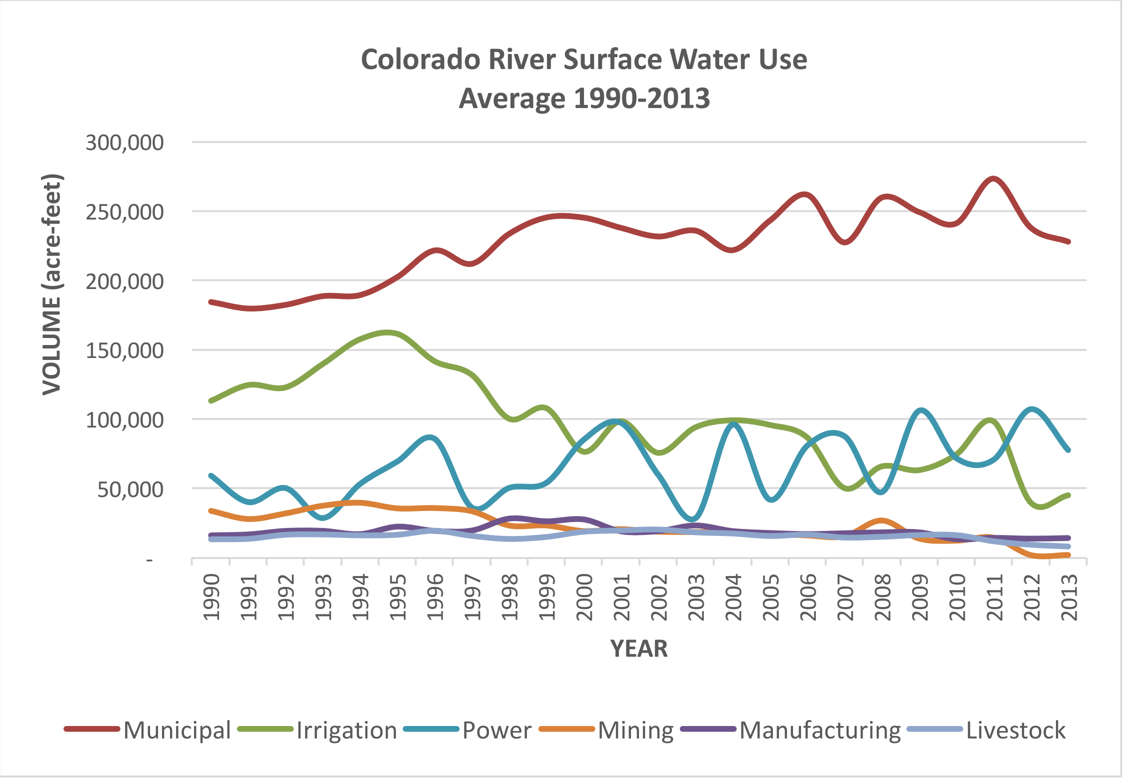


Figure 5. Colorado River surface water use by sector, 1990 – 2013.

3. Supporting Underserved Communities

A variety of social outcomes can be achieved by a community water trust. Poor and marginalized families in the Colorado River basin are impacted by declines in natural resources such as fisheries by losing an important part of their food security or jobs in the commercial fishing industry. At its terminus, the Colorado River flows into Matagorda Bay. Freshwater flows into this once thriving estuary are repeatedly dropping below levels that have been defined by scientists as being necessary to protect the its health. As a result, fishermen have reported fewer crabs and fish and oyster harvesting has repeatedly been shut down. Thousands of people participate in the fishing industry around the Bay, many of whom are living below the poverty level (e.g., Matagorda County has a poverty rate of 21%). By improving freshwater inflows into the Bay, the CWT can help restore the estuary and associated industries.

Water Acquisition

The CWT model has successfully been applied in the Murray-Darling basin of Australia, the country's largest watershed. As the first application of a CWT, the Murray-Darling experience provides invaluable insights into how a CWT can and should function. However, there are significant differences between Australia and Texas, not the least of which is the fact Australia already has a robust water market in place, allowing the CWT to easily purchase water rights through the market and build its portfolio. In contrast, the Colorado River basin has little to no water rights trading and, as a result, the CWT must acquire water through other means.

Irrigation is the second largest use of Colorado River water behind municipal but represents the greatest potential for water savings. Existing agricultural operations in the basin present significant opportunities for irrigation efficiency improvements and transitioning to less water intensive crop types. By partnering with ranchers and other landowners to implement water conservation measures and reduce the volume of water being consumed for agriculture, the CWT can effectively acquire saved water for its portfolio. However, it is important to note that by implementing water conservation measures, agricultural output will be maintained or enhanced in order to maintain rural economies.

Study Area

The Upper Colorado River basin was selected for initial water rights acquisition for multiple reasons: a number of aquatic species in the area have been impacted by depleted river flows; and the Highland Lakes offer water storage potential that can be used to transfer water to cities or to release increased freshwater inflows into the downstream estuary. Five main tributaries flow into the Upper Colorado River: the Concho, San Saba, Llano, and Pedernales rivers and the Pecan Bayou. In consultation with The Nature Conservancy, the planning team selected the Llano River as the study area for the following reasons:

- The presence of an SB3 gauge and chronic failures of meeting defined environmental flow standards.
- Demonstrated need for flow restoration to maintain key species, such as the Guadalupe Bass (*Micropterus treculii*).

- An abundance of irrigation water rights located in the upper extent of the Llano River sub-basin.
- The water storage potential of offered by Lake Lyndon B. Johnson, one of the Highland Lakes, located at the mouth of the river.

After selecting the Llano River sub-basin as the study area, it became readily apparent that Kimble County, located at the headwaters of the Llano, should be the primary focus of our analysis (Figure 6). Farms and ranches cover over 75% of the land area of Kimble County, making agriculture the largest sector of the local economy by far. The county also has a concentration of senior irrigation water rights that represent the greatest potential for flow restoration and reallocation.

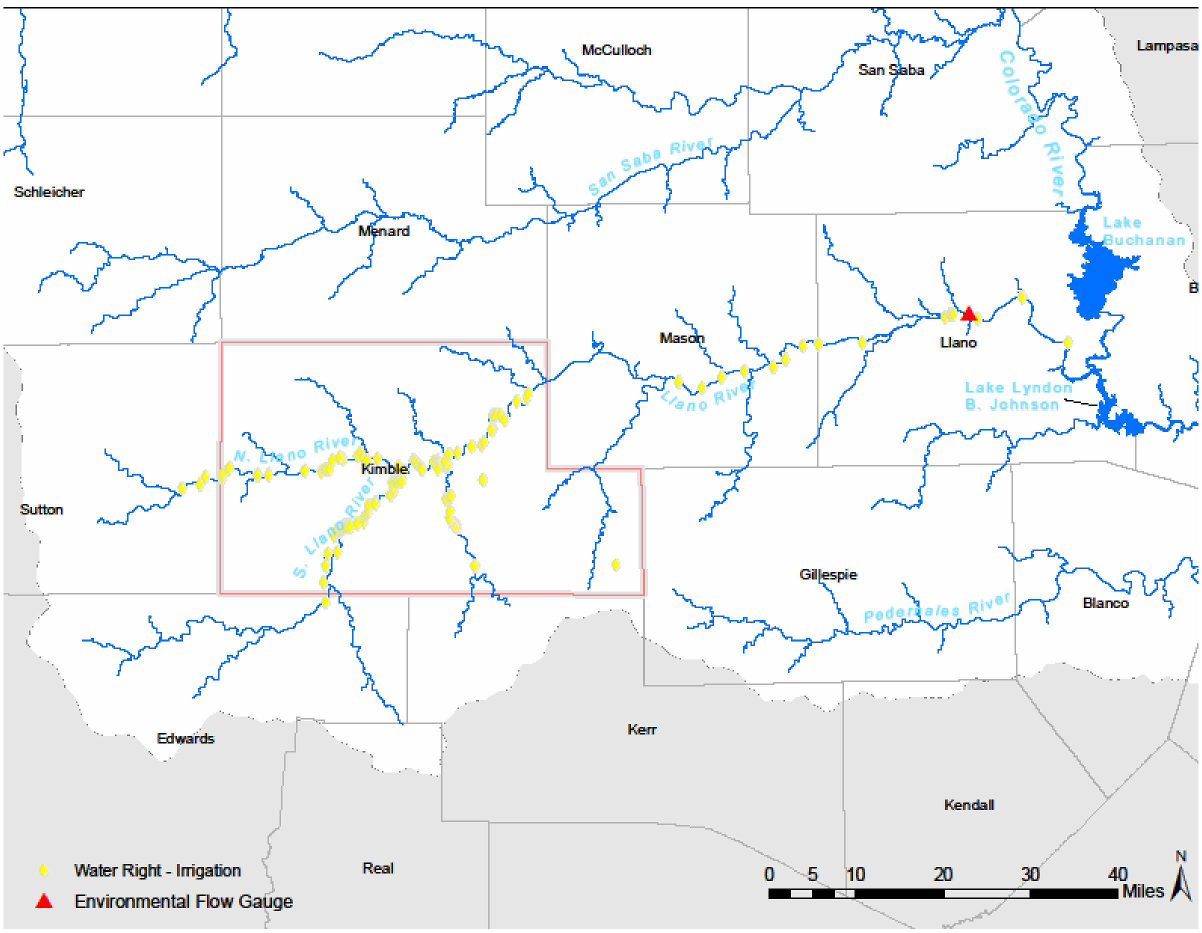


Figure 6. Study Area: The Llano River sub-basin and Kimble County

Project Framework

This study was designed to assess agricultural water use in the Llano River sub-basin and to explore the feasibility of implementing a community water trust (CWT) in Texas using Kimble County as a case study. The following goal statement and project tasks were co-developed by the planning team and The Nature Conservancy staff and were carried out over the course of the Spring 2016 semester (January – May):

GOAL STATEMENT

The goal of this study is to identify and prioritize irrigation water rights and associated properties where water saving strategies could secure water for a community water trust.

KEY PROJECT TASKS

1. **Develop Methodology for Data Collection**

Understanding water use patterns is a critical first step to establishing a functioning water market in Texas. Consequently, the first goal of this project was to develop a thorough methodology for building a water rights database and characterizing associated agricultural properties. The development of this methodology is critical to the replicability of these efforts across the Colorado River basin. Eventually, The Nature Conservancy hopes to build a comprehensive database for the upper Colorado River basin as a means of further understanding water use patterns and identifying water rights for acquisition and water conservation efforts.

2. **Build Water Rights Database**

The methodology was used to build the Water Rights Database, which represents the combination of multiple data sources that characterize water right use, ownership, and associated land uses. The database is spatially linked to water right point of diversion (POD) locations along the river. This database will later be used by The Nature Conservancy to identify priority water rights for acquisition or water conservation efforts.

3. Conduct Field Verification

Many data sources used to complete the water rights database leave unanswered questions about water and land use. For example, the team relied largely on aerial imagery to define irrigation type for each water right. Field visits were conducted to identify any inaccuracies in the water rights database, verify information garnered from digital data sources, and document observed property characteristics.

