CHANGING PATTERNS AND PERCEPTIONS OF WATER USE IN EAST CENTRAL TEXAS SINCE THE TIME OF ANGLO SETTLEMENT

A Dissertation

by

WENDY WINBORN PATZEWITSCH

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2007

Major Subject: Geography

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Approved by:

Chair of Committee,	Jonathan M. Smith
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ABSTRACT

Changing Patterns and Perceptions of Water Use in

East Central Texas Since the Time of Anglo Settlement. (May 2007)

Wendy Winborn Patzewitsch, B.A., Trinity University;

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Patterns and perceptions of water use have changed since Anglo settlement in Texas in the early nineteenth century. Change has not been constant, gradual, or linear, but rather has occurred in fits and spurts. This pattern of punctuated equilibrium in water use regimes is the central finding of this dissertation. Water use is examined in terms of built, organizational, and institutional inertias that resist change in the cultural landscape. Change occurs only when forced by crisis and results in water management at an increasing scale. Perception is critical in forcing response to crisis.

Four water use regimes are identified. The agrarian regime was characterized by individual family and plantation units that were self-sufficient in their water supply. Water was perceived as abundant, but used sparingly. The agrarian regime began with Texas's declaration of independence from Mexico in 1836 and lasted for the remainder of the nineteenth century. The waterworks regime was characterized by the introduction of piped water. During this second regime, water was still perceived as abundant, but was also taken for granted. The crisis forcing the waterworks regime was the need for better fire protection in cities. The almost constant threat of flood and drought,

underscored by the Drought of the 1950s, in conjunction with a demographic shift, brought about the dam and levee regime. As a consequence of the Drought of the 1950s, water was for the first time perceived as scarce. We have just entered the groundwater regime. Recent water legislation and a state supreme court decision in favor of a bottled water company are putting new emphasis on groundwater sales from rural property owners to municipal water companies.

Empirical studies supporting this theoretical framework are drawn from the heretofore unpublished 1868 journal of Pleasant B. Watson, from municipal bond records in the archives of the Texas Comptroller, from the early history of the waterworks at Bryan, Texas, from newly discovered records of a levee along the Brazos River, from an overview of dam and reservoir construction, and from a recent proliferation of groundwater districts.

DEDICATION

To my parents

ACKNOWLEDGMENTS

Acknowledgments are due first to my advisor, Jonathan M. Smith, who introduced me to the literature of historical geography and geographic thought. His logic, organizational and editing skills, respect for the literature, and appreciation for the richness of archival data are his distinctive and much appreciated imprint upon this dissertation. I am also grateful that he agreed to supervise a dissertation about Texas water resources.

Many others are due recognition, especially Peter Hugill, the senior member of my committee, for our shared fascination with the levees of Burleson County, and my other committee members, Brad Wilcox, Christian Brannstrom, and Rob Dull. My sincere gratitude is extended to those who guided me through a seemingly endless amount of archival material on Texas water resources—all the while sharing their ideas, enthusiasm, and expertise—especially Anne McGaugh and Shawn Carlson of the Star of the Republic Museum in Washington, Texas for access to the journal of Pleasant B. Watson and for their thoughtful suggestions; Bill Page and Kathy Weimer of the Evans Library at Texas A&M University in College Station, Texas for eagerly donating time, resources, and expertise; Nan Ross and the staff of the Carnegie Library in Bryan, Texas for help accessing records from both Brazos County and the City of Bryan; Lisa Lee of the Map Room in the Burleson County Courthouse in Caldwell, Texas whose enthusiasm for Burleson County is contagious; Jenny Spurrier and the staff of the Southwest Collection at Texas Tech University in Lubbock, Texas for help with the archives of the Center for Historic Preservation and Technology and its predecessor programs at Texas Tech University; and Ellen Kuniyuki Brown of the Texas Collection at Baylor University in Waco, Texas.

I am also indebted to T. Lindsay Baker, Craig Colten, Clarissa Kimber, Martin Melosi, and Todd Votteler for their time, suggestions, and comments; as well as Ric Jensen of the Texas Water Resources Institute at Texas A&M University in College Station for encouraging a qualitative geographical dissertation about water. John Anderson, preservation officer for the Texas State Library and Archives Commission in Austin, Texas, was instrumental in the restoration of J.C. Nagle's map and five levee profiles from the Burleson County Improvement District No. 1, included at the end of this dissertation as Plates 1 through 6.

Grateful acknowledgment is made for unexpected sources of financial support—all with ties to Texas A&M University. My longtime friend Judy Paine-Marshall used the auspices of the Hollis Marshall Foundation to contribute to my geographic library in memory of her late Texas Aggie husband (Hollis Marshall, Class of 1954). The books acquired with this funding will, in time, be passed on to future graduate students. I also received financial support from the Association of Former Students, the Texas Water Resources Institute through the Mills Scholarship Program, and the Department of Geography at Texas A&M University.

On a more personal note, thanks go to my friends and family. From A&M's Department of Geography, fellow graduate students Serena Aldrich, Zheng Cheng, Jose Gavinha, and Xu Zengwang were always a welcomed sight in the O&M

Building and around campus as each of us pursued our studies. Sincere best wishes to each of these fellow Aggies.

A very personal acknowledgment is made to my parents whose excitement about world travels and their work with the Dallas Committee for Foreign Visitors brought an almost endless caravan of delightful foreign visitors to our dinner table. Their curiosity, insights, and wonderment about other places were instrumental in cultivating my interest in geography. Then, finally, my son gave me a valuable insight into the concept of scale. My parents introduced me to people and places far away, but my son opened my eyes to Texas and Texans in my own backyard. And to a special friend … pause.

To all of these, I owe a sincere debt of gratitude. Words seem inadequate, but—thank you, thank you, thank you!

TABLE OF CONTENTS

CHAPTER Page

Page

LIST OF FIGURES

FIGURE Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

The ways in which water is used, managed, and perceived have changed in Texas since the time of Anglo settlement in 1836. In spite of steadily increasing stress in the form of relentless population growth, this change in patterns of water use has occurred in fits and spurts. This pattern of punctuated equilibrium in water use regimes is the central finding of this dissertation. Virtually all disciplines have an interest in water, but there is little in the academic literature that explores change in water use. Almost all water use data comes from government agencies,[1] frequently as part of a water management plan,[2] but water use patterns and what causes them to change have been largely ignored. The word "pattern" invokes spatial distribution and "changing" suggests the passage of time; thus, there is a need for examination of changing patterns of water use within the context of historical geography.

This develops into an examination of the geography of change, using empirical data from archival sources grounded in traditional methodology of historical geography. A definition of environmental geography is explored that stands firmly upon four legs—historical, political, technological, and cultural—situated within the regional setting of

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This dissertation follows the style of *Philosophy & Geography*.

[1] United States Geological Survey, *Water Use in the United States: 50 Years of Water Use Information, 1950-2000,* http://water.usgs.gov/watuse/ (accessed March 12, 2007). See also, Rima Petrossian "Water Use Patterns and Trends: The Future in Texas," in *Water for Texas*, edited by Jim Norwine, John R. Giardino, and Sushma Krishnamurthy (College Station, TX: Texas A&M University Press, 2005), 52-61.

[2] Texas Water Development Board, *Water for Texas—2002* (Austin, TX: Texas Water Development Board, 2002), 30-32.

nineteenth and twentieth century Texas. Patterns of use, *per se*, recede in the analysis, as the human-environment relationship comes to the fore. It is not that water use itself loses its significance, but rather that some aspects of the human-environment relationship demand more attention from a society at any one given time. Water use itself remains a factor, but managing a problematic element in the human-water relationship becomes an overriding concern in defining critical elements in the relationship between humans and water. The roles of both perception and scale emerge as critical. Change in water use becomes integrated with response to crisis that challenges the human-water relation. And as the reasoned response to a new challenge emerges, it brings with it a new water regime, defined by a modified perception of water and implemented by a change in scale of water management.

This dissertation cuts a wide swath through human geography. Its qualitative approach is designed to contribute to the exploration of the human-environment interface by juxtaposing the general topic of water use with the challenge and response posed by the intersection of this interface with change in a society. To human geographers—in light of my impression that so much of the geographic work on water resources has historically been dominated by physical geographers—it is modestly hoped that this work will encourage a more exacting dialog about water's use and management within their chosen sub-disciplines. To historical geographers, the archival sources used here, particularly municipal bond data, may suggest other applications for this rich data set. The early history of the Bryan, Texas waterworks has, heretofore, been unpublished. The section on the levees of Burleson County brings a previously undocumented water management and construction project to the literature. To environmental geographers, I present my affirmation of a portion of this unwieldy sub-discipline as a way of situating this dissertation within the literature. In the spirit of Terry Jordan-Bychkov and Donald Meinig, students of the regional geography of Texas will find here something of interest.[3] To the historian, I introduce an interpretation of an unpublished journal written in Texas between 1858 and 1868. And finally, to those interested in water management policy, I graphically reiterate what they must certainly already know—change comes at a cost, predicated by crisis, and *influenced by history*. The role of perception is critical and generally underappreciated. Long established institutions, organizations, and elements of the environment all act to resist change. In other words, an entire history of entrenched water management attitudes and practices must be overcome in order to implement new policy.

There are many things this dissertation is not. In spite of its title, this dissertation is not a comprehensive treatise on water use in Texas. Water use data was not even collected in Texas until the mid-twentieth century, and yet this dissertation covers a time span of almost two hundred years. Instead, by extracting references to water from a

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[3] Jordan-Bychkov's work on Texas includes *German Seed in Texas Soil: Immigrant Farmers in Nineteenth Century Texas* (Austin, TX: University of Texas Press, 1966); "The Imprint of the Upper and Lower South on Mid-nineteenth Century Texas," *Annals of the Association of American Geographers* 57 (1967): 667-690; *Texas Log Buildings: A Folk Architecture* (Austin, TX: University of Texas Press, 1978; *Environment and Environmental Perceptions in Texas* (Boston: American Press, 1980); *Texas Graveyards: A Cultural Legacy* (Austin, TX: University of Texas Press, 1982); and (with John L. Bean, Jr. and William M. Holmes), *Texas: A Geography* (Boulder, CO: Westview Press, 1984). Meinig's work on Texas includes *Imperial Texas: An Interpretive Essay in Cultural Geography* (Austin, TX: University of Texas Press, 1969); "Texas and the Lower Rio Grande" in *The Shaping of America, Volume 1: Atlantic America, 1492-1800* (New Haven, CT : Yale University Press, 1986), 202-205; and "Annexation and Conquest: Texas and the Hispanic Borderlands" in *The Shaping of America, Volume 2: Continental America, 1800-1867* (New Haven, CT: Yale University Press, 1993), 128-158.

wide variety of archival sources, both expressly documented and implied, water's place in the landscape is gauged. This dissertation is not quantitative; no attempt is made to use statistical analysis to *prove* anything. Rather, I present an interpretation of observations for my reader's consideration. Nor does this dissertation attempt a comprehensive exploration of the work of human geographers on the topic of water.[4] And, in spite of my interest in human-environment relations, and even in the face of my argument that groundwater is rapidly becoming a commodity in Texas, I do not explore commodification or privatization through the literature of political ecology or political economy. Nor does this dissertation claim to break new ground theoretically. Instead, I develop the concept of water regimes by applying Robert Dodgshon's ideas on inertial elements in the landscape[5] in juxtaposition with Carville Earle's ideas on the role of crisis in the cyclic nature of American agricultural history,[6] always at an expanding scale,[7] and always influenced by the perceived abundance or scarcity of the resource.[8]

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[4] For a nice overview of recent works by human geographers on water-related topics, see James Wescoat, "Water Resources," in *Geography in America at the Dawn of the 21st Century*, edited by Gary L. Gaile and Cort J. Willmott (Oxford, UK: Oxford University Press, 2003), 283-301.
[5] Robert Dodgshon, *Society in Time and Space: A Geographical Perspective on Change* (Cambridge, UK: Cambridge University Press, 1998).
[6] Carville Earle, "The Periodic Structure of the American Past: Rhythms, Phases, and Geographic Conditions," in *Geographical Inquiry and American Historical Problems* (Stanford, CA: Stanford University Press, 1992), 446-540.
[7] Andrew Herod, "Scale: The Local and the Global," in *Key Concepts in Geography*, edited by Sarah L. Holloway, Stephen P. Rice, and Gill Valentine (London: Sage Publications, 2003), 229-247.
[8] William Cronon, "Landscapes of Abundance and Scarcity," in *Oxford History of the American West*, edited by Clyde A. Milner II, Carol A. O'Connor, and Martha A. Sandweiss (New York: Oxford University Press, 1994), 603-637.

The Geography of Water Supply

There is a finite amount of water, at least at the scale of the earth,[9] and it is distributed unevenly. Furthermore, this water is in motion, propelled by energy from the sun and cycling from the oceans into the atmosphere in the form of water vapor, returning to the earth's surface as precipitation, and flowing across and through the earth on its path back to the oceans again in what is known as the hydrologic cycle. Yi Fu Tuan has referred to the hydrologic cycle as the organizing principle for the natural sciences during the eighteenth century and a visible expression of the harmony of nature and "the wisdom of God." Tuan's idea was that in the eighteenth century, much of the learned world lived in temperate zones and did not give proper consideration to the beauty and value of arid lands. The result, somewhat to Tuan's dismay, was that arid lands were less settled and less studied than their more humid counterparts.[10]

I think of the hydrologic cycle as a logical starting point for this dissertation because it provides the driving mechanism for a naturally occurring, albeit uneven, water supply. In the United States precipitation varies from humid in the Southeast to arid in the Southwest. Thornthwaite added the concept of moisture index to the familiar isohyet maps showing precipitation decreasing from the humid eastern US to the semi-arid western US. The moisture index adds effects of temperature to varying levels of precipitation. Vegetation in the southern US requires more moisture than in the northern

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[9] Peter H. Gleick, "The Best and Worst of Science: Small Comets and the New Debate Over the Origin of Water on Earth," in *The World's Water: The Biennial Report on Freshwater Resources*, 1998-1999 (Washington, DC: Island Press, 1998), 193-199.

[10] Yi Fu Tuan, *The Hydrologic Cycle and the Wisdom of God: A Theme in Geoteleology* (Toronto: University of Toronto Press, 1968).

US due to increased evaporation rates caused by higher temperature, even when precipitation amounts are similar.[11]

Precipitation may occur in predictable average annual amounts across the United States, but its occurrence is by no means uniform. Droughts and floods have long plagued the human condition. Gilbert White's pioneering work on hazards studies in the United States has focused attention on problems associated with construction and reconstruction within the boundaries of a flood plain. Much of his work is in managing human response to temporal variations in surface water.[12] Increased paving within urban areas and the conversion of urban creeks into covered drainage ditches have increased the amount of runoff in urban areas, so hazards from flooding remain in spite of massive efforts at flood control. Droughts and floods are problematic. Water supply is uneven and irregular, and within the discipline of geography, has been approached largely through hazard studies.[13]

The Geography of Water Supply in Texas

Water supply in Texas comes from both surface water and aquifers. Surface water occurs naturally in rivers and creeks which run generally from the northwest to the

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[11] C.W. Thornthwaite and John Russell Mather, *The Water Balance*: Publications in Climatology, Volume VIII, Number 1 (Centerton, NJ: Drexel Institute of Technology Laboratory of Climatology, 1955), 70-75.
[12] Gilbert F. White, *Choice of Adjustment to Floods*, Department of Geography Research Paper No. 93 (Chicago: University of Chicago, 1964), especially 1-21 for a summary of an oft repeated theme in his work.
[13] Donald Hyndman and David Hyndman, "Streams and Flood Processes: Rising Waters," and "Floods and Human Interactions," in *Natural Hazards and Disasters* (Belmont, CA: Thomson, 2006), 268-325.

southeast, and in stock tanks, ponds, and lakes—most of which are man-made.[14] Groundwater occurs in aquifers oriented perpendicular to Texas rivers and parallel to the shoreline of the Gulf of Mexico.[15]

This variety results in diverse vegetation, animal species, soil types, and mineral deposits. Ultimately this contributes to variety in how the land is used by its human inhabitants, in the livelihoods people pursue, and in the ways natural resources are perceived and utilized. The climate of Texas ranges from humid in its southeastern corner to semi-arid in West Texas. Precipitation varies from less than ten to almost sixty inches annually,[16] and when it rains, it pours.[17] Thornthwaite's zero moisture index line representing no runoff with no transpiration deficit splits Texas in half.[18] The thirty inch per year isohyet marks a key transition for dryland agriculture and also runs through the center of the state. Central Texas is the most populous part of the transition zone between the Humid East and the Arid West in the United States today.[19]

The annual water budget for Texas has been estimated at 413 million acre-feet, supplied by precipitation. Of this amount, 49 million acre-feet supply watershed drainage or recharge aquifers. The remaining water is cycled back into the atmosphere

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[14] Texas Water Development Board, *Water for Texas—2002*, see Section 5.3.2 on Surface Water, 47-53 and Plate insert "Existing Major Water Supply and Permitted Reservoirs."
[15] Texas Water Development Board, *Water for Texas—2002*, see Figure 5-8, "The major aquifers of Texas," 40 (also included as Figure 7.3 in this dissertation); and Figure 5-9, "The minor aquifers of Texas," 41.
[16] Jordan-Bychkov et al., *Texas: A Geography,* 7-45.
[17] Todd H. Votteler, "Flood. When It Rains, It Pours—and That Can Mean Trouble for the Most Flood-Prone State in the Nation. Is Texas Ready for the Next Big One?" *Texas Parks & Wildlife* (March 2002).
[18] Thornthwaite and Mather, *Water Balance*, 71.
[19] United States Census Bureau, "Census 2000 Population Distribution in the United States," http://www.census.gov/geo/www/mapGallery/2kpopden.html (accessed March 11, 2007).

through evaporation and transpiration.[20] Current annual usage is 17.8 million acre-feet.[21] Demand is expected to increase to 20 million acre-feet by 2050.[22]

General History of Water Demand

While the starting point of a study of water supply may begin with physical geography and the hydrologic cycle, the geography of water demand falls within the realm of human geography. This work examines the geography of water demand in both a region and a period situated between water abundance and water scarcity. In humid lands, water is taken for granted, while in arid lands, water is a constant consideration even during migration and settlement. Journals from North America's age of exploration frequently make mention of water and the role it played in locating settlements. Father Juan Crespí described the eighteenth century exploration of the California coastline in search of a location for a mission outpost and reported in his journal that the site of Los Angeles was selected because its relatively flat coastal margin could support a more widespread area of irrigation than any other location along the California coast. One of the first duties of the original Spanish settlers of Los Angeles in 1781 was to dig irrigation ditches so that crops could be grown to support a mission and presidio.[23] But this establishment of an outpost was in a region thought to be semi-arid,

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[20] Ronald A. Kaiser, *Handbook of Texas Water Law* (College Station, TX: Texas Water Resources Institute, Texas Agricultural Experiment Station, 1987), 4.
[21] Texas Water Development Board, *Water for Texas—2002*, 58.
[22] Texas Water Development Board, *Water for Texas—2002*, 29.
[23] Blake Gumprecht, *The Los Angeles River: Its Life, Death, and Possible Rebirth* (Baltimore, MD: The Johns Hopkins University Press, 1999), 35-45.

and by a people, the Spanish, with prior knowledge of similar irrigation techniques in areas of new settlement in the New World.

In addition to its physical diversity, there has been diversity in the human geography of Texas. The dominant culture has shifted several times within the past two hundred years. Native Americans who inhabited the region prior to European conquest not only used rivers, but also had trails connecting thousands of springs and seeps. Some of these trails later became routes for Anglo settlers.[24] The Spaniards dug several community irrigation ditches called acequias in San Antonio and El Paso in the eighteenth and nineteenth centuries.[25] Anglo settlement began in earnest in the 1820s. Geopolitically, Texas during the nineteenth century was under the rule of five different sovereignties. Texas began the nineteenth century under Spanish rule. In 1821 Texas was part of Mexico when it was granted independence from Spain. The Republic of Texas was established as Texans declared independence from Mexico and defeated the Mexican army at the Battle of San Jacinto in 1836. Ten years later Texas was annexed as the twenty-eighth state in the United States only to secede from the Union to enter the Confederate States of America in 1861. After the Civil War and Reconstruction, Texas re-entered the United States in 1870.[26]

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[24] Gunnar Brune, *Springs of Texas, Volume I* (College Station, TX: Texas A&M University Press, 2002 [self-published, 1981]), *v*, 31.
[25] T. Lindsay Baker, *Building the Lone Star: An Illustrated Guide to Historic Sites* (College Station, TX: Texas A&M University Press, 1986), 280, 300.
[26] Robert A. Calvert and Arnoldo De Leon, *The History of Texas*, Second Edition (Wheeling, IL: Harlan Davidson, Inc., 1996).

Political sovereignty is one aspect of culture. Peirce Lewis has defined seven axioms for reading the cultural landscape. The first he calls the "axiom of landscape as clue to culture" and one of its corollaries is that of cultural change—if there is a change in the look of the landscape, then it follows that there is a change in the culture.[27] I would turn this around and say that if there is a change in the culture, then it follows that there will often be a change in the landscape. Certainly the political turmoil in Texas in the nineteenth century presents fertile ground for exploring the likelihood of cultural change.

Demographically the study area has undergone an almost complete transformation during the timeframe of this study. The sparse population at the turn of the nineteenth century was ethnically Native American and Hispanic. Today the Native American population has been largely displaced by a population that is predominantly of European, Hispanic, and African descent. Texas's population grew from an estimated 7,000 in 1806, to 3 million in 1900, to over 20 million in the year 2000.[28]

This exponential population growth resulted in thousands of new settlements. In 1820 San Antonio and Nacogdoches were the only established towns. By 1840 there were more than fifty settlements.[29] Today there are thousands of cities and towns across

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[27] Peirce Lewis, "Axioms for Reading the Landscape" in *The Interpretation of Ordinary Landscapes: Geographical Essays*, edited by D.W. Meinig (New York: Oxford University Press, 1979), 15.
[28] Texas State Historical Association, *The Handbook of Texas Online*, entry "Census and Census Records," http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).
[29] Elizabeth Silverthorne, *Plantation Life in Texas*, First Edition (College Station, TX: Texas A&M University Press, 1986), 215.

the state.[30] More significant than simply the number of settlements is the population distribution between rural and urban areas. Almost all of the early Anglo settlers in Texas in the first half of the 19th century came to Texas because of the opportunity to acquire land. Their livelihood was largely agrarian, many settling in the Brazos and Colorado River valleys, and many involved in the production of cotton. From this predominantly rural Anglo population in 1850 there has been an almost complete transition to an urban population today.[31]

Demographic change is another aspect of culture and as such is a second argument for a change in the landscape. It places stress on a water supply system by virtue of increasing demand. Complications also arise when this increased demand does not occur at locations of natural water supply. Hence, Texas in the last two hundred years provides a diverse physical setting, rife with the seeds of cultural change, compounded by the stress of rapid population increase, from which to launch an exploration of the geography of water demand.

Texas Water Use Regimes and Why They Changed

Just as water supply varies both across time and with location, so, too, does water demand. Within Texas since the time of Anglo settlement in the 1830s, water use has gone through four stages of relatively constant patterns of use followed by rather abrupt transitions to different patterns of use. I am calling these stages 'water regimes.'

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[30] *Texas Almanac, 2004-2005* (Dallas, TX: Dallas Morning News, 2004).

[31] D.W. Meinig, *Imperial Texas: An Interpretive Essay in Cultural Geography* (Austin, TX: University of Texas Press, 1969), 110-121.

The first water regime is the agrarian regime. It is characterized by self-sufficiency of the individual family unit, and water was perceived to be abundant. Small groups of people, usually families or plantations, secured their own water on a daily basis. The scale of acquisition was small, but the demand was ever-present. Water use was predominantly for domestic and livestock purposes. Industrial uses were relatively minor, although water was used in transportation.

The second water regime is the waterworks regime. It resulted from a larger scale need to manipulate water than was present in the agrarian regime. In developing cities, need for better fire protection in the Central Business District led to the creation of local waterworks. Although originally created as an insurance necessity for the preservation of small businesses, the piping of water for domestic purposes soon followed. A division of labor occurred, and individual family units were no longer responsible for securing their own water. There was a fundamental difference in how water was perceived as soon as water became available from the tap. Water's use in sanitation increased as sewage systems were constructed and indoor plumbing became the norm. As energy sources shifted from wood and coal to electricity, water assumed a significant new role in the generation of hydroelectric power. In this regime, water was still considered to be abundant, but it was now taken for granted.

The third water regime is the dam and levee regime. Flooding and drought required water management at an even larger scale. Severe drought in the 1950s occurred just as the demographic shift from rural to urban took place in Texas. Securing water for a rapidly growing population in an increasingly concentrated area in the face of severe drought required innovative thinking about water supply on a larger scale. Flood control had earlier been attempted with the construction of levees, but this proved to be ineffective. It was decided that a better way of managing flood waters was to divert them into reservoirs, and to conserve this surplus water for irrigation or times of drought. This was made possible by technological advances in soil science and engineering construction. This water management strategy was severely tested by the Drought of the 1950s. Domestic uses increased as both water availability and the number of home appliances increased. At the same time, the use of water for irrigation increased because of better pump technology and the spread of rural electric power. Awareness of surface water supply limits increased among the populace, and water pollution became a concern. The dam and levee regime is characterized by the perception that water was scarce. The scale of water management increased with significant involvement from state and federal government agencies.

The fourth water regime is the groundwater regime. The establishment of businesses designed to make a profit from the sale of water rights resulted in increasing tension between rural property owners and urbanites. Litigation and legislation related to water increased. Private ownership of groundwater and its availability as a marketable item became an issue. The bottled water industry grew rapidly. Water allocations to sustain the environment became part of the public debate as an increased awareness of human impacts on the environment was absorbed into the culture. Groundwater districts proliferated. This regime is characterized by the perception that there are only limited quantities of fresh, pure groundwater, and unease that rural Texans will lose property values if groundwater is transported to urban population centers without adequate compensation to landowners. Groundwater is increasingly viewed as a commodity by rural Texans, much as oil and gas was viewed in terms of mineral rights a generation earlier.

These are the four water regimes, but why was there change from one regime to the next? I argue that change is related to a major crisis. The crisis can be natural, such as a drought, or it can be human-induced, such as legislation or technology. It can also be demographic. In every case, response to crisis brings about a change in the landscape that leads to changing patterns and perceptions of water use.

The role of perception is integral, and I invoke it at three levels. First, I move from a time when water was perceived not to be a problem into one in which it is perceived as a problem, so change in perception forms the backdrop of this work. Second, perception is the lens through which culture is experienced, and culture is an important aspect of how I understand environmental geography. In invoking another of Lewis's axioms for reading the landscape, the historic axiom, I must unravel past cultural contexts or perceptions in order to understand not only past landscapes but vestiges of the past in contemporary landscapes.[32] Finally, perceptions themselves may be the basis of the crises that precipitate change. After all, scarcity and abundance are relative terms.

[32] Lewis, "Axioms for Reading the Landscape," 22-23.

So this is the story of perception of, and change in, patterns of water use in a place and during a time of myriad transitions. This is not a comprehensive review of all uses made of water during the last two hundred years. Nor is this intended to be a comprehensive historical geography or environmental history of Texas. This dissertation begins by offering a way of organizing our understanding of patterns of water use, and proceeds to an investigation of how changing perceptions of water influences patterns of water use. The focus is to define patterns of water consumption and to determine under what conditions individuals have altered their patterns of water use. My goal is to combine archival research with the literature of historical geography and environmental history to contribute to a dialogue on resource utilization in American historical environmental geography.

This work is organized into eight chapters. Chapter I explores the rationale for a water-related human geography study and defines the organizing concept of water regimes. Both the location and timeframe of the setting are detailed. Chapter II situates the dissertation within environmental and historical geography, and affirms my belief that environmental geography stands on historical, political, technological, and cultural legs. Relevant work from other disciplines, particularly environmental history, is reviewed. Geographic thought providing the theoretical underpinnings of my argument is reviewed in Chapter III. Chapters IV through VII document each of the specific water use regimes, and are arranged chronologically. In Chapter IV, I use travelers' accounts and settlers' journals to interpret water use during Anglo migration and settlement in east central Texas. Of particular interest is the inclusion of material from the journal of

Pleasant B. Watson, written between 1858 and 1868, and heretofore unpublished. In Chapter V, I examine the early history of Texas waterworks, arguing that they were constructed, in large measure, in response to the need for better fire protection in the central business districts of market towns. I incorporate information on almost fifteen hundred municipal water bonds passed before 1930 to show which communities put an early emphasis on developing public water supplies and which did not. I include a case study of the early history of the waterworks in Bryan, Texas by using Sanborn insurance maps. In Chapter VI, I examine response to flood and drought through a change in scale of the management of surface water. In particular I examine the grassroots organization of the Burleson County Improvement District Number One that resulted in the construction of a twenty-seven mile long flood protection levee along the west bank of the Brazos River in 1910, and the later construction of more than two hundred dams to conserve surface water in the face of drought and increasing water demand. In Chapter VII, the recent establishment of groundwater conservation districts is chronicled as a response to the perceived need to begin regulation of groundwater extraction and transportation across the state. In Chapter VIII, conditions resulting in changing patterns of water use are summarized.

CHAPTER II

AMERICAN HISTORICAL ENVIRONMENTAL GEOGRAPHY

> While recognizing for the convenience of argument the existence of 'boundaries' around fields of knowledge, I have both acknowledged their permeability and advocated more border crossings. It is the very hybridity of historical geography and geographical history which appeals to me.[33] … Alan R.H. Baker

This essay is situated within the context of American historical environmental geography. Political ecology constitutes a large and important segment of environmental geography, but this dissertation does not explore this part of the literature. Even without considering political ecology, a definition of environmental geography is elusive. This omission should not be taken as an implicit assertion that political economy is irrelevant to the questions addressed in this dissertation. Answers to questions of political economy were simply not readily supplied by the types of archival resources I consulted. The latest edition of the *Dictionary of Human Geography* has no such listing. In 1986 the Second Edition did, however, contain entries for environmental determinism, environmental hazard, environmental impact assessment, environmental learning, environmental perception, and three definitions for environmentalism. Environment itself is listed but not defined—referring the reader instead to listings for behavioral environment, phenomenal environment, environmental determinism, and nature. By the publication of the Fourth Edition of this same dictionary in 2000, there

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[33] Alan R.H. Baker, *Geography and History: Bridging the Divide* (Cambridge, UK: Cambridge University Press, 2003), 226.

was no longer any listing for environment, although entries had been added for environmental audit, environmental economics, environmental justice, environmental movement, and environmental psychology. The term environmental is not confined to human geography. In the latest edition of the *Dictionary of Physical Geography* entries are included for environmental assessment, environmental impact, environmental impact statement, environmental issue, and environmental management, all of which contain significant overlap with traditional aspects of human geography.[34] Although not itself defined, the title would seem to cover an expanding range of topics of interest to a large number of geographers. But a catch-all phrase that collects so many different topics from both physical and human geography is unwieldy. It is not that there is no such thing as environmental geography, but rather that it is understood from so many different vantage points that its definition becomes problematic—either so general as to encompass much, even most, of geography or so specific that it is useful only to a small subset of geographers. Yet I do believe there is something called environmental geography.

According to the *Oxford English Dictionary* environ originally meant to form a ring around, surround, or encircle. The definition subsequently expanded to include the conditions under which any person or thing lives or is developed: the sum-total of influences which modify and determine the development of life or character. In the

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[34] R.J. Johnston, Derek Gregory, David M. Smith, eds., *The Dictionary of Human Geography*, Second Edition (Oxford, UK: Blackwell Reference, 1986), 131-7. R.J. Johnston, Derek Gregory, Geraldine Pratt, and Michael Watts, eds., *The Dictionary of Human Geography*, Fourth Edition (Oxford: Blackwell Publishers, 2000), 212-25. David S.G. Thomas and Andrew Goudie, eds., *The Dictionary of Physical Geography*, 3rd Edition (Oxford, UK: Blackwell Publishers, 2000), 169-77.

1960s environment became associated with the earth sciences and pollution. Its common usage today stems from Paul Ehrlich's 1970 volume *Population, Resources, Environment* and denotes the natural environment as contrasted with the built environment.[35]

Introducing the word natural as a modifier is problematic. Raymond Williams has described nature as "perhaps the most complex word in the language" and ascribes to it three broad definitions. The first pertains to the innate characteristics of something, the second to forces that drive a process, and the third to the physical world itself. How humans and their actions, their constructions, their usages of other material objects enter into the definition is a matter of contention, with the basic problem being that some understandings include humans as a part of nature, while others do not.[36]

The words nature and environment have become interchangeable in the vernacular. In this manner environment commonly refers to those parts of our surroundings that are not constructed by humans. This is a misuse of the word, albeit widespread. Unless otherwise specified, in this dissertation I use the word nature in the sense of Williams' third categorization—that of the physical world itself, and I use the word environment to refer to that physical world standing in relation to humans.

In addition to these problems of the scope of environmental geography and vagaries resulting from differing usages of the words environment and nature, environmental geography also carries the heavy baggage of history. Backlash against

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[35] *Oxford English Dictionary*, Second Edition, 1989, http://dictionary.oed.com/ (accessed March 11, 2007).
[36] Raymond Williams, *Keywords: A Vocabulary of Culture and Society*, Revised Edition (New York: Oxford University Press, 1983), 219-24.

environmental determinism as espoused by Ellsworth Huntington and his colleagues in the early part of the twentieth century was strong enough to stagger much of American geography for decades. The response was a regional descriptive phase, dominated by the ideas of Richard Hartshorne, in which environmental analysis was superficial. Respect for the discipline waned as geographers were accused of nothing more than collecting information about regions. In a reaction against the perceived non-scientific nature of the regional approach to geography, quantitative analysis was injected into the discipline in the mid twentieth century, and geography became nomothetic. Turmoil created by the cultural revolution of the 1960s changed patterns of thinking as the human element forced its way back into the geographic equation. At the same time environmentalism became a rallying cry for widely disparate groups in American society, and this breathed new life into American environmental geography. This rebirth took place as the environmental determinist legacy turned itself inside out and redirected itself to studies of human impacts on the environment.[37]

Environmental geography should not be taken to include all work by geographers on the physical world, simply because this definition is too broad. For this dissertation, environmental geography is taken to comprise studies of the relationship between

[37] R.J. Johnston, *Geography and Geographers: Anglo-American Human Geography since 1945*, Fifth Edition (London: Arnold, 1997). Roderick Frazier Nash, *American Environmentalism: Readings in Conservation History*, Third Edition (New York: McGraw-Hill Publishing, 1990). William L. Thomas, Jr. ed., *Man's Role in Changing the Face of the Earth* (Chicago: University of Chicago Press, 1956). B.L. Turner II et al., *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years* (Cambridge, UK: Cambridge University Press, 1990). Andrew Goudie, *The Human Impact on the Natural Environment*, 5th Edition (Cambridge, MA: The MIT Press, 2000).

humans and their natural environment in a place-specific setting, and of how this relationship varies over time. It encompasses technological and political response to change from a culturally constructed point of view. In examining these relationships, the perception of the natural environment needs to be reconstructed.

Key to perception in geography is J.K. Wright's concept of geosophy, or geographical knowledge. Wright argued that geographic knowledge is possessed by everyone, not just geographers, and that we cannot understand the environmental behavior of a group until we understand the type of world they *thought* they lived in.[38] Perception is inferred from responses to stress, in this case, on water demand. Individual responses, varied though they may be, are a cultural by-product, because culture forms individual attitudes toward the uses and role of water in society. Individual responses to stress may lead to technological or political innovations that may or may not be adopted as a group response to changing conditions. This understanding of environmental geography and its reliance on cultural, technological, political, and historical legs is the basis for this work.

By insisting upon including a historical component in my definition of environmental geography, I may be encroaching upon territory normally associated with environmental historians. In this respect I am heavily indebted to Alan R.H. Baker for so eloquently framing a comparison between geography and history. Environmental geography is similar to environmental history with the differences being the same as the

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[38] J.K. Wright, "*Terrae Incognitae*: The Place of the Imagination in Geography," *Annals of the Association of American Geographers* 37 (1947): 1-15.

differences between historical geography and geographic history. Baker contends that place is as central to the geographer as period is to the historian. The topics under consideration by the two disciplines may be identical, but the questions asked are usually different. Each brings different methods to bear upon a problem. At the same time, Baker admits the differences between the two disciplines are sometimes exaggerated. Baker identifies three key concerns in historical environmental geography: past physical environments, the impact of human activities upon natural environments in the past, and human perceptions of environments in the past.[39] I am starting with his third concern—perceptions of environments both past and present—and analyzing how these perceptions have affected patterns of water use. Past physical environments and human impacts are not ignored, but my emphasis is upon how the use of water changed from one period to another. With my definition of environmental geography, and further emboldened by Baker's approach to historical environmental geography, I am by no means attempting either to construct or enforce rigid sub-discipline boundaries. Rather, I am drawing a map for my reader, locating a position and providing direction as to the inputs I will choose to chart my course.

The past has colored the present in American environmental geography. Much recent environmental geography has focused on human impacts and policy. While this approach has much to offer, it is reactionary and largely synchronic. By this I mean the environment is studied because it is perceived to have a problem—a river is polluted, an

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[39] Baker, *Geography and History*, 2-4, 79-108.

endangered plant species is located in the path of a highway, an ecosystem is fragmented into fenced pastures, a non-native species is introduced where it has no natural predator, urban sprawl is infringing upon animal habitats, dams affect fluvial sediment transport, automobile and industrial emissions alter the atmosphere, irrigation lowers the water table. I am not arguing against such human impact studies, but I do not think they constitute the whole of environmental geography. My position is that environmental geography includes the exploration of causal relationships and unintended consequences in iterative processes between humans and their natural surroundings over time spans greater than several decades—the typical length of a researcher's active career. In the remainder of this chapter I will describe past and recent geographical literature that affirms my belief that environmental geography stands on historical, political, technological, and cultural legs. The four underlying statements about environmental geography are an affirmation of principles I believe presently inform this rather nebulous sub-discipline. They are not exhaustive and should not be taken to proscribe other understandings of environmental geography; nor are they to be interpreted as novel or rigid normative statements.

Environmental Geography Is Historical

The study of environmental geography is historical because, as Carl Sauer long ago taught us, every pattern must be understood as a stage in a process. In his "Foreword to Historical Geography," Sauer said, "knowledge of human processes is attainable only if the current situation is comprehended as a moving point, one moment in an action that has beginning and end." And he further cautioned against putting undue emphasis on the present simply because it is more accessible.[40]

When I write that environmental geography is historical, I mean that present patterns of interaction with natural processes are not completely rational. That is, they are not based solely upon how we presently think the natural world works and ought best be exploited. There is a historical process at work, and in this there is structural inertia, so that present day options are as much limited by past decisions as they are by realities of the natural world. Humankind's interactions with natural processes do not begin anew with each new insight into how these natural processes occur.

Further exploring the relation between geography and history, Alan Baker proposes organizing geographic discourses around discourses of location, environment, and landscape—all overlapping, in Venn diagram format, in what he calls the "central discourse of regional geography" at the core. He compares and contrasts how each discourse has been treated in both geography and history, and points to significant overlaps between the two disciplines. Baker argues against rigid disciplinary boundaries and focuses instead on the types of questions being asked and the perspective of the researcher. His acceptance of the expansiveness of an inquiry and his willingness to put regional geography at the core of geographic discourse provide an intellectual framework for the approach I am taking in this dissertation.[41]

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[40] Carl Sauer, "Foreword to Historical Geography" in *Land and Life: A Selection from the Writings of Carl Ortwin Sauer*, edited by John Leighly (Berkeley, CA: University of California Press, 1963[1941]), 361.
[41] Baker, *Geography and History*, 8.

The work this dissertation most resembles is Craig Colten's work on New Orleans. Colten has taken a historical approach to the human-environment coupling[42] in a place dominated by its physical setting. He has relied on archival work, specifically city records, newspaper accounts, government reports, historical documents, health records, and the rich literature about New Orleans, and has situated his account within the current literature of historical geography and environmental history. Colten's account makes it clear that New Orleans cannot be understood without placing it within the dominating context of the Mississippi River, whether it be the physical presence of the river, its wetlands, and levees; the economic significance of the river to every aspect of local, regional, even some national livelihoods; or the cultural consequences of the river. In his short epilogue Colten concludes that environment in New Orleans has always mattered and continues to matter.[43] This was written just prior to the destruction of the city by Hurricane Katrina.

The principal historical geographer to write on matters of water is J. M. Powell. He argues that because Australia is one of the driest settled areas on Earth, the most effective ways to study its history is through how it has managed its water. He examines the debate over whether water would better be managed as a centralized or decentralized resource, and notes, as I have in Chapter VI, the influence of drought on water policy.[44] He also notes that Australia's identity is partially determined by its natural resources—a

[42] More about this 'human-environment coupling,' a term borrowed from B.L. Turner II, in Chapter III.
[43] Craig E. Colten, *An Unnatural Metropolis: Wresting New Orleans from Nature* (Baton Rouge, LA: Louisiana State University Press, 2005).
[44] J.M. Powell, "Environment and Institutions: Three Episodes in Australian Water Management, 1880-2000," *Journal of Historical Geography* 28, No. 1 (2002): 100-114.

bravado that almost has a ring of Texan to it—and that Australians have on occasion taken an overly optimistic view of their water supply.[45]

Donald Meinig made one brief foray into a water topic, also situated in Australia. In an examination of the longevity of Goyder's Line of Rainfall marking the extent of drought in South Australia in 1865, Meinig noted that this line had persisted on maps of the region for almost eighty years. When first laid out by then Surveyor-General G.W. Goyder, the line separated agricultural land from pastoral land, but later was used to determine which acreage could be bought on credit for agricultural purposes. This line was viewed with open hostility by agriculturalists who expanded their farming into the semi-arid territory during the 1870s, with apparent success. Goyder maintained that rainfall in this territory was problematic, and when drought returned a decade later, he was vindicated. The resulting economic agricultural failure was significant enough to have secured the Goyder's Line a place on maps of the region almost a century later.[46] The story that Meinig told is a good example of an institutional inertia etched into the mentifacts of South Australian culture by the crisis of drought, a theme I will return to in Chapter III.

[45] J.M. Powell, "Enterprise and Dependency: Water Management in Australia," in Ecology and Empire: Environmental History of Settler Societies, edited by Tom Griffiths and Libby Robin, 102-121 (Seattle, WA: University of Washington Press, 1997). See also, J.M. Powell, *Watering the Western Third: Water, Land and Community in Western Australia, 1826-1998* (Western Australia: Waters and Rivers Commission, 1998). This is reviewed by Michael Williams in *Progress in Human Geography* 24, No. 2 (2000): 336-337.

[46] D.W. Meinig, "Goyder's Line of Rainfall: The Role of a Geographic Concept in South Australian Land Policy and Agricultural Settlement," *Agricultural History* 35, No. 4 (1959): 207-214.

Much contemporary historical work in environmental geography has roots in historical geography. One example is the volume edited by Brian Graham and Catherine Nash entitled *Modern Historical Geographies*. Papers are organized into "Modernity and Its Consequences," "Spatial Contexts," and "Past and Present." Themes include globalization, identity, imperialism, colonization, urbanism, and the environment.[47] The paper on the environment, by J.M. Powell, is a history of environmental geography, although reference is made to human impacts on Australia's changing indigenous vegetation. Powell encourages more work that blends archival work with physical geography at a variety of scales.[48]

A second example is the recent trilogy of review articles by Deryck Holdsworth in *Progress in Human Geography*. Holdsworth begins by noting that the collection by Graham and Nash consists almost entirely of work relevant to researchers in cultural, political, and economic geography. On the other hand, he notes Peter Goheen's admonition to historical geographers for not critically examining the most important work from their own field, such as Donald Meinig's *The Shaping of America*. Holdsworth concludes that historical geography is vibrant because it maintains a healthy balance between new topics inspired by mainstream human geography and traditional settlement studies (exemplified by Meinig's work), between studies at the local,

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[47] Brian Graham and Catherine Nash, eds., *Modern Historical Geographies* (Harlow, UK: Pearson Education Limited, 2000).
[48] J.M. Powell, "Historical Geographies of the Environment," in *Modern Historical Geographies*, edited by Brian Graham and Catherine Nash, 169-192 (Harlow, UK: Pearson Education Limited, 2000).

regional, and global scales, and between established historical geographers and a new cadre of historical geographers who employ new archives and interpretations of power.[49]

In his second review article, Holdsworth encourages use of new media sources to interpret both past geographies and present interpretations of heritage.[50] The most obvious example of new media used in this dissertation is Google Earth, a computer program that allows almost instantaneous access to recent satellite imagery, at resolutions sometimes approaching one meter, for anywhere in the world. I have also used the ever-increasing amount of archival information available on the internet. For example, the Star of the Republic Museum in Washington, Texas—a resource I used extensively in collecting material for Chapter IV—is in the process of photographing all of their artifacts so they can be viewed online. The State of Texas has implemented Texas Archival Resources Online (TARO) with annotated lists of collections of holdings in many different archives across the state.[51] The archives are not online, but such aids for finding records are extremely helpful. In some cases, the records themselves are online. When researching the history of the waterworks at Bryan, Texas, I began by visiting the Water Department at City Hall. I should have looked to the internet instead.

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[49] Deryck W. Holdsworth, "Historical Geography: The Ancients and the Moderns—Generational Vitality," *Progress in Human Geography* 26, No. 5 (2002): 671-678.
[50] Deryck W. Holdsworth, "Historical Geography: New Ways of Imaging and Seeing the Past," *Progress in Human Geography* 27, No. 4 (2003): 486-493.
[51] Texas Archival Resources Online, "Finding Aids," http://www.lib.utexas.edu/taro/index.html (accessed March 16, 2006).

The earliest preserved minutes of Bryan's City Secretary are available online by going to the city's webpage and selecting "e-services."[52]

Holdsworth's third review article is on urban and environmental themes. He uses the metaphor of an octopus extending itself across many fields of interest to describe how urban centers are increasingly entangling themselves with resources from the environment beyond.[53] The topic of this dissertation could be considered in similar light. The population of Texas has increasingly concentrated itself in the urban centers of Dallas-Fort Worth, Houston, and Austin-San Antonio. Consequently, municipal water demand is also concentrating in these cities. In Chapter VII, I explore the mechanism by which groundwater may be drained from rural Texas by its thirsty cities. This transportation of water to Texas' cities will not be without its controversies, and fundamental issues of power, frequently at the heart of today's human geography, will be contested.

Themed issues from *Historical Geography* also indicate current interests in the sub-discipline. These include the use of GIS in historical geography, edited by Anne Knowles.[54] I have used GIS techniques in this dissertation, both to build maps and to organize data sets. Municipal water bond data has been organized into timeslice maps using archival information I gathered in combination with proper place locations from

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[52] City of Bryan, "Welcome to City of Bryan E-Services," http://www.bryantx.gov/ (accessed December 17, 2006).
[53] Deryck W. Holdsworth, "Historical Geography: The Octopus in the Garden and in the Fields," *Progress in Human Geography* 28, No. 4 (2004): 528-535.
[54] Anne Kelly Knowles, Guest Editor, "Thematic Issue: Emerging Trends in Historical GIS," *Historical Geography* 33 (2005).

the United State Geological Survey database on Geographical Names. A shaded relief map situating the Burleson County levee was made using latitude-longitude data interpolated from USGS topographical sheets, Google Earth, and a digital elevation model obtained from the Texas Water Development Board. Another themed issue of *Historical Geography* particularly relevant to this dissertation is that of "Geography, Law, and Legal Geographies" edited by Benjamin Forest.[55] Inequities in Texas water law, particularly with respect to groundwater, form the basis of my argument in Chapter VII.

Environmental Geography Is Political

Environmental geography demonstrates an awareness of the political dimension of social life. This means an awareness of conflict, and power, and how collective decisions are made. How a resource is managed, by whom, and for what purpose is inherently political and the result of struggles, compromises, and clashes. Because water is vital and yet not always available where in demand, water management has long been a political concern. Critical to understanding water management in a particular locale is identification of the groups of stakeholders competing for its use, and the political structures that guide the policy-making process. A key element in the management of natural processes is recognition of the need for both a vehicle to manage environmental change and a vehicle to change management policies. This raises the question of

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[55] Benjamin Forest, Guest Editor, "Thematic Issue: Geography, Law, and Legal Geographies," *Historical Geography* 28 (2000).

whether management practices have been designed to manage constant one-time change. Historical analysis of environmental management provides numerous examples of unintended consequences, so management for a one-time change is generally ineffective.

George Perkins Marsh was the first to combine the theme of managing change with that of unintended consequences in his criticism of the clearing of the woodlands of Europe. Although the conversion of little used forest into agricultural land was widely seen as a beneficial land management practice with economic and social benefits, Marsh repeatedly pointed to negative unintended consequences including effects on stream water temperature and turbidity.[56] Clearing was managed as a one-time alteration of the land. Marsh not only saw no indication of management for change, once the land was used by humans he was pessimistic restoration would ever be possible.[57] In spite of this sweepingly negative perception of human environmental impacts, Marsh pointed with approval to reclamation of coastal lowland in the Netherlands and in the wetlands of western Italy. In both cases he indicated overwhelming public support for reclamation, citing both economic and health benefits for local citizenry.[58]

Karl Butzer studied irrigation of the Nile River Valley prior to 332 B.C., and describes another seemingly successful political process at work. Local influence rather than centralized control was evident in water allocations, according to Butzer. Because control was local, allocations could be altered by pressures from some in the local community. This system put responsibility in the hands of one individual, but this

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[56] George Perkins Marsh, *Man and Nature*, (Seattle, WA: University of Washington Press, 2003),107-8
[57] Marsh, *Man and Nature*, 352-3.
[58] Marsh, *Man and Nature*, 284-99, 353-65.

person responded to community pressure. Thus, there was built into this system a method to allow for changing water allocations on an annual basis. [59]

Karl Wittfogel argued that the control of water was the key element in political control, particularly in a semi-arid environment. He argued that a well-developed bureaucracy controlled irrigation and, therefore, the economy of civilizations in eastern Asia for millennia. This bureaucracy lacked the flexibility of the water allocation system described by Butzer. The infrastructure was so large and impersonal as to discourage flexibility in water allocations and made change in water management practices nearly impossible.[60]

Here in the United States individuals with strong personalities emerged to shape both the landscape and government agencies. John Wesley Powell understood the power of politics, but never mastered the ability to persuade others. His water management plan for the western US was thoroughly researched through extensive field surveys complemented by utopian ideals. Powell was uncompromising in his beliefs, but failed to convince Congress to organize the West along watershed boundaries and eventually resigned as the Director of the USGS.[61] Several decades later, it was another agency of the Department of the Interior—the Bureau of Reclamation—that reshaped the landscape of the American West through massive dam building efforts and irrigation

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[59] Karl W. Butzer, *Early Hydraulic Civilizations in Egypt: A Study in Cultural Ecology* (Chicago: University of Chicago Press, 1976).
[60] Karl A. Wittfogel, “The Hydraulic Civilizations” in *Man’s Role in Changing the Face of the Earth*, edited by William L. Thomas, Jr. (Chicago: University of Chicago Press, 1956), 152-164.
[61] Wallace Stegner, *Beyond the Hundredth Meridian: John Wesley Powell and the Second Opening of the West* (New York: Penguin Books, 1954), 345.

projects fueled by the politics of the New Deal. Under the directorship of Floyd Dominy, most of the rivers of the western US, and some in the eastern part of the country, were dammed to conserve surface water.[62] Another person of enormous influence, William Mulholland, wrested land and resources from across the state of California to secure water for the City of Los Angeles in the early twentieth century.[63] The amount of environmental change instigated at the hands of these three politically influential men is staggering.

Power concentrated in the hands of a few can be abused. Political ecologists and political economists hold the view that environmental change can be best understood through principles of Marxism. Political ecology encompasses a dialectic between nature and society that is frequently manifested as a narrative of peasants in developing countries trapped a downward spiral of escalating poverty due either to increasing impoverishment of the soil or exploitation by a powerful and wealthy ruling class. As an example, Erik Swyngedouw has compared recent water supply problems in Spain to those encountered a century ago. In each case he argues that "imbalances in its climatic and hydraulic regimes" required restoration of wealth that could only be provided by hydraulic engineers working under strong central governance to produce the transformation of nature. In theory the central government represents the collective

[62] Donald J. Pisani, *Water and American Government: The Reclamation Bureau, National Water Policy, and the West, 1902-1935* (Berkeley, CA: University of California Press, 2002); Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water* (New York: Penguin Books, 1986); John McPhee, *Encounters with the Archdruid* (New York: Farrar, Straus and Giroux, 1971).
[63] Gumprecht, *The Los Angeles River*, 1999.

voice of the peasants.[64] There is vast discussion in recent literature about the commodification and privatization of water, much of it within the realm of political economy. This dissertation is not framed within the constructs of political economy, but this literature is acknowledged because access to fresh water and its entire delivery infrastructure certainly contain significant elements that are both environmental and political. Karen Bakker, for example, analyzes almost fifteen years of privatization of water in England and Wales, and suggests that because it is essential, for both humans and the environment, water is ill-suited for commodification.[65]

Not only does the nature of political power affect environmental conditions, but environmental conditions also affect the nature of political power. The heart of the matter is the question: What is the relation between scarcity and liberty? A strong case can be made that liberty is a luxury of abundance. David Potter has argued, I believe convincingly, that there is such a thing as national character, and that the national character of the United States is predicated upon its abundance. This was exemplified during frontier expansion when an abundance of land and perceived limitless natural resources were absorbed into the nation's psyche. Scarcity causes conflict, and this leads to authoritarian control—Wittfogel's point exactly. Conversely, abundance leads

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[64] Erik Swyngedouw, "Modernity and the Production of the Spanish Waterscape, 1890-1930" in *Political Ecology: An Integrative Approach to Geography and Environment-Development Studies*, edited by Karl S. Zimmerer and Thomas J. Bassett (New York: Guilford Press, 2003), 94-112.
[65] Karen Bakker, "Neoliberalizing Nature? Market Environmentalism in Water Supply in England and Wales," *Annals of the Association of American Geographers* 95, no. 3 (2005): 542-565.

to possibilities for "freedom to grasp opportunity" and pathways to equality and liberty.[66]

Donald Worster does not share this view of a direct correlation between liberty and abundance when considering control over water supplies. He argues in his classic work on water in the American West that water has been used to control a mutually beneficial relationship between capitalists and government for the last hundred years, and that this has resulted in Westerners having sold their freedom for the security of a relatively dependable water supply. Worster urges a return to water self-sufficiency in this desert environment by dismantling the large cities and embracing a much simpler lifestyle. He is arguing that only by being self-reliant does one truly have freedom.

> One cannot have life both ways—cannot maximize wealth and empire and maximize democracy and freedom too…. Approached deliberately as an environment latent with possibilities for freedom and democracy rather than for wealth and empire, the unredeemed desert West might be an unrealized national resource…. In the midst of what had once been regarded as the bleakest scarcity [Americans] would find abundance.[67]

These views are echoed in current literature. Martin Reuss argues that in order to understand the development of America's water resources, it is necessary to understand American culture and politics. The imprint of freedom as both a cultural and political legacy has dictated that the development of water resources proceed carefully so as not to trod upon these individual freedoms. As a result, water resources have been developed in a piecemeal fashion, with more care given to preservation of freedoms than

[66] David Potter, *People of Plenty: Economic Abundance and the American Character* (Chicago: University of Chicago Press, 1954), 92, 114-5, 204-6.
[67] Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Oxford University Press, 1985), 334-5.

to conceiving and implementing a coherent national plan for the development of water resources.[68]

Philip Steinberg and George Clark have examined a Massachusetts case study in which proposed changes in access and recreation policy at a large lake supplying Boston's water have exacerbated tensions between urban growth and environmental preservation. Scale matters in this example, both regionally and temporally. The authors suggest that, although emotions were running high and stakeholders feared the worst, given enough time most would come to see they had objectives that were not dissimilar. Because of this, compromise and relative agreement on resource allocation are possible. The authors suggest that this might be accomplished by turning the narrative away from resource conflict and focusing instead on "politics from the perspective of the resource-receiving region."[69]

The politics that control water management systems are certainly important, but so, too, is the scale at which water is managed. Christian Brannstrom has studied decentralized water management in three Brazilian states. As decentralization practices were put into effect at the local level, it was expected that downward accountability would produce better equity and efficiency. Grass-roots involvement was expected to encourage conservation and better management practices. In practice, the results were

[68] Martin Reuss, "The Development of American Water Resources: Planners, Politicians, and Constitutional Interpretation," in *Managing Water Resources Past and Present*, edited by Julie Trottier and Paul Slack, 51-71 (New York: Oxford University Press, 2004).
[69] Philip E. Steinberg and George E. Clark, "Troubled water? Acquiescence, Conflict, and the Politics of Place in Watershed Management," *Political Geography* 18(1999): 477-508.

mixed, with further studies underway.[70] Sarah O'Hara has noted that a sudden reduction in the scale of water management in the Central Asian Republics due to the collapse of the Soviet Union in 1991 created serious problems for water supply and infrastructure in the area. For most of the twentieth century, water in the Central Asian Republics had been managed from Moscow. With independence, the individual nations were responsible for funding their own maintenance of the aging infrastructure, something they lacked the resources to accomplish. Furthermore, with the breakup of Central Asia into separate countries, the mountainous source area for surface water was often in a different country from the irrigated acreage where crops were produced. New water management techniques are a necessity with this change in scale.[71] The scale at which water is managed in Texas has changed several times, and is an integral part of how I have defined water regimes.

Water resource policy is integrally related with the political process. A geographic overview on the subject is Rutherford Platt's "Geographers and Water Resource Policy."[72] Historian Donald Pisani has written of United States water policy through the major dam building era. In *To Reclaim a Divided West*, Pisani begins with the use of water in mining communities in the American West and proceeds to the development of irrigation, examining the tension between individual freedom and the

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[70] Christian Brannstrom, "Decentralising Water Resource Management in Brazil," *European Journal of Development Research* 16, No. 1 (March 2004): 214-234.
[71] Sarah O'Hara, "Lessons from the Past: Water Management in Central Asia," *Water Policy* 2 (2000): 365-384.
[72] Rutherford H. Platt, "Geographers and Water Resource Policy," in *Water Resources Administration in the United States: Policy, Practice, and Emerging Issues*, edited by Martin Reuss, (East Lansing, MI: Michigan State University and American Water Resources Association, 1993), 36-54.

security of a dependable water supply in the semi-arid American West. It is a political history of early irrigation in the western United States, culminating with the Reclamation Act of 1902.[73] In *Water and American Governance*, Pisani continues the story of how the Bureau of Reclamation operated from its inception through the building of the Hoover Dam.[74] For a more comparative analysis of how water is managed at different scales and in different locales, mainly in Asia, see Wescoat and White's *Water for Life*.[75]

The works cited in this section concerning the political aspect of environmental geography share a common topic—the control of water, and a common theme—that the scale of governance makes a difference. They also explore mechanisms for collective decisions about the control of water. In other words, in various places at various times, some possibilities for solutions are more possible than others because of the type of political structure in place.

Environmental Geography Is Technological

Technology—the artifacts, institutions, and ideas that are the means of livelihood—sets the ultimate limits to the possible forms of environmental interaction. Technology is also a siren song constantly suggesting the possibility of lifestyle improvements. In either case—that of present use or future possibilities, the relation between humans and the resources drawn from their environment is a dynamic one

[73] Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy 1848-1902* (Albuquerque, NM: University of New Mexico Press, 1992).
[74] Pisani, *Water and American Government*, 2002.
[75] James L. Wescoat, Jr. and Gilbert F. White, *Water for Life: Water Management and Environmental Policy* (Cambridge, UK: Cambridge University Press, 2003).

because of technological change. There is no generic human or human/environmental relation, only humans relating to their environments in specific historical, political, technological, and cultural settings.

Imperialism and colonization for raw materials is a theme in historical geography. Peter Hugill points to a series of technological changes that led to shifts in world hegemony, frequently with imperialistic overtones. He speaks to the importance of naval power, but then considers the implications for the balance of world power of the locomotive, the automobile, and the airplane. These transportation advances were revolutionary in terms of time-space compression. Hugill also considers technological advances in what he terms hardware and software. Hardware advances are new manufactured products. Software advances are new processes, ways of thinking, or organization. By conceiving ways of organization as technological innovation, Hugill provides the connection between technology and culture—learned behavior.[76]

Donald Jackson provides an example of Hugill's software and hardware in his article describing an innovative way of organizing in order to build the Cave Creek Flood Control Dam near Phoenix, Arizona in 1923. During a period of considerable influence by the federal government in reclamation projects in the western United States,[77] the Cave Creek Flood Control Dam was constructed with no federal funding. Instead, it was a joint collaboration between the private sector and municipal

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[76] Peter Hugill, *World Trade Since 1431: Geography, Technology and Capitalism* (Baltimore, MD: The Johns Hopkins University Press, 1993).
[77] Pisani, *Water and American Government*, 2002.

government. It was also innovative in that it utilized multiple arch dam technology developed by John S. Eastwood.[78]

Perhaps the most fundamental technological change related to water occurred when water was available from the tap—piped delivery. Gilbert White studied water use in East Africa during the late 1960s and noted that when piped water came to villages, per capita water use increased, sometimes by as much as an order of magnitude.[79] The current literature on water research is overwhelming, but fortunately, in 1998, Peter Gleick began publishing *The World's Water: The Biennial Report on Freshwater Resources*. A new volume in the series comes out every other year, and together this collection is an outstanding synthesis of current topics of concern to water researchers. Floods and droughts, water law, water privatization, groundwater, bottled water, and desalination—all topics touched relevant to this dissertation—are addressed in *The World's Water*.[80]

Technological advances are made during times of war, a point not lost on Peirce Lewis in his essay "America between the Wars: The Engineering of a New Geography." Lewis argues that during the period between World War I and World War II, the United

[78] Donald C. Jackson, "Private Initiative, Public Works," in *Fluid Arguments: Five Centuries of Western Water Conflict*, edited by Char Miller (Tucson, AZ: University of Arizona Press, 2001), 251-275.
[79] Gilbert F. White, David J. Bradley, and Anne U. White, *Drawers of Water: Domestic Water Use in East Africa* (Chicago: University of Chicago Press, 1972), 109-149.
[80] Peter H. Gleick, ed., *The World's Water: The Biennial Report on Freshwater Resources, 1998-1999* (Washington, DC: Island Press, 1998); Peter H. Gleick, ed., *The World's Water: The Biennial Report on Freshwater Resources, 2000-2001* (Washington, DC: Island Press, 2000); Peter H. Gleick, ed., *The World's Water: The Biennial Report on Freshwater Resources, 2002-2003* (Washington, DC: Island Press, 2002); Peter H. Gleick, ed., *The World's Water: The Biennial Report on Freshwater Resources, 2004-2005* (Washington, DC: Island Press, 2004); Peter H. Gleick, ed., *The World's Water: The Biennial Report on Freshwater Resources, 2006-2007* (Washington, DC: Island Press, 2006).