4. Categorize Water Right Typologies

In order to further organize water rights and recommend implementation strategies, the team used the water rights database and field observations to categorize water rights into typologies based on water use. Creating these typologies helps to further characterize water use in the region and creates a framework for providing implementation recommendations.

5. Provide Water Saving Strategies

Using research gathered by an independent research group at the University of Virginia, a suite of water saving strategies was provided for each water use typology. Recommendations include typology-specific water conservation methods with associated costs, water savings, ease of implementation, and reliability of research grounding each recommendation.

6. Prioritize Water Rights

Using information gathered both from online data sources and from field visits, water rights in Kimble County were prioritized based on permitted volume, priority year, and irrigated area on associated properties. A ranking system was used to create a final list of priority water rights. The top six water rights and their associated properties are included in this report. A full ranking is available in the water right database produced for this study.

7. Conduct Stakeholder Assessment

The Colorado River Basin is home to a wide range of water users. From agricultural, municipal, and industrial users to the flora and fauna that rely on the river's flow for survival, water is a shared resource between stakeholders with a wide range of interests. In order to develop a politically viable water market, it will be critical to engage and include stakeholders in the planning process. While larger engagement efforts will occur as the community water trust undergoes further development, the initial stages of community engagement will include an assessment of stakeholders and initial outreach to potential project partners. This will allow The Nature Conservancy to gather feedback on the feasibility of the CWT from trusted contacts and partners. The planning team conducted the initial stakeholder assessment and participated in initial stakeholder meetings during a trip to Texas in March 2016.

Database Methodology

The following is a methodology for compiling water right and land data for the development of the comprehensive water rights database. This methodology is specific to water rights and land in Kimble County, Texas, but can be replicated to characterize water rights throughout the Colorado River basin.

Water Right Information

Initial data for each irrigation water right was acquired from the Texas Commission on Environmental Quality (TCEQ). This data was formatted into an Excel workbook and includes columns giving Object ID, water right number, TCEQ database number, water right type, water right sequence, water right issue date, amendment letter, water right owner name, water right owner type code, diversion amount in acre feet (AF), water right use code, priority date, acreage, basin code, river order number, stream name, alternative stream name, latitude, longitude, remarks, and a link to a digital copy of the water right's certificate of adjudication (COA). An initial filtering of the data showed a significant number of water rights below 50 AF, which were determined to be too small to significantly influence river flow regimes. This cutoff reduced the amount of water rights in the database from 181 to 38.

The COA for each water right was then reviewed in detail. COAs are issued by TCEQ in order to adjudicate claims to surface water and contain all pertinent information to an individual water right. This data was captured and recorded in the database, including the number of owners, number and location of points of diversion, flow rate of withdrawal in cubic feet per second (cfs), permitted applied volume, permitted storage volume, and required return flow. The COA is a scanned PDF document usually no longer than three pages, but can be much longer if it has been altered significantly since the original issue date. An important section of the COA is entitled "Diversion" and is where the points of diversion are listed and the maximum combined rate (flow rate) is listed (Figure 7).

2. DIVERSION

A. Location:
(1) At a point on the west bank of Johnson Fork Creek which is S 87°E, 1225 feet from the northwest corner of the B.B.B. & C. R.R. Co. Survey 669, Abstract 42, Kimble County, Texas.

(2) At a point on the west bank of Johnson Fork Creek which is N 63°E, 1980 feet from the southwest corner of the B.B.B. & C. R.R. Co. Survey 668, Abstract 44, Kimble County, Texas.

(3) At a point on the west bank of Johnson Fork Creek which is N 01°30'W, 3595 feet from the southwest corner of the B.B.B. & C. R.R. Co. Survey 668, Abstract 44, Kimble County, Texas.

B. Maximum Combined Rate: 2.01 cfs (900 gpm).

Figure 7. Example of diversion and flow rate shown in a Certificate of Adjudication (COA).

Land Information

In addition to detailed information about the water right itself, the key aspect of the database is associating the water right with the land in which it is being used. Land data needs included: parcel ID, number of parcels, physical address, total parcel area, parcel owner, number of parcel owners, type of parcel owner, total parcel value, crop type, production value, irrigation method, irrigation source, irrigation area, and number of wells on each parcel. To gather this information, we utilized three sources – Water Sage, property records, and Google Earth.

Water Sage: Water Sage is an online platform with water right, parcel, and well data for the entire state of Texas. Water Sage spatially maps water right and parcel data, but it does not link the two. In order to accomplish this, we searched for the water right using its assigned number (e.g., 1583). Water Sage will locate the point(s) of diversion (POD) on a map with aerial imagery (see Figure 8). Next, using the "Area Search" tool, we drew a box around the POD to search for adjacent land parcels and groundwater wells (Figure 9). Parcels that were in proximity to the POD of the water right, owned by the same person or organization, and appeared to contain agricultural fields (based on aerial imagery) were identified and Parcel ID recorded in the database (Figure 10). In some cases, all land parcels in proximity to the POD were under different ownership than the water right. In this circumstance, we examined nearby water rights and agricultural operations evident through aerial imagery to make reasonable assumptions on which parcels the water right was being used, if at all. Next, we searched for land parcels by using water right owner information to identify any other parcels that may have been overlooked. The presence of groundwater wells on any of the identified parcels was also recorded in the database.

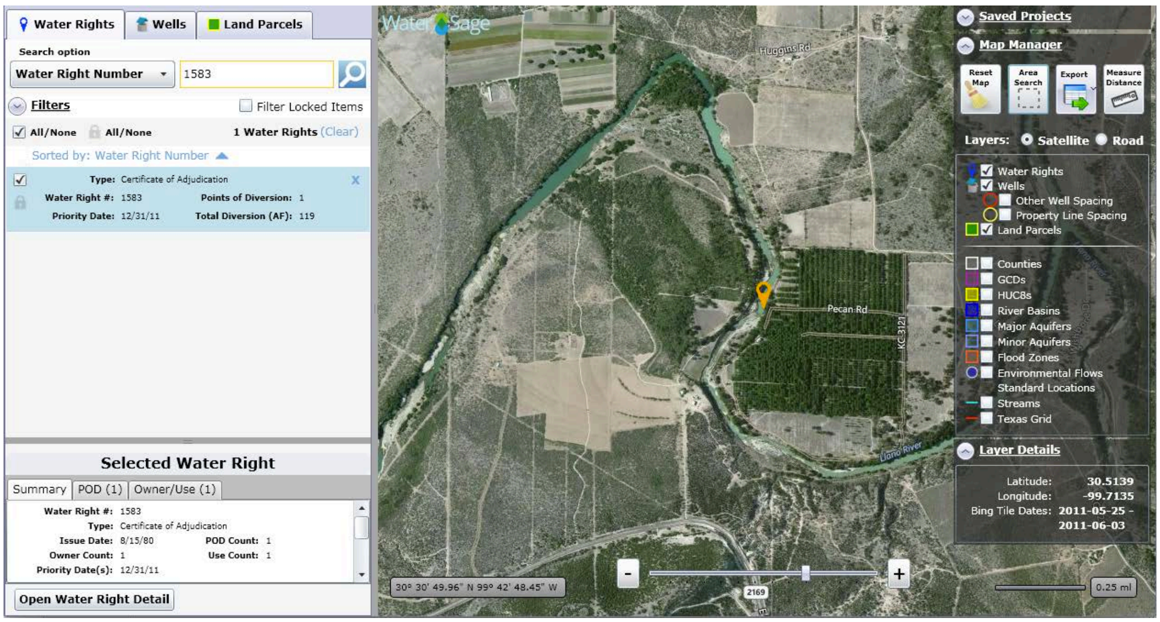


Figure 8. An example of a water right search shown on the Water Sage interface.

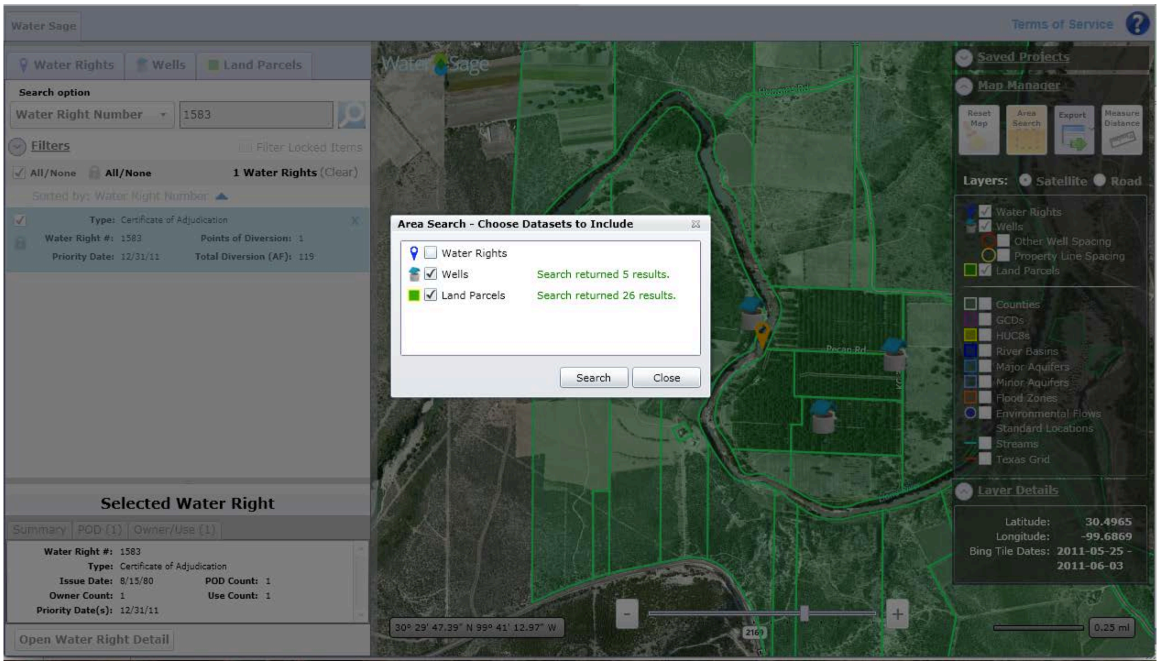


Figure 9. An example search for adjacent properties and wells in Water Sage.