States underwent a technological revolution that completely revamped the country's transportation and communications systems. It was a step function of sorts that separated the nineteenth century from the twentieth century. It wasn't just that the automobile, telephone, motion pictures, and radio were invented. The big change, according to Lewis, is that they were *engineered*—that "ingenious combination of machinery and corporate organization that would transform these curiosities into cheap, reliable, mass-produced necessities. That happened almost simultaneously in the short period between 1910 and 1925, when all four abruptly reached critical mass and were enthusiastically adopted by millions of Americans."[81] Concurrently, a political metamorphosis occurred as the government took over roles previously reserved by its citizens and a demographic transformation took place as Americans widely relocated. In this dissertation, the role of crisis is critical in providing the tipping point from one water regime to the next, although war itself did not provide the reason.

This technological and demographic revolution described by Lewis produced increasing amounts of waste materials, and distributed these wastes unevenly throughout both the natural and built environments. Craig Colten has asked pertinent questions as to when there was sufficient technological knowledge to recognize that wastes from this new industrial technology were contaminating groundwater. Through the use of technical and trade journal articles, he makes a convincing case that groundwater contamination from surface waste disposal should have been recognizable by the mid

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[81] Peirce Lewis, "America Between the Wars: The Engineering of a New Geography" in *North America: The Historical Geography of a Changing Continent*, edited by Thomas F. McIlwraith and Edward K. Muller (Lanham, MD: Rowman & Littlefield, 2001), 382.

twentieth century.[82] Technology created the new industrial wastes, and technology is called upon to recognize and mitigate the effects of this very same waste. Colten's point is that technology may temporarily outstrip its ability to predict its consequences. This raises questions of when and how a new technology should be adopted, and what might the consequences be of its implementation. These are not new questions, as we have learned from Marsh,[83] but rather questions that eventually seem to arise as a result of each new solution. The role of unintended consequences in solutions to water management challenges is also a factor in this dissertation.

Anuradha Mathur and Dilip da Cunha have written a beautiful book that is technological in its outline, but touches on all normative aspects of environmental geography. In *Mississippi Floods*, Mathur and da Cunha examine elements of the meanders, flows, banks and beds of the Mississippi River after the massive flooding of 1993, organized with a chapter for each of these fluvial features. This event had been prepared for since the river flooded in 1927, but the flood control measures in place proved to be completely inadequate in 1993. Mathur and da Cunha question what the response to the flooding should be, invoking thoughts of Gilbert White's ideas of avoiding building in a river's floodplain. Their analysis draws upon historical maps,

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[82] Craig E. Colten, "A Historical Perspective on Industrial Wastes and Groundwater Contamination," *Geographical Review* 81, no. 2 (April 1991): 215-228.
[83] Marsh, *Man and Nature*, 36, 29, 280.

government reports, and cultural response to the flooding in a book that is equal parts art and science.[84]

It is tempting once again to turn to Sauer, this time to make the transition from the technological to the cultural in environmental geography. His "culture" is essentially technology expressed as what he calls a *genre de vie* or way of life. Sauer was interested in understanding the possibilities disclosed by a culture with its distinctive technology and values, and he did this by examining the livelihoods of its people, the hardware and software they employed as means to stay alive in their particular environment.[85]

Environmental Geography Is Cultural

According to Sauer,

> Environmental response is the behavior of a given group under a given environment. Such behavior does not depend upon physical stimuli nor on logical necessity, but on acquired habits, which are the culture of the group. The group at any moment exercises certain options as to conduct, which proceed from attitudes and skills that it has learned. An environmental response, therefore, is nothing more than a specific cultural option with regard to the habitat at a particular time.[86]

In other words, environment is a term of evaluation. Sauer's observation was that geographers in the early twentieth century "came to think that human geography and

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[84] Anurdaha Mathur and Dilip da Cunha, *Mississippi Floods: Designing a Shifting Landscape* (New Haven, CT: Yale University Press, 2001).
[85] Sauer, "Foreword to Historical Geography," 358.
[86] Sauer, "Foreword to Historical Geography," 359.

history were really quite different subjects, not different approaches to the same problem, the problem of cultural growth and change."[87]

Gerry Kearns argues that Sauer's understanding of the cultural landscape is still relevant. He agrees with Sauer that the human imprint is indelible upon the landscape and that a closer examination of the contested use of space across time should be one of the goals of the "environmental history turn" which he believes is happening in cultural geography. In particular, Kearns is interested in examining how the use of property promotes power relationships.[88] The story of the levees of Burleson County, told as part of the dam and levee regime described in Chapter VI, is an instance of how landowners were able to leverage the potential earnings from their landholding to raise revenue via taxation and the issuance of bonds to put into place a flood protection system. At least initially, the group supplying the capital was the group reaping the economic benefits of the levees. The economic benefits did not trickle down to the laborers themselves, however.[89]

A prevalent theme in the literature of cultural geography today is that of environmental justice. With regard to water use, Kate Berry has taken a lead in writing about Native American struggles for water rights in the American Southwest.[90] The

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[87] Sauer, "Foreword to Historical Geography," 354.
[88] Gerry Kearns, "Environmental History," in *A Companion to Cultural Geography*, edited by James S. Duncan, Nuala C. Johnson, and Richard H. Schein (Malden, MA: Blackwell, 2004), 194-208.
[89] See excerpts from the levee blues songs sung by the laborers as recorded by John and Alan Lomax and included in Chapter VI of this dissertation.
[90] Kate A. Berry, "Race for Water: American Indians, Eurocentrism, and Western Water," in *Environmental Injustices, Political Struggles: Race, Class, and the Environment*, edited by David E. Camacho (Durham, NC: Duke University Press, 1998), 101-124.

specific issue of Native American water rights does not enter into this dissertation, but access to public water supplies across the socio-economic spectrum is. The establishment of waterworks, as described in Chapter V, was clearly for the benefit of those operating in the central business districts of towns. By mapping the spread of water mains, I have laid the groundwork for a methodology to examine access to public water supplies by different socio-economic groups. The related theme of environmental equity exposing racial biases is explored in Colten's work on the development of New Orleans sanitation system.[91] Heywood Sanders has found similar inadequacies in the environmental equity of San Antonio's water supply and sanitation.[92] While I do not examine sanitation systems in this dissertation, the location of the water mains and hydrants is an initial step in the study of access to public water supply. In the case study presented on Bryan, Texas, the first area served was the central business district. From there the water system was extended along the railroad to protect the cotton warehouses—the economic engines of the town—and then to places of value: schools and churches. An incursion of the water system was made into the town's lower socio-economic neighborhood to the northeast to protect its school by 1912, but most of the expansion then was to wealthier neighborhoods to the southeast.[93] There is much more work to be done on environmental equity studies specific to Texas. The location of

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[91] Colten, *An Unnatural Metropolis,* 77-107. Also, Craig E. Colten, "Basin Street Blues: Drainage and Environmental Quality in New Orleans, 1890-1930," *Journal of Historical Geography* 28, No. 2 (2002): 237-252.

[92] Heywood Sander, "Empty Taps, Missing Pipes: Water Policy and Politics," in *On the Border: An Environmental History of San Antonio,* edited by Char Miller (Pittsburg, PA: University of Pittsburg Press, 2001), 141-168.

[93] See Figures 5.9-5.12 in Chapter V.

Texas sewerage plants, industrial sites, agricultural feedlots, and landfills is an issue that has not received significant scrutiny in the academic literature. Access to fresh water supplies and sanitation is now widely available in urban Texas, although the history of its access has not been written. Rural Texans still frequently provide their own well water and septic tank sewerage, and there are unincorporated communities with no services. The largest constituency unserved with basic sanitation and fresh water are those living in the colonias near the Rio Grande. This is the subject of increasing attention from the Texas Water Development Board, non-governmental agencies, and the academic literature.

Culture is also rooted in perception. In telling the story of a short-lived copper mine deep in the bowels of southeastern Alaska, William Cronon makes this point by example. He imagines two little girls, both picking berries in the same location only a few years apart. One is the 10-year old daughter of a Scandinavian miner who had lived in this place only a short time. This little girl picked the cranberries for recreation, as a chance to get out of town and into nature. The berries were not a necessity, but a welcomed treat that her mother made into a pie for dessert using an old Norwegian recipe. The other is an Ahtna girl who gathered the berries to store through the winter to use for dyes, medicine, and sustenance.[94] The actions of the two little girls were similar, the product harvested identical, but their perceptions were different because their cultures were different.

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[94] William Cronon, "Kennecott Journey: The Paths out of Town" in *Under an Open Sky: Rethinking America's Western Past*, edited by William Cronon, George Miles, and Jay Gitlin (New York: W.W. Norton & Company, 1992), 28-51.

The perception of water is a central theme in Maria Kaika's *City of Flows*, a cultural geography of water that studies water systems in London and Athens using modernity as the underlying theme. Kaika admits to taking water for granted until drought made water from the tap problematic. It was then that she started considering differences between home, city, and nature and realized just how unnatural a process was involved in her water supply.[95] Her ideas on taking water for granted until forced to do otherwise by drought mirror a major theme in Chapter VI.

Bret Wallach is also concerned that there will be inadequate supplies of water—so inadequate that our society could collapse. He provides statistics suggesting that in some parts of the world, including the United States, there is considerably more rainfall than water consumption. And yet he, and many others, are concerned that population growth combined with unchecked resource usage will lead to catastrophic problems. Wallach concludes that this is because we are relying on "progress" to save us from our woes, but that secretly we as a society do not have complete confidence that progress will save us.[96]

Finally, culture is rooted in place. In situating this dissertation, Meinig's *Imperial Texas* is an overview of the cultural history of Texas in the tradition of an American historical geographer.[97] Robin Doughty has also explored the landscape of Texas through the eyes of Anglo setters and notes changes in the environment, particularly with respect to changes in the state's animal species after Anglo

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[95] Maria Kaika, *City of Flows: Modernity, Nature, and the City* (New York: Routledge, 2005).
[96] Bret Wallach, *Understanding the Cultural Landscape* (New York: Guilford Press, 2005), 258-280.
[97] Meinig, *Imperial Texas*.

settlement.[98] Richard Francaviglia has written about historical and cultural symbols of Texas and the Southwest.[99] Otis Templer specialized in contributing analyses of Texas water law to the geographic literature. His work encompassed both surface water and groundwater, noting inconsistencies between Texas water law and the science of the hydrologic cycle.[100] More recently, Robert Glennon has written on the logic of revising groundwater law, using examples from across the United States.[101] These examples of Texas water law are cultural expressions with deep roots in both Spanish and English law, a theme developed in Chapter VII. Along a related line, Todd Votteler explores the nature of conflict about Texas rivers and aquifers and issues which affect Texas policy, specifically litigation concerning the Edwards aquifer and more generally the need to plan for floods and drought.[102]

Managing surface water in Texas has been accomplished through the establishment of river authorities. The first such authority was the Brazos River Authority. The history of the first fifty years of this agency has been chronicled by

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[98] Robin W. Doughty, *At Home in Texas: Early Views of the Land* (College Station, TX: Texas A&M University Press, 1987); Robin W. Doughty, *Wildlife and Man in Texas: Environmental Change and Conservation* (College Station, TX: Texas A&M University Press, 1983).

[99] Richard Francaviglia, *The Cast Iron Forest: A Natural and Cultural History of the North American Cross Timbers* (Austin, TX: University of Texas Press, 2000); Richard Francaviglia, *The Shape of Texas: Maps as Metaphors* (College Station, TX: Texas A&M University Press, 1995).

[100] See, for example, Otis Templer, "Water Law and Geography: A Geographic Perspective," in *Geography, Environment, and American Law*, edited by Gary L. Thompson, Fred M. Shelley, and Chand Wije (Niwot, CO: University of Colorado Press, 1997)

[101] Robert Glennon, *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters* (Washington, DC: Island Press, 2002).

[102] Todd H. Votteler, "Raiders of the Lost Aquifer? Or, the Beginning of the End to Fifty Years of Conflict Over the Texas Edwards Aquifer," *Tulane Environmental Law Journal* 15 (2002): 258-334; Todd H. Votteler, "The Little Fish that Roared: The Endangered Species Act, State Water Law, and Private Property Rights Collide Over the Edwards Aquifer," *Environmental Law* 28 (Winter 1998), 845.

historian Kenneth Hendrickson.[103] This history is now twenty-five years old, and the river authority has assumed significant new duties.[104] This follows in the theme of Chapter V, managing surface water. No review of the culture of this place called Texas would be complete without an enormous debt of gratitude to Terry Jordan-Bychkov, who centered his studies on Texas for much of his academic career. Although Jordan did not write about water, he did publish a short essay on environmental perception in Texas, largely rooted in observations about its physical geography.[105] Jordan-Bychkov's work most influential on this dissertation is his geography of Texas, but his recent *Upland South* is a convenient compendium of much of the work on cultural artifacts that so characterized his work in this region.[106] And finally, there is a recent book on Texas water, entitled *Water for Texas*, edited by geographers Jim Norwine, John R. Giardino, and Sushma Krishnamurthy. It includes several climatological articles, but most are about regional water needs assessments, water quality, and water conservation measures.[107]

This dissertation attempts to reconcile ideas about the relationship between culture and nature in east central Texas as these are exemplified in water use and management. It does this with a detailed empirical study guided by the four assumptions

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[103] Kenneth Hendrickson, *The Waters of the Brazos: A History of the Brazos River Authority 1929-1979*. Waco, TX: Texian Press, 1981.
[104] Brazos River Authority, "Timeline of the Brazos River Basin," www.bra.org (accessed November 1, 2001) and Appendix A of this dissertation.
[105] Jordan-Bychkov, *Environment and Environmental Perceptions in Texas*.
[106] Jordan-Bychkov et al., *Texas : A Geography*; Terry Jordan-Bychkov, *The Upland South: The Making of an American Folk Region and Landscape* (Santa Fe, NM: Center for American Places, 2003).
[107] Jim Norwine, John R. Giardino, and Sushma Krishnamurthy, *Water for Texas* (College Station, TX: Texas A&M University Press, 2005).

described in this chapter. Environmental geography, as I am interpreting it in this dissertation, is historical, political, technological, and cultural. As I have shown, these assumptions are widely shared by past and practicing geographers, however I believe I have connected them in a novel and useful fashion. And, as Peter Gould said, geography is about discovering connections.[108]

[108] Peter Gould, *Becoming a Geographer* (Syracuse, NY: Syracuse University Press, 1999), 118-119.

CHAPTER III

THEORETICAL FRAMEWORK

Having outlined my general understanding of environmental geography, I now turn to the framework I will use to examine changing patterns of water use. First I make the connection between environmental geography and coupled human-environmental systems and propose an answer to the general question of environmental change. I then examine change in patterns of water use, perception, and management using the concept of water regimes. This establishes the theoretical groundwork for the empirical chapters that follow.

Environmental geography studies the relationship between humans and their environment in specific places. B.L. Turner II has referred to these relationships as linkages and to the natural environment as the biosphere. In studying global environmental change, Turner and his colleagues argue that there are complex and uneven relationships between humans and the biosphere within which they are situated. In the emerging field of vulnerability analysis in sustainability science, these relationships are referred to as coupled human-environment systems.[109] This concept of coupled human-environmental systems is at the core of environmental geography.

It is not the purpose of this chapter to attempt to untangle this coupling, but rather to begin by noting that such a coupling exists. From this starting point the next

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[109] B.L. Turner II et al., "A Framework for Vulnerability Analysis in Sustainability Science," *Proceedings of the National Academy of Sciences* 10, no. 14 (July 8, 2003): 8074-8079. B.L. Turner II et al., "Illustrating the Coupled Human-Environment System for Vulnerability Analysis: Three Case Studies," *Proceedings of the National Academy of Sciences* 100, no. 14 (July 8, 2003): 8080-8085.

step is to note that it is part of a system. This means there is an ongoing series of actions and responses resulting from interactions between humans and their surroundings, each of which triggers other responses that react in complex and even unrecognized ways, possibly with unintended consequences. Furthermore these responses may be different across the surface of the earth from one time to the next, and across different socio-economic classes.

Change and Causality

Change can occur gradually, abruptly, or in rhythmic phases of alternating gradual and abrupt changes. All patterns are found in the environment as changed by humans, and in humans as changed by the environment. In these exchanges causality moves across the human-environment boundary in both directions. Human-induced change in the environment results from what we might call a *cause* proper. The environmental reaction is determined by the human action and the nature of the coupled human-environment system. Environment-induced change in humans, on the other hand, often results from a perceived *reason.* [110] The human response to a reason is voluntary, but more importantly it comes after the reason has been perceived and evaluated as sufficient to warrant the human reaction. This is why some human responses to environmental change are immediate (they are caused by causes proper)

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[110] Antony Flew, *Thinking about Social Thinking*, Second Edition (Amherst, NY: Prometheus Books [Basil Blackwell], 1995 [1985]), 113-134.

and others come only after a long build-up of environmental “pressure” (they are “caused” by reasons).[111]

An expression of change in the natural sciences is the theory of evolution—the cumulative development of characteristics of species over time. Darwin explained evolutionary change through the mechanism of natural selection. Those species with the most appropriate characteristics for survival contribute more offspring for successive generations. Some adaptations to environmental stresses are more conducive to survival than others.

But is this change gradual or abrupt? If the evolution of species is a series of random genetic mutations, some of which increase the likelihood of survival, then a series of relatively minor genetic adjustments would over time result in slow and steady transformation of species. This is the argument of the gradualists. In 1972 paleontologists Niles Eldredge and Stephen Jay Gould argued for a different type of speciation. They took note of the fact that the fossil record does not yield evidence of gradual transformation, but that time and again it suggests abrupt transitions between long periods of stasis. Eldredge and Gould proposed that this was, in fact, how evolution proceeded—in fits and starts, a theory they named punctuated equilibrium. Gradualists explain this inconsistency between the fits and starts of the observed fossil record and their idea of continuous change by noting that the fossil record is incomplete, a fact that Eldredge and Gould do not dispute. They do, however, argue that their

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[111] Jonathan M. Smith, “Ethics and the Human Environment,” in *A Companion to Cultural Geography*, 209-220, edited by James S. Duncan, Nuala C. Johnson (London: Blackwell, 2004).

evolutionary theory of punctuated equilibrium at least conforms to the data by including long periods of stasis followed by occasional bursts of species change. In punctuated equilibrium, change is relatively rapid when considered on a geologic time scale, but the rate of change is not uniform. Gould explains change as the result of the splitting of a species into two groups, one of which is much smaller and isolated from the larger group. This peripherally isolated group provides a more fertile ground for propagating change when compared with the larger group of the species. Any genetic change will have a greater effect when concentrated within a smaller group.[112]

In the mid twentieth century, Ludwig von Bertalanffy introduced the concept of general systems theory to try to address the complex interrelationships between different components of a larger entity. His basic unit of organization was the system. A system is defined as 'sets of interrelated parts.' This in and of itself is problematic because definition of the limits of a system is difficult. A system has inputs and outputs. One of the major tasks of general systems analysis is to identify and map these inputs and outputs, and to ask whether these inputs and outputs change the nature of the system over time, or preserve in the system some sort of equilibrium. This concept of feedback loops is at the heart of general systems theory and explains why a system changes or stays the same. (Bertalanffy's ideas were quickly adopted by geographers Arthur Strahler and Richard Chorley.) Bertalanffy intended his idea to be a general theory that

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[112] Niles Eldredge and Stephen Jay Gould, "Punctuated Equilibria: An Alternative to Phyletic Gradualism," in *Models in Paleobiology*, edited by Thomas J.M. Schopf (San Francisco: Freeman, 1972): 82-115. Stephen Jay Gould and Niles Eldredge, "Punctuated Equilibrium Comes of Age," *Nature* 366 (18 November 1993). Stephen Jay Gould, "Opus 200," *Natural History* 100, no. 8 (August 1991): 12-18.

could unite research between the physical and social sciences. I am here interested in Bertalanffy's cascading systems, which is to say a system that is in stasis, even in the face of constant inputs, until suddenly that equilibrium is upset and a new stasis is established. Gould's punctuated equilibrium and Bertalanffy's cascading system are both accounts of discontinuous change predicated upon cause and effect, and grounded in the natural sciences but with widespread application in the social sciences. [113]

The idea that change can occur suddenly, however, does not mean that it occurs without a history, without provocation, or without being precipitated by a series of events. It does mean, however, that there is a point beyond which the system cannot respond in the same manner as it has in the past. In general systems theory this is referred to as a threshold—that is, the point beyond which the system requires a different response to a constantly increasing stress. In this dissertation the term "tipping point" is used to describe the event or combination of events that precipitates a new response to water management. It must be emphasized that this new response does not result from a cause proper, however. Rather, it is a chosen or reasoned response made from within a particular political, technological, and cultural context, and working with a particular inherited landscape.[114]

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[113] Richard Chorley and R. Bennett, *Environmental Systems: Philosophy, Analysis and Control* (London: Methuen, 1978). For human geography adaptations see J. Langton, "Potentialities and Problems of a Systems Approach to the Study of Change in Human Geography," *Progress in Geography* 4 (1972): 125-79. Another example is Peter Atkins, Ian Simmons, and Brian Roberts, "Environmental Degradation and the Collapse of Civilizations," in *People, Land and Time: An Historical Introduction to the Relation between Landscape, Culture and Environment* (London: Arnold, 1998), 53-62.

[114] Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (Boston: Little, Brown, 2000). Gladwell explains using the idea of the spread of the flu in a metropolitan area. The flu is present in the population, but affecting only a relatively small percentage because the number of people

In human history, patterns of change are frequently interpreted in terms similar to those used in the natural sciences. One such analogy draws a comparison between an organism and a civilization, with both going through stages of birth, maturation, and death. Arnold Toynbee thought civilizations were the appropriate unit for the study of history. He was intrigued with parallels between his own experiences in Britain during the First World War and that of the Hellenistic society that had been the basis of his education. This led him to question why societies thrive and then meet what he viewed as their inevitable demise. He argued that adversity, not abundance, stimulates the evolution of civilizations, and that a few creative individuals influence a society with their example. Toynbee argued history has shown that a society that successfully responds to one challenge rarely is successful in adapting to the next. There is a rhythm to the growth and disintegration of societies that corresponds to a series of challenges and responses. In Toynbee's analysis, the third failure to respond successfully to a challenge leads to a fatal loss of confidence, and the society disintegrates only to be succeeded by another elsewhere. [115]

Economist Joseph Schumpeter compared economic change generated by capitalism to an evolutionary process he called 'creative destruction.' Innovation is the process that drives capitalism, be it in the form of new products, new markets, or new

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coming down with the illness each day approximately equals the number recovering each day. The tipping point occurs when the holiday shopping season arrives, increasing subway ridership sharply, thereby putting people in contact with more of the general population, some of whom are infected. Although the flu virus has been present for some time pre-dating the epidemic, it is the response to the holiday season that is identified as the tipping point for the epidemic.

[115] Arnold J. Toynbee, *A Study of History*, Abridgement of Volumes I-VI by D.C. Somervell (New York: Oxford University Press, 1947): 548-558.

technology. He invoked the metaphor of industrial mutation to describe endogenous processes of change in which the consequence of the new is to replace, rather than supplement, the old.[116] Schumpeter believed challenges and responses of capitalism are endogenous. I agree that innovation is a response to challenge in a human society, but also would argue that a similar response can and does come from exogenous stress.

Geographer David Harvey has used this concept of creative destruction to describe the transition from modernity to postmodernity. He envisions societal change as inexorably wrapped in political economy. Harvey argues that the order of modernism has been destroyed by the flexibility of time-space compression inherent in postmodernism. He harkens back to Marx, who pointed to the innovations of capitalism as ultimately creating crises of obsolescence. As soon as capital was "sunk," it became necessary to return that capital to liquidity so it could take advantage of new, more profitable investment opportunities. Innovation creates new investment opportunities; meanwhile market saturation causes the profitability of sunk capital to decline toward zero. According to Harvey and Marx, the rhythmic change of creative destruction results from capitalists' need constantly to seek maximum profits.[117]

What Toynbee, Schumpeter, and Harvey have done is extend the discussion of change from the realm of the natural sciences to that of the social sciences. Their emphasis has gone from cause and effect of the discontinuous change of Gould and

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[116] Joseph Schumpeter, *Capitalism, Socialism, and Democracy*, Third Edition (Boston, MA: Houghton Mifflin, 1962), 81-86.
[117] David Harvey, *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change* (Oxford, UK: Blackwell, 1990), vii-viii, 16-18, 105-7.

Bertalanffy to talk of challenge and response. This is important in understanding the coupling of natural and human systems. This coupling is both reaction to deterministic physical laws and an expression of ways the human element responds to stress. I am interested in one type of change—historical change in human societies. And of historical change, I am primarily interested in those that are caused by exogenous environmental factors. Schumpeter and Harvey are not looking specifically at change in the human-environment coupling, but they, along with Toynbee, have contributed to the dialogue about how human societies respond to change. Toynbee asked whether it is adversity or abundance that stimulates growth of a civilization. Schumpeter considered innovation as a response to challenge, and Harvey sheds light on effects new responses have on established ways of doing things. All have considered challenge and response in ways I think are important for understanding the coupling between nature and humans. Understanding response to change is part of the equation; resistance to change is also a factor.

One need not restrict causes to situations that are deterministic (e.g. “the blow to her head caused her to lose consciousness), and the term can be usefully applied to situations where, despite what we might call theoretical freedom, the behavioral effect is for all practical purposes determined (e.g. his threat to strike her over the head caused her to comply with his wishes). Reasons are distinguished by the fact that the person or group being presented with the reason can *choose* from a range of possible responses, may even indeed choose not to respond. This is not to say that responses to reasons are deliberate. Each possible response entails different costs and benefits. Freedom consists in the fact that the individual or group can choose to incur these costs.

The natural environment thus presents human societies with causes of change, which these societies are effectively powerless to resist or interpret, and reasons for change, which the society can ignore (perhaps with disastrous consequences) or respond to in one of several ways. Inadequate water management practices and the hardships they entail are clearly *reasons* to change, not causes of change, because the society engaged in those practices has the option of continuing to suffer these hardships. In late nineteenth century Texas, as we shall see, fire and flood were reasons to institute radical changes in water management practices, but they did not *cause* change. Texans could have elected to live with fire and flood. Indeed, as the following section will show, societies normally choose to ignore reasons for change for as long as possible.

Resistance to Change

The idea that it is human to resist change is not novel—fear of the unknown is not a hollow phrase. Perhaps in its most primal form, fear of the unknown is a fear of death. Plato attributed wisdom to "the appearance of knowing the unknown."[118] More often this fear of the unknown manifests itself as a resistance to change. Resistance to change is, however, more than just an unwillingness to change, since even societies that wish to change may find it difficult. While such psychological causes for conservatism

[118] Robert Andrews, Mary Biggs, and Michael Seidel, eds. *The Columbia World of Quotations*, CD-ROM Version 1.1 (New York: Columbia University Press, 1996), quotation 44488, "The fear of death is indeed the pretence of wisdom, and not real wisdom, being the appearance of knowing the unknown."

in individuals are present in a society, it is more often structural inertias within a society that explain the persistence of institutional arrangements such as water regimes. Inertia is what Harvey calls sunk capital, the most obvious example of structural inertia is the physical infrastructure of the built landscape. As Harvey makes clear, it is not possible to replace this infrastructure until a long period of use ("disinvestment") generates sufficient new liquid capital for new investment.[119] Impending obsolescence is a stress pressuring for change, but the existence of the current facility with all of its expended capital serves as a structural resistance to change.

In the physical sciences resistance to change is expressed by the concept of inertia. The word inertia was first used in 1687 by Sir Isaac Newton to describe that property of matter that allows it to continue in its existing state unless it is altered by an external force. In numerous analogies to its roots in the science of physics, the word inertia has been widely used to mean a resistance to change even *in* the presence of external stress.[120]

Economist John Kenneth Galbraith coined the phrase 'conventional wisdom' to describe the substantial inertia of widely held beliefs in a society. He argued that the status quo rather than change is the likely outcome when a new idea or opportunity presents itself. The values of the public at large form the collective conventional wisdom, and this is difficult to alter because of vested interests. Individuals whose

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[119] David Harvey, *Limits to Capital* (Oxford, UK: Blackwell, 1982), 222. Also Harvey, *Condition of Postmodernity*, 311.

[120] *Oxford English Dictionary*. Second Edition, 1989, http://dictionary.oed.com/ (accessed march 11, 2007).

views differ from the collective are ignored because their differing views would, if accepted, require inconvenient adjustments in thought and behavior. Thus, according to Galbraith, conventional wisdom provides “inertia and resistance” to new ideas, even after conditions may warrant a change in course. [121]

Geographer Robert Dodgshon has taken the classic physics term ‘inertia’ and used it as the cornerstone of his argument that change has a profoundly geographic component. In order to understand change, Dodgshon argues that one first has to understand resistance to change. Hence, his interest in inertia. He uses the concept to denote constraints on flexibility in a society. Dodgshon argues for three categories of inertia: the built-environment, organizational, and institutional. He then argues that many of these resistances have a geographic component because they are place-specific. Resistance to change from the built-environment we have already encountered in Harvey’s description of sunk capital. In Dodghon’s words,

> the emergence of large-scale industrialization and urbanization has worked to raise the degree of capital embedded in the construction of the human landscape. To this extent, it has worked to increase greatly the potential inertia of landscape and its built forms… When the rate of fixed capital formation did increase, its early stages were marked by heavy investment in buildings (including domestic housing), transport systems, notably railways and dock systems, and other forms of public utilities like sewage and water supplies. As a commitment of capital and resource, they were largely irreversible. [122]

The second form of inertia, according to Dodgshon, is organizational. This revolves around networks of relationships that constrain possible outcomes.

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[121] John Kenneth Galbraith, *The Affluent Society*, Fourth Edition (Boston, MA: Houghton Mifflin Company, 1984), 6-17.
[122] Dodgshon, *Society in Time and Space*, 155-6.

Organizations have a situatedness that is both temporal and spatial, but Dodgshon argues particularly that the spatial component is inertial.