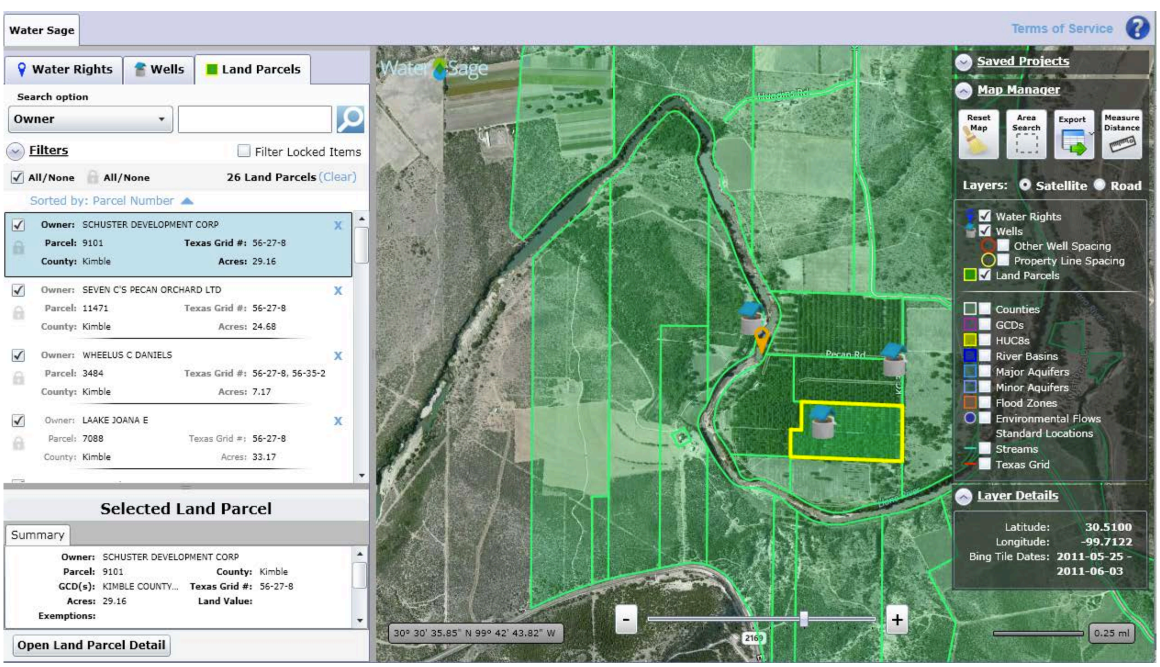


Figure 10. Properties being analyzed for matching land ownership to water rights in Water Sage.

Kimble County Central Appraisal District: The Kimble County Central Appraisal District website contains online property records for all parcels in the County. Using the Parcel ID from Water Sage, we confirmed parcel owner and obtained mailing address, physical address, total parcel area, land value, and production value, all of which were recorded in the database. The total parcel value is derived from the market value listed for each parcel. The production value is derived from the agricultural market valuation listed for each parcel. Combined parcel data for each water right is represented on the master database. Individual parcel data can be found in an adjoining Excel spreadsheet.

Google Earth: Aerial imagery was used to identify crop type, irrigated area, and irrigation infrastructure. Google Earth provides high resolution imagery over multiple years, allowing for a historical review of farming and ranching practices for each parcel. Field observations were later used to verify this information.

Additional Data Needs

Slope data for each parcel and proximity to electrical substations are important to determine the feasibility of solar installations. Additionally, information on groundwater pumping and use beyond the simple existence of a groundwater well would allow for a greater understanding on the source of irrigation water; however, groundwater use is not reported. Also, bathymetry data and key habitat areas would help inform critical segments to target for flow restoration.

Field Observations

While online data sources allowed the planning team to collect information on land use, irrigation method, and crop type for properties associated with water rights, many data sources used to complete the water rights database left unanswered questions about water and land use. For example, the team relied largely on aerial imagery to define irrigation type for each water right and thus the accuracy of this data point is reliant on the quality of aerial imagery and the visibility of irrigation infrastructure. Field visits were conducted to identify any inaccuracies in the database, verify information garnered from digital data sources, and gather any additional property information.

The team field verified data for nearly half (47%) of the water rights included in the Kimble County database. The field verification was also used as an opportunity to make general observations about land and water use in Kimble County. Observations from the field were used to later categorize water rights into typologies. The following summary outlines the methodology used and key field observations.

Methodology

A total of eighteen water rights (out of 38 total) were chosen for field verification by the planning team. Selection was based on an initial prioritization that used permitted volume, priority year (seniority), simplicity of parcel ownership, and intensity of water use to identify high-value water rights.

Windshield surveys were used to observe land uses, ranch operations, crop type, and irrigation methods on properties associated with the selected water rights in Kimble County. While most properties were visible from public roads, some areas were unobservable due to topography or lack of public access.

Summary of Observations

1. Low-Value Crop Production

Several ranches in Kimble County grow hay for commercial sale or as supplemental feed for livestock. All hay fields observed were sprinkler or flood irrigated.

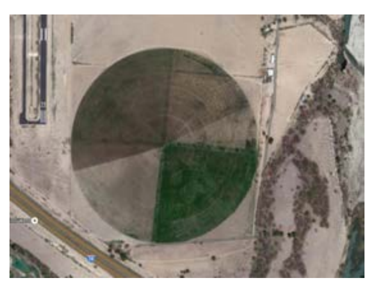
2. Irrigated Grazing Pastures

Many Hill Country ranchers also irrigate pastureland for grazing cattle, sheep, goats, and exotic game. All observed irrigated grazing pastures were sprinkler irrigated.

3. Inefficient Pecan Orchards

Pecan trees are native to the Texas Hill Country. While nut production was once a major industry in Kimble County, many orchards have fallen into disrepair. Those that remain are irrigated with inefficient flood and sprinkler systems.

4. Groundwater Pumping



Groundwater is used to irrigate fields growing hay and alfalfa throughout Kimble County. Center-pivot sprinklers are most commonly used to irrigate crops from groundwater wells. Unlike surface water, groundwater in Texas is governed by the rule of capture (i.e., unregulated).

5. **Unused Water Rights**
   There are several irrigation water right owners who are not actively irrigating their land. These ranchers likely generate revenue by operating exotic game hunting parks. High game fencing and signage advertising hunting grounds demonstrated the presence of hunting operations. Acquiring these rights would protect water from being used for irrigation in the future.

Water Right Typologies

Using information gathered from the water right database and field observations, water rights greater than 50 AF were categorized into typologies based on production type. These typologies were created to further organize water rights and provide the framework for a user-friendly suite of implementation recommendations. In the following 'Water Saving Strategies' section a list of water saving options has been provided for each typology. Once specific water rights are identified for partial water right acquisition, The Nature Conservancy will enter into a joint venture partnership with these landowners. Under this partnership, water saving strategies will be implemented and the resulting water savings will be transferred to the community water trust.

Four typologies were identified during this process: Unused Water Rights, Commercial Hay Production, Supplemental Hay Production, and Pecan Orchards (Figure 11). The typology of each water right is recorded in the water rights database using the following code: 1- Unused Water Right, 2- Commercial Hay Production, 3 –Supplemental Hay Production, 4 –Pecan Orchard. Note that many properties include more than one production type and are coded with more than one typology number. In many cases, it is too difficult to determine whether hay production was for commercial or on-site use. In these cases, water rights are labeled with codes for both typologies (2 and 3).

Water Right Typologies

1. Unused Water Rights

Several irrigation water rights in Kimble County appear to be unused. These water rights and their associated properties show no evidence of agricultural production or water diversion from the Llano River or its tributaries. Several of these ranches appear to have been converted to game hunting parks. Operating hunting parks now represents the most lucrative use of ranches in the region.

2. Commercial Hay Production

Some evidence of commercial hay sales was observed in Kimble County. Roadside for-sale signs posted outside properties with irrigation water rights indicated properties engaged in commercial sales. It is difficult to determine which ranches are commercially selling hay without the presence of such signs. Contact with property owners will be needed to verify commercial sales.

3. Supplemental Hay Production

Conversations with regional project partners and stakeholders revealed that many ranch owners in Kimble County use irrigation water rights to irrigate hay fields that provide supplemental feed for livestock and hunting game. However, it is not possible to determine which ranches produce hay for supplemental feed and which produce hay for commercial sale without the presence of signs indicating hay sales.

4. Orchard

Pecan trees are native to the Texas Hill Country (although non-native, higher yield varieties are also grown) and nut production has a long history in Kimble County and surrounding areas. While nut production was once a major industry in the region, many orchards have fallen into disrepair. Those that remain continue to use irrigation water rights and are mostly irrigated with inefficient flood and sprinkler systems.

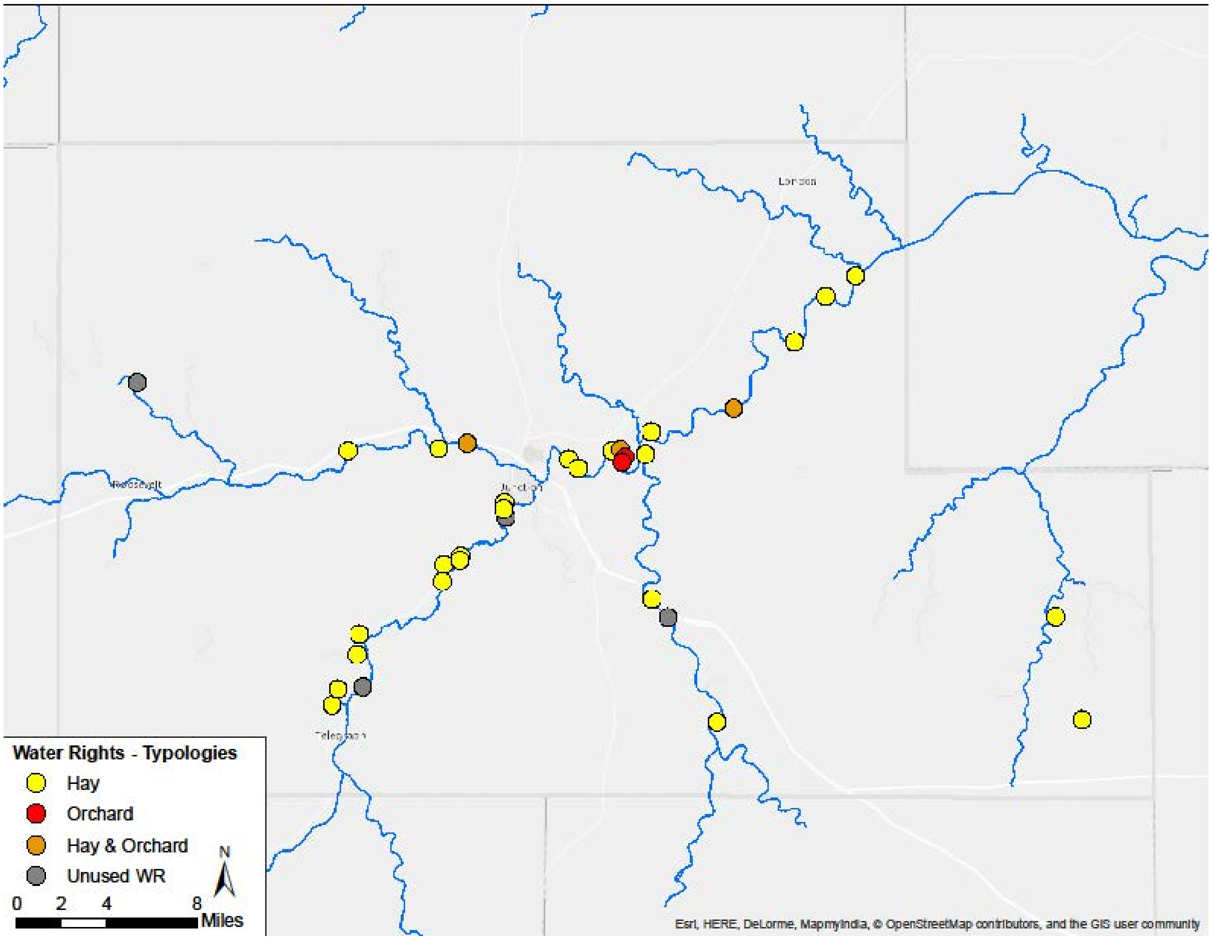


Figure 11. Water right typologies.

Water Saving Strategies

The following water savings strategies are organized by water right typology for agricultural land utilizing irrigation in Kimble County. A separate research team at the University of Virginia supplied the initial findings outlined below. The strategies were then organized according to the typology for which they would be most effective in saving water. These water savings can then be transferred to a community water trust (CWT) and allowed to flow downstream. These strategies comprise our recommended water saving methods for Kimble County water rights.

Acquisition of Water Rights

There are two primary approaches to acquiring water rights in the Llano River sub-basin in lieu of an active water market. The first approach is fee-simple purchase of agricultural land and associated water rights. The Nature Conservancy may choose to permanently decommission the land from agricultural production and return irrigation water to the river to supplement flow or keep the land in production but implement water saving strategies to reduce irrigation requirements and produce water savings that would be transferred to a CWT. The Nature Conservancy could then place these lands under conservation easement in order to limit future water use on the land, generating tax credits, and sell protected land to buyers interested in less water-intensive land uses.

The second approach involves partnering with the existing ranchers and land-owners through a joint-venture program to implement water savings strategies. The Nature Conservancy would provide the capital to fund these measures in exchange for a percentage of agricultural yield and/or associated water savings.

Water Saving Strategies by Water Right Typology

Unused Water Rights

Figure 12. An irrigation water right not in use.

Unused water rights are prevalent throughout Kimble County (Figure 12). Despite the 'use it or lose it' policy of the prior appropriation water right system in Texas, some water right owners are not using their water. This underutilization of water is beneficial for the health of the stream and maintaining environmental flows, but leaves the water at constant risk to future use. In order to keep the water in the river indefinitely, the water saving strategy for the continued disuse of water rights on these properties should attempt to change the legal ownership or status of the water. This could be accomplished through two main strategies – conservation easement or fee simple purchase. The CWT could assist water right owners to place their land and water into a conservation easement by connecting the property and/or water right owner to conservation organizations in Texas, such as The Nature Conservancy. These easements would keep the water in the river in perpetuity, and reduce the owner's tax burden. The CWT could also pursue the fee simple purchase of unused water rights, allowing for the greatest control of their instream and extractive use.

Commercial Hay Production

Figure 13. Commercial hay production in Kimble County.

Commercial hay farms are an important aspect of the irrigated agricultural landscape in Kimble County (Figure 13). Hay is a relatively water-intensive crop to grow and a relatively low-value crop to sell. In order to reduce water consumption on commercial hay farms, ranchers should implement crop shifting, water efficiency increasing technology for sprinklers, or utilize sprinkler irrigation as opposed to flood irrigation (Table 1).

Crop shifting simply involves shifting from lower-value, water-intensive crops to higher-value, water-efficient crops. According to research done by the Pacific Institute, switching from field crops such as hay to vegetable crops can conserve water and provide higher returns, benefitting both the farmer and the environment. Crop shifting can also include the complete fallowing of land. Depending on land conditions, the fallow land can be converted to solar production as well. This measure reduces irrigation water usage by 100% and saves the most water of all methods implementable on commercial hay farms.

Increasing the efficiency of sprinklers is another option for commercial hay production. Much of the commercial hay production in this area uses center-pivot irrigation sprinklers. Low-energy precision application (LEPA) and low elevation spray application (LESA) sprinklers are an adaptation of center-pivot systems that use drop tubes that extend down from the pipeline to apply water on the ground or a few inches above the ground. LEPA and LESA systems can save both water and energy by applying the water at a low-pressure close to the ground, which reduces water loss from evaporation and wind, increases application uniformity, and decreases energy requirements. These new methods of sprinkler-applied irrigation can reduce water usage for hay production by 4-6%. These methods are easily applied to the large fields necessary for cost-effective commercial hay production.

Table 1. Water Saving Methods for Commercial Hay Production

Hay				
Method	Cost ($/acre)	Water Savings (% saved)	Ease of Implementation	Reliability of Research
Crop Shifting (fallowing)	$100	100%	Moderate	High
Sprinkler Equipment Changes	$200	4-6%	Moderate	Moderate
Conversion to Solar	$0	100%	Moderate	High
Irrigation Timing	$0	10-20%	Easy	High

Supplemental Hay Production

Figure 14. Image shows an irrigated field used to produce supplemental feed for livestock.

Many properties in Kimble County operate as wild game hunting grounds, making the majority of their profits by charging high rates for hunters to hunt exotic animals. The owners of these properties usually use their water rights to grow feed (hay or alfalfa) for their exotic game (Figure 14). These hay producers are not interested in the value of the actual hay. Instead, they are only interested in the crop as an input into their valuable exotic game 'crop'. By utilizing irrigation scheduling and soil moisture monitoring, these ranchers could greatly reduce their water use (Table 2).

Irrigation scheduling is the use of weather models and soil moisture measurements to estimate crop water requirements and optimize the timing and amounts of irrigation applications. This irrigation method has been found to reduce water use by 13-27% (Cooley et al., 2008; Gleason, 2013). Soil moisture monitoring is done by constantly measuring the soil moisture content with a tensiometer and enables ranchers to water only when soil moisture is lower than desired. Soil moisture monitoring can greatly reduce water usage on supplemental hay ranches.

Table 2. Water Savings Methods for Supplemental Hay Production

Hay				
Method	Cost ($/acre)	Water Savings (% saved)	Ease of Implementation	Reliability of Research
Irrigation Timing	$0	10-20%	Easy	High
Soil Moisture Monitoring	$60-500	20%	Moderate	High

Pecan Orchards

Figure 15. Pecan Orchard in Kimble County

Pecan orchards are operated throughout Kimble County (Figure 15). Orchards are ordinarily flood irrigated, which presents many opportunities for water savings. Drip irrigation, soil enhancement, regulated deficit irrigation, and irrigation scheduling and timing could all provide water savings for these pecan orchards (Table 3).

Drip irrigation refers to the slow application of low-pressure water from plastic tubing placed near the plant's root zone. Sub-surface drip irrigation involves burial of the drip lines, thereby reducing or nearly eliminating surface evaporation and runoff. In deficit irrigation, water is applied at a rate lower than the crop's full water requirements. Regulated deficit irrigation involves an irrigation regime that applies the deficits at developmental stages when water stress will not impact yields negatively. Irrigation scheduling and timing, as discussed above, could both have water saving benefits on orchards as well as hay fields.

Table 3. Water Saving Methods for Pecan Orchards

Pecan Orchards				
Method	Cost ($/acre)	Water Savings (% saved)	Ease of Implementation	Reliability of Research
Drip	$200	30-50%	Moderate	Moderate
Soil Enhancement	$10	30-50%	Easy	Moderate
Regulated Deficit Irrigation	$50	5-20%	Difficult	Moderate
Irrigation Scheduling	$20	10-30%	Moderate	Moderate
Irrigation Timing	$0	10-20%	Easy	High

Universal Water Savings Strategies

For all water use typologies there are relevant methods for increasing water savings. For example, irrigation infrastructure improvements will always lead to water savings regardless of what the water is being used to grow. Irrigation infrastructure improvements include any changes to the infrastructure used to carry irrigation water from the river or aquifer to the field it is applied to. These can include cementation of channels, covering channels, and reduction of water-intensive invasive species around crops and irrigation ditches. Similarly, leaving the land fallow and pursuing non-water related financial gains, such as solar energy production, will also always lead to a decrease in water use on the land and an increase in water available for the CWT.

Priority Water Rights and Properties

In order to understand which water rights have the greatest potential for water conservation and best meet the needs of the community water trust, the planning team developed a ranking system to prioritize water rights. Three parameters were used to rank water rights: volume, priority year, and irrigated area (Figures 15, 16, and 17).

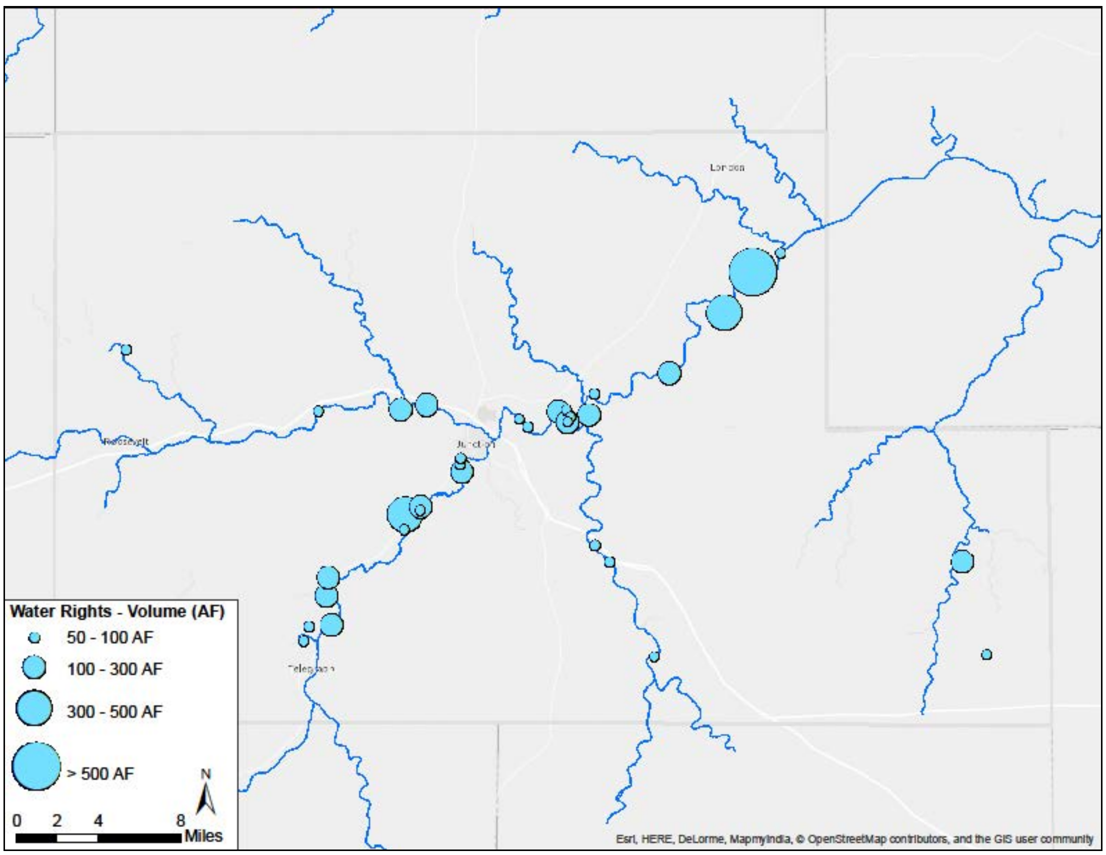


Figure 15. Water rights by permitted diversion volume.