> We can define the institutional or organizational forms of a society as being made up of either integrated, unified systems of roles, rules and relationships or as focused networks of information gathering, processing and decision-making… Almost by definition, they are an aspect of society's character which is least responsive to change and which has a delayed relaxation time when faced with pressures for change. Almost as soon as they come into being, they have a tendency to become inertial and to act as a constraint on any pressures for change or for new forms.[123]

People within an organization come and go, but newcomers normally step into the roles, rules and relationships of their predecessors and so do not disturb the organization.

Finally, Dodgshon considers institutional and cultural aspects of a society—the habits of its people, their ways of thinking and investments in training that are both geographic and inertial. He argues that culture provides inertia for a way of life by providing mechanisms for conveying perceptions and behaviors from person to person and from generation to generation. As these habits are taught, so, too, are lifestyles conveyed. The possibilities which both allow and limit world views come from institutional inertia. Particularly important is the role of perception, which is a critical component in the geography of change.

All three types of inertia described by Dodgshon play a role in keeping patterns of water use relatively stable in the presence of constantly increasing external stresses. The most obvious inertia comes from the built-environment. A water supply has to

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[123] Dodgshon, *Society in Time and Space*, 123.

come from somewhere. Once a source of water is located, it tends to continue to be used until either it is used up or is polluted. During migration and settlement, water was usually drawn from springs, streams, and rivers. After settlement, a more permanent water source was secured, frequently a hand-dug well or cistern. As municipal water supplies became part of the landscape in the United States during the nineteenth century, many more aspects of the water supply system became, literally, entrenched in the landscape. Foremost among these was a network of underground pipes running between the water source and end-users. This sort of inertia is given in the *artifacts* of wells, pumps, pipes, and spigots.

Dodgshon's second type of inertia is organizational. Its function is to manage the built-environment, and it encompasses the entire process of meeting water demand with a water supply. Involved are flows of capital to finance construction of a water supply network, the actual construction of the networks of pipes to direct water flows, systems for the maintenance of water lines, legislative processes to make laws, public utilities and regulatory agencies to deliver water. Here inertia exists in the *sociofacts* that build, manage, regulate, finance, and enjoy the benefits of a water supply system.

Finally, consider institutional and cultural aspects of society—the habits of its people, ways of thinking, and investments in training that are both geographic and inertial. With regard to earlier hydraulic societies, Dodgshon considers cultural adaptations accrued over generations not only as inertial groundings, but specifically as indelible with respect to patterns of water use.[124] Included in individual inertia is both the knowledge and practice of where a water supply is located, obtained, and used. The roles of individuals are also defined—who decides upon the water source, who calculates how to get it to where it is needed, who hauls the water, who uses it. Culture also specifies how water is moved, how is it used, and how much is appropriate for each task. These are some of the *mentifacts* that govern water use. The most important of these mentifacts is the *belief* that water is either scarce or abundant. A society that developed habits of water use in the belief that water is abundant will, for example, find it hard to respond quickly to scarcity.

All three of Dodgshon's inertias within the cultural landscape act in concert to resist change in patterns of water use. My next step is to consider what effect these different types of resistances to change have had upon a society's response to challenges to its water supply and how this has affected water demand. I do this by introducing the concept of water regimes.

The Structure of Water Regimes

It is a given that patterns of water use have changed. The questions to be asked are—how and why? Describing changes in the perception and use of water is the means rather than the end of this study. In the words of Robert Dodgshon, "My intention is not to show that such change takes place. That would be to repeat what is patently obvious.

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[124] Dodgshon, *Society in Time and Space*, 106.

Rather is it to show that there are other neglected dimensions to the argument"[125] The neglected dimension in the transition to different patterns of water use is understanding the motivation for change. It is my contention that this is one of the most important, but least understood, elements in the water management. But before considering the transitions in detail, I must describe patterns of water use, the role of perception, and what this means about water management.

Is there even a precedent for organizing water use? Do discernable patterns of water use even exist? I believe the answer is yes, and for this I owe an intellectual debt of gratitude to Donald Worster, who organized the history of the American West into three modes of water control: local subsistence, agrarian state, and capitalist state. Worster believes water has an under-appreciated role in the development of a society. Water in any form is power, and those who control water control all. He argues that in the local subsistence mode, there was a strong bond between humankind and the earth. Humans expended more individual energy in the pursuit of water in their daily living, but were rewarded with more individual freedom. The progression to the agrarian state mode of water control involved massive government aid in the form of water supply projects. This resulted in landmark legislation, the Reclamation Act of 1902. The transition to the capitalist state in Worster's scheme revolved around interpretation of limits to the amount of land irrigated per landowner at the expense of the federal government.

[125] Dodgshon, *Society in Time and Space*, 84.

Worster's describes centralized, top-down water control. In his view, modes of water control have historically been imposed upon the entire population of the American West by whichever group held the most power at the time.[126] In the case I study here, I believe it is more appropriate to examine how *choices* collectively made by a society with regard to their own water use and management give rise to change and discernable patterns. Integral to this is the perceived abundance or scarcity of water, and the consequent need for new approaches to water management. This is not the story of the imposition of modes of water control, but rather of challenges presented by water management and choices made in response, frequently at a different scale.

I denote distinctly discernable patterns of relatively stable water use as water regimes. Their stability depends upon one or more of Dodgshon's three sources of inertia offering resistance to change in response to external stress on water supply. In every society during every historical period there exist elements of the built-environment, ways of organizing and managing water supply, perceptions of the abundance or scarcity of water, and habits of water use that influence the society's response to stress. Dodgshon's inertias arise from artifacts, sociofacts, and mentifacts that become anchored to specific places and result in acceptance of the status quo until such time as the stresses are large enough to overwhelm these inertias and force a new response. Only then does a new water regime emerge. Then new habits are learned as sociofacts and artifacts are adjusted to the changed situation.

[126] Worster, *Rivers of Empire*, 22-60.

A water regime manifests itself as a group of interrelated elements exerting control over how water is used as a result of how it is perceived and by means of how it is managed. In order to define specific water regimes I first identify inertial elements in the cultural landscape around which the society maneuvers with respect to how it manages its water. In order to understand historic water use habits and concerns, I attempt to view the world as it was understood at that time.[127] Perception is integral to this understanding. In order to reconstruct past geographies I identify lineaments of the past in the present landscape, according to Carl Sauer, and use these traces "to see the land with the eyes of its former occupants, from the standpoint of their needs and capacities."[128] William Cronon has argued that the identity of the American West is tied to the alternating perception of the scarcity or abundance of its natural resources.[129] How a society *perceived* its water was integral to how it used and managed its water. The role of both perception and scale became increasingly clear to me as this dissertation progressed, to the point where each has become part of the fabric of how each water regime is defined. The data I use is primarily archival, supplemented with fieldwork and syntheses, the latter largely government reports. The complications are twofold: selecting data points from the multitude of possibilities and interpreting the meaning of the collective data in terms of how it was perceived in its historical context.

[127] L. Guelke, "Historical Geography and Collingwood's Theory of Historical Knowing," in *Period and Place: Research Methods in Historical Geography*, edited by Alan R.H. Baker and Mark Billinge (Cambridge, UK: Cambridge University Press, 1982), 189-96.
[128] Sauer, "Foreword to Historical Geography," 362.
[129] Cronon, "Landscapes of Abundance and Scarcity," 603-637.

I have drawn widely on Dodgshon's ideas to explain stable patterns of water use in each regime. Stresses constantly added to the water demand system include natural stresses, largely in the form of uneven amounts of water as a result of flooding and droughts, and population increase. The movement to each new regime is relatively rapid, operating in a manner much like punctuated equilibrium, albeit on a much more compressed time scale. The mechanism for the change is a cascading response, as described in general systems theory, with recognition of elements of creative destruction making the transition from one regime to the next more distinctly apparent. The event or combination of events resulting in the transition from one regime to the next I am calling the tipping point, and although the tipping point is sometimes demographic, sometimes a response to a natural hazard, and other times the result of human agency, it is in every case the response to a crisis.

Crisis is the final phase of a water regime, and denotes the period in which there is rapidly diffusing recognition of the pressing and unavoidable need for change. A crisis is that moment when further postponement of choice between responses to a reason presented by the environment becomes increasingly difficult. Because crisis denotes the need for a decision, there can be no crisis in a deterministic or strictly causal chain of events. Carville Earle has studied broad patterns of cultural change and argues that there is a periodic structure to American history dating back to the seventeenth century. This structure is defined as recurring historical periods, each approximately fifty years in duration, containing six distinct phases in each period. Earle's cycles are spurred by agricultural innovations and contain both economic and religious components. Of particular interest is the role of crisis in Earle's account. Earle's macrohistory begins each cycle with a crisis resolved by creativity in the form of an agricultural innovation. The innovation is diffused throughout American society in the face of conflict and dissent. This leads eventually to decline and a new crisis, and the beginning of the next historical period. The details of each period differ, but the underlying rhythm is remarkably consistent.[130]

Earle's periodic structure of the American past serves as a model for water regimes in Texas. The elements of crisis, creativity, diffusion, and decline can all be identified in patterns of water use. The timing of water use regimes also corresponds roughly with Earle's forty-five to sixty year American historical periods. Earle presents his ideas in a series of three propositions. In particular I am interested in the recurrent crisis phase proposed in his second proposition, "The periods of American history, in turn, consist of six shorter and typically overlapping phases: Crisis, creativity, conflict, diffusion, dissent, and decline. These phases are recurrent and determinant, but historical responses within them are remarkably variable." [131]

Earl's periods begin with crisis. One can certainly debate whether crisis marks the beginning or the end of a cycle described as periodic. In the case of water use regimes, I believe habits of water use persist until forced to change. For this reason, crisis forces the end of each regime, and it is response to that crisis that leads to the next set of water use patterns. If it were not for the perception of a crisis, there would be

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[130] Earle, "The Periodic Structure of the American Past," 446-540. Earle argues that crisis spurs innovation using examples from agriculture in the American South.
[131] Earle, "The Periodic Structure of the American Past," 448.

incentive to change patterns of water use. This is not, however, the point of Earle's proposition nor reason for diminishing the role of crisis, creativity, or diffusion in either the establishment, continuation, or demise of a water use regime. Rather, my intention is to highlight the crucial role crisis plays in overcoming inertial points in the landscape by using empirical evidence I have gathered from archival sources.

As an illustration, here is a 1928 editorial from the *Dallas Morning News* that called for legislation to regulate groundwater in order to protect aquifers from being wasted. "Our limit will not be our land or our minerals or our timber. Rather the limit will be set by the amount of water which we can provide for consumption and for the growing of crops. Unless we get an early start on protecting all likely water sources of supply we may find ourselves so behindhand as to be actually in distress."[132] Yet in spite of the prescient wisdom of this editorial, almost eighty years later this action has not yet been taken by the State legislature, although the recent establishment of groundwater districts has partially addressed this concern. The slow depletion of an aquifer does not yet seem to the public to be a crisis that needs immediate attention. On the other hand, flooding and drought bring more immediate action, many examples of which are provided later in this dissertation. Here I point to just one example, from an article in the *Dallas Morning News* from the spring of 1922. "The unprecedented rainfalls of the last number of weeks, over two months, would not engage serious attention if they had been merely local. But this has not been the case. Scarcely a

[132] "Wasting Water from Artesian Wells," *Dallas Morning News*, 4 June 1928, Sec: Part 2, p. 10.

section, if, indeed, a single one, of our entire country has escaped. We have been reading of these rains and floods even in European countries and in Asia. The consequence is that people everywhere have been 'sitting up and taking notice.'"[133] What these two examples provide illustrates the kinds of empirical evidence from archival sources that I have woven together in this dissertation to illustrate widespread resistance to change and, therefore, the role of crisis in forcing change in how water has been perceived, used, and managed.

The Sequence of Water Regimes

With the concept of punctuated equilibrium, inertia, and crisis in hand, I am able to define four water regimes in Texas since the time of settlement. The first regime is related to individuals' use of water in the settlement process of an agrarian society. In the second regime individuals turn to the pooled resources of their local governments to fund water management projects beyond their individual means in the initial transformation from an agrarian to a more urbanized society. The third regime encompasses planning for and managing water as government agencies were pressured to turn to technology to control water excesses and shortages through the construction of dams. In the fourth and current regime, water is treated as a commodity. Although data pertinent to Texas has been selected to test this approach because of the diversity of both

[133] Charles L. Martin, "Flood Control By Use of Reservoirs, Suggestions Are Made For Conservation of Excess Waters. Serves Many Uses: Overflows Would Be Prevented and Water Would Be Stored for Irrigation," *Dallas Morning News*, 28 May 1922, Sec: Part Four, p. 16.

its physical and cultural geography over the past two hundred years, the general patterns of water use outlined here may not be unlike those found in other societies.

The Agrarian Regime

The agrarian regime was characterized by individual family or plantation units that were by necessity self-sufficient in their daily water requirements. The water source was usually a hand-dug well or cistern. The delivery system was a slave or family member, and primary uses were domestic and for livestock. Industrial uses were relatively light and included steam as a source of power. In time towns were established to serve as a gathering point for the shipment of agricultural products, particularly cotton, and as a supplier of goods for the agricultural community. It was in these towns, rather than in rural areas, where the cause of the first tipping point was located. The crisis ending the agrarian regime was brought on by urbanization and the need for fire hydrants to protect central business districts. This necessitated the change in scale in water management that marked the end of the agrarian regime.

The Waterworks Regime

There was a fundamental change in the perception and use of water when it became commonly available from the tap in the waterworks regime. Waterworks began to be constructed in Texas in the mid 1870s, and the Spanish even built a network of acequias to supply San Antonio residents with water from canals a century earlier. This began a widespread restructuring of local waterworks into public utilities and forever changed Texans' perception of water. In this regime water was still perceived as abundant, but it was also taken for granted. The perception of water as an abundant resource was, however, eventually challenged by drought, and a new approach to water management based upon conserving runoff came into being.

The Dam and Levee Regime

The dam and levee regime began in Texas as a need to protect the cotton economy and was compounded by the Drought of the 1950s and urbanization. It was not until after the Texas Constitution was amended in 1904, however, that state funds could be expended on water projects. Levees had previously been built in Texas for purposes of flood control, but the tipping point into this regime occurred with government involvement in surface water management in the state. The crisis which ended the dam and levee regime came when legislation and judicial decree opened the door to a re-evaluation of the use and management of groundwater in Texas.

The Groundwater Regime

Drought in the 1990s precipitated the passage of Senate Bill 1 in 1997 and opened the door on the groundwater regime. This bill revised the state's water planning process in significant ways. Surface water was to be managed in sixteen regional water planning districts, each based largely on natural watershed boundaries. Senate Bill 1 greatly restricted the transfer of surface water out of each regional water planning area. Suddenly there were municipalities in other parts of the state whose long-term plan for additional water supplies had involved purchase from the lakes around Dallas and could no longer consider this as a viable option. Groundwater was the obvious solution, but a Texas Supreme Court ruling in 1999 made the inadequacy of the state's groundwater law apparent. Rural property owners had access to, but no control over, groundwater. Their vulnerability spurred action. More municipalities than ever before were looking beyond surface water to groundwater for future water supplies. Rural landowners have, therefore, begun organizing into water alliances to sell their water rights to all of the major cities in the state. As a reaction against this sale and transfer of significant amounts of groundwater, in concert with a Texas Supreme Court ruling upholding the right of the bottled water industry to extract large quantities of groundwater, even to the demonstrated detriment of their rural neighbors, there has been the recent creation of more than 80 local groundwater districts across the state. As a result, water sources, water regulations, and water legislation are currently in a state of flux caused by a crisis of legislation and judicial rulings.

The next four chapters illustrate the theoretical claims of this chapter with empirical studies of each of the four water regimes. In Chapter IV, travelers' accounts and journals are used to discern attitudes about water's abundance, supply, use, and management during the agrarian regime. Particular use is made of an unpublished journal by Pleasant B. Watson[134] written between 1858 and 1868, with an additional autobiographical essay covering the first twenty-one years of his life. The response to the crisis of fire protection in the central business district of Texas market towns was the establishment of waterworks. Chapter V describes mounting public pressure for municipal water projects using data from almost fifteen hundred water bonds approved

[134] Pleasant B. Watson, *Journal, 1858-1868*, unpublished manuscript from the collection of the Star of the Republic Museum at Washington, TX.

in local elections between the 1870s and 1931, as well as a case study of the establishment of the waterworks in Bryan, Texas utilizing Sanborn insurance maps.

A third fundamental change in water management was deemed necessary in response to flooding and drought. Management at the county scale was tried unsuccessfully, followed by both state and federal involvement to conserve surface water through the construction of levees and dams. This crisis and response is explored in Chapter VI through a case study of the Burleson County Improvement District No. 1, a twenty-seven mile long levee along the Brazos River heretofore undocumented in the academic literature. Historical archives of the *Dallas Morning News*, minutes from the Burleson County Commissioners' Court, archives from the State Reclamation Engineer, and data from the Texas Water Development Board were used. Dam construction for the management of surface water is also examined through the tabulation of records about the more than two hundred reservoirs in the state that impound greater than 5,000 acre-feet of water.

Chapter VII describes the current water regime, which is now emerging in response to a crisis precipitated by new legislation and a Texas Supreme Court decision reaffirming the Rule of Capture. The response to the combination of these two has been the proliferation of groundwater districts in much of the rural part of the state.

CHAPTER IV

THE AGRARIAN REGIME

Challenge and Response

GTT—Gone To Texas! Those were the letters left scrawled in the dust across the American South in the 1840s as folks packed up and headed for a new life in Texas. Cotton took a lot out of the soil, there were run-ins with the law, but most of all there was land, vast amounts of unsettled land—and land spelled opportunity to nineteenth century Anglo settlers. Where did they come from?

They came in three streams from the eastern United States—from the Upper South, from the Lower South, and from New England—and they came from Europe. The Upper Southerners were farmers and came in the first wave, especially from Tennessee. The Lower Southerners were cotton growers and slave owners from states along the Gulf of Mexico, particularly Alabama. The New Englanders were relatively few in number, but large in importance. They were the businessmen who worked to establish trade in the agrarian society of nineteenth century Texas. The European settlers were from Central and Eastern Europe. They, like those from the American South, were predominantly farmers, but some among them were skilled mechanics and tradesmen. [135]

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[135] Jordan-Bychkov et al., *Texas: A Geography*, 69. For a much more detailed account of German immigrants to Texas see Gilbert J. Jordan, *Yesterday in the Texas Hill Country* (College Station, TX: Texas A&M University Press, 1979).

What was the mindset of these people? Why did they leave their homes for Texas? A mentality of abundance of land and natural resources existed in the United States, and yet the Panics of 1819 and 1837 created widespread economic depression. This was an agrarian society with Jeffersonian ideals predicated upon the idea that the yeoman farmer was the key to a prosperous and egalitarian nation. When Jefferson authorized the purchase of Louisiana from the French in 1803, the land that is now Texas became immediately adjacent to US territory; and when Louisiana achieved statehood in 1812, Americans increasingly looked toward Texas as the next logical step in the westward expansion of the United States. But Texas was still part of New Spain in 1812, and under Mexican jurisdiction beginning in 1821. While the lure of Texas increased as the US border moved westward, it was not until Texans declared their independence from Mexican rule in 1836 that the floodgates opened to settlement. The official language became English, Catholicism was no longer the required religion, and more importantly to Southerners—slavery was legalized in Texas.[136]

Europe at the turn of the nineteenth century was in turmoil. It was a time of revolutions and wars. Population densities were high compared with those of the United States. Land passed from father to eldest son under the right of primogeniture, but other siblings were left without landhold and with more limited opportunity. The European mindset was different than that of the American—land was scarce rather than abundant, but its lure was just as powerful. In 1848 Europe was in revolution again, and

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[136] Meinig, *Imperial Texas*, 26-46.

emigration from there seemed the only hope for many. The United States was perceived as a land of opportunity, and some of the settlers headed for Texas. The largest European immigrant group to settle in Texas in the 1840s was German, primarily Saxon and Hessian, and German-speaking Alsatians from eastern France. The Germans settled between Galveston and the Hill Country with a concentration from New Braunfels to Mason County and another in the vicinity of Austin County.[137] In Ireland the Potato Famine of 1845 to 1848 forced people to leave their homes, and to these folks also, land availability made Texas an attractive destination. The Irish were primarily from County Wexford in southeast Ireland and settled in San Patricio and Refugio Counties in Texas. Other European source regions included Prussia, northern Moravia, southern Bohemia, Myjava in Slovakia, Norway, Sweden, and Denmark.[138]

Why was this land called Texas even open for settlement? In the eighteenth century Texas was unsettled by Europeans with competing French and Spanish claims. In 1684 LaSalle had claimed for France all lands drained by the Mississippi, including eastern Texas. The French were interested in trade with the Indians and established several trading posts. The Spanish were more concerned with missions and had even earlier claims to parts of Texas because of explorations by Cabeza de Vaca, Coronado, and DeSoto in the sixteenth century. De Pineda mapped the Gulf Coast and established a short-lived colony at the mouth of the Rio Grande as early as 1519. Two centuries

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[137] Jordan-Bychkov et al., *Texas: A Geography*, 89; Calvert and De Leon., *History of Texas*, 111. See the map of "German Settlements" in Jordan-Bychkov et al., *Texas: A Geography*, 86.
[138] Jordan-Bychkov, *Texas: A Geography*, 83-92, especially map of "Major European Source Regions of Texas Settlers," 85.

later the Spaniards were temporarily chased out of east Texas by the French when war broke out in Europe between the two countries. By the 1750s there were several Spanish settlements along Rio Grande, including one near present-day Laredo. Spain acquired Louisiana from France in 1762, and their Texas Two Step came to an end. Each country's reach had exceeded its grasp. Texas was no longer a defensive frontier outpost against incursion from the French. It was only a few decades, however, before Texas again became a buffer—this time from the Americans on its eastern border.

Historians have recognized the colonizing skills of the Spanish, but other than establishing missions and a few defensive outposts in Texas, the Spaniards had little interest in colonizing the area of present-day Texas.[139] This may be in large part because of the demographic decimation that was being experienced in the more densely populated parts of New Spain, and later Mexico, as a result of disease. The Spaniards did not establish a solid presence in Texas once the competition with the French ceased in the mid eighteenth century. This does not imply that they were not concerned about incursions into Texas from along its eastern border, however. In 1813 Spanish law prohibited the settlement of Americans within fifty-two miles of the border of New Spain and American territory without special permission. Eight years later, Moses Austin received authorization from the government of New Spain to settle three hundred Catholic families in Texas. That same year Mexico was granted its independence from Spain and in 1823 the Empressario Act was passed, authorizing Mexican land grants to

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[139] Carl Sauer, *Sixteenth Century North America: The Land and the People as Seen by the Europeans* (Berkeley, CA: University of California Press, 1971), 277-280. Sauer argues that Spain did not have enough people to colonize vast areas of New Spain.

new settlers in Texas. As a result there were recognized Spanish and Mexican land grants to Anglo settlers in Texas during the 1820s and early 1830s. Some of the more onerous terms of the land grants were resolved when Texas won its independence from Mexico in 1836, and this is when the inevitable settlement of Texas gained momentum. Thus, significant numbers of settlers were lured from both the United States and parts of Europe during the early to mid nineteenth century, resulting in enormous cultural change. [140]

Historical Processes

Migration, settlement, and livelihood are topics long studied by historical geographers, and water plays an important role in each. The water source during migration was local—from nearby springs, creeks, and rivers along migration pathways. After settlement, water supply was supplemented by hand-dug wells and cisterns. If water was transported, it was over short distances in buckets or barrels. Wherever and however it was acquired, the need for water on a daily basis was an immediate concern resolved at a local scale. [141]

In order to explore how water was perceived and used during these processes of migration, settlement, and livelihood, primary source materials in the form of travelers' accounts and journals have been searched for references to water in Texas during the

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[140] Meinig, *The Shaping of America*, 11-17, 24-28, 202-203. See also, Calvert and De Leon, *The History of Texas*, 10-36.
[141] Ellis W. Shuler, "The Influence of the Shore Line, River and Springs on the Settlement and Early Development of Texas," *Texas Geographic Magazine* 4, no. 1 (Autumn 1940): 26-31.

nineteenth century. I am following the example of John Jakle, who studied travelers' accounts of the Ohio Valley during migration and settlement between 1740 and 1860. Jakle focused his analysis on how the landscape was perceived, and noted that travelers tended to see things that inhabitants took for granted because, "most travelers had a heightened sense of environmental awareness."[142] The Texas landscape was, likewise, new to travelers and to settlers who wrote about it. While none were concerned specifically with water, their perception and use of water can often be inferred from what they say and do not say.

Migration

Migration from the Lower South directly westward along the Gulf Coast was not possible because of the impenetrable Atchafalaya Swamp in Louisiana, so the land migration entrance to Texas was through Nacogdoches, 150 miles north of the coast. Migration along this route roughly paralleled the coastline, crossing the main rivers of Texas at right angles. Indian trails and the Spanish roads El Camino Real and La Bahia served as the primary routes across the territory, important because they indicated the best locations for crossing rivers and creeks, and because they connected springs. Ferry crossings were established at these crossings as Anglo migration increased. [143]

Rivers were hindrances to transportation rather than being major migration routes into Texas. Galveston Bay sheltered the only major ports along the Texas coast. The rivers are barely navigable—narrow with shallow mouths—usually less than ten feet in

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[142] John Jakle, *Images of the Ohio Valley: A Historical Geography of Travel, 1740 to 1860* (New York: Oxford University Press, 1977), viii.
[143] See map of "Migration and Settlement" in Meinig, *Imperial Texas*, 44.

depth. A letter from Mrs. Anson Jones to her husband in December 1850 indicated that construction on their home had been delayed because the Brazos had been too low to transport the necessary lumber.[144] With a relatively wide and flat coastal plain and clay soils, rain could render trails virtually impassable. Trips that would normally take several days by horseback could easily be extended to several weeks. 'I'll be there tomorrow, God willing and the creeks don't rise' was not a hollow phrase.

Settlers from the Upper South also came through Nacogdoches during the early part of the nineteenth century, although a second route opened up through Dallas after the Native American population was forced farther to the northwest during the last half of the nineteenth century. Others from the Upper South came down the Mississippi River to New Orleans and then took passage on a ship to a Texas port—usually Galveston. From there it was overland to an inland destination.

Migration from the northeastern United States and Europe also generally passed through New Orleans. From there, some took a steamboat up the Mississippi and Red Rivers to Natchitoches, before continuing overland. Others continued on a schooner, or later on steamship, to Galveston.[145] From there the journey was overland and quite variable in length, depending on how much precipitation occurred. Galveston is located near the southeast corner of Texas, where average annual precipitation is fifty inches per

[144] Shawn Bonath Carlson, ed., *The Anson Jones Plantation: Archaeological and Historical Investigations at 41WT5 and 41WT6, Washington County, Texas*. Reports of Investigations No. 2 (College Station, TX: Center for Environmental Archaeology, Texas A&M University, 1995), 53.
[145] Meinig, *Imperial Texas*, see map "Migrations & Colonizations 1830's-1860," 44.

annum.[146] This much rain on soils with a high clay content and poor drainage is a serious hindrance to overland transportation across unimproved roads.

Mary Maverick was a pioneer and diarist who migrated to Texas with her husband and baby in 1838 when she was twenty years old. She was from Tuscaloosa, Alabama, and he was from South Carolina. The Mavericks traveled across the Lower South with ten slaves, by horseback, carriage, and wagon. They crossed the Sabine and passing through Nacogdoches, Washington on the Brazos, and Columbus on their way to the Navidad River. Mrs. Maverick described the Sabine River—the eastern border of Texas—as "a sluggish, muddy, narrow stream." In her memoirs she commented repeatedly on travel difficulties caused by rain and mud.

> We now had to travel in occasional rains and much mud, where the country was poor and sparsely settled and provisions for man and beast scarce… Now came a dreadful time; about January 26th [1838], we entered a bleak, desolate, swamp-prairie, cut up by what were called "dry bayous," i. e. deep gullies, and now almost full of water. This swamp, crossed by the "Sandy," "Mustang" and the head branches of the Navidad, was fourteen miles wide. We had passed Mr. Bridge's, the last house before we got into this dreadful prairie, and had to cross the Navidad before we got to Mr. Keer's, the next habitation. Every step of the animals was in water, sometimes knee-deep. We stalled in five or six gullies, and each time the wagon had to be unloaded in water, rain and north wind and all the men and animals had to work together to pull out.
>
> The first Norther I ever experienced struck us here—this norther was a terrific howling north wind with a fine rain, blowing and penetrating through clothes and blankets—never in my life had I felt such cold. We were four days crossing this dreadful fourteen miles of swamp. The first day we made three miles and that night my mattress floated in water which fell in extra quantities during the night. The baby and I were tolerably dry; all the others were almost constantly wet during the four weary monotonous days—but no one suffered any bad effects from the great exposure, and Mr. Maverick kept cheerful all the while and was not a bit discouraged that we could see—said that water was better than

[146] Jordan-Bychkov, *Environment and Environmental Perceptions in Texas*, 10.

mud to pull in and that we were only eight or nine miles from Keer's.[147]

Mrs. Maverick's comments on how water was an impediment to travel are typical of observations from other travelers and settlers. They suggest that migrants perceived central Texas as a region that received ample rainfall, more than enough to satisfy the needs of travelers and settlers, so much in fact that the precipitation was a frequent nuisance. Mrs. Dilue Harris recounted when her family moved fifteen miles from Harrisburg to Stafford, near present-day Houston, in the winter of 1833 that, "It was rough traveling… Three miles from town we left the timber. The prairie was covered with water. Bray's Bayou had overflowed and the road looked like a river."[148]

When ferries were not available, the choices were to wait for the water to subside, to swim across, or to look for a better crossing. Sometimes there was not time to wait for better conditions, but it was always a problem to be solved through the ingenuity and perseverance of the travelers and settlers themselves. During the Texas Revolution in the spring of 1836 mass panic occurred, as Texas families scrambled east to escape the advancing Mexican army in an episode known as the Runaway Scrape. General Sam Houston's defeat of the Mexican army at San Jacinto removed the need for this chaotic exodus, but this news needed to be spread quickly. A courier named McDermot was sent across the Trinity River to spread the good news. The ferry was not operating at Liberty where he crossed the river because no one was left in town Mrs.

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[147] Mary Maverick, *Memoirs of Mary A. Maverick* (San Antonio, TX: Alamo Printing Co., 1921), 12-14.

[148] Mrs. Dilue Harris, *Life in Early Texas: The Reminiscences of Mrs. Dilue Harris*, no publisher for date, 7. From the library of the Star of the Republic Museum at Washington, Texas. Originally published in the *Quarterly* of the Texas State Historical Association 4, 7 (October 1900, January 1901).