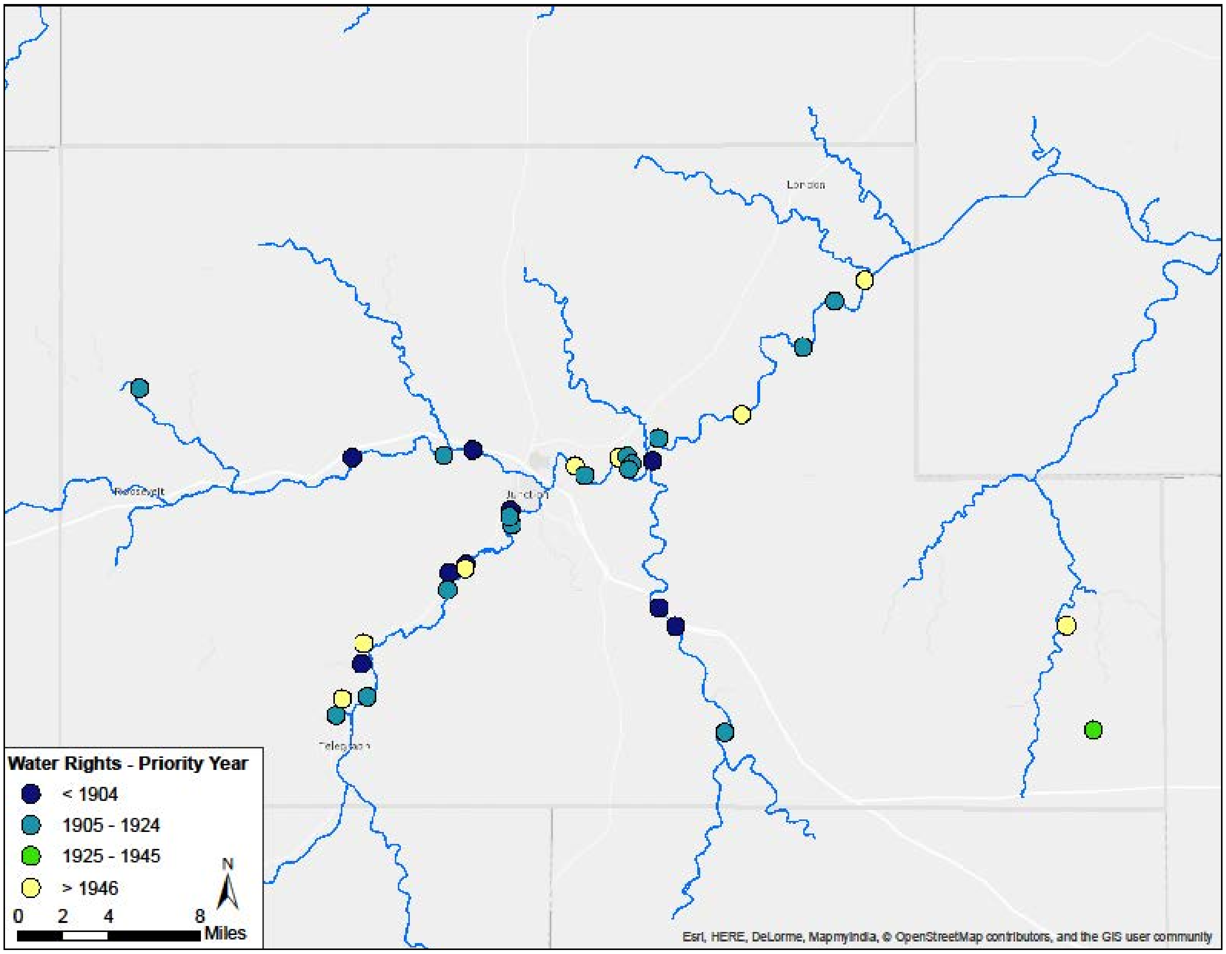


Figure 16. Water rights by priority year (seniority).

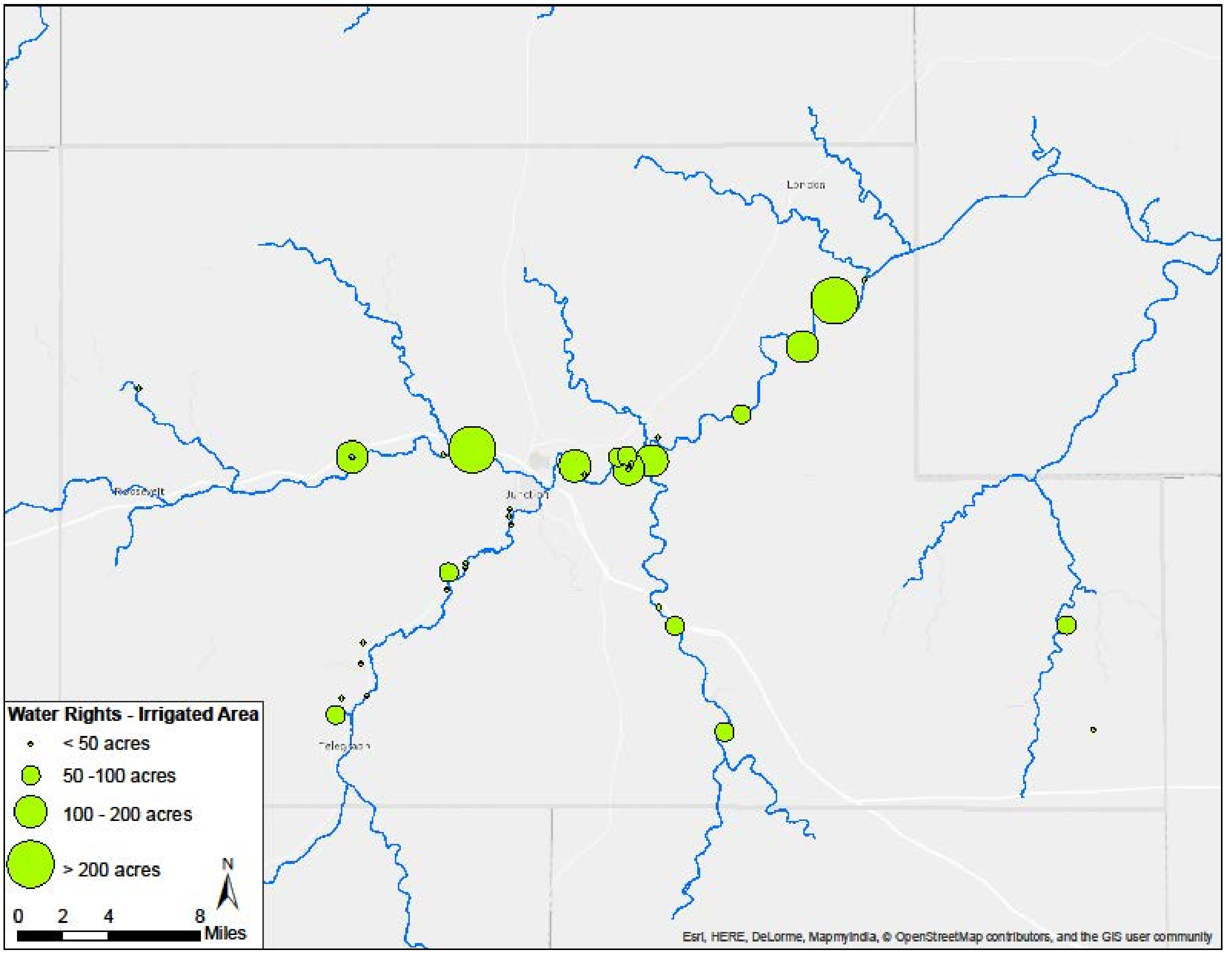


Figure 17. Water rights by irrigated area.

Volume and irrigated area directly correlated to the quantity of water being applied for agriculture. Priority year, or the seniority of the water right, has important implications for its reliability, improving flow regimes, and the potential for leasing to downstream users. Each parameter was divided into four classes and a value of 1-4 was given to each class, with 4 considered most desirable (Table 4).

Table 4. Water Rights Ranking System

Value	Volume (AF)	Priority Year	Irrigated Area (acres)
1	0-100	1945-1967	0-50
2	100-300	1925-1945	50-100
3	300-500	1904-1924	100-200
4	>500	<1904	>200

Water rights received an individual score for each parameter and a total score using a weighted average to give the greatest importance to water right volume (50%), while priority year and irrigated area contributed equal parts (25%). Cumulative scores across all analyzed water rights ranged from 1 – 3.75. The six water rights with the highest cumulative score are listed below (Table 5).

Table 5. Prioritized Water Rights

	WR No.	Volume (AF)	Seniority	Irrigated Area (acres)	Typology	Priority Score
1	1624	1,740	1907	397	Hay	3.75
2	1524	140	1904	216	Hay + Orchard	3
3	1556	437	1904	94	Hay	3
4	1623	400	1907	144	Hay	3
5	1604	150	1903	160	Hay	2.75
6	1583	119	1911	117	Orchard	2.5

Stakeholder Assessment

A preliminary stakeholder assessment was conducted to identify major project stakeholders, inform regional stakeholders about the community water trust strategy, and to gather feedback and recommendations for community water trust development. Stakeholder engagement efforts will be ongoing throughout the development of the community water trust.

Table 6. Regional stakeholders by interest and sector

Interest	Sector	Stakeholder	Notes
Water	Public	Lower Colorado River Authority (LCRA)	Owns and manages all reservoirs in the Colorado River basin, and would be one of two likely lessors/buyers of CWT water.
		Texas Water Development Board	Manages the Texas Water Trust, which may be a necessary tool for protecting environmental water rights.
		Kimble County Groundwater Conservation District	Operates under a prior appropriation and reasonable use doctrine
		City of Austin	The most likely lessor/buyer of CWT water.
		Regional Water Planning Groups	Develop regional water plans to predict and plan for future water demands in conjunction with TWDB.
	Private	Local and downstream landowners, irrigators, and surface water users	Neighboring landowners could be our biggest obstacle if they decide to protest the water rights transactions being submitted to TCEQ; alternatively, some may become our greatest champions if we can demonstrate benefits of value to them.
	Non-Profit	Colorado River Alliance	Local non-profit organization that works to conserve and protect the Colorado River through community involvement and collaboration.
Wildlife	Public	Texas Parks and Wildlife Department	Likely to be our strongest supporter of the CWT concept; instrumental in negotiating agreements surrounding endangered species recovery plans.
		US Fish and Wildlife Service	May be involved in monitoring efforts, especially for ESA candidate and listed species.
	Private	Game Hunting Park Owners	Potential seller of water rights
	Non-Profit	Texas Parks and Wildlife Foundation	Non-profit funding partner to TPWD
Land Conservation/ Natural Resource Management	Public	Natural Resources Conservation Service, Texas Office	Works directly with and provides technical assistance to landowners and farmers seeking to improve their land and water resources.
	Private	Conservation Easement holder	Potential seller of water rights or partner for water conservation implementation
	Non-Profit	Hill Country Conservancy	Non-profit land trust working with farmers and ranchers to preserve agriculture, could be help find willing landowners
Agriculture	Public	Texas Department of Agriculture	Provides support and leadership in improving, expanding, and protecting Texas agricultural interests.
	Private	Upstream agricultural interests (landowners, irrigators, commodity groups)	Potential sellers of water rights and/or farmland, key influencer on success of scale CWT
	Non-Profit	Texas Farm Bureau	Very powerful player in agricultural community; earning their support could rapidly accelerate our partnership development with farmers and irrigators.

1. Stakeholder Identification

A list of project interests was first generated for a community water trust. Project interests included agricultural water use, municipal water use, industrial water use, water conservation, land conservation, and biodiversity protection. A list of representative stakeholders was then generated for each interest group and includes private, public, and non-profit groups. See Table 6 for stakeholder list.

2. Identify Stakeholders for Preliminary Meetings

Using the list generated, stakeholders were selected for preliminary engagement. Groups chosen represent existing project partners or The Nature Conservancy contacts with which existing relationships have been established. Because the objective of the preliminary meetings was to gather feedback on the feasibility of a community water trust, it was important to strategically schedule meetings with stakeholders that could offer valuable insights about the regional political and cultural landscape.

Stakeholders selected for preliminary meetings included:

- Hill Country Conservancy
- Texas Parks and Wildlife Department
- Texas Tech, Llano River Field Station (Llano River Watershed Alliance)

3. Stakeholder Meetings

Meetings with each of the initial stakeholders were held in Texas during the week of March 21st – 25th. Each meeting included an introduction to the community water trust concept, an update on the Kimble County pilot study, and time for feedback, questions, and discussion.

4. Summarizing Feedback

Individual meeting summaries were compiled for each stakeholder meeting and can be found in Appendix B. Meeting summaries include lists of attendees, discussion points and key questions, and lists of additional contacts and stakeholders gathered from the meetings. Major takeaways from each meeting are included below:

Hill Country Conservancy:

- Land use in Hill Country has changed significantly over the last 20-30 years as ranchers have shifted away from heavy grazing and toward hunting parks, which now represents the most profitable use of ranch land. As a result, most agricultural irrigation occurring in the Hill Country is in the form of irrigated plots used to grow supplemental feed for game and livestock. Groundwater infiltration in the region has also improved as a result of this shift due to less erosion and soil compaction from livestock grazing.
- Tips for land owner outreach:
    - HCC stressed the importance of building long-term relationships before making proposals to Hill Country landowners. They have found success in first partnering with landowners that are already on their side and then using those contacts to connect with other landowners. Texas landowners are generally skeptical but willing to engage in conversation as long as the conversation does not turn too controversial too quickly.
    - TNC will have the advantage of having a financial offer, which will serve as an effective conversation opener.
    - Use caution when mentioning Austin. There is an "us vs. them" mentality in Hill Country where Austin is perceived as intruding upon and taking advantage of more rural communities.
    - Using regional language will be important for gaining the trust of landowners. For example, use "ranchers" in place of "farmers" and "stock tanks" in place of "ponds".
    - "Conservation" is generally received favorably in the region. Conservation is considered a mark of good land stewardship and not of political affiliation. While most ranchers would consider themselves conservationists, few would label themselves environmentalists.
- Outreach Resources:
    - Steve Nelle – Uses effective messaging for land owners and has produced papers on how to engage Texas landowners
    - Soil and Water Conservation Board has conducted effective public information campaigns

Texas Parks and Wildlife Department:

- Irrigation is generally using low efficiency equipment to grow low-value crops, including hay, alfalfa, and general pasture land. Sprinkler and flood irrigation equipment dominates. These properties represent the best opportunities for water savings.
- There is an existing suite of programs that exist to support ranchers and landowners, including the TPWD Landowner Incentive Program, NRCS Extension Agents, etc. Partnering with these existing programs could provide a direct path to willing ranchers and landowners, eliminating the hurdle of developing new relationships. Other existing programs include the Water Development Board's Ag Conservation Program, Federal Farm Bill programs, CRP, TAMU Ag Extension programs. Preston Bean may be able to provide a more exhaustive list of programs that work with landowners.
- The Texas Water Monitoring Council (savewaterfortexas.org) has produced BMP's for municipal, industrial, and agricultural water use. The Texas State Water Plan also includes proven BMP's.
- Kyle will send water use data, which includes data on crop type, groundwater, and associated water rights. While data exists for every county, files are data intensive so Kyle will start by sending Kimble and Mason County.
- The Farm Bureau is a powerful stakeholder and one that needs to be involved and in support of the CWT concept. Jay Bragg works with stream flow for the Farm Bureau and may be a good contact.

Texas Tech University, Llano River Field Station (Llano River Watershed Alliance):

- Researchers are studying brush control as a means of water supply enhancement (the success of this method is debated). Researchers have set a goal to remove 98,000 acres of medium to high brush, which they claim would result in a 75,000 AF reduction in water loss due to reduction in evapotranspiration. They also note that there are several ecological benefits to brush clearing beyond water savings.

- A group of students at the field station conducted a study of the economic benefits of the Guadalupe Bass in Hill Country and found that the species generates $7.7 million in economic activity and generates over 800 jobs in the region.
- Environmental literacy is very low in Texas, making environmental education an important strategy for promoting water conservation. However, with an absentee landowners rate of over 55%, outreach can be a challenge.

Conclusion and Next Steps

Summary of Deliverables

This project served as a pilot study for the development of a community water trust (CWT) in the Colorado River basin in Texas and the resulting deliverables were produced to aid in the further development and implementation of a CWT. A methodology detailing the necessary sources and steps for assessing and analyzing the irrigation water rights and associated ranch and farmlands will be a valuable tool moving forward with this project. This methodology, developed using water rights in Kimble County, is intended to serve as a replicable model for use throughout the remaining sub-basins of the Colorado River.

The water right typology characterization and associated water saving strategies provide a systematic approach to implementation of water conservation measures throughout the basin. Furthermore, the prioritization method is also intended for use throughout the basin. The list of priority water rights provides The Nature Conservancy a starting point as they push forward on establishing CWT and begin to work with landowners to implement water saving measures.

Finally, the stakeholder assessment conducted as part of this study provides The Nature Conservancy with a list of potential stakeholders and project partners as well as feedback and additional resources collected from stakeholder meetings. Meetings with Texas Parks and Wildlife Department, Llano River Watershed Alliance, and Hill Country Conservancy demonstrated key stakeholder support for the idea of a CWT in Texas.

Lessons Learned

Due to the complicated nature of water use and water right distribution in Texas, the project approach changed over the course of the study. Initially, the team intended to choose the highest priority properties and develop water conservation plans for those properties. As the project moved forward the team determined a more useful methodology would include developing property typologies and determining the best water conservation strategies to employ on each typology. This end product is better suited for replication and expansion throughout the river basin.

The stakeholder assessment also changed over the course of the project. Initially, the goal was to create a comprehensive strategy for landowner interactions. After the site visit, the team determined stakeholder and landowner interactions were going to be dependent on individual circumstances and would not fit well into a detailed strategy. Instead, the team assessed the stakeholders in the basin and determined which groups and organizations will be valuable partners moving forward in the implementation of the CWT.

Several valuable lessons resulted from the review of water rights in Kimble County that have important implications for the expansion of the methodology throughout the Colorado River basin. The use of the water rights in Kimble County was more complex than initially assumed. Because each water right is not being utilized the same way, detailed research was needed in order to capture the variations between the properties. In addition, since accurate and detailed water use data is simply unavailable, the team was forced to make reasonable assumptions about water use and irrigation methods from aerial imagery.

Next Steps

The work performed by the project team will contribute to a larger effort by The Nature Conservancy in the Colorado River basin to understand irrigation water rights. The methodology, database, implementation strategies by typology, and water right prioritization are intended to be a model for the rest of the basin that can be used in other counties and sub-basins of the Colorado River. Moving forward, the water rights in the remaining counties of the Llano River should be assessed and added to the database. A similar procedure for should then be implanted in the San Saba and Concho river basins, and a portion of the mainstem of the Colorado River. With a complete database of assessed irrigation water rights, The Nature Conservancy can begin identifying properties and landowners to work with, implement water saving strategies, and acquire water for the CWT.

Appendix A: Database Metadata

The following describes user-created data fields in the Kimble County Water Rights Database and the source of the information

Num_Owner – number of owners for water right; COA and Water Sage.

Flow_cfs – permitted maximum flow rate of water right in cubic feet per second; COA.

Storage_af – permitted maximum storage of water right in acre-feet; COA..

Retur_Flow – required return flow of water right in cubic feet per second; COA.

Div_point – number of points of diversion for water right; COA and Water Sage.

Parcel_ID – the parcel identification number for parcel(s) assumed to be irrigated. Includes parcels that may be only partially irrigated; Water Sage.

Num_Parcel – total number of parcels assumed to be irrigated; Water Sage.

Mail – mailing address for owner of parcel(s); property records.

Physical – the physical address for the parcel(s); property records.

Total_Area – total area of parcel(s) in acres; property records.

Owner – name of owner for parcel(s); Water Sage and property records.

P_Num_Own – number of owners for parcel(s); property records.

P_Owner_Type – type of ownership of parcel(s) (private, partnership, limited, corporation); property record.

P_Value – total assessed value of parcel(s); property record.

Crop – dominant crop(s) being cultivated on parcel(s); aerial imagery.

Prod_Value – total assessed agricultural production value of parcel(s); property records.

Irr_Method – observed irrigation method being used on parcel(s); aerial imagery.

Irr_2 – observed irrigation method being used on parcel(s), if more than one; aerial imagery.

Irr_3 - observed irrigation method being used on parcel(s), if more than two; aerial imagery.

Irr_Source – source of water being used for irrigation (surface, groundwater); Water Sage and aerial imagery.

Irr_Area – area of land assumed to be irrigated in acres; aerial imagery.

Wells – number of groundwater well(s) located on parcel(s); Water Sage.

Typology – primary water right typology (unused WR, commercial hay production, supplementary hay production, orchard).

Typology2 – other water right typology, if applicable.

Typology3 – other water right typology, if applicable.

Type_Sum – overall water right typology (hay, hay & orchard, orchard, and unused)

Prior_total – total prioritization score for water right.

Notes – any applicable notes from research on water right.

Visited – if parcels associated with water right were visited during field work.

Field Observation – notes from field work.