Dilue Harris reported that, "The courier had crossed the Trinity River in a canoe, swimming his horse with the help of two men."[149]

Texas rivers are not particularly wide, but even creeks could pose serious obstacles. Mary Maverick noted that "In 1843 or '44 [Dr. Weideman] was drowned in attempting to cross Peach Creek, near Gonzales when the water was very high—his horse and himself and one other man were carried down by the rapid current and drowned, whilst the others of the party barely escaped."[150]

There is nothing in the record of the migration phases that indicates migrants perceived deficient water supply as a problem in central Texas. Those who mention water instead complain that excessive rainfall, mud, and flooding were problems. This was not an accurate or objective assessment of the hydrology or climate of Texas, but nicely illustrates the truth that humans' perception of an environment is always *relative* to the task in which they are immediately engaged. The traveler sees a different landscape than the farmer.[151]

Settlement

Settlement took place along the migration routes, as Spain restricted Anglo settlement along the coast. Along the route from Nacogdoches to San Antonio, the poor soils and piney woods of east Texas were generally less attractive to settlers than the Brazos River Valley. Settlement focused in Stephen F. Austin's land grant area between

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[149] Harris, *Reminiscences*, 59.
[150] Maverick, *Memoirs*, 40-41.
[151] D.W. Meinig, "The Beholding Eye," in *The Interpretation of Ordinary Landscapes* edited by D.W. Meinig, 33-48 (New York: Oxford University Press, 1979).

the Brazos and Colorado Rivers. Austin explained his choice of a location for his colony in a letter dated October 12, 1821, "In order that they may not scatter out too much, I have assigned them (over fifty families who had promised to move to the interior) the territory between the Colorado and Brazos rivers and between the San Antonio and Bahia Roads. The reason for selecting that stretch of territory is that it is beyond the reach of the Carancahuas and Comanchie Indians; and besides it is located in the territory where buffalo are found, and these will serve for sustenance of the new colony. It is much more healthful than the coast; and, since it is between the two highways, immigration to it will be made easier.[152] Between 1820 and 1840 more than forty towns were established, although the majority of settlers were rural, not urban. "Anglo-Americans do not like to build large towns where there is land for expansion," reported Juan N. Almonte in his *Statistical Report on Texas* compiled in 1834 for General Miguel Barragán, the president of Mexico.[153] Settlement stalled west of Austin and San Antonio, where there was less water and more hostile Indians.

A dependable water supply was vital in the selection of a settlement location. The first land grants were along rivers near migration routes. In 1831 Richard Carter was one of the first Anglo settlers in what would later become Brazos County. Because land along the Navasota and Brazos River bottoms had been claimed, Carter settled on the interfluve by a creek in what is now the city of College Station. Near the city of

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[152] Lucile Batman, "Washington-on-the-Brazos" (Department of History Thesis: Commerce, TX: East Texas State Teachers College, 1952), 2.
[153] Silverthorne, *Plantation Life in Texas*, map p. 212; and Meinig, *Imperial Texas*, 36 quoting from Almonte's 1834 document.

Austin, the tracts along the Colorado River were claimed early in the settlement process.[154] Since most of the settlers were establishing themselves in rural location, their water supplies were for individual family or plantation units. Large volume was not necessary, but reliable supply was. Springs, wells, and cisterns all were the source of water supply for farmers and planters. Plantation houses were often situated near springs for convenient household use, and to cool dairy houses so that butter and milk would stay fresh longer. Water runoff from the roof was collected in cisterns for drinking. Wells were hand-dug, and their water was not always suitable for drinking. In 1836 David Edward commented that a dependable water supply was not a problem to the Texas settler:

> A man must in some situations sink a well for the convenience of his family; but he seldom would have to dig deep, before he would find cool and good tasting water; superior in one respect to the water of the cistern, which must so often be had recourse to, on the bottom lands of Red River, to the eternal production of that teasing and annoying insect the musketo. When a family is thus in possession of a well, their live stock can without going too far find a plentiful supply.[155]

Even though their extended family settled on the banks of the Colorado River in Fayette County, Mary Rabb reported that her husband dug a well rather than relying on river water. Anson Jones' Barrington Farm in Washington County had a small creek, a well, and a cistern. Archaeologic investigations from the historic period include locating

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[154] Shawn Bonath Carlson, *The Richard Carter Site, Brazos County, Texas* (College Station, TX: Texas A&M University, 1987), 9. Also, personal communication with Kevin Anderson concerning the settlement along the Colorado River between Austin and Bastrop (April 2005).
[155] David B. Edward, *History of Texas or the Emigrant's, Farmer's & Politician's Guide to the Character, Climate, Soil & Productions of That Country, Geographically Arranged from Personal Observation & Experience* (Austin, TX: Texas State Historical Association, 1990 [1836]), 56.

a well on Texas sites.[156] Slave stories recorded by the Works Progress Administration make reference to both wells and cisterns—usually located near the kitchen—on Texas plantations. Moss concluded that there was no standard layout for the location of buildings on a plantation, but that it was influenced by "local tradition, topography, and availability of water." [157]

As important as water was in the selection and development of a site for agricultural settlement by individual families, a ready water supply was just as vital in locating new towns and cities. Harriet Smith noted that many of Texas' prominent cities are located where the outcrop of the Austin Chalk formation intersects rivers,

> It is an interesting fact that the larger cities and towns are built upon the Austin Chalk, a narrow exposure running for nearly 500 miles in a generally northeast-southwest direction from Sherman to San Antonio. Here the early settlers found the most favorable sites for their homes. Building material was at hand, and a natural rock foundation; the altitude was higher than that of the adjacent blacklands, hence the drainage was away from the house; the farm, with its black waxy soil, was accessible, the breezes were fresh, and the views were entrancing. Geographic influence, which set the early homes on the white rock, determined later the location of the cities. Here we find Sherman, McKinney, Dallas, Waco, Temple, Austin, New Braunfels, and San Antonio. The Missouri, Kansas and Texas railroad follows the western edge of the Austin Chalk across the state. [158]

I would note here that this was the migration route into Texas from the northeastern United States, the route favored after the initial wave of settlers entered along the Old

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[156] Carlson, *Richard Carter Site,* 1, 19, 40. Mary Crownover Rabb, *Travels and Adventures in Texas in the 1820's: Being the Reminiscences of Mary Crownover Rabb,* with an Introduction by Ramsey Yelvington (Waco, TX: W.M. Morrison, 1962), 13.

[157] Sue Winton Moss, "A Plantation Model for Texas," in *The Anson Jones Plantation: Archaeological and Historical Investigations at 41WT5 41WT6, Washington County, Texas,* Reports of Investigations No. 2, edited by Shawn Bonath Carlson (College Station, TX: Center for Environmental Archaeology, Texas A&M University, 1995) 82-4; Carlson, *Anson Jones Plantation*, 232.

[158] Harriet Smith, "Geographic Influences in the History of the Settlement of Black Prairie in Texas," *Journal of Geography* XIX, No. 8 (November, 1920): 294.

Spanish Road from Nacogdoches to San Antonio a generation earlier. This later migration pathway along the Austin Chalk had been used earlier by Native Americans for millennia. The white rock that outcrops through this relatively narrow band was less affected by rainfall and much easier to negotiate with horse or ox-drawn wagon teams than the clay of the adjacent blackland prairie. It formed a natural transportation corridor. Interstate 35 follows this route today. Smith noted specifically that river crossings transecting the Austin Chalk were favored sites for cities,

> In addition to the influence of the White Rock, local conditions were further determiners. Dallas was located at a widely known road crossing of the Trinity River, just below the junction of two of its most important branches. San Antonio was so located because of a number of springs just north of the site, which give rise to the San Antonio river. Austin is situated on the Colorado River at the foot of the Balcones Scarp, just below the canyon part of the Colorado valley. Waco is situated on both sides of the Brazos River, just below the mouth of the Bosque. Still other important cities of the section are located on the White Rock or on rivers.[159]

Smith is expressing the then popular theory of environmental determinism.

Important as a dependable water supply was, when it came to settlement, river bottoms were perceived as an unhealthy place to live. In 1843 Mary Maverick noted, “We concluded it would not do to live here any longer; the Colorado bottoms were too unhealthy. Mr. Maverick decided to take us to the Gulf Coast where we could enjoy sea bathing.”[160] This was after both she and one of her young sons had spent several months with chills and fever. Illness continued to attack the family after their move to the coast. Consequently, they relocated to San Antonio where they had experienced the fewest

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[159] Smith, “Geographic Influences,” 294.
[160] Maverick, *Memoirs*, 84.

health problems. "I felt that I could not live any longer at the old place [near Matagorda Bay], and Mr. Maverick, too, did not want to live there. We concluded that the high ground on the Alamo Plaza would be a more healthful location."[161]

Livelihood in the rural settlement pattern of nineteenth century Texas was almost entirely related to agriculture. In the 1850 census of Washington County, a location central to Austin's original 300 family group of settlers, a majority of heads of household listed their occupation as farmer. Whether subsistence farming or growing cotton on a plantation, the dominant occupation was related to agriculture and other livelihoods were supportive of agriculture. According to Moss, Genovese defined a planter as one with a slaveholding of at least twenty slaves. Another definition of a planter provided by Curlee is based upon the production of a minimum of forty 400-pound bales per year. Moss notes that the terms "farm" and plantation" were used interchangeably by Anson Jones in reference to his own situation as a landowner in Washington County. She believes his interchangeable usage of the terms reflects the convention of the time.[162] For this reason, I have deemed this first water use regime the agrarian regime because regardless of the scale of the operation and the presence or absence of slaves, the vast majority of livelihoods were agriculture-based. This agrarian water use regime had its roots with the first Anglo settlers in Texas, but gained significant momentum in 1836 with the establishment of the Republic of Texas and continued throughout the course of the nineteenth century.

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[161] Maverick, *Memoirs*, 107.
[162] Moss, "Plantation Model," 68.

Water's impact during migration and settlement was pronounced, although emphasis and source may have varied. Having considered briefly the influence of water on historical processes at work in Texas during the nineteenth century, I now turn to specific uses for water in that time and place.

Water Use

Drinking water has always been a daily necessity for people, livestock, and other living things; and obtaining drinking water was a daily chore in the agrarian regime. Although moving water was at this time laborious, there is no indication in the records I consulted that drinking water was scarce. Mrs. Dilue Harris mentioned a watering hole along the route she took returning home from Liberty on April 30, 1836, "Early in the morning we broke camp. We were alone; the other families lived farther down the country. The weather was getting warm, and we stopped two hours in the middle of the day at a water hole. When the sun set we were still five miles from home."[163] Women in households without slaves were in charge of securing water. On another occasion Mrs. Harris does not tell us what the source of water was or how far away it was, but she does say that, "Mrs. M-------- took a bucket and went back to give water to her sick oxen, but found the ox dead."[164] From this I infer that water was readily available nearby.

[163] Harris, *Reminiscences*, 66.
[164] Harris, *Reminiscences*, 68.

Water has always been used for cooking and cleaning, and its use for such during the agrarian regime in Texas is no exception. These uses are so common almost no mention is made of them in the diaries of early settlers. An exception was noted by Dilue Harris when her family returned from the Runaway Scrape on a Sunday morning to find their Stafford home destroyed by the Mexican army. "When brother and I got home we found mother and Mrs. M----- at the wash tub. I was shocked, for mother had always kept the Sabbath. At noon father and brother put down the floor, Mrs. M-----'s girls and I scoured it, and we moved in."[165] The washing of clothes and floors were not so unusual, but rather it was their occurrence on a Sunday that made these events significant enough to merit notation in her memoir.

Although the uses of water for drinking, by both people and livestock, and for cooking and cleaning were important during the agrarian regime, they were too ordinary to warrant frequent mention in journals. Water had always been used for these functions, and always would be. What was unique to the agrarian regime was the primitive technique of water transport that made fetching water a daily chore.

Transportation

Overland transportation was powered by horses and mules, and this livestock needed regular water. Rivers were looked to as highways, but try as they might, Texans never succeeded in utilizing rivers for effective transportation. Texas rivers simply were not deep or wide enough, even though special shallow draft steamboats were built. One

[165] Harris, *Reminiscences*, 68.

early pioneer from Alabama described the Sabine River, on the eastern boundary of Texas, as only "a sluggish, muddy, narrow stream."[166] Immigrants brought ideas of river transportation from the eastern United States, and effort was expended trying to realize a system of river transportation in Texas. An initial obstacle was the shallow depth of the rivers at their mouth to the Gulf of Mexico. The solution was to try to utilize the natural bays behind the line of barrier islands along the Gulf of Mexico. To this end canals were dug and several different locations in Matagorda Bay were tried as ports during early European exploration. None succeeded. [167]

Using Texas rivers as inland waterways was pursued with stubborn determination, but little success. Transportation overland was certainly fraught with difficulty because of the deleterious effects of heavy rain and a drainage pattern with frequent gullies. The Brazos River runs through the center of the early settlement area where cotton production was most prolific. The cotton crop had to be exported to textile mills in other parts of the world, so effective transportation for large quantities of cotton bales was vital. The Brazos River seemed a better choice than overland. Puryear and Winfield chronicled the history of steamboats on the Brazos. In 1843 the steamboat Mustang made the roundtrip from Galveston to Washington on the Brazos with freight inbound and cotton outbound. Shallow rapids on the Brazos prevented regular service farther upriver, except in times of high water. In addition to difficulties caused by the

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[166] Maverick, *Memoirs*, 13.
[167] In 1844 Mary Maverick indicated a canal altered the course of Caney Creek from emptying into the Gulf of Mexico instead into Matagorda Bay. See Maverick, *Memoirs*, 85. This is the same bay LaSalle had selected for his outpost on the Gulf of Mexico more than 150 years earlier.

shallow, narrow river, the riverbank was unstable and did not provide a reliable anchorage for dock facilities. The coming of the railroad to the Brazos Valley in 1857 signaled the end of a very short-lived era of river transportation in Texas.[168]

The railroad proved to be a much more effective means of transportation, and required regular water supply for its steam locomotives. Railroad companies needed water for the boilers in their locomotives. Water wells were drilled near stations along their routes. The effectiveness of rail transport between the cotton producing Brazos River Valley and the port facilities in Houston and Galveston influenced regional economic growth. Towns along the rail route flourished and river towns struggled economically.

Water Power

Water and steam also supplied industrial power, although industrial uses were relatively minor. As early as May of 1833 there was a steam saw mill at the mouth of Bray's Bayou in Harrisburg near present-day Houston. It was destroyed by the advancing Mexican army in 1836, but a second steam saw mill was constructed in the new town of Houston in July of that year. [169] Whether powered by steam or water, mills were an important part of nineteenth century life. Carlson notes that the Brazos was a good location for gristmills and sawmills as early as the 1830s.[170]

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[168] Pamela A. Puryear and Nath Winfield, Jr., *Sandbars and Sternwheelers: Steam Navigation on the Brazos* (College Station, TX: Texas A&M University Press, 1976). The notation about the unstable riverbank of the Brazos is from an anonymous 1834 author cited in Carlson, *Anson Jones Plantation*, 20.
[169] Harris, *Reminiscences*, 4, 72.
[170] Carlson, *Anson Jones Plantation*, 20.

Therapeutic and Recreational Use

Medicinal and health uses were made of water. Widely differing stories are given about the frequency of bathing during migration and settlement. Gray's diary recounts rare baths for a man who was a lawyer and land speculator. Mary Maverick recounted the story of Mrs. Webster who was kept in captivity northwest of Austin by Comanches for nineteen months before making her escape to San Antonio on March 26th, 1840. She was found and cared for by Mary and four others, "We got her some clothing, and, having prepared a bath, we helped her to undress and found her skin yet fair and white beneath the buckskin. We bathed and clothed her and left her to sleep and rest. The stench of the poor woman's clothes was so dreadful, while we were undressing her, that Mrs. Jacques fainted away, and Mrs. Smith told me to get a bottle of cologne on her mantel in the adjoining room."[171] The inference is that during captivity, Mrs. Webster was not allowed to bathe—a circumstance contrary to the way of life experienced by Mrs. Maverick in San Antonio, described thus:

> During this summer [1840], the American ladies led a lazy life of ease. We had plenty of books, including novels, we were all young, healthy and happy and were content with each others' society. We fell into the fashion of the climate, dined at twelve, then followed a siesta, (nap) until three, when we took a cup of coffee and a bath.
>
> Bathing in the river at our place had become rather public, now that merchants were establishing themselves on Commerce Street, so we ladies got permission of old Madame Tevino, mother of Mrs. Lockmar, to put up a bath house on her premises, some distance up the river on Soledad Street, afterwards the property and homestead of the Jacques family. Here between two trees in a beautiful shade, we went in a crowd each afternoon at about four o'clock and took the children and nurses and a nice lunch which we enjoyed after the bath.

[171] Maverick, *Memoirs*, 45.

> There we had a grand good time, swimming and laughing, and making all the noise we pleased. The children were bathed and after all were dressed, we spread our lunch and enjoyed it immensely. The ladies took turns in preparing the lunch and my aunt Mrs. Bradley took the lead in nice things. Then we had a grand and glorious gossip, for we were all dear friends and each one told the news from our far away homes in the "States," nor did we omit to review the happenings in San Antonio. We joked and laughed away the time, for we were free from care and happy. In those days there were no envyings, no back-biting.[172]

From this passage it is evident that "bathing" means what we would today call swimming. Clearly Mrs. Maverick did not view water as a scarcity, nor bathing as a rarity.

Mrs. Harris reported that on one occasion her brother went bathing to escape mosquitoes and was fortunate to escape with his life. In June of 1836 there was much talk about the establishment of a new town named Houston ten miles up Buffalo Bayou from Harrisburg.

> There were circulars and drawings sent out, which represented a large city, showing churches, a courthouse, a market house and a square of ground set aside to use for a building for Congress, if the seat of government should be located there… There was so much excitement about the city of Houston that some of the young men in our neighborhood, my brother among them, visited it… They said the mosquitoes were as large as grasshoppers, and that to get away from them they went bathing. The bayou water was clear and cool, and they thought they would have a nice bath, but in a few minutes the water was alive with alligators. One man ran out on the north side, and the others, who had come out where they went in, got a canoe and rescued him. He said a large panther had been near by, but that it ran off as the canoe approached.[173]

Water served as a refuge from the mosquitoes yet it harbored an even greater immediate threat in alligators.

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[172] Maverick, *Memoirs*, 56-7.
[173] Harris, *Reminiscences*, 69-70.

In addition to its medicinal uses water was valued for its cleansing and cooling effects. When Mary Maverick's young daughter was kicked in the head by a horse in 1843, water was the treatment, "We picked the scrap of hoof out of her forehead, bathed her head in cold water and we sat almost hopeless at her side awaiting the result. At midnight she became quiet and went to sleep, and just before daybreak she opened her eyes and said: "Papa, give me a drink of water." He said with deep emotion: "Blessed be God," and she was out of danger."[174] A year later Mrs. Maverick described herself as "most miserable and sick" after she and her family moved to the peninsula by Matagorda Bay. Whether for personal hygiene, or medicinal purposes is not clear, but she noted in her diary on December 7th, 1844 that their new house "was very close to the bay, and every evening Mr. Maverick took me down to bathe in the salt water."[175]

The recuperative powers of mineral water from springs was an upper class European idea brought to America via the colony of Virginia. From there it spread across the southern states and into Texas. J.B. Jackson noted the importance of mineral springs in the southern landscape and its absence across the rest of the United States.[176] When cholera struck the Maverick household, indeed their entire community, Mrs. Maverick noted, "July 10th, Mr. Maverick sent me with the four boys and Betsy to Sutherland Springs to rest and recuperate. We stopped first at Dr. Sutherlands, and Mrs. Frank Pashal with her three children stopped at Mrs. Johnson's. Mrs. Sutherland was

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[174] Maverick, *Memoirs*, 84.
[175] Maverick, *Memoirs*, 87.
[176] J.B. Jackson, *The Southern Landscape Tradition in Texas: The Anne Burnett Tandy Lectures in American Civilization* (Fort Worth, TX: Amon Carter Museum, 1980), 8-9, 20-21.

very kind to us, but as all the water ther [sic] was mineral, we moved to Mrs. Johnson's and drank Chalybeate water."[177]

Although mineral springs were largely considered therapeutic, they were also a source of recreation. The Piedmont Hotel was built at the site of the sulphur springs on the Navasota River in the mid nineteenth century. It was described, with shameless hyperbole, as the "playground of the South" and as a health resort. The hotel contained a large dining room, ballroom with orchestra, and well furnished guest rooms. It was topped with an observatory with views for miles. There were stables, a lake for fishing and hunting and the springs for sulphur baths.[178]

Irrigation

Even though the economy was agrarian, little use was made of irrigation. Dryland farming was the convention, hence the population settled in the eastern half of the state where precipitation averaged greater than twenty inches per annum. An exception to this was in a German settlement in Mason County, just into the western half of the state and hence in a dryer climate. Gilbert Jordan recalled that his mother loved flowers, and would irrigate them from one of their shallow wells when the water supply would permit.[179] Irrigation is a use of water that increased dramatically in south and west Texas during the next water use regime, but irrigation has not been a significant influence in the Texas Urban Triangle.

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[177] Maverick, *Memoirs*, 105. Chalybeate water is mineral water impregnated with iron.
[178] Dorothy Terrell, "The Piedmont Hotel," Typescript (Navasota, TX: Navasota High School, 1925), from the collection of the Star of the Republic Museum, Washington, TX.
[179] Jordan, *Yesterday in the Texas Hill Country*, 28.

Pleasant B. Watson

This general survey of water's use and the self-sufficient nature of water supply and its management, in the words of nineteenth century travelers and settlers, are illustrative of the agrarian regime. The survey's passages are, however, *selected*—an admittedly subjective process. I thought it instructive to analyze one account or journal in its entirety with respect to attitudes about water. To this end, the journal of Pleasant B. Watson was selected for two reasons. First, Pleasant B. Watson arguably fit the mold of a "typical" Texan of his time, at least in that he was born in Tennessee and moved to the Republic of Texas as a child with his family in 1839. Of the Anglo-Americans who immigrated to Texas by 1850, more came from Tennessee than from any other state.[180] Watson's family settled at Washington-on-the-Brazos, an area that was included in Stephen F. Austin's land grant, and a place favored by many of the early settlers. His father died while he was a young boy, and then his stepfather died before Pleasant established himself in adulthood. He was in his mid-twenties when the Civil War broke out, and he fought for the Confederacy. After the conclusion of the war, Watson was despondent and considered moving to the Frontier. Instead he married, tried farming in Burleson County (unsuccessfully), and moved his family to Buffalo Bayou four miles east of Houston where he planted fruit trees. His economic status was unclear. Although as a child he said he wanted for nothing, as a young man he described himself as poor. For these reasons, it is not unreasonable to consider him as a typical settler who

[180] Jordan-Bychkov et al., *Texas: A Geography*, 74.

likely held typical views of water. The second reason I selected the Journal of Pleasant B. Watson to look for clues to water's use and perception is because it is a newly discovered and unpublished journal, never before studied by academic scholars. As a historical geographer I take great pleasure in introducing this primary source material to the literature.[181]

Pleasant B. Watson was born in DeKalb County, Tennessee on September 4, 1836. His *Journal* begins on October 4, 1858 in Washington, Texas with an autobiographical essay of his life to that point. The last entry was made August 4, 1868 in Houston, Texas. He studied law briefly when he was nineteen because that had been the desire of his father, but his studies were interrupted after only a few months and never formally resumed. On November 16, 1856, Watson left for Nicaragua to fight with Walker's Rangers. Upon his return he was hired to travel to the Yucatan to collect property for a Mr. Allen. His entries include comments about transportation by both steamship and schooner and his fascination with turbulent storms at sea. Shortly after his return to Washington, Texas, he began his journal, making regular entries until 1860.

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[181] Watson, *Journal*, unpublished manuscript from the collection of the Star of the Republic Museum, Washington, TX. The methodology used to assess the Pleasant B. Watson *Journal* was to look for references to water and organize by type. Each reference was noted with a color-coded tag placed in the journal. Then each tagged reference to water was tabulated (see Appendix D). Because the Civil War entries did not occur in Texas, these references are not included in Appendix D. After compiling the list of references to water in Watson's *Journal*, they were summarized into categories that included: using rivers for transportation, using rivers and streams for giving directions and locating positions on a map, needing water for livestock and personal consumption, using cold water and mineral waters for medicinal purposes, using rainwater for agriculture, and using moving water itself directly for power or indirectly for steam power. This is consistent with uses and perceptions of water selected from other travelers' accounts and settlers' journals of the mid-nineteenth century.

Watson was hired again to retrieve property, this time from Mexico, and the portion of the journal describing his Mexican trip contains some of the most insightful passages with regard to water. Watson traveled on horseback to Brownsville, and then went one hundred fifty miles into Mexico before his return. In his regular journal entries, Watson consistently used rivers and streams to report his location. If mention of water was made, it was with respect to the evening campsite's proximity to a river or stream. The only time Watson mentioned a problem obtaining water was on this trip to Mexico. November 13, 1858, while in the vicinity of what is today Kingsville, he reported, "Camped at a tank called Los Animas. Water plenty here, but we had suffered considerably for it."[182] Several days later he reported there had been no rain in northern Mexico for six months. "The greatest inconvenience in raising stock is the scarcity of water. The water is obtained by digging wells and have trough for stock to drink from. The Mexicans are mean enough to sell water. We had to buy water for our horses and ourselves, and however justifiable the selling of it may appear in a Mexican's opinion, *Texans certainly consider it penurious and low in the* <u>*extreme*</u>."[183]

Although Mexico falls outside of the study area of this dissertation, Watson's comments are significant because they reflect his strong opinion that water was a public good rather than a commodity. If one were at a natural source of water, and not in a place to which water had to be hauled, one was free, in the perspective of Watson's culture, to take all the water one needed.

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[182] Watson, *Journal*, 25.
[183] Watson, *Journal*, entry dated 22-30 November 1858, 26. My emphasis. The underlining is Watson's.

On Watson's return trip home in December, all references to water were either with respect to location (his position was usually noted at river and stream crossings) or with regard to the weather, which was cold and rainy. After returning to Washington-on-the-Brazos, Watson's water-related entries were restricted to fishing, a recreational boat ride up the river, mention of the steamboat Belle Sulphur, and "disagreeable" weather including rain, snow, and sleet. He also took a three week trip to Austin and Lampasas Springs with a friend. The trip to the springs may have been for medicinal purposes. He reported that his health improved while camping out and that there were "a great many persons at the springs, about 600."[184]

With a trip to Tennessee in the spring of 1860 to settle affairs for his mother,[185] and the start of the War Between the States, Watson's journal entries became less frequent. He enlisted in the Confederate Army in March of 1862, and went through Mobile, Alabama to Richmond, Virginia, was wounded in battle, and returned home to Washington, Texas on February 16, 1863. His war descriptions are some of the most vivid entries in his journal, but there are few references to water other than naming rivers and comments on dismal weather. On July 10, 1862, Watson did mention that he bathed at Mill Pond near Richmond, Virginia. This is the only specific reference to bathing in his journal.[186]

A month after returning from the war, Watson married, but did not resume his journal until February 4, 1867. He was despondent over the results of the war and of the

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[184] Watson, *Journal*, 35-47.
[185] Watson, *Journal*, 51-55.
[186] Watson, *Journal*, 74-99.

politics afterward, and this state of mind probably contributed to his lack of enthusiasm for writing. When he did resume his journal, he described a two month trip that he and his wife took to Mr. Byrd's mill on Richland Creek near Corsicana to get flour.[187] On today's roads, using the route recommended by Google Earth, this is a one-way distance of 163 miles. This may have been a water-powered mill, although by the 1890s, the town of Richland in Navarro County had two steam-powered gristmills.[188] In the spring of 1867, Watson took his family—which now included a baby daughter—to San Marcos while he and several others went to Llano County to round up cattle. Watson became ill and resorted to cold water for a cure. He described his situation as thus,

> the very day we commenced herding I was taken sick with bilious fever. Up in the mountains, 50 miles to a physician, and no medicine. You can imagine my situation. I had a hot burning fever for a week. I at least broke the fever by drinking an abundance of cold water but I was so weak that I could not walk. I hired a man to take me down to Blanco City about 25 miles in the hopes of finding some medicines there but was disappointed and had to go back to my cold water.[189]

The only other significant mention of water was also related to medicinal purposes. In the summer of 1867, Watson took his wife and child with him to Sour Lake in southeast Texas for several months for the expressed purpose of improving his health. He set up two tents surrounded with boards to keep out the hogs and camped by the lake. Watson wrote,

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[187] Watson, *Journal*, 101.
[188] Texas State Historical Association, *Handbook of Texas Online*, entry "Richland, Texas (Navarro County), http://www.tsha.utexas.edu/handbook/online/ (accessed March 12, 2007).
[189] Watson, *Journal*, 107.

> The camping done us as much good as the waters, though I think the waters are the best medical waters in the world, for a great many diseases. There was not a great many visitors at the Lake, but enough to make it agreeable and pleasant….. I will always remember my visit to Sour Lake with pleasure. Besides the sport I had hunting and fishing, the health of my wife and myself was very much benefited. When I went there I weighted 119 lbs and when I cam away I weighed 140 lbs. I had been in bad health for several years previous, but have had good health ever since. My wife and little girl both improved in health and appearance.[190]

Certainly the use of mineral water for medicinal purposes is characteristic of the agrarian regime. The final water-related entries in Watson's journal reverted to the theme of weather. After moving his family to the banks of Buffalo Bayou east of Houston, Watson wrote of heavy rain and the most severe thunderstorm he could remember. The journal ends abruptly, without fanfare or comment, with an entry dated August 4, 1868.[191] Pleasant B. Watson never mentioned the source of the water supply at his parents' house in Washington, or at his own house on Buffalo Bayou. At Buffalo Bayou he did record that he cleared the land, built a log-house for a kitchen, dug ditches, built a chicken house, and intended to plant fruit trees and grapevines.

As with the journals previously cited, the absence of entries complaining of water shortages in the journal of Pleasant B. Watson strongly indicates that water was perceived to be in abundant supply, and that he wrote of rain never as a blessing but always as disagreeable. There is, at the same time, nothing in his journal to indicate that anyone else provided water for him. The agrarian regime is characterized by the perception that water was abundant and by the self-sufficiency of the individual family

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[190] Watson, *Journal*, 115, 118.
[191] Watson, *Journal*, 130.

or plantation units in supplying their own water and in managing by themselves whatever water-related experiences were presented.

Toponyms

What other ideas about water did the settlers bring with them? In addition to journals, evidence can be found in toponyms. Jordan has demonstrated that place names provide a clue not only to the origins of the settlers of a community, but also to their perceptions of the local landscape. Jett also has examined the environmental perception of place names in the Navajo culture, and found that most are descriptive of the environment, particularly in terms of rock descriptions. However, Jett found few references to water, even though this culture was located in a desert environment.[192]

Much of the current place name literature is concerned with the interpretation of power relationships, particularly those between an indigenous culture and a colonizing group, or between elites and subordinate classes.[193] Many examples of both types are present in Texas. Spanish colonization is remembered in San Antonio, San Augustine, Quintana, Velasco, Goliad, San Felipe on the Brazos, Gonzales, Laredo. Anglo colonization is remembered in the reproduced names of eastern cities, or ideological terms like Washington, Industry, Liberty, Victoria, Columbia, and Independence. German colonization is remembered in names such as New Braunfels and

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[192] Stephen C. Jett, "Place-Naming, Environment, and Perception among the Canyon de Chelly Navajo of Arizona," *Professional Geographer* 49, no. 4 (1997): 481-493.
[193] For a summary of this literature, see Robin A. Kearns and Lawrence D. Berg, "Proclaiming Place: Towards a Geography of Place Name Pronunciation," *Social & Cultural Geography* 3, No. 3 (2002): 283-302.

Fredericksburg that were established along the western outlier of settlement. Prominent landowners and civic leaders also furnished many early settlement names: Harrisburg, Millican, Bryan, Galveston, Houston, and Austin.

There are in Texas town names descriptive of the local landscape—places such as Prairie View, Moss Hill, Spring, Wildwood, and Grapeland—but this type of place name is relatively uncommon. It appears the local citizenry was more concerned with family names and ties to place names from their places of origin than with their new physical surroundings. Nevertheless, a clue as to how water was perceived by the new settlers can sometimes be found in the name of a new settlement.

Springs were the most welcomed source of drinking water in the migration process. An examination of the proper place names in Texas shows that about two percent contain the word "spring," a result similar to that noted by Jett in his Navajo study.[194] There are only one hundred fifty-eight proper place names containing the work "spring" among the more than nine thousand four hundred proper place names of Texas documented by the U.S. Board on Geographic Names in the Geographical Names Information System (GNIS). Several of these are listed in the historic record, but an exact location has been lost, leaving only one hundred thirty-five Texas proper place names containing "spring" with actual latitude and longitude coordinates in the GNIS

[194] Jett, "Place-Naming, Environment, and Perception," 486. I am simply noting that my observations from the Texas GNIS data and Jett's Navajo data give similar results for the word "spring" in terms of its usage in place naming in two different cultures, periods, and places. My work is by no means quantitative, but I find this interesting, nonetheless.

database.[195] These places are located on the toponym map in Figure 4.1. Compared with Figure 4.2, showing all proper place names in the state, Figure 4.1 is not dissimilar. It therefore appears that springs were not considered especially noteworthy, but were taken for granted. Part of the mindset settlers brought with them to Texas was that water supply was adequate.

The preceding sections can be summarized in two parts: (1) Water scarcity was not perceived as a problem, and indeed travelers tended to note excessive water as a problem. Settlers could not begin to tax the resource because (a) population was low, and (b) per capita use was kept low by the labor cost of hauling water. (2) The agrarian regime was, from a technological point of view, the regime of the bucket and barrel. The difference between this and the subsequent regimes of the pipe is best understood using concepts from economics. In the regime of the bucket and barrel, the *variable costs* of water are high and the fixed costs are low. This means the *marginal cost* of each additional gallon of water that is used is high and there are, consequently, strong incentives to limit water use. In the regimes of the pipe, on the other hand, the *fixed cost* (of the pipes) is high and the *variable cost* (of each additional gallon drawn through the pipes) is low. The marginal cost of each additional gallon consumed is, thus, much lower than in the regime of the bucket and barrel and the incentives to reduce consumption are greatly reduced.

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[195] United States Geologic Survey, U.S. Board on Geographic Names, "Geographical Names Information System," http://geonames.usgs.gov/index.html (accessed March 10, 2005).

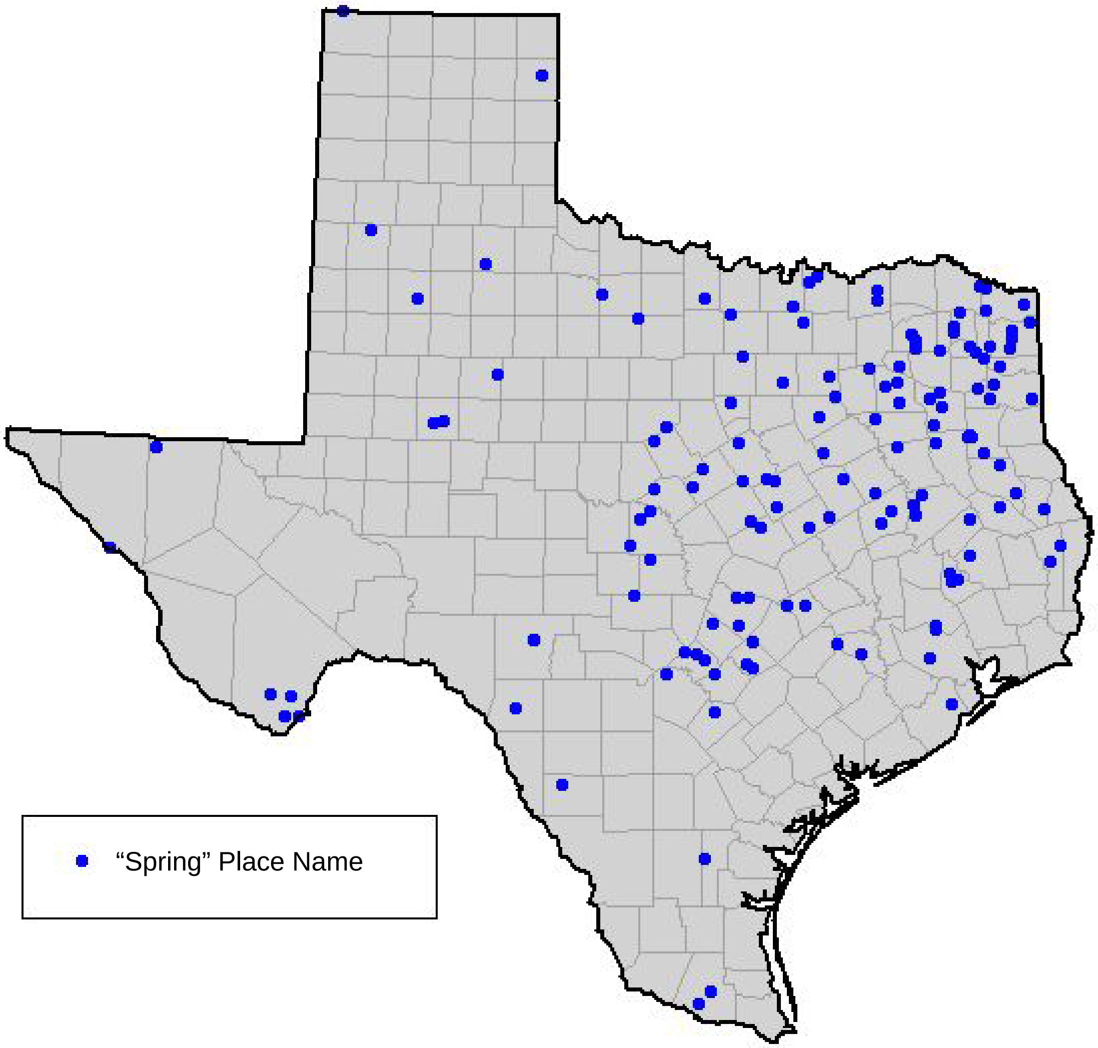

Figure 4.1. "Spring" Place Names. This toponym map locates proper place names in the state containing the word "spring." Of the more than 9,400 proper place names in Texas, 158 contain the word "spring." With the exception of the Gulf Coast region, this distribution is not unlike that of all populated places in the state, with a higher density in the eastern, more humid, part of the state. Although springs were an important influence in the location of early settlements, their occurrence was not so unusual as to be routinely included as part of the name of the settlement. Dallas, Austin, San Antonio, and Waco all had springs, but none include this designation as part of the name of their settlement. [196]

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[196] United States Geologic Survey, U.S. Board on Geographic Names, "Geographical Names Information System," http://geonames.usgs.gov/index.html (accessed March 10, 2005).

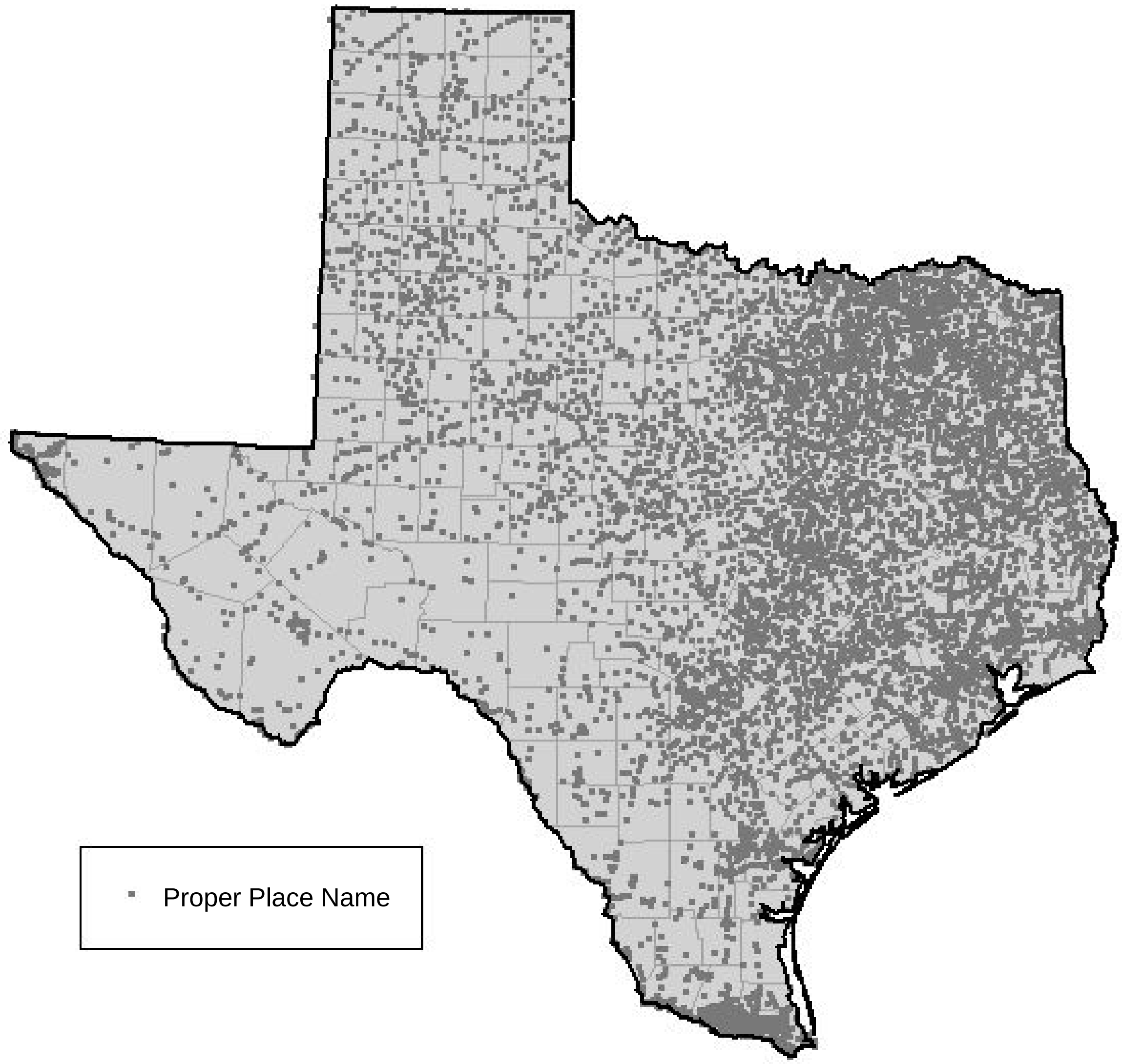

Figure 4.2. Proper Places in Texas. This map shows the more than 9,400 proper place names recognized in Texas by the United States Geological Survey, and was made for comparison with the proper place names containing the word "spring" shown in Figure 4.1. Although there is a far greater density of locations on this map, the spatial distribution of places in the two maps is not dissimilar.[197]

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197 United States Geologic Survey, U.S. Board on Geographic Names, "Geographical Names Information System," http://geonames.usgs.gov/index.html (accessed March 10, 2005).

One additional feature of the regime of the bucket and barrel, of particular interest to geography, is that, whenever possible people moved themselves (or their livestock) to the water rather than moving the water to themselves (or their cattle), e.g., bathing in rivers, bayous, or the sea. In later regimes, water was moved, instead.

The Agrarian Regime Generalized

As argued in Chapter III, a water use regime is characterized by distinctive ways of perceiving, using, and managing water. It was also argued that regimes become entrenched due to various types of inertia, but are eventually overturned by a forcing crisis. We have so far seen that, in the agrarian regime, water was *perceived* as abundant, *used* rather sparingly because of the high marginal costs connected to a distribution system of buckets and barrels, and *managed* by individuals and households. The great change at the end of the agrarian regime came in the areas of use and management. Like any change, this was a result of a forcing crisis that overcame the inertias of the agrarian regime. These inertias are detailed below, following Dodgshon's distinction between built inertia, organizational inertia, and institutional inertia.

Built Inertias

At first glance the agrarian regime might appear to have little built inertia, for the infrastructure of water collection, storage, and distribution was minimal. On farmsteads there was usually a well or a cistern located near the kitchen, and in the developing towns and cities water supply was also from wells and cisterns. However, so long as this infrastructure met the needs of Texans it was unlikely anyone would attempt to replace it. This is because the inertia of any particular technological infrastructure cannot be calculated simply as equal to the capital sunk in that infrastructure. It is always the potential valve still to be realized in the existing infrastructure *plus* the cost of the new infrastructure. To illustrate with a concrete example, a shallow well that was dug in a week will have great inertia if (a) it promises to meet demands for the foreseeable future and (b) its replacement would consume limited capital and labor that might be better employed building a new barn, or buying additional land. Thus the built inertia of the agrarian regime was unlikely to be overcome unless the wells and cisterns proved inadequate and other demands for capital improvement appeared less urgent. And this is precisely what happened.

Organizational Inertias

Organizational inertias were the least significant of the three inertias during the agrarian regime because of the self-sufficient nature of this rural society. Securing water was a daily chore assigned to a slave, if available, or to an older child or the woman of the household. The placement of the cistern or water well near the kitchen is an indication of who was responsible for drawing and using water on a daily basis in the rural household. The division of labor was simple, with few layers.

This simple division of labor was also present in towns and cities, where some made their livelihood hauling water for sale to private residences. John Lockhart recalled seeing men loading barrels of water from Buffalo Bayou near the present day Turning Basin in Houston’s Ship Channel. This was in 1839, when Houston was just a fledgling town, but already some residents purchased their water.[198] Most residents of Texas towns obtained their water from public cisterns during the course of the nineteenth century. The delivery system was simple, each family drew the water themselves, or bought water from the driver of a water wagon who made household delivery. In towns and cities the cisterns were usually excavated and rock lined rooms below ground where runoff rainwater was collected and made available to the public at no cost.[199] This organizational system, simple as it was, reinforced an institutional inertia linking a common supply of water provided at no charge to the public to the list of civic duties expected of the local government.

Like built inertia, the organizational inertia of the agrarian regime appears at first to be limited, since apart from a small number of commercial water haulers no one had a material stake in preserving the status quo. Improvements on this system would, indeed, appear to have been highly desirable because they would have *released labor* for more productive activities. Such a view, however, ignores the *politics* of the agrarian regime. Slavery and later employment discrimination created a pool of very cheap labor that could supply more affluent whites with water. Blacks and whites who had to haul water for themselves, and who could have benefited most from a public water supply (which would release their labor for productive employment) lacked the capital and political

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[198] Mrs. Jonnie Lockhart Wallis, *Sixty Years on the Brazos: The Life and Letters of Dr. John Washington Lockhart, 1824-1900* (Los Angeles [Waco]: privately printed [reprinted by Texian Press], 1930), 79.

[199] Shawn Bonath Carlson, "Water Resource Features," in *Archaeological and Historical Investigations at the Ball Park at Union Station, Houston, Harris County, Texas,* Report of Investigations No. 260, Draft Edition edited by Shawn Bonath Carlson, Draft 19.1-19.5 (Moore Archeological Consulting, Inc., May 2002).

power to force a change. It was not until the agrarian regime's organization failed people with capital and political influence—namely merchants whose stores needed fire protection—that this inertia was overcome.

Institutional Inertias

The Americans who settled in Texas brought with them a belief that water was abundant.[200] This attitude differed from the small number of settlers from New Spain, who brought with them the arid-land attitudes of Mexico and the Iberian Peninsula. A good example of the American's *assumption* that water in Texas was abundant was their assumption that Texas rivers would be navigable, and important transportation arteries, like rivers in the east. Yet, as it happens, one of the least effective uses of water in Texas history has to be that of river navigation and transportation. Although repeatedly frustrated, this idea persisted, and so gives evidence of institutional inertia.

Emigrant guides to Texas proliferated in the 1830s, and several contain descriptions of Texas rivers in terms of their navigability. David Edward described each of the rivers in his 1836 guide and concluded that the Brazos was conducive to steamboat navigation "in all ordinary seasons" for two hundred miles if only the sand bar were dredged at the mouth of the river.[201] But Edward was not, however, entirely deluded, and admitted that Texas rivers were not the equal of those in the east.

> Texas can boast of having as many water courses within its boundaries, as any other given portion of the same extent in America; but in the aggregate they are of less consequence to the people, and of less utility to the country, in a

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[200] Worster, *Rivers of Empire*, 191-193.
[201] Edward, *History of Texas*, 21.

> commercial point of view than the rivers of any other district of the same proportion on the continent. A map of Texas, displaying as it does, so many rivers and their branches, would lead one to infer that the country enjoyed extraordinary facilities for inland navigation; which is not the fact.[202]

When the railroad came to the Brazos Valley in the late 1850s, cotton transport immediately shifted from river to rail. The Civil War disrupted rail construction—and just about everything else—from 1861 to 1865, but after the war, rail lines were extended into an effective transportation network between inland cotton producing areas and the ports of Galveston and Houston. Yet in spite of the burgeoning rail network, the idea of river transportation did not die. In 1874 an act of Congress authorized the United States Army to survey the Brazos River from Waco to its mouth at the Gulf of Mexico. Special care was to be taken to assess the sand bar across the mouth of the river. As a result of this survey, a recommendation was made by the Captain of Engineers for the Army to construct jetties in an attempt to funnel the water of the Brazos through a more narrow opening into the Gulf so that the river itself could scour a deeper channel for navigation. These jetties were indeed constructed during the 1880s, but were destroyed and not rebuilt after the Hurricane of 1900.[203] A series of locks was constructed on the Brazos River, especially around Hidalgo Falls between Washington and Brazos Counties, in the early part of the twentieth century. The locks were rendered inoperable

[202] Edward, *History of Texas*, 55.
[203] C.W. Howell, *Annual Report of the Chief of Engineers for 1875 upon the Improvement of the Mouths of the Mississippi River; Improvement of Rivers and Harbors in the States of Louisiana and Texas* (Washington: Government Printing Office, 1875), 113-125 available in the archives of the Star of the Republic Museum at Washington, TX. See also Texas State Historical Association, *Handbook of Texas Online* entry “Quintana” (accessed March 12, 2007).

by the Flood of 1913, before even being put into operation. Remnants of the locks are still visible today.

Institutional inertia describes ingrained attitudes and beliefs. These attitudes and beliefs are largely formed by experience. Geographers have long taken an interest in the way that attitudes and beliefs formed in one geographical setting will be carried by migrants to new settings where they may not be warranted. The movement of Americans from the humid East to the arid (treeless) West is a classic example. The *inertia* of such beliefs and attitudes largely results from the *effort* it takes to digest new experiences and form new beliefs. It is *hard work* for a person to change his or her mind, and so he or she cannot be expected to do so until the cost of retaining the old beliefs is manifestly higher than the cost of forming the new beliefs. This calculus does not, of course, apply with equal force to children, who have no vested interest in past accretions of now irrelevant environmental experience. Institutional inertia is, therefore, primarily undermined by inappropriate behavior with very high cost and the replacement of settlers by first generation natives. The second factor was the most important cause of the end of the agrarian regime.

Conclusion

The inertia of the agrarian regime consisted in the fact that it was sufficient to the needs of settlers and its major defects were not felt acutely by people with the resources and power to change it. As we will see in the next chapter, however, the regime was brought to crisis by urbanization and its utter inadequacy for fire suppression. Commercial fires and fire insurance rates bore directly on elites, who consequently began to *reorganize* water management into municipal systems of reliable piped water. Certain institutional attitudes of the agrarian regime also began to erode in the late nineteenth century when the settlement generation began to die off and be replaced by natives who had a different experience and perception of water.

CHAPTER V

THE WATERWORKS REGIME

Fire in the Central Business District

Ironically, the crisis that spelled the end of the agrarian regime did not occur in rural Texas—it began in the central business districts of Texas' towns and cities. Although mid-nineteenth century Texas was a rural state, by the 1870s economic recovery from the Civil War and Reconstruction was such that market towns were developing and expanding. The first waterworks in the state were built and as they became part of the cultural landscape, the perception of water changed. Water was not only abundant, but it became taken for granted. But how did it come to happen that waterworks were built? Was it simply a logical and desired-for increase in the standard of living, as those of us accustomed to such comforts might think? Nelson Blake attributes their rise to fear of disease and the threat of fire.[204] More recently, Martin Melosi agrees.[205] Yellow Fever is spread by mosquitoes, but a Yellow Fever epidemic in Philadelphia in 1789 caused Benjamin Franklin to advocate that the city look for a new fresh water supply. In 1801, Philadelphia became the first city in the United States to have a municipally owned water supply.[206] In Texas, however, the overwhelming reason waterworks were established was for fire protection. Fire in the central business

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[204] Nelson Manfred Blake, *Water for the Cities: A History of the Urban Water Supply Problem in the United States* (Syracuse, NY: Syracuse University Press, 1956), 5.
[205] Martin Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore, MD: The Johns Hopkins University Press, 2000), 29.
[206] Melosi, *The Sanitary City*, 31.

districts of Texas cities was such a hazard during the latter half of the nineteenth century that eight of Texas' ten largest cities, plus many smaller towns, were listed in the *New York Times* "Losses by Fire" column, which regularly included reports not only from New York, but from across the nation. [207] Figure 5.1 shows the location of Texas cities

[207] Texas fires reported in the "Losses by Fire" column of *The New York Times* include, 8 February 1871, p. 5, an entire block of Jefferson burned destroying at least seven businesses; 14 May 1873, p. 1, fire destroyed half a block of Calvert's business district; 8 March 1874, p. 1, large fire at Bryan; 8 May 1877, p. 5, fire destroyed several businesses in Sherman; 2 October 1877, p. 5, a block of stores, dwellings, a photograph gallery, blacksmith shop, and stables destroyed by fire in Corsicana; 16 February 1878, p. 8, ten buildings destroyed by fire at Hempstead; 26 January 1879, p. 7, fire consumed nearly an entire block on Main Street in Denison; 21 March 1879, p. 5, fire destroyed 14 businesses on the west side of the public square in Tyler; 5 April 1879, p. 5, the American ship Lancaster and her cargo of 1770 bales of cotton were destroyed by fire at the wharf at Galveston; 19 November 1879, p. 2, a four story furniture warehouse and three other large brick buildings on the north side of the Strand were burned; 22 December 1879, p. 1, the Post Block at Fort Worth was destroyed by fire; 31 December 1879, p. 2, the opera-house and adjoining buildings at Sherman were burned; 6 February 1880, p. 2, the County courthouse with many valuable documents burned in Dallas; 15 December 1880, p. 2, a gin, 100 bales of cotton, and 5 rail car loads of cotton seed burned in Cuero; 25 December 1880, p. 5, fire destroyed almost the entire business district of Elkhart; 25 August 1881, p. 2, railroad shops, three locomotives and a passenger car were destroyed at Harrisburg; 25 August 1881, p. 2, nearly the entire business district of Daingerfield was destroyed by fire; 25 September 1881, p. 2, fire at Denton destroyed twelve businesses, a church, and a dwelling; 29 September 1881, p. 5, fire at Bryan destroyed one of the principal business blocks of the city including the post office; 5 October 1881, p. 2, fire destroyed grain elevator and 15,000 bushels of grain at Galveston; 16 October 1881, p. 9, fire destroyed nearly all the businesses houses on the public square in Palestine. The same dispatch also reported a large part of Belton was destroyed by suspected arson; 25 November 1881, p. 5, nine business houses in Whitesboro were burned; 27 December 1881, p.5, Napier Building in downtown Waco destroyed at loss of $50,000; 28 December 1881, p. 2, fire in grocery in Marlin destroyed all the buildings between Carter's Bank and Wood's Corner; 4 January 1882, p. 1, almost all buildings on west side of the public square in Greenville were destroyed by fire; 13 January 1882, p. 5, every building in the little town of Kemp burned; 31 January 1882, p. 2, block containing the telegraph office in Houston burned; 18 June 1882, p. 1, fire destroyed 20 buildings in Willis, almost their entire business district; 27 December 1882, p. 3, Waco fire destroyed photography gallery for loss of $8,000 and furniture and toy company for $30,000 loss; 2 May 1883, p. 5, fire destroyed five buildings including a grain elevator in Waxahachie; 29 August 1883, p. 5, fires destroyed four businesses in San Antonio and three in Laredo; 18 September 1883, p. 1, four of Madisonville's principal stores were destroyed by fire; 23 September 1883, p. 9, Lampasas lost half a block of buildings between Third and Fourth Streets; 8 October 1883, p. 1, grain elevator fire in Dallas destroyed eight companies; 31 December 1883, p. 5, fire destroyed hotel and fourteen businesses in Whitesboro; 22 January 1884, p. 2, barbershop fire in Mineola destroyed 13 stores; 21 March 1884, p. 2, the grocery store and hardware, general store, and saloon in Whitewright were destroyed by fire; 11 April 1884, p. 1, the whole east side of the public square in Huntsville was destroyed by fire; 14 February 1885, p. 2, county courthouse and records were burned at Athens just as 5 murder trials were scheduled to begin; 15 October 1885, p. 5, Gainesville's grocery, bank, drug store, telegraph office, and furniture store on the main square burned; 11 November 1885, p. 5, the county courthouse and 30 years of county documents burned by a suspected

and towns with major central business district fires as reported in this "Losses by Fire" column between 1870 and 1893. During the late nineteenth century, Texas cities were small with average population of only 1,500 (See Appendix C). Their central business districts generally consisted of several blocks around a central square containing the county courthouse or several blocks fronting the railroad or Main Street. Birdseye view maps were common during the last quarter of the nineteenth century and nicely illustrate the layout of individual towns.[208]

The ten largest cities in Texas in 1880 were Galveston (population 22,248), San Antonio (20,550), Houston (16,513), Austin (11,013), Dallas (10,358), Waco (7,295), Fort Worth (6,663), Sherman (6,093), Marshall (5,624), and Brownsville (4,938).[209] Of these, only Austin and Brownsville did not have major central district fires reported in the *New York Times* "Losses by Fire" column. Both cities did, however, have major fires reported elsewhere in that newspaper during the same time period. Austin's fire involved a suspected attempt by abolitionists to burn the entire town by setting fire to a

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arsonist in Centerville; 1 September 1886, p. 2, the Howard Oil Mills burned at Houston and were insured by 67 different companies; 24 October 1886, p. 2, fire destroyed half a dozen stores in Dublin. "It was only by the greatest exertions that the entire town was saved from destruction." 9 January 1887, p. 5, the town of Duck Creek [now Garland] with three hundred inhabitants was destroyed by fire from a defective chimney; 23 January 1887, p. 7, the entire west side of the town square at McKinney was consumed by fire, destroying 15 businesses; 18 March 1887, p. 2, disastrous fire quickly destroyed the greater portion of two entire blocks of Big Spring; 7 November 1887, p. 5, fire destroyed eight stores in Temple; 15 November 1887, p. 5, fire at Greenville destroyed the Texas Compress Association's cotton compress, 8 rail cars, and 3,000 bales of cotton; 26 October 1892, p. 5, the cotton compress and 5,000 bales of cotton burned in Belton; 27 December 1892, p. 3, one entire block of Houston Street in San Antonio destroyed by fire including a business college, telephone company, drug store, jeweler, auction house, dentist's office, physician's office, and commission merchants' business.

[208] Texas State Library and Archives Commission, "Map Collection Indexes and Types of Maps," Austin, TX, http://www.tsl.state.tx.us/arc/maps/indexesandtypes.html (accessed March 12, 2007).

[209] *Texas Almanac, 1964-1965* (Dallas: A.H. Belo Corporation, 1963), 122-126.

flour mill and was reported by the *Times* on August 3, 1860 in the column "News of the Day." Brownsville's fire was the result of an explosion of ninety-five kegs of gunpowder that was reported in the *Times* on November 16, 1857 under the headline "The Great Fire and Explosion at Brownsville, Texas." It is evident from the map in Figure 5.1 that the towns in the most populated part of the state, the future "Texas Urban Triangle" extending from Dallas/Fort Worth in the north to San Antonio in the southwest corner to Houston/Galveston in the southeast corner,[210] suffered from the effects of fires. The problem was not limited to one particular fire in one particular city, but rather was widespread throughout the state's population centers.

In addition to the direct economic losses suffered by merchants, the economic impact on insurers was also significant. This was compounded by a high number of incendiary fires and a controversial judicial ruling that left the insurance industry staggering. Fully thirty percent of all destructive fires in the United States were thought to have been set intentionally in 1885.[211] This may have left insurance companies unusually wary of claimants. Then, in a United States Circuit Court ruling that was both controversial and questionable, the Texas case of Hinchman versus the Royal and California Insurance Companies, it was ruled that the full value of an insurance policy had to be paid to a claimant even if fire losses suffered were less than the amount of the policy and even if the owner of the policy committed fraud to collect from his policy. The Home Insurance Company of New York led a protest against this decision,

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[210] Hugill, *World Trade Since 1431*, 302.

[211] "Men Who Run Risks. Matters and Measure Pertaining to Insurance Here, There and Everywhere," *Dallas Morning News*, 1 October 1885, p. 5.