Appendix B: Stakeholder Meeting Notes

Meeting with Hill Country Conservancy
March 22, 2016

ATTENDEES

Chloe Lieberknecht – TNC Texas
Emily Powell – TNC Global Water

Briana Bergstrom – University of Virginia
John Harbin – University of Virginia
Ben Pickus – University of Virginia
Summer Xiang – University of Virginia

George Cofer – HCC, Executive Director
Romey Swanson – HCC, Conservation Project Manager
Frank Davis – HCC, Director of Land Conservation

MEETING NOTES

Background on HCC's work:

- A lot of their work is steered by development pressures
- Kimble and Mason not officially part of their jurisdiction but if they make a case that work in that area fits the HCC mission then they would be willing to work in those counties
- HCC Strategic Conservation Plan –
    - driven by data from 60-70 data layers
    - protection of water quality and quantify is the most important factor (measured using slope, prox to surface water intakes, vulnerability indicators from TCEQ, etc.)
    - also interested in biodiversity, scenic views, prime farmland soils
    - HCC uses an iterative suitability analysis to identify areas to focus their work
- Approaches for talking to land owners
    - Find a connection to make an introduction

- Make a soft presentation
- Landowners in Texas are generally skeptical but conservational if you don't get too controversial too quickly
- Need to build a long term relationship before you can make an ask
- First find the people who are already on your side
- Let them do the talking
- Don't mention Austin – there is an "us vs them" mentality here
  - They think that Austin is always trying to take advantage of them
  - Spectrum of perceptions (ie. Kimble doesn't like Fredericksburg, Fredericksburg doesn't like Austin)
  - Many places like this want to protect their resources from Austin who is perceived as taking advantage of these rural areas to benefit their own economy
  - People out west not seeing the benefit of some of the partnerships with Austin
  - Everyone's open to a discussion about water
  - Land owner concern: How do we protect our interests in the groundwater, concerned with quality and flow of springs
  - Their first complaint when water dries up is that the neighbors upstream are taking it
  - Most landowners believe you should be able to use your property rights until someone else impinges on your rights

- HCC easements limit the use of groundwater to home use, wildlife and livestock use (some landowners have aesthetic ponds they try to pass off)
- HCC doesn't regulate surface water pumping – for most properties this isn't really a concern
- HCC talking to investors about investing in conservation easements

Electropurification of Wells – Hayes County:

- Hayes County is rural but developing
- Land owners to sell groundwater to developers
- Developers pumping a lot of groundwater – undermines HCC relationship with landowners who have agreed to not pump groundwater (if their neighbors pump them dry and make a lot of money)
- Can make a groundwater exploiter richer by preserving more water for them to pump
- Some people say you cannot protect the resource with an easement so don't use that tool but HCC still thinks its worth the effort

Hill Country:

- Two sand and gravel quarries in Mason (maybe Kimble?) for supplying to fracking operations
- If we buy surface water rights, how can we prevent them from switching to groundwater?
- Better groundwater infiltration now in Hill Country than 20-30 years ago because land use has improved – not as much active grazing as 20-40 years ago (can get info from Stockman's Group) – something to consider
- How is hunting affecting infiltration?
- Exotic game hunts – the best way to make money on a hill country ranch - Hunting is a huge industry in Texas
- HCC easements allow game hunting, don't like to allow high game fencing but if you have it you need a management plan for the game and landscape
- HCC would rather see native animals benefiting from easement but recognize that landowners need to make a profit on land – also hunting is a good stewardship practice
- Ranches are irrigating "food plots" for the game – happens more out west – it's a feed supply issue

Land changes:

- Highland lake levels have been impacted by land use changes – improved conditions
- Hydrology of the area has changed because of land use changes
- There is good land use trend data
- What is the threshold in terms of conservation to get to optimal recharge? Do we want to answer that question?
    - When you establish a number, politics always negotiate it down

Money:

- Need to figure out how to make the transaction conversation not a scary conversation
- Financial offer to landowners can be a conversation opener for TNC
- Ideal situation is to have a big bucket of money and have people bid to work with us – reverse auction system
- Incentives: cash, tax exemptions for ag and wildlife management – TNC tried to add water benefits to that list of tax exemptions but didn't win

Water:

- Charlie Kreidler – Hydrogeologist
- How to value water as they do appraisals for the easements
- Once you put a number on water it becomes a dispute

- HCC would love to put economic figures on groundwater recharge of the Edwards aquifer but it just leads to disputes
- Some outfits in the west that do water valuation
    - WestWater and Texas Water Exchange
- Data:
    - WAMS, TCEQ, water use reporting (self-reported)
    - Watersage
    - TNC's ultimate goal is to have publicly available water use database

Lexicon:

- Not many farmers in hill country – don't use that word to generalize – typically call themselves ranchers
- Language – be careful when talking to landowners – helps to make a good first impression
- Stock tanks not ponds
- The word conservation is seen favorably generally – most landowners would probably say that they are conservationists – they see themselves as good stewards of the land – conservation is about good stewardship - not political
    - Perhaps different definition between urban and rural communities
    - People say they are conservationists but not environmentalists
- Don't ever ask people how many acres they own – its like asking them how much money they make
-

Outreach:

- Steve Nelle – example of good messaging for land owners
    - Papers on how to work with landowners
- Soil and Water conservation board has public information campaigns
- HCC partners with conservation orgs that have tools that can benefit land owners – cost share programs for fencing, etc. CE one of many tools available to the land owner – tool to talk to landowners – use stories

Texas Ranchers:

- An aging population
- Next generation not generally interested in keeping up ranch operations
- Taxes on land inheritance incentivize the fragmenting of land - conservation easements are an attractive alternative used to save taxes
- HCC trying to get really expensive properties in easements so that land owners can pass land on to heirs without big penalties

Contacts:

- South Llano Watershed Alliance – Scott Richardson
- Catherine at Hill Country Alliance
- Preston Bean – Texas Parks and Wildlife – riparian rivers guy – does a lot of land owner outreach
- Ask Catherine Romans for a good partner that might help make introductions to other stakeholder groups
- Delbert Roberts in Kimble County will know the county judges
- Gary Merrit in Real County – very conservation friendly

Miscellaneous Notes:

- UT MUEP project focused on regional planning efforts in Hill Country
    - Catherine Lieberknecht (Chloe's sister at UT's MUEP program)
- Private land owner offers tour of the seven springs – head waters of the Llano
- A&M maybe has more credibility and respect than UT among ranchers but A&M is also seen as being in the pocket of the state – (ie. science behind endangered species de-listings coming out of A&M)

Meeting with Texas Parks and Wildlife Department
March 23, 2016

ATTENDEES

Briana Bergstrom – University of Virginia
John Harbin – University of Virginia
Summer Xiang – University of Virginia
Ben Pickus – University of Virginia

Emily Powell – TNC Global Water
Brian Richter – TNC Global Water, Chief Scientist

Cindy Loeffler – TPWD, Water Resources Branch
Dakus Geeslin – TPWD, Aquatic Biologist
David Bradsby – TPWD, Water Quantity Branch
Kevin Mayes – TPWD, Aquatic Biologist, Texas Instream Flow Program
Kyle Garmany – TPWD, Hydrologist
Lynne Hamlin – TPWD, Water Resources Specialist

MEETING NOTES

Water Conservation Strategies:

- Check out in-stream flow council website
- Texas has water monitoring council – savewaterfortexas.org – includes BMP's for municipal, industrial, and ag
    - Haven't seen those tools used to save water for the environment
- Texas state water plan also has proven BMP's

Data:

- Groundwater – well data available– not sure how much is being used
    - Figuring out which wells are still in use can be difficult
- Water development board – ag conservation board – has estimates of water use – cropspace CDL
    - TPWD will send data – crop data + groundwater data + water right data
    - Data available for all counties but data intensive – will send data for Kimble and Mason to start
    - Data goes back to 2007, other datasets go back to 1995

- Data is from 3 different locations and merged together
- Kyle will send

- Crop coverage data – LULC, historic imagery that goes back to mid 90's

Domestic and livestock water use:

- D and L rights are exempt
- These rights don't show up in TCEQ database
- Not required to be permitted if under 200 AF
- Can recognize these rights b/c there will be infrastructure but no right
- If growing hay for your own livestock it counts as D and L – if selling hay or livestock this water use requires a permit
- Lots of these in hill country
- Amenity ponds do need a permit but livestock or wildlife ponds don't
- Only way to enforce is if someone complains about someone's use
- Lots of priority calls based on these D and L rights after the drought
- San Saba:
    - Ag pumpers and pecan growers
    - Dries up for 90 days even during wet years
    - Trying to change policy
    - Claim that pumpers are directly influencing river flows – shallow wells pumping alluvial groundwater
    - Not a good monitoring system in place
    - During drought downstream D and L users (have senior riparian rights) made calls on upstream users
- Making a call:
    - If not receiving the amount of water they are allocated
    - Lets state know you're not receiving your water
    - State then looks at upstream rights that are more junior to you
    - State reduces the amount junior rights can pump
    - D and L trumps everything – highest priority
    - Futile call – basically the water wouldn't reach you even if the junior water users were to stop using
    - This is how enforcement takes place (except in places with Water Masters who's job it is to monitor and enforce)
    - In areas with more oversight – there is a perception that your water rights will be protected – brings more security to a water market system
- Reluctance for more government oversight in the state
- Water masters are fee based – and people don't want to pay more for their water
- Really large right in the San Saba – 1890's right for 9000 AF, diverted into irrigation canal

- Not metered canal – concern that they were diverting more than they are allocated for
- Call made on this right made by downstream D and L users that have banded together
- Menard Irrigation District
- Similar situation at Goldway on the main stem – pecan farmers wanted to move a water right – encountered local and downstream opposition

- Rice farmers and pecan farmers – using a ton of water to grow plants not appropriate for arid west – and not monitoring how much they water

Where are best opportunities for water saving on farms:

- Hay growers and other low value crops
- Lower Colorado rice irrigators – see SAWS deal
    - Cities worked with rice irrigators – laser leveled the rice fields to help save water to transfer water to San Antonio
    - Nora Mullarchy was involved with that deal
- Need to do AF/$ comparison of methods
- Pecans – need to increase water efficiency rather than switch crop type

Community Water Trust Goals:

- Goal is to reduce use and have agreement that saved water isn't diverted , like an easement agreement
- Sever and transfer of instream right – trust becomes owner of instream right
- Community water trust implies a system wide approach
- Unsustainable if we don't include groundwater rights and usage
- Need to document economic benefits of restoring flows
- Kimble county relies on eco-tourism – should leverage this

Outreach:

- TPWD is all about voluntary efforts because people are so opposed to more government oversight
- Water development board doesn't approach single land owners – they go to Ag shows and community events to educate ranchers about BMPs – WDB more interested in moving ag water to municipal water where TPWD more interested in moving ag water to e-flows
- Think about talking to these groups that are already on the ground talking to ranchers about these BMPS – so that it is framed as a new strategy within an existing program
    - Water development board – ag conservation program
    - Federal programs through the Farm Bill

    - CRP
    - TPWD has a program- landowner incentive program
    - TAMU has ag extension programs – local ag extension agents could be good intermediary
    - Preston Bean can probably give us a list of programs that work with land owners
- Major advertising strategy: a handful of success stories
- Lone Star Land Stewards Award Winner Program – landowners really value these awards – some use land as demonstration areas
- Farm Bureau needs to be involved and on board with CWT idea
    - They can sue a state agency and win so we need their support
    - Jay Bragg on Farm Bureau does some stream flow