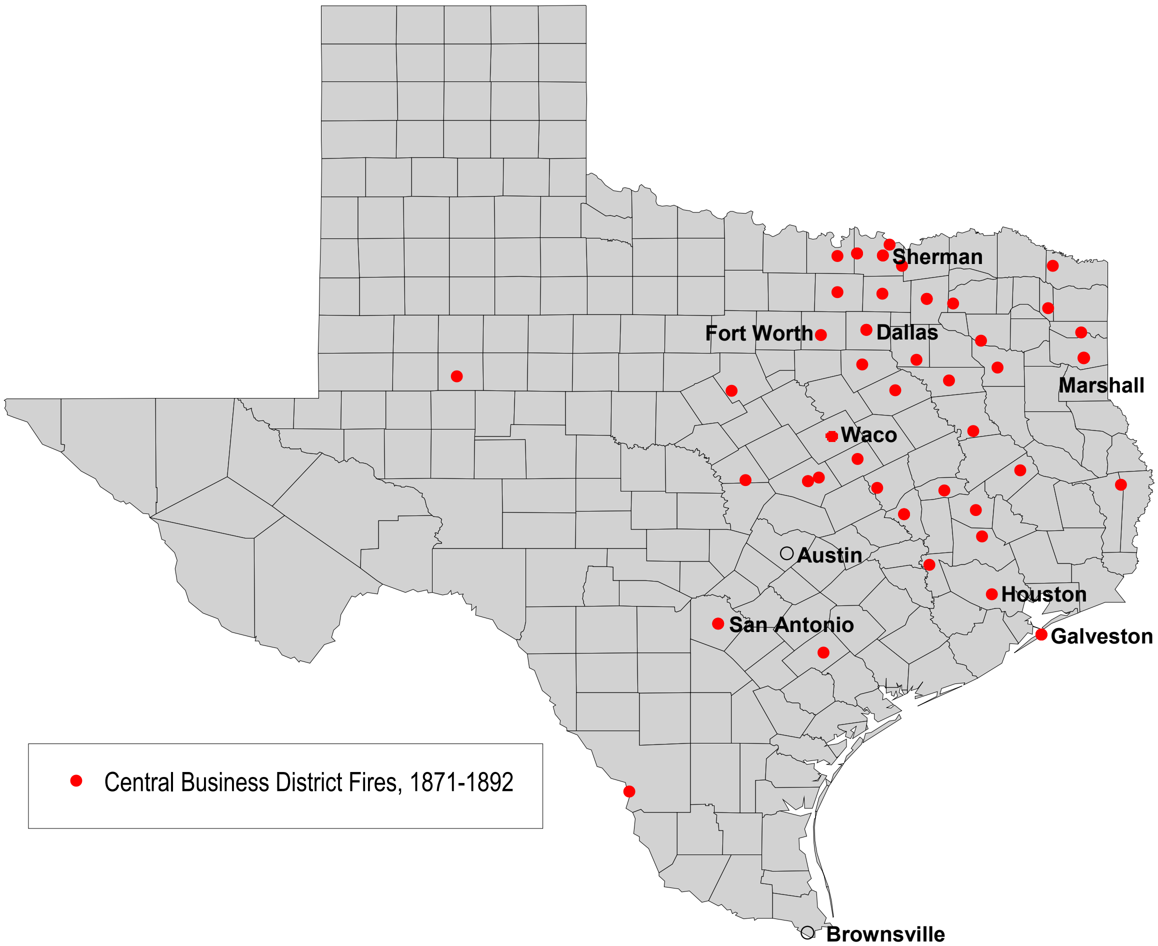

Figure 5.1. Central Business District Fires. Fires reported in the "Losses by Fire" column in *The New York Times*, from 1871 to 1892 are indicated with a red dot. Of the ten largest cities in Texas according to the 1880 census (identified by name on the map), eight were included in *The Times* "Losses by Fire" reports. The other two, Austin and Brownsville (indicated with an open circle), each had a major fire reported elsewhere in *The Times*. Galveston had the largest population (22,248) in the state and Brownsville was tenth (4,938). Austin's fire involved a suspected attempt by abolitionists to burn the entire town by setting fire to a flour mill, and was reported on August 3, 1860 in the column "News of the Day." Brownsville's was the result of the explosion of 95 kegs of gunpowder, reported on November 16, 1857 under the headline "The Great Fire and Explosion at Brownsville, Texas." A number of smaller towns had serious central business district fires, with possibly even greater economic consequences than those suffered by the larger cities because of the relatively small size of the business districts of the smaller towns.

instructing its agents to cease issuing new policies in the state, to refrain from guaranteeing existing policies for more than sixty percent of the estimated value of the property, or simply to cancel policies until the ruling was overturned.[212] The effect was that companies seeking insurance took out numerous small policies with many different insurance companies. For example, when the Howard Oil Mills burned in Houston in August of 1886, it was insured by sixty-seven separate policies ranging in coverage from $6,500 through the New-Orleans Association, to a $500 policy from Security of Davenport, Iowa. Seven of Howard Oil Mills' policies, ranging in value from $2,000 to $5,000 each, were from companies in Canada, England, and Germany.[213]

The challenge, then, was to decrease fire loss in the central business district. Once a fire started, there was little chance of stopping it until the entire city block burned. This was a loss many towns had difficulty absorbing, because a city block was a significant part of the business district. Insurance was difficult to obtain, and inefficiencies added to the cost of doing business. Reducing the risk of fire, and decreasing and containing its destruction, became of paramount importance.

Establishment of Waterworks

The response to central business district fires was threefold. First, insurance companies raised rates and limited liabilities. In Galveston, insurance rates went up by

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[212] "No Insurance for Texas: The Companies Alarmed by Judge Pardee's Recent Decision," *New York Times*, 20 January 1885, p. 8.
[213] "Losses by Fire," *New York Times*, 1 September 1886, p. 2.

twenty-five percent until fire prevention controls were implemented.[214] Second, fire departments sprang up and were almost universally praised for their brave and gallant efforts (although significant fire losses continued). While both responses were significant, it was the construction of waterworks that was the tipping point to a new water regime because in town after town, the water supply, adequate for most purposes, simply did not deliver either the quantity or the water pressure needed for fighting fires.

The establishment of local waterworks began in Texas in the 1870s in its major cities. Between 1875 and 1880, Austin, Dallas, Waco, San Antonio, Houston, and Galveston, in that order, saw the establishment of a waterworks. Only Galveston tackled the project directly without working with a private company to provide some of the necessary capital. By the end of the 1880s, there were more than fifty waterworks in Texas. The editors of the *Engineering News* trade journal published a survey of all waterworks in the United States and Canada in 1890, and the results for Texas are summarized in Table 5.1.[215] From this, some generalizations can be drawn.

[214] "Galveston. Citizens of the Island City Rejoicing at a Reduction of Insurance," *Dallas Morning News*, 2 October 1885, p. 1. Describes how rates that had escalated 25% were lowered 15% with the establishment of a waterworks and another 10% with the addition of a paid fire department. Citizens were still discontent because rates were only lowered to what they had been before fire and water protection. They thought the risks were less, so rates should be reduced even more. Within the Central Business District, buildings were constructed of brick, not wood. Galvestonians rejoicing was short-lived, however. Galveston's Great Fire occurred November 13, 1885. It began in a foundry on the Strand but high winds spread the fire quickly south across the island through a residential area. Forty blocks were destroyed, a thousand families left homeless, and an estimated two million dollars of property loss was reported. See "Galveston's Great Fire," *New York Times*, 14 November 1885, p.1; "The City of Galveston. A Lack of Water Facilities in the Burned District—The Insurances," *New York Times*, 14 November 1885, p. 1; "Almost From Bay to Gulf. A Great Fire Sweeps Over Galveston," *Dallas Morning News*, 14 November 1885, p. 1. *DMN* article includes map.

[215] Baker, M.N., ed., *The Manual of American Water-Works* (New York: Engineering News Publishing Co., 1890), 571-586.

Table 5.1. Texas Waterworks Established Before 1890. This table of 55 Texas waterworks is compiled from descriptions of 2,047 waterworks in the United States and Canada published by the editors of the *Engineering News* trade journal in 1890.[216] The first waterworks in Texas were constructed in 5 of its largest cities during the decade of the 1870s: Austin (1875), Dallas (1876), Waco (1878), San Antonio (1878-1879), and Houston (1879-1880). The typical arrangement was for the waterworks to be built, owned, and operated by a private company in some sort of partnership with the city. During the 1880s, fifty new waterworks were built in the state and twenty-six more were reported to be under consideration, with half of those projected to have fair prospects for construction. Water supply was from a local source, either surface or groundwater, with an artesian well considered the best. A standpipe with capacity on the order of 100,000 gallons was the preferred method of storage. Both gravity and pumps were used for delivery. Progress in development was measured in miles of mains, numbers of taps and hydrants, and in increased water pressure for fire fighting. Consumption figures represent average daily consumption. Additional technical specifications on pump types, power supplies, and financial obligations of the waterworks have not been included in this table, but are described in *The Manual of American Water-Works*. Abbreviations: cap. capacity; c.i. cast iron; dy. cap. daily capacity; k.i. kalamein iron; w.i. wrought iron.

Waterworks	**History**	**Supply**	**Dy. Cap.**	**Storage**	**Distribution**	**Consumption**	**Pressure**
Abilene (Pop. Est., 3,500)	Built by private company 1885-6, bought by city in 1887. Managed by council.	Wells and directly from Lytle Creek.	720,000 gallons.	Standpipe, cap., 70,000 gal.; 12x85 ft.	35 hydrants, 85 taps, no meters.	60,000 gallons.	65 lbs.
Austin (Pop., 10,960; est., 27,000)	Built in 1875 by private company, rebuilt in 1882, reorganized in 1887 as Austin Water, Light & Power Co..	Colorado River by direct pumping.	6,000,000 gallons.	No storage capacity.	Mains, c.i., 40 miles. Taps, 1,603. Meters, 382. Hydrants, 142.	2,000,000 gallons.	Ordinary, 55 lbs. Fire, 140 lbs.
Beaumont (Pop., est., 3,500)	Built in 1888 by city and leased for 30 years to Beaumont Ice, Light and Refrigerating Co.	Neches River, pumping to standpipe.	1,5000,000 gallons.	Standpipe, cap., 102,000 gallons; 12x120 ft.	Mains, c.i., 3 miles. Meters, none. Hydrants, 42.	700,000 gallons.	Not given.
Belton (Pop., 1,797; est., 5,000)	Built in 1884 by town. Leased and operated by Belton Light and Water Co.	Leon River, pumping to standpipe.	1,000,000 gallons.	Standpipe, cap., 200,000 gallons; 20x86 ft., 80 ft. above public square	Mains, c.i., 6 miles. Taps, 450. Meters, 1. Hydrants, 28.	300,000 gallons.	Ordinary, 70 lbs. Fire, 140 lbs.

[216] Baker, M.N., ed. *The Manual of American Water-Works* (New York: Engineering News Publishing Co., 1890), 571-586.

Table 5.1 Continued

Waterworks	History	Supply	Dy. Cap.	Storage	Distribution	Consumption	Pressure
Brenham (Pop., 4,101; est., 7,500)	Built in 1885 by private company under 25 year franchise.	Springs pumping to standpipe.	1,500,000 gallons.	Standpipe, cap., 110,000 gallons; 14x100 ft.	Mains, c.i. 5½ miles. Taps, 200. Meters, 3. Hydrants, 35.	125,000 gallons.	Ordinary, 40 lbs. Fire, 100 lbs.
Brownwood (Pop., 725; est., 3,500)	Built in 1886-1887 by town.	Natural reservoir in bed of Pecan bayou, 2 miles from court house, pumping to standpipe.	2,400,000 gallons.	Standpipe, cap., 220,000 gallons; 20x100 ft.	Mains, 10 to 4 in., c.i., 5¼ miles. Taps, 190. Meters, none. Hydrants, 46.	50,000 gallons.	Ordinary, 46 lbs. Fire, 120 lbs.
Bryan (Pop., est., 4,500)	Built in 1889-1890 by Bryan Water, Ice & Electric Light Co. under 25 year franchise.	Wells pumping to standpipe.	750,000 gallons.	Standpipe, cap., 84,600 gallons.	Mains, 8 to 4 in. c.i., 4 miles. Hydrants, 16.	No data. To begin operation Apr 1st of 1890.	Ordinary, 40 lbs. Fire, 150 lbs.
Calvert (Pop., 2,280; est., 3,500)	Built in 1886-1887 by Calvert Water, Ice and Electric Light Co. under 25 year franchise.	Artesian well pumping to standpipe & reservoir.	1,500,000 gallons.	Standpipe, cap., 85,000 gallons; 12x100 ft. Reservoir, cap., 35,000 gallons; brick and cement.	Mains, c.i. 5½ miles. Taps, 145. Meters, 30. Hydrants, 11.	50,000 gallons.	Ordinary, 45 lbs. Fire, 150 lbs.
Castroville (Pop., 731; est., 1,000)	Built, engineered, and owned in 1887 or 1888 by J. Conover.	Stream, pumping to tank.	50,000 gallons.	Tank, cap. 10,000 gallons.	Mains, wrought iron.	Not reported.	Not reported.
Cleburne (Pop. 1,855; est., 8,000)	Built in 1883-1884 by town. Managed by city council.	Springs, pumping to tank and direct.	1,250,000 gallons.	Tank, cap., about 60,000 gallons; 20x25 ft. on brick tower 51½ ft. high.	Mains, k. i., 8 miles. Taps, 232. Meters, none. Hydrants, 40.	120,000 gallons.	Ordinary, 40 lbs. Fire, 200 lbs.
Colorado (Pop., est., 2,000)	Built in 1885 by town. Leased and operated by Caldwell & Fletcher.	Wells, pumping to standpipe.	350,000 gallons.	Standpipe, cap., 285,000 gallons; 22x100 ft.	Mains, c.i. 7 miles. Taps, 300. Meters, 32. Hydrants, 16.	40,000 gallons.	Ordinary, 75 lbs. Fire, 80 lbs.
Columbus (Pop., 1,959; est., 3,000)	Built in 1884 by town.	Colorado River, pumping to tank and direct.	350,000 gallons.	Tank, cap., 52,000 gallons; 20x22 ft.; iron, on 60 ft brick tower; 110 ft. above pump. Wooden tank was formerly used.	Mains, 6 and 4 in. c.i., 3 miles. Taps, 80. Meters, none. Hydrants, 9.	15,000 gallons.	Ordinary, 35 lbs. Fire, 100 lbs.

Table 5.1 Continued

Waterworks	History	Supply	Dy. Cap.	Storage	Distribution	Consumption	Pressure
Corsicana (Pop. 3,373; est., 10,000)	Built in 1884 by Corsicana Water Co. under 25 year franchise.	115 acre lake, pumping to standpipe.	2,000,000 gallons.	Standpipe, cap., 235,000 gallons; 20x100 ft; on hill 45 ft. above surrounding land.	Mains, k. i., 7 miles. Taps, 400. Meters, none. Hydrants, 61.	500,000 gallons.	Ordinary, 55 lbs. Fire, 150 lbs.
Cuero (Pop., 1,333; est., 3,500)	Built in 1889-1890 by city.	Guadalupe River, pumping direct and to standpipe.	1,000,000 gallons.	Standpipe, cap., 157,000 gallons; 16x105 ft.	Mains, c.i., 6 miles. Hydrants, 35.	No data as waterworks had not begun operations.	Ordinary, 50 lbs. Fire, 150 lbs.
Dallas (Pop., 10,358; est., 45,000)	Built by city in 1876, and rebuilt in 1884.	Trinity River and springs, pumping to reservoir and standpipe. Originally water pumped to standpipe from well 32x80 ft., sunk in gravel.	4,500,000 gallons.	Turtle Creek Reservoirs, cap., 140,000,000 gallons. Standpipe, cap., 150,000 gallons.	Mains, 18 to 4 in., c.i. 25.3 miles. Taps, 1,764. Meters, none. Hydrants, 177.	2,548,132 gallons.	50 lbs.
Decatur (Pop. 579; est., 3,000)	Built in 1883 by A.R. Whitehead, enlarged in 1889.	Well pumps to tank.	72,000 gallons. 1,000,000 gallons added in 1889.	Tank, cap., 36,000 gallons.	Mains, 3 in., extending throughout village.	Not reported.	Not reported.
Del Rio (Pop., est., 1,800)	Built in 1883 by Southern Pacific Railroad Co.	Springs, pumping to tank.	Not given.	Tank, cap., 10,000 gallons.	Mains, 4 and 2 in. c.i., 10 miles. Taps, 150, Meters, none. Hydrants, 30.	75,000 gallons.	Ordinary, 65 lbs. Fire, 160 lbs.
Denison (Pop., 3,975; est., 15,000)	Built in 1886-1887 by Denison City Water Co. under 20 year franchise.	Wells and surface water impounded in reservoir, pumping to standpipe.	3,000,000 gallons.	Standpipe, cap., 160,000 gallons; 15x125 ft.	Mains, c.i., 12 miles. Taps, 375. Meters, 38. Hydrants, 75.	Not given.	Ordinary, 75 lbs. Fire, 150 lbs.
Eagle Pass (Pop., est., 2,500)	Built in 1884 by Eagle Pass Water Supply Co. under 40 year franchise. To be connected to waterworks in Porfino Diaz, Mexico to supplement service.	Rio Grande River, filtered, pumping to reservoir.	Not given.	Reservoir, cap., 2,000,000 gallons.	Mains, c.i., 5½ miles. Taps, est. 200.	1,000,000 gallons.	Ordinary, 40 lbs. Fire, 65 lbs.

Table 5.1 Continued

Waterworks	History	Supply	Dy. Cap.	Storage	Distribution	Consumption	Pressure
East Dallas (Pop., est., 4,000)	Built in 1886 by East Dallas Water Supply Co. under 50 year franchise.	Well, pumping to standpipe.	500,000 gallons.	Standpipe, cap., 110,000 gallons; 14x100 ft.	Mains, c.i., 3½ miles. Taps, 110. Meters, 3. Hydrants, 15.	200,000 gallons.	40 lbs.
El Paso (Pop., 736; est., 10,600)	Built in 1882 by El Paso Water Co. under 25 year franchise.	Rio Grande River, pumping to reservoirs.	3,500,000 gallons.	3 reservoirs, at elevation 180 to 200 ft higher than city, cap., 6,000,000 gallons.	Mains, both kalamein and wrought iron, 10 miles. Taps, 800. Meters, 450. Hydrants, 44.	600,000 gallons.	74 lbs.
Fort Worth (Pop., 6,663; est., 30,000)	Build by private company 1882-3, owned by city in 1890.	Trinity River, Clear Creek and gang wells (EN, vol XVII, p. 396) in gravel bed under river, by direct pumping.	4,000,000 gallons.		Mains, c.i., 21 miles. Taps, 1,500. Meters, 30. Hydrants, 128.	3,000,000 gallons.	Ordinary, 85 lbs. Fire, 120 lbs.
Gainesville (Pop., 2,667; est., 10,000)	Built in 1883-1884 by Gainesville Water Co. under 50 year franchise.	Elm River, by direct pumping.	1,500,000 gallons.	Reservoir, cap., 115,000,000 gallons.	Mains, c.i. 8.4 miles. Taps, 400. Meters, 103. Hydrants, 84.	500,000 gallons.	Ordinary, 60 lbs. Fire, 120 lbs.
Galveston (Pop., 22,248; est., 40,000)	Built in 1888-1889 by the city.	13 Artesian wells, pumping to standpipe and storage tank.	2,000,000 gallons.	Tank, cap., 1,177.500 gallons. Standpipe, cap., 485,00 gallons, 25x150 ft.	Mains, c.i., 32 miles. Taps, 50. Meters, none. Hydrants, 350.	1,000,000 gallons.	Not given.
Georgetown (Pop., 1,354; est., 3,500)	Built in 1884 by city and leased to San Gabriel Water-Works Co.	San Gabriel River, pumping to stand pipe and direct.	1,000,000 gallons.	Standpipe, cap., 230,000 gallons; 20x100 ft.	Mains, k.i., 6½ miles. Taps, 250. Meters, 5. Hydrants, 21.	350,000 gallons.	Ordinary, 40 lbs. Fire, 120 lbs.
Gonzales (Pop., 1,581; est., 2,500)	Built in 1884 by Gonzales Water-Works Co..	Guadalupe River, pumping to stand pipe, tank and direct.	280,000 gallons.	Standpipe, cap., 80,000 gallons; 12x100 ft. Tanks, cap., 40,000 gallons; 2 of cypress 51 ft. above city.	Mains, k.i., 6 miles. Taps, 220. Meters, none. Hydrants, 14.	90,000 gallons.	Ordinary, 30 lbs. Fire, 120 lbs.

Table 5.1 Continued

Waterworks	History	Supply	Dy. Cap.	Storage	Distribution	Consumption	Pressure
Greenville (Pop., est., 7,000)	Built in 1888-1889 by Greenville Water & Electric Light Co..	Cowleach fork of Sabine River, pumping from reservoir, through filter, to standpipe.	2,500,000 gallons.	Masonry dam forms reservoir, cap., 310,000 gallons. Standpipe, cap., 165,210 gallons.	Mains, 15 to 6 in., c.i., 5.2 miles. Taps, 53. Meters, 7. Hydrants, 60.	About 50,000 gallons.	60 lbs.
Houston (Pop. 16, 513; est., 34,000)	Built in 1879-1880 by Houston Water-Works Co.	Flowing artesian wells, pumping to standpipe and direct. Supply formerly from Buffalo Bayou.	1,750,000 gallons flow from wells. Last well sunk was 312 ft deep with daily yield of 400,000 gallons. Pumping cap., 8,000,000 gallons.	Storage tank, cap., 235,000 gallons; 20x100 ft. Standpipe, cap., about 790,000 gallons; 30x150 ft. Formerly used 20x88 ft standpipe.	Mains, c.i., 29 miles. Taps, 1,100. Meters, 22. Hydrants, 198.	2,000,000 gallons.	Ordinary, 40 lbs. Fire, 90 lbs.
Kyle (Pop., est., 1,000)	Built in 1887-1888 by Kyle Water Co.	Rio Blanco river, pumping to tanks.	100,000 gallons.	2 Tanks, cap., 63,000 gallons.	Mains, wrought iron, 7 ½ miles. Taps, 18. Meters, none. Hydrants, 10.	25,000 gallons.	48 lbs.
Lampasas (Pop., 653; est., 3,400)	Built in 1885 by town.	Sulphur creek, pumping to standpipe and direct.	1,250,000 gallons.	Standpipe, cap., 115,000 gallons; 20x50 ft.	Mains, c.i., 6½ miles. Taps, 182. Meters, 2. Hydrants, 25.	50,000 gallons.	Ordinary, 40 to 50 lbs. Fire, 100 to 120 lbs.
Laredo (Pop., 3,521; est., 8,500)	Built in 1883-1884 by Laredo Water Co., under 30 year franchise. With city having privilege of buying works.	Rio Grande River, filtered through wells on island in river, by direct pumping.	3,000,000 gallons.	No storage.	Mains, k.i., 10 miles. Taps, 410. Meters, none. Hydrants, 100.	600,000 gallons.	Ordinary, 45 lbs. Fire, 125 to 150 lbs.
Llano (pop., est., 1,000)	Built in 1886 by W.W. Knowles & Son.	Llano River, pumping to tank.	25,000 gallons.	Tank, cap., 17,000 gallons.	Mains, wrought iron, 2 ½ miles. Taps, 60. Meters, 1. Hydrants, 0.	15,000 gallons.	40 lbs.
Lockhart (Pop., 1,500)	Built in 1887 by Lockhart Water Supply Co.	Well, pumping to tank.	20,000 gallons.	Tank, cap., 10,000 gallons.	Mains, 4 in., 1 mile. Taps, 24. Hydrants, not given.	5,000 gallons.	Not given.

Table 5.1 Continued

Waterworks	History	Supply	Dy. Cap.	Storage	Distribution	Consumption	Pressure
Marshall (Pop., 5,624; est., 8,500)	Built in 1888-1889 by city.	24 wells, pumping to standpipe and direct.	1,000,000 gallons.	Standpipe, cap., 165,000 gallons; 15x125 ft.	Mains, c.i., 9 miles. Taps, 104. Meters, none. Hydrants, 50.	Est., 1,500,000 gallons.	50 to 200 lbs.
Mexia (Pop., 1,298; est., 3,500)	Built in 1887-1888 by Mexia Water, Ice and Light Co.	Artificial lake, pumping to standpipe and direct.	1,000,000 gallons.	Standpipe, cap., 86,000 gallons.	Mains, 6 in. c.i., 5 miles. Taps, 100. Meters, none. Hydrants, 15.	30,000 gallons.	Ordinary, 40 lbs. Fire, 60 to 80 lbs.
Morgan (Pop., est., 700)	Built in 1889 by J. Muirhead.	Flowing artesian well, by gravity to tank. Well is 680 ft. deep.	Not available.	Tank, cap., 8,640 gallons; 72 ½ ft. above ground.	Mains, 1 ½ miles. Taps, 34. No hydrants.	Not available.	20 lbs.
Navasota (Pop., 1,611; est., 4,000)	Built in 1886-1888 by city, and leased to E.L. Bridges for 25 years.	Artesian well, pumping to standpipe and tank.	900,000 gallons.	Standpipe, cap., 58,800 gallons; 10x100 ft. Tank, no data.	Mains, 8 to 2 in., 4 ½ miles. Taps, 110. Meters, 3. Hydrants, 12.	60,000 gallons.	Ordinary, 60 lbs. Fire, 160 lbs.
New Braunfels (Pop., 1,938; est., 2,000)	Built in 1886 by town.	Comal River, pumping to reservoir and direct.	900,000 gallons.	Reservoir, cap., 350,000 gallons.	Mains, c.i. 4 miles. Taps, 140. Meters, none. Hydrants, 28.	200,000 gallons.	Ordinary, 24 lbs. Fire 120 lbs.
Palestine (Pop., 2,997; est., 5,000)	Built in 1881-1882 by Palestine Water Co., under 30 year franchise.	Nearly 100 springs, collected in reservoir, pumping to standpipe and direct.	500,000 gallons.	Reservoir, 65 ft. in diameter, 30 ft deep, with brick walls.	Mains, c.i., 7 miles. Taps, 210. Meters, 11. Hydrants, 10 public and 15 private.	240,000 gallons.	Ordinary, 30 lbs. Fire, 65 lbs.
Panhandle City (Pop., est., 350)	In 1889, contract by private company.	Artesian well. Previous supply hauled by train.	Not reported.	Not reported.	Not reported.	Not reported.	Not reported.
Paris (Pop., 3,980; est., 12,000)	Built in 1888 and owned jointly by city and Paris Water Co.	Well, pumping to standpipe.	2,500,000 gallons.	Standpipe, no data reported.	Mains, 10 miles. Taps, 100. Meters, 37. Hydrants, 81.	Not reported.	Not reported.
San Angelo (Pop., 4,000)	Built in 1884 by San Angelo Water-Works Co., under 50 year franchise.	North Concho River, pumping to tank and direct.	500,000 gallons.	Wooden tank, cap., 60,000 gallons; 24x18 ft.	Mains, wrought iron, 4 miles. Taps, 138. Meters, 6. Hydrants, 44.	60,000 gallons.	Ordinary, 50 lbs. Fire, 125 lbs.

Table 5.1 Continued

Waterworks	History	Supply	Dy. Cap.	Storage	Distribution	Consumption	Pressure
San Antonio (Pop., 20,550; est., 45,000)	Built in 1878-1879 by San Antonio Water-Works Co., under 50 year franchise.	San Antonio springs, pumping to reservoir and direct.	10,250,000 gallons.	Reservoir, cap., 5,000,000 gallons; 18 ft deep and 150 ft above city. Slopes paved with limestone.	Mains, 24 to 4 in. c.i., 75 miles. Taps, 3,600. Meters, 25. Hydrants, 420.	2,000,000 gallons.	Ordinary, 65 lbs. Fire, 90 lbs.
San Marcos (Pop., 1,232; est., 2,500)	Built in 1883 by San Marcos Water Co., under 12 year franchise.	San Marcos River, pumping to reservoir and direct.	1,500,000 gallons.	Reservoir, cap., 230,000 gallons; 60 ft in diameter, 9 ft. deep; walls of stone; 190 ft. above pumps and 162 ft. above town.	Mains, c.i., w.i., 7 miles. Taps, 350. Meters, none. Hydrants, 21.	300,000 gallons.	Ordinary, 65 lbs. Fire, 90 lbs.
Seguin (Pop., 1,363; est., 2,500)	Built in 1886-1887 by Seguin Water & Ice Co., under 20 year franchise.	Guadalupe River, pumping to standpipe and direct.	1,500,000 gallons.	Standpipe, cap., about 60,000 gallons; 10x100 ft.	Mains, c.i., w.i., 6 miles. Taps, 150. Meters, none. Hydrants, 15.	50,000 gallons.	Ordinary, 45 lbs. Fire, 100 lbs.
Sherman (Pop., 6,093; est., 10,000)	Built in 1887-1888 by city.	Gang wells, pumping to standpipe.	1,500,000 gallons.	Standpipe, cap., 300,000 gallons.	Mains, 9 miles. Taps, 250. Meters, 30. Hydrants, 70.	100,000 gallons.	60 lbs.
Taylor (Pop., est., 4,000)	Built in 1882-1883 by Taylor Water Co., under 50 year franchise.	Springs and San Gabriel River, pumping to tank, standpipe and direct.	1,000,000 gallons.	Tank, cap., 93,000 gallons. Standpipe, built in 1889; 100 ft high.	Mains, c.i., w.i., 8 miles. Taps, 185. Meters, 2. Hydrants, 25.	200,000 gallons.	Ordinary 57 lbs. Fire, 90 to 125 lbs.
Temple (Pop., est., 5,000)	Built in 1884 by Temple Water-Works Co., under 50 year franchise.	Surface wells, pumping to standpipe. Supply from Leon River, 6 ½ miles distant, contracted for in 1889.	720,000 gallons.	Standpipe, cap., 55,000 gallons.	Mains, c.i., 2½ miles. Taps, 150. Meters, none. Hydrants, 12.	50,000 gallons.	Ordinary, 52 lbs. Fire, 100 lbs.
Terrell (Pop., 2,003; est., 4,000)	Built in 1884 by town.	Two wells, pumping to standpipe and direct.	1,000,000 gallons.	Standpipe, cap., about 45,000 gallons; 10x75 ft.	Mains, k.i., 3 miles. Taps, 75. Meters, 1. Hydrants, 32.	100,000 gallons.	Not reported.
Texarkana (Pop., 3,225)	Not reported, but in operation in 1890.	Supply pumping to standpipe.	2,000,000 gallons.	Standpipe of unreported capacity.	Mains, 8 miles. Hydrants, 50.	Not reported.	45 lbs.

Table 5.1 Continued

Waterworks	**History**	**Supply**	**Dy. Cap.**	**Storage**	**Distribution**	**Consumption**	**Pressure**
Texas State Penitentiary (Pop., 600)	Built in 1884 by State.	Artesian well, 630 ft. deep, pumping to standpipe and direct.	50,000 gallons.	Standpipe, cap., 128,000 gallons; 16x85 ft.	Mains, 6 and 4 in. c.i., 2,500 ft. Hydrants, 16.	40,000 gallons.	Ordinary, 40 lbs. Fire, 100 lbs.
Tyler (Pop., 2,423; est., 7,000)	Built in 1883 by Tyler Water Co. under 50 year franchise. Works begun by city but sold before completion.	Springs, pumping from reservoir to standpipe.	1,000,000 gallons.	Reservoir, cap., 40,000,000 gallons. Standpipe, cap., 397,000 gallons; 35x55 ft.; 15 ft. added in 1888 or 1889. Formerly used a plate-iron tank 24x22 ½ ft on brick tower 50 ft .high.	Mains, 8 to 4 in. c.i., 11 miles. Taps, 200. Meters, 4. Hydrants, 100.	400,000 gallons.	Ordinary, 60 lbs. Fire, 80 to 100 lbs.
Victoria (Pop., 4,000; est., 5,000)	Built in 1885 by city.	Guadalupe River, pumping to standpipe and direct.	1,000,000 gallons.	Standpipe, cap., 150,000 gallons; 16x100 ft.	Mains, c.i., 5 miles. Taps, 186. Meters, none. Hydrants, 48.	45,000 gallons.	Ordinary, 42 lbs. Fire, 150.
Waco (Pop., 7,295; est., 22,000)	Built in 1878 and enlarged in 1886-1887 by Waco Water Co. Reorganized in 1890 as Waco Water & Power Co.	Wells and Brazos River, pumping to reservoir. New company will extend mains 3 miles to Bosque River for additional supply.	3,500,000 gallons.	Reservoir, cap., 6,000,000 gallons. Before reservoir, wooden tanks with cap. of 100,000 gallons were used.	Mains, c.i., w.i., 24 ½ miles. Taps, 1,200. Meters, 75. Hydrants, 150.	2,000,000 gallons.	60 lbs.
Weatherford (Pop., 2,046; est., 5,000)	Built in 1888 by Weatherford Water, Light and Ice Co., under 25 year franchise.	Large well with radiating tunnel, pumping to elevated reservoir.	1,000,000 gallons.	Reservoir, cap., 1,100,000 gallons; 80 ft. square, 14 ft. deep in rock excavation, rammed with clay, then paved with rough stone.	Mains, c.i., 3½ miles. Taps, 42. Meters, none. Hydrants, 25.	Not determined.	Ordinary, 40 lbs. Fire, 100 lbs.

Although the details vary, the story from one town to another is remarkably consistent. After devastating fire, the promise of a local waterworks that could supply water under greater pressure upon demand held almost universal appeal to local citizenry. Waterworks were usually established as some sort of a public-private partnership. Towns had a small tax base with limited financial resources, so the waterworks usually was established by a private company under a franchise agreement with the local government. This meant that the town agreed to pay a monthly fee to the waterworks in return for a guaranteed water supply that could be delivered at a specified pressure within the central business district whenever the need arose in the case of fire. This franchise agreement was negotiated to last for a period of years, frequently something like twenty-five. The multi-year franchise was meant to encourage investment in infrastructure by the private company since it was guaranteed to have the town's business for a significant length of time. Both the town and the private company took risks together that were designed to benefit both entities. Each contributed the type of assets it had or anticipated having. In the case of the private company, it might own an existing building or well that could be utilized by a waterworks. Its owners might even have more capital than the municipality itself, and be less averse to risk. Municipalities on the other hand, could use the political process to organize themselves through the ballot box. This meant that decisions could not be made overnight, but were expected to be debated in a public forum and then voted on, either by representatives of the people, as in the city council, or by the people themselves in an election. With voters' approval, the city was able to contribute bond money to capitalize the building of waterworks, and even turn over bond money to private companies with which they had a franchise agreement.

In the earliest Texas waterworks the preferred water supply was from artesian wells. Many towns were established around natural springs, including San Antonio, Dallas, and Waco.[217] If a naturally flowing spring were not available, a well was often drilled in the hope fresh water would flow to the surface. If this worked, water was available without the investment and maintenance of a pump, and the well was known as an artesian well. If water did not flow to the surface, but the well still contained water at some depth within the wellbore, a pump was added to the water supply system to bring water to the surface.

Rainwater was collected in cisterns, and this water was sometimes preferred over well water for drinking. Although artesian wells had the advantage of no expense beyond that of drilling the well, the purity of the water was sometimes questionable, particularly in an urban setting. Runoff from privies, a lack of sewerages, and lack of understanding about the need for regulating well locations sometimes resulted in contaminated well water.[218] Although rainwater might have been preferred for drinking, it was impractical for fighting fires as it could not be depended upon to provide an adequate supply.

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[217] See Brune, Gunnar, *Springs of Texas*, 2nd ed. (College Station, TX: Texas A&M University Press, 2002) for much more on the subject.

[218] Shawn Bonath Carlson, “Water Resource Features,” in *Archaeological and Historical Investigations at the Ball Park at Union Station, Houston, Harris County, Texas*, Report of Investigations No. 260, Draft Edition, 19.1-19.14 (Houston: Moore Archaeological Consulting, 2002).

Surface water from nearby rivers and creeks was also used by some communities. As surface water supply systems got more complex, settling basins were incorporated to remove some of the sediment load from the river water. Creek water might be intermittent during drought conditions, but river water provided adequate quantities. The limiting factor when fighting fires was still transporting the water under adequate pressure. Also, many central business districts did not have access to river water because Texas rivers were not large enough to have been a significant factor in settlement patterns. As we saw in the last chapter, river transportation never really materialized, in spite of institutional ideas that it should. Also, the Brazos River, which runs through the heart of the preferred early settlement territory in Texas, did not attract settlement along its banks because the river was thought impure and the water itself was salty.

Regardless of the source of a community's water supply, most of the early systems pumped water to a standpipe for storage. A standpipe was a cylindrical container resembling a vertical pipe, with a height greater than the diameter of its base. See Figure 5.2 for an example of a standpipe that is still in use in the town of La Grange. It is an integral part of a water system designed to pump water from the Colorado River a distance of a half a mile away into the standpipe located on a hill two-thirds of a mile northwest of the center of town. From the standpipe water flowed by gravity through five miles of pipes called mains to twenty double hydrants in La Grange's central business district. The purpose of the standpipe was to store under pressure a reasonably large quantity of water for use in a fire. The La Grange standpipe is located immediately

Photograph by author, 25 June 2006

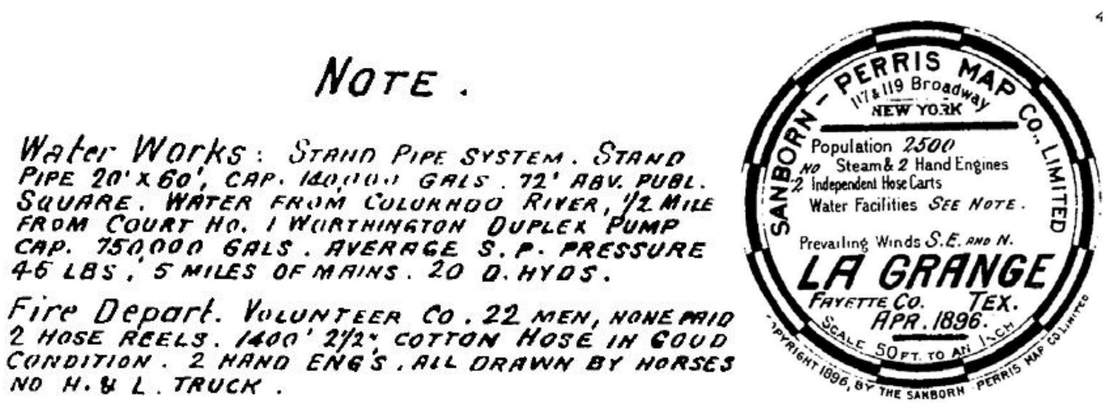

Figure 5.2. Stand Pipe at La Grange, Texas. A stand pipe was the most common method employed for municipal water storage in early Texas waterworks. The waterworks at La Grange, Texas still has its original stand pipe, located to the left of its newer water tower and to the right of the two door Hilltop Fire Station at the intersection of U.S. Highway 77 (formerly Jefferson) and North Line Street. The Note describing La Grange's waterworks is from Sheet 1 of the legend of the April 1896 Sanborn Insurance Map of La Grange, Texas.

adjacent to the old Hilltop Fire Station (This system is not included in Table 5.1 because it was built in the 1890s, just after the publication of the data collected in the table.) [219]

After water was obtained and stored, it still needed a delivery system. This was accomplished with a network of underground mains connecting a standpipe to hydrants. Even if the normal water supply from the standpipe was by gravity feed, in case of fire, systems typically engaged pumps to increase water pressure. Note the "Pressure" column in Table 5.1. Most circa 1890 waterworks were designed to supply significantly higher water pressure under fire demand.

In spite of the establishment of waterworks serving central business districts, the problem of fires continued. Inadequate water supply and especially inadequate water pressure continued to plague waterworks. There was widespread dissatisfaction with water service. Consider this editorial comment from an Austin newspaper in 1901:

> The *Current Issue* regrets to ever complain concerning local public enterprises, but patience sometimes ceases to be classed as a virtue. The Austin people are patient … Compared to them, Job was a fretful, peevish, complaining old reprobate.
>
> When the project for building the great granite dam was originated, people were assured that when that huge piece of masonry once held the Colorado River in its grasp, Austin would have water to waste and lights to burn.
>
> Allow us to state right here that all these promises were not dreams, but were easy possibilities and should have been fulfilled. That they were not is ancient and painful history. Even when the dam was so full of water that a huge steamer could navigate the river for twenty-five miles, there was eternally trouble, and lack of water or power.
>
> Now the dam is gone, and a steam plant has been substituted which the management promised would be balm of Gilead to the suffering people. The local papers announced (in head letters twice the size of that of the editors) that

[219] Sanborn Insurance Maps, *Texas 1876-1970*, Digital, "La Grange, Texas April 1896" (Ann Arbor, MI: Bell & Howell Information and Learning, c2001) http://sanborn.umi.com./ (accessed March 12, 2007).

> as soon as the steam was turned on, water, blessed water, would go scooting through the mains, and incandescent lights would burn so bright that the sun would have a much needed holiday.
>
> Somehow or other the water refused to scoot to any satisfactory degree. Why is it thus? Is the city steam plant inadequate to the demand? Is there some obstruction in the pipes, or is the entire system suffering with municipal appendicitis?
>
> For weeks and weeks past, the citizens of Hyde Park have been practically without water. Some time during the night a timid stream has dribbled through the mains to the distressed subers [*sic*], and the good men and women have played ghosts in their "nighties," endeavoring to fill enough vessels with the precious fluid to tide over another day of heat and dust.
>
> Will conditions improve? We have been told daily by the local press that when the 'third plunger' (whatever that was) was put in, the Austin people would be able to wash their feet once a week without interfering with the fire department. That mysterious 'third plunger' was finally put in, and our great city dew company (it cannot be truthfully termed water company) didn't even run a heavy mist through the pipes. If some crazy fellow would drop in a 'fourth plunger,' God save the people unless they dig wells or move to the river.
>
> Austin people are heartily sick and disgusted with the everlasting daily explanations as to why the water does not run in the mains. Everytime they read something about 'connecting two atlas engines,' or a 'third plunger,' they throw up both hands and their last meal. What they want is pipe connection with the Colorado and a much needed bath.[220]

The author's frustration, even anguish, over Austin's water problems are particularly eloquent, but certainly not unique. One might even argue they were ubiquitous in Texas circa 1900. By this time most of the incorporated cities and towns had some form of waterworks, but were still plagued with water problems.

I would argue that there was a settling out process that was happening because of the drastic change in the landscape of water supply. Conceptually, the problem of central business district fires had been solved—build waterworks. But implementation

[220] "Editorial," *Austin Daily Statesman*, 4 September 1901 reprinted from the September 1901 *Austin Current Issue*, Austin, TX. From the archives of the Center for Historic Preservation and Technology, the Southwest Collection, Texas Tech University, Lubbock, TX.

of this solution was not easy. Long-term water franchise agreements between private companies and municipal governments were challenged, with the municipality typically assuming ownership of the waterworks, sometimes after legal wrangling. The case study of the waterworks in the town of Bryan, recounted below, provides a typical example with details of how some of these issues were resolved in one locality. Town after town reported similar problems. Blame was frequently targeted at water plant management, hence the almost universal movement to assume municipal control over the waterworks. In 1890, the percent of waterworks owned by private companies stood at 56.4 percent in the United States, but at 65.8 percent in the southwest region that includedTexas, Missouri, Arkansas, Colorado, and the Indian and New Mexico Territories.[221] Municipal ownership was hindered not so much by design, but by a lack of financial resources within local governments in these states.

While Table 5.1 contains a summary of Texas waterworks before 1890, a more complete chronology of public water supplies in the state is displayed in Table 5.2 using data from the Center for Historic Preservation and Technology archived in the Southwest Collection at Texas Tech University.[222] In Table 5.2, public water supplies are organized by date of establishment, then described by the source of their initial water supply. Included is a column identifying the box and file number of information on each

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[221] Baker, *Manual of American Water-Works,* xxx.

[222] In 1970 the History of Engineering Program at Texas Tech was initiated by history professor Seymour V. Connor and civil engineering professor Joseph E. Minor to document historical engineering structures in the southwestern United States. History graduate student T. Lindsay Baker and civil engineering graduate student Steven R. Rae were hired to do the field work. They visited hundreds of sites and many archives during the 1970s. Much of their work, and that of others, is included in a 70 box collection of the Center for Historic Preservation and Technology.

waterworks, and a synopsis of the more unusual records in each file. Also summarized is a 1971 survey of waterworks across the state of Texas and information from an early edition of *The Handbook of Texas,*[223] newspapers, local history volumes, engineering reports, and trade journals. Data in Table 5.2 spans two hundred fifty years and includes waterworks established as late as the mid-1940s. When available, an indication change in the water source for a city is noted. Data gathered within this table is by no means a complete listing of all Texas waterworks, but all major city waterworks are included, as well as information from more than one hundred smaller waterworks.

The earliest public water supplies included in Table 5.2 were the Spanish acequias of El Paso and San Antonio. These were drainage ditches used for both irrigation and public consumption, built prior to the period covered by this dissertation. The cisterns of Indianola are an excellent example of the public cistern water supplies of the 1830s and 1840s. Salt water incursion into wells near the Gulf Coast made cisterns the water supply of choice in coastal towns. But ditches, wells, and cisterns were inadequate for dealing with central business district fires, and waterworks were established for this purpose in the Texas Urban Triangle in the latter decades of the nineteenth century, and expanded westward through the state in the first half of the twentieth century. Most of the first waterworks were built and operated by private companies, and then several decades later purchased and operated by municipalities.

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[223] Walter Prescott Webb, ed., *The Handbook of Texas*, 3 volumes, Austin: Texas State Historical Association, 1952.

Table 5.2. Chronology of the Establishment of Public Water Supplies in Texas. Tabulation of 121 Texas water supply systems built for public use and contained within a larger collection of data on historic engineering sites throughout the southwestern United States by the Center for Historic Preservation and Technology at Texas Tech University beginning in the 1970s. Springs had long been used for public water supplies, but are not "built," and so are included here only if modified and incorporated into a larger public water supply. The first public water supplies associated with Anglo settlement are attributed to the Spanish acequias at El Paso and San Antonio, but this irrigation ditch approach was not widely utilized in other Texas locations. The first waterworks complete with a distribution network were built by private companies in the major cities of the state in the latter half of the 1870s. Half of the waterworks in this list were established by the turn of the 20th century. The nature of the public-private partnership between cities and their waterworks was often contentious and continued to evolve from what was frequently a franchise agreement at the time of construction to actual municipal ownership, usually several decades later.

The "Water Supply" column identifies a public water supply and the present day county of its location. "Date" refers to the date of its construction, and in some cases, whether construction was under the direction of the city or a private company. "Description" identifies the water source, method of storage and distribution, and any particularly distinguishing facts about that waterworks. "Records in Collection" column refers to the archival organization within the records of the Center for Historic Preservation and Technology Collection and is provided as a courtesy to others interested in using the collection. Included is a selection of the more unusual or authoritative references about the water supply, but is not intended to be a complete inventory of each file. Abbreviation "TLB" refers to T. Lindsay Baker, the historian who collected much of the data in this archive. Compiled from records of the Center for Historic Preservation and Technology in the archives of the Southwest Collection, Texas Tech University, Lubbock, Texas and corroborated with the Handbook of Texas Online and images from Google Earth.

Water Supply	**Date**	**Description**	**Records in Collection**
El Paso Acequias, El Paso County.	Circa 1680.	Irrigation ditches dug by Pueblo Indians under direction of Spanish friars following Moorish design channeled water from the Rio Grande. Also used for domestic purposes.	Box 5, Files 75-86, 101. Outstanding annotated bibliography by T. Lindsay Baker in File 101. See also HB of TX (Handbook of Texas Online) entry "acequias."
San Antonio Acequias, Bexar County.	1718.	Ditches that supplied water from the San Antonio River and San Pedro Creek to the city from the time of its settlement.	Box 12, Files 70-80 and Box 13 Files 1-7.
Indianola Cistern Water Systems, Calhoun County.	1845-1886.	Port of entry for European immigrants. Population reached 6,000. Water supply consisted of numerous round domestic cisterns, some of which are preserved at state historic park. The city was devastated by hurricane in 1875, then again by hurricane and fire in 1886.[224] Abandoned 1887.	Box 8, File 75 includes photo of round shell concrete cistern. Dept of Interior Historic American Engineering Record (HAER) with map. Garner, L. Edwin, "Indianola State Historic Park and Port Lavaca Causeway State Park," pp. 114-5 in Maxwell, R.A. et al., *Geologic and Historic Guide to the State Parks of Texas*. Bureau of Economic Geology, Guidebook No. 10. Austin: University of Texas, 1970. 1853 Quartermaster's report on inspection of Indianola Depot reprinted in *Southwestern Historical Quarterly*, vol. 51, 1947-8, p. 56.

[224] Relief for the citizens of Calhoun County and the destroyed city of Indianola was approved by the State legislature in the form of tax relief, 20 August 1886, *Gammel's Laws of Texas, 1822-1897*, Vol. 9, p. 847, http://texashistory.unt.edu/permalink/meta-pth-6729 (accessed April 17, 2006).

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
Fort Belknap Water System, Young County.	1851-1867.	Brazos River water (Red Fork) too salty so utilized Whiskey Creek and intermittent springs. Tried digging 60 ft well. Site abandoned in 1859 and again in 1867 due to inadequate water supply.	Box 6, File 28. T. Lindsay Baker annotated bibliography including, Braly, E.B. "Fort Belknap of the Texas Frontier," *West Texas Historical Association Yearbook*, XXX (1954), pp. 83-114. Neighbors, K.F., A History of Fort Belknap Outpost on the Texas Frontier, Fort Belknap, TX: Fort Belknap Society, 1962, 6 pages, includes map locating the post well.
Fort Davis Water System, Jeff Davis County.	1854.	Hauled Limpia Creek water ¾ mile from the post, then spring water, and finally pumped dug well water stored in cypress tanks. Abandoned in 1891.	Box 6, File 41. Contains photos. See also Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, pp. 83-85.
Austin Waterworks, Travis County.	Built by private company in 1875.	Pumped water from the Colorado River to storage reservoir. Between 1891 and 1893, Austin Dam was built for hydroelectric power and municipal water supply, but dam failed in 1900. In 1907 infiltration wells along the river provided water. Later supplemented by river water that was allowed to settle before distribution. Water treatment plant added in 1924.	Box 2, File 51. Greene, George, untitled typescript of the history of Austin's waterworks from 1876 to 1975, 4 pages. Mykland, Gunnar, "History Municipal Ownership of Utilities City of Austin," typescript, University of Minnesota, April, 1941, 7 pages contains 1974 quote from Austin's mayor on the dire need for water for fire and dust protection, p. 3. *Austin Daily Statesman*, September 4, 1901 reprinted an opinion piece from the *Austin Current Issue*, Sept 1901, highly critical of the water company. Water Supply Systems Questionnaire dated May 17, 1971. See also Box 2, File 47 on the Austin Dam.
Dallas Waterworks, Dallas County.	Built by private company in 1876.	Privately owned Dallas Water Supply Company pumped water from Mill Creek to stand pipe near present site of City Park. In 1878, nearby Browder Springs was purchased by the company to augment water supply. In 1881, city purchased entire water system. By 1891, water was stored in reservoir behind earthen dam. Public well supplied water. White Rock Lake added water supply in 1911.	Box 5, File 3. Cites "Stand Pipes for Water-Works," *Engineering News*, XX (October 6, 1888, pp. 271-273 list includes 10 Texas cities with stand pipes. Dallas' stand pipe was erected in 1877, the earliest Texas stand pipe on the list. "Dallas, Tex., Water-Works Land-Slide," *Engineering Record*, XXIV, No. 12 (August 22, 1891), p. 187. "Water Waste and Water Famine in Dallas, Texas," *Engineering News*, LXVI, No. 6 (August 10, 1911), pp. 169-170. Crouch, Eugene, "Water Supply for Dallas, Texas," *Engineering News*, LXVII, No. 3 (January 18, 1912), pp. 107-109. Includes illustrations. Bolding, E.H., "Development of Water Utilities in Dallas," *Southwest & Texas Water Works Journal*, LX, No. 4 (July 1978), pp. 4-7. HB of TX entry "Browder's Springs."
San Antonio Waterworks, Bexar County.	Built by private company in	Water was pumped from the San Antonio River to a reservoir in Mahnke Park. From there	Box 13, File 19. TLB compiled 46 item annotated bibliography with water-related articles from the San Antonio

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
	1878.	gravity flow was used for delivery. Patronage of LaCoste waterworks was limited. Most obtained water from springs, acequias, citizens' own wells or cisterns, or purchased water from aguadores.	newspaper dating back to 1856. Also included are Corner, William, "The Water Works," in *San Antonio de Bexar*, San Antonio: Bainbridge & Corner, 1890. McLean, Bert J., *The Romance of San Antonio's Water Supply and Distribution*, San Antonio Print Co., 1927. Report of the Water Works Board of Trustees of San Antonio covering the period from 1925 to 1930.
Waco Waterworks, McClennan County.	Built by private company in 1878.	First public water supply was spring. Later artesian wells were drilled. In 1928 construction began on Waco Dam across Bosque River by City of Waco. Between 1958 and 1965, the Corps of Engineers and Brazos River Authority built a new dam expanding Lake Waco.	Box 16, File 1. *Manual of American Water Works*, 1890, pp. 584-585. See also HB of TX entries "Waco, TX" and "Lake Waco."
Houston Waterworks, Harris County.	Built by private company in 1879.	Water pumped from Buffalo Bayou until concerns about its purity escalated. In 1887 a successful artesian well was drilled and became preferable to surface water. In 1906 the city purchased the water system. Groundwater became the sole supply until the construction of Lake Houston in 1954. Concerns about subsidence caused by groundwater withdrawal has Houston's future water supply in a state of flux.	Box 5, File 58. See also Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, pp. 127-129. Baker, T. Lindsay, "Houston Waterworks: Its Early Development," *Southwest Water Works Journal*, Vol. 56, no. 4 (July, 1974), p. 37.
Galveston Water System, Galveston County.	1880.	Needing better water system for fire protection than the cisterns used since the city's incorporation in 1839, city aldermen commissioned the drilling of a well that reached water at 700 ft. The water did not flow to the surface and quickly turned brackish. In 1885, the city leased a fire-protection system for part of the central business district that pumped water directly from the ocean, and drilled a series of 13 artesian wells for fire protection, industrial, and domestic use. The wells turned brackish.	Box 7, File 15. Very thick file gathered by TLB and summarized in his 1986 book *Building the Lone Star*, pp. 112-115.
Palestine Waterworks,	1881-1882.	Supply from springs and pumped to brick reservoir and	Box 11, File 20. *Manual of American Water Works*, 1890, p. 581.

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
Anderson County.		stand pipe.	
El Paso Waterworks, El Paso County.	Built by private company in 1882.	Pumped river water from Rio Grande to earthen reservoir above city, then flowed by gravity to central city. Did not supplant aguadores who delivered filtered water via burro-drawn cart in many parts of the city. In 1883 a silting reservoir was added to water system, but water quality still considered too silty and too expensive. In 1891, well water from hand-dug well, 65 ft deep and 18 ft in diameter at the surface, was added to system. Water quality still unsatisfactory because of high dissolved solids content, so consumers bought water shipped by rail from Deming, New Mexico or from aquadores. In 1902, groundwater from wells drilled in mesa east of city added to supply. In 1910, city purchases water plant and constructed several reservoirs for storage. In 1943, treatment plant for river water added.	Box 5, File 102. See also Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, pp. 80-83.
Fort Worth Waterworks, Tarrant County.	Built by private company in 1882.	Water pumped from Trinity River, Clear Creek, and gang well system drilled beneath riverbed. Supplemented by surface reservoir in 1915.	Box 6, File 79. Includes 1971 Water Supply Systems Questionnaire. "Fort Worth, Tex., Water-Works," *Engineering News-Record*, XXX, No. 1 (June 2, 1894, pp. 5-7 includes 6 drawings. "West Fork Waterworks Dam at Fort Worth," *Engineering News-Record*, LXXI, No. 5 (January 30, 1915), pp. 147-148. McCormick, H.G., and John B. Hawley, "West Fork Waterworks Dam at Fort Worth," *Engineering News-Record*, LXXI, No. 10 (March 6, 1915), pp. 307-308 contains letters by McCormick and Hawley criticizing the design of the dam, blaming rotten politics for its adoption.
Temple Waterworks, Bell County.	Built by a private company in 1882.	Began with 5 wells and a standpipe supplying the central business district and the Santa Fe Railway. By the early 1890s water was also pumped from the Leon River and water clarity became a problem. The city purchased the water works in 1907.	Box 14, File 114. "The Water Works," in *Bell County History*, compiled by Temple Junior Chamber of Commerce, Fort Worth: University Supply & Equipment, 1958, pp. 52-53. Annotated bibliography and photos by TLB on standpipe failure. Adair, W.S., "Early Days in Texas," *Dallas Morning News*, January 24, 1932, Sec. III, p. 11 includes the recollections of William Minton

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
			concerning the Temple water standpipe.
Taylor Waterworks, Williamson County.	1882-1883.	Supply pumped from San Gabriel River and springs. In 1913 drilled well to Trinity aquifer at depth of 3260 ft, considered deepest water well in country at that time.	Box 14, File 109. *Manual of American Water Works*, 1890, p. 583. Water Supply Systems Questionnaire, 8 July, 1971.
Cleburne Waterworks, Johnson County.	1883.	Water piped from springs along Buffalo Creek, sent to public cistern, and stored in underground reservoir. After 1891, water supply was from wells with stand pipe and concrete reservoir storage. City took control of water system in 1912. In the 1960s, a new water supply was tapped by damming the Nolan River just west of town to form Lake Pat Cleburne.	Box 4, File 15. Gordon, Dudley M. "The History of Cleburne," unpublished M.A. thesis, University of Texas, Austin, 1929, pp. 11-12. "Fabled Spring Led to City Water System," *Cleburne Times-Review*, June 28, 1936, Sec. 4, pp. 1, 5. Guinn, Ernest, E., "Cleburne Water Supply," in "A History of Cleburne, Texas," unpublished M.A. thesis, University of Texas, Austin, 1950, pp. 76-85. Baker, T. Lindsay, "A Brief History of the Cleburne Water System," *Cleburne Times-Review*, November 18, 1973, Section 3, Page 1+, includes photos. Baker, T. Lindsay, "Cleburne: A Case Study for Small City Water Systems," *Southwest Water Works Journal*, LVI, No. 6 (September, 1974). See also Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, pp. 36-39.
Decatur Waterworks, Wise County.	1883.	A 72,000 gallon Cook Deep-well pump lifted water to 36,000 gallon storage tank. In 1889, a one million gallon pump added.	Box 5, File 13. Site Investigation Summary. No other data.
Del Rio Waterworks, Val Verde County.	1883.	Water works built by Southern Pacific Railroad Company. Water supply from springs pumped to tank. Later used turbine wheel and stand pipe.	Box 5, File 17. *Manual of American Water-Works*, 1890, p. 575.
San Marcos Waterworks, Hays County.	Built by private company in 1883.	San Marcos Springs form headwaters of river at townsite and archaeological data indicate springs have provided water for settlements for thousands of years. Water company formed to pump from San Marcos River in 1883.	Box 14, File 7. *Manual of American Water Works*, 1890, p. 582. See also HB of TX entry "San Marcos Springs."
Tyler Waterworks, Smith County.	Built by private company in 1883.	In 1894 water impounded in Lake Bellwood behind dam constructed using hydraulic steam pump at cost of $1140.	Box 15, File 60. "History of Water Distribution and Water Plant of the City of Tyler," May 19, 1936, 7 page typescript on City of Tyler letterhead. *Manual of American Water Works*, 1890, p. 584. See also, Baker, T. Lindsay, "Tyler Hydraulic Fill Dam," in *Building the Lone Star*, College Station: Texas

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
			A&M University Press, 1986, pp. 252-255.
Corsicana Waterworks, Navarro County.	1883-1884.	Arrival of railroad in 1871 brought rapid growth. Stand pipe erected in 1884. Water company established in early 1880s was inadequate by 1890s so the city organized the Corsicana Water Department Company and drilled a shallow artesian well in 1894. Instead of water, they found a large oil field.	Box 4, File 62. *Manual of American Water Works*, 1890, pp. 573-574. Stephens, B.F. "Stand Pipes for Water-Works," *Engineering News*, XX (October 6, 1888), pp. 271-273. See also Baker, T. Lindsay, *Building the Lone Star*, College Station, TX: Texas A&M University Press, 1986, pp. 47-48.
Gainesville Waterworks, Cooke County.	1883-1884.	Supply from Elm Fork of Trinity River pumped to reservoir for storage.	Box 6, File 94. *Manual of American Water Works*, 1890, p. 577.
Laredo Waterworks, Webb County.	Built by private company 1883-1884.	Water tower erected in 1894.	Box 9, File 28. *Manual of American Water Works*, 1890, p. 579. File contains old drawing of water tower and photos.
Belton Waterworks, Bell County.	1884.	Water supply from Leon River pumped to stand pipe. Supplemented by surface reservoir storage behind dam built in 1949.	Box 2, File 83. *Manual of American Water Works*, 1890, pp. 571-572. See also Box 2, File 82, for information on Belton Dam and Reservoir.
Columbus Waterworks, Colorado County.	1884.	Water pumped from Colorado River to town and one storage tank.	Box 4, File 40. *Manual of American Water Works*, 1890, 0. 573. See also Box 4, File 39 on the Columbus brick water tower (1883).
Corpus Christi Waterworks, Nueces County.	1884.	Water mains laid in 1890. Supply from Nueces River. In 1910 city investigated using Houston drilling company to look for artesian supply for city.	Box 4, File 60. Contains annotated bibliography by T. Lindsay Baker including references to several articles from local newspaper.
Georgetown Waterworks, Williamson County.	1884.	Water pumped from San Gabriel River to stand pipe.	Box 7, File 31. *Manual of American Water Works*, 1890, p. 577.
Gonzales Waterworks, Gonzales County.	Built by private company in 1884.	Water pumped from Guadalupe River to consumers. Stand pipe erected in 1884.	Box 7, File 46. *Manual of American Water Works*, 1890, pp. 577-578. "Stand Pipes for Water-Works," *Engineering News*, XX (October 6, 1888), pp. 271-273 and unpaged fold-out table.
San Angelo Waterworks, Tom Green County.	Established on April 28, 1884.	Water was pumped directly from the North Concho River and piped to town. Supply is now supplemented by water from several lakes. Owned by local businessmen, then in 1912 by Interstate Electric Corp of New York. Purchased by West Texas Utilities Company in 1924 and by the City of San Angelo in 1950.	Box 12, File 68. January 26, 1935 letter from W. E. Beaty to H.H. Batjer reporting on the early history of San Angelo water system. Water Supply Systems Questionnaire dated June 25, 1971. See also Box 4, File 44, Concho Water Company includes Historical Site Questionnaire from Mrs. Francis Strother identifying water company site founded in 1901 along Concho River impounding water for San Angelo

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
			behind stone dam.
Temple Waterworks, Bell County.	Built by private company in 1884.	Site of dramatic stand pipe failure in 1890.	Box 14, File 114. *Manual of American Water Works*, 1890, p. 583. Annotated bibliography and mid