Meeting with Texas Tech University, Llano River Field Station
TTU Center at Junction
March 24, 2016

ATTENDEES

Brian Richter – TNC Global Water

Briana Bergstrom – University of Virginia
John Harbin – University of Virginia
Ben Pickus – University of Virginia
Summer Xiang – University of Virginia

Tyson Broad – Llano River Field Station, Watershed Coordinator
Thomas L. Arsuffi, PhD – TTU, Llano River Field Station Director

MEETING NOTES

- Hill Country
  - Cedar and brush predominant vegetation
  - Headwater for 5 Texas river systems
  - Not very much farming occurring in the hills other than floodplain
- Texas Tech Water Management Plan
  - Healthy watersheds initiative - EPA
  - Focus on invasive species: elephant ears, giant cane
    - Higher evapotranspiration and blocks rainfall
- Identify reaches that need flow using SB3 data
  - Tech made recommendations on goals and TCEQ overrode these expert recommendations and ignored other suggestions to SB3
- WAM – based on water flow assumptions from the 1950s
  - Much more water (and sedimentation) in the 50s
    - Led to high over allocation of resources
  - S. Llano is spring fed
    - 700 Springs Ranch is major spring source – open to visitors in April
  - N Llano does not have as much flow as the South
  - Aquatic diversity is the same despite flow differential
- Brush control as a means of water supply enhancement
  - Debate over how successful this method is
  - N and S Llano brush removal project – projected $18 million

        - 1 million acres in brush– 50% is medium to high density brush
        - goal to clear 98,000 acres
            - this would result in a 75,000 AF reduction in evapotranspiration
    - lots of ecosystem benefits to brush clearing beyond water savings
    - doesn't save water with granite underlying rock layer because water can't infiltrate much anyway
    - works well with karst because water can infiltrate if not blocked by the brush
- Relationship between rainfall and recharge is not linear
    - At some point, water will not recharge even if the rain continues
- Example of farmers willing to conserve water
    - Panhandle farmers near Lubbock
    - Cotton production is very water intensive in a pretty water scarce region
        - Have done lots of research into water conservation
- Endangered Species Act
    - Major means to protect water in the river
    - San Antonio water markets are driven by endangered listing in the river
    - Mussels in Colorado may get listed and could have a similar result
- Study of Economic Benefits of the Guadalupe Bass in Hill Country
    - $7.7 million in economic activity
    - 800 jobs generated
- Environmental Literacy
    - Environmental education is a way to promote water conservation
    - Environmental literacy in Texas is very low currently
    - Healthy watershed initiative
        - Putting together a landowner task force to tackle water issues
        - Working to protect rivers from bacteria and ferrel hogs

55% absentee landowners creates an issue with landowner outreach

Appendix C: Water Saving Strategies Report

This aspect of the project was researched and written by the UVA independent study group working under Brian Richter.

Summaries of Water-Saving Measures

No-till: Crop residues reduce the evaporation of water from soil by shading, causing a lower surface soil temperature and reducing wind effects.

Deficit irrigation: Water is applied at a rate lower than the crop's full water requirements. "Regulated" deficit irrigation involves an irrigation regime that applies the deficits at developmental stages when water stress will not impact yields negatively. (we include only studies in which yields did not decrease)

Crop Shifting: Shifting from lower-value, water-intensive crops to higher-value, water-efficient crops

Irrigation Scheduling: Use of weather models and soil moisture measurements to estimate crop water requirements and optimize the timing and amounts of irrigation applications.

Sprinkler equipment changes: Low-energy precision application (LEPA) and low elevation spray application (LESA) sprinklers are an adaptation of center pivot systems that use drop tubes that extend down from the pipeline to apply water on the ground or a few inches above the ground. LEPA and LESA systems can conserve both water and energy by applying the water at a low-pressure close to the ground, which reduces water loss from evaporation and wind, increases application uniformity, and decreases energy requirements.

Drip irrigation: Drip irrigation refers to the slow application of low pressure water from plastic
tubing placed near the plant's root zone. Sub-surface drip irrigation involves burial of the drip lines, thereby reducing or nearly eliminating surface evaporation and runoff.

Irrigation infrastructure improvements: Changes to the infrastructure used to carry irrigation water from the river or aquifer to the farm.

Direct seeding of rice: Direct or dry seeding of rice involves sowing seeds directly into unpuddled, rather than continuously flooded, soil. While these fields are irrigated over the course of the season, the crop is not kept in continuously standing water, thus saving a significant amount of irrigation.

Soil moisture monitoring: Soil moisture content is typically measured with a tensiometer. Soil moisture monitoring enables farmers to water only when soil moisture is lower than desired.

Water-Saving Measure	Saved Volume	Water Savings %	Study Location	Citation
Soil Management				
No-till farming (increased crop residue in soil, reducing evaporation)	1,000-1,300 m3/ha each year		Kansas, USA	Klocke and others, 2009*
No-till farming (increased crop residue in soil, reducing evaporation)	800-1,300 m3/ha each year		Nebraska, USA	Pryor, 2006*
No-till farming (increased crop residue in soil, reducing evaporation)	900-1,250 m3/ha each year		Nebraska, USA	van Donk and others, 2010
No-till farming (increased crop residue in soil, reducing evaporation)	1,020 m3/ha each year		California, USA	Mitchell and others, 2012
No-till farming (increased crop residue in soil, reducing evaporation	591 m3/ha each year	48-54%	Kansas, USA	Klocke and others, 2009
Rainwater harvesting in ridge-and-furrow irrigation using plastic-mulched ridges	1,500 m3/ha each year	50%	Shaanxi Province, China	Wu and others, 2015
Irrigation Application				
Switch from sprinkler to sub-surface drip irrigation (reduced evaporation)	3,000 m3/ha each year		Kansas, USA	Lamm, 2005
Switch from sprinkler mounted on center pivot truss to LEPA sprinkler near ground (reduced evaporation)	33 m3/ha per irrigation event		Texas, USA	Schneider and Howell, 1993, cited in Lamm 2005
Reduced sprinkler evaporation using increased nozzle diameter or decreased wind speed		4 - 6%	Florida, USA	Zazueta, 2011
Regulated deficit irrigation (pistachios)	1,230 m3/ha each year		California, USA	Iniesta and others, 2008
Regulated deficit irrigation (almonds)	1,270 m3/ha each year		California, USA	Stewart and others, 2011
Regulated deficit irrigation (grapefruit)	1,213-1,296 m3/ha each year		Turkey	Unlu and others, 2014

Regulated deficit irrigation (pears)	3,000 m3/ha each year (peaches) 2,000 m3/ha each year	?	Australia	Mitchell and others, 1989 as cited in Goodwin and Boland, 2002
Regulated deficit irrigation (peaches)	1,600 m3/ha each year	40%	China	Goodwin and others, 1998 as cited in Goodwin and Boland, 2002
Regulated deficit irrigation (olives)	?	25%		Goldhamer, 1999 as cited in Goodwin and Boland, 2002
Regulated deficit irrigation (almonds)	?	5%	California, USA	Goldhamer and others, 2003 as cited in Cooley and others, 2008
Regulated deficit irrigation (citrus)	?	12-22%	Spain	González-Altozano and Castel, 2000 as cited in Cooley and others, 2008
Regulated deficit irrigation		20% (citrus, almonds, pistachios) 39% (grape vines)	California, USA	Cooley and others, 2008 based on literature review
Regulated deficit irrigation (strawberries)	2,289-2,315 m3/ha each year	19-27%	Huelva Province, Spain	Lozano and others, 2016
Regulated deficit irrigation (quinoa)	650 – 1,400 m3/ha each year	32-82%	Altiplano, Bolivia	Geerts and others, 2008
Regulated deficit irrigation with mulching (vs. conventional flood irrigation)	583 m3/ha each year	76%	Shaanxi Province, China	Zhou and others, 2011
Alternate wetting and drying (AWD) in rice cultivation (vs continuous flooding)	1,429-2461 m3/ha each year	18-31%	Arkansas, USA	Linquist and others, 2015
Irrigation scheduling	200 m3/ha each year	13%	California, USA	Cooley and others, 2008 (based on CA DWR, 1997)
Irrigation scheduling	1,390 m3/ha each year	27%	Colorado, USA	Gleason, 2013
Irrigation timing (daytime vs. nighttime irrigation with		12%	France	Molle et al, 2012

sprinklers)				
Soil moisture monitoring	170 m3/ha each year	22%	Punjab, India	Perveen and others, 2012
Tailwater runoff management	30-90 m3/ha per irrigation event	8-35%	California, USA	Arnold and others, 2014
Irrigation Infrastructure Improvements				
Replacement of conveyance ditches with pipes	9.8 m3 per meter of replacement	5-36%	Australia	National Water Commission (Australia), 2006
Canal lining and replacement of canals with pipes	802 m3 each year per meter of canal	29-48%	Oregon, USA	Newton and Perle, 2006
Canal modernization and automation	56 m3 each year per meter of canal	20%	Victoria, Australia	Rubicon Water, 2012
Multiple infrastructure improvements	211-370 m3/ha each year		New South Wales, Australia	Ricegrowers Association of Australia, 2014
Multiple infrastructure improvements	3,700 m3/ha		New South Wales, Australia	Lachlan Catchment Management Authority, 2014
Rehabilitation of irrigation system and laser levelling	2,200 – 3,500 m3/ha		New South Wales, Australia	Ricegrowers Association of Australia, 2014b
Crop Management				
Complete fallowing of farm land	3,305 m3/ha each year	100%	California, USA	Palo Verde Irrigation District, 2015
Complete fallowing of farm land	4,343 m3/ha each year	100%	Texas, USA	NRCS, 2015
Complete fallowing of farm land	1,530 m3/ha each year	100%	California, USA	Cooley and others, 2008
Crop shifting	Up to 1,273 m3/ha each year (dependent on before/after crop type)		California, USA	California Dept. of Water Resources, 2010

Other Vegetation Management				
Removal of invasive introduced vegetation	7,400-12,200 m3/ha (if no replacement vegetation)	~100%	New Mexico, USA	Cleverly and others, 2002
Removal of invasive introduced vegetation	2,000-4,000 m3/ha each year	~50%	New Mexico, USA	Weeks and others, 1987
Removal of invasive introduced vegetation	345 m3/ha each year	~100% reduction of groundwater use	Northern Cape Province, South Africa	Dzikiti and others, 2013
Control of aquatic vegetation in canals & reservoirs (vs open water)	2,446 m3/ha each year	27%	Nile Delta, Egypt	Rashed, 2014
Weed control through mulching in rice farming	3,179 m3/ha each year	46%	Jiangsu Province, China	Towa and Guo, 2014
Combined Treatments				
Large variety of water-conserving measures	653 m3/ha each year		California, USA	Imperial Irrigation District, 2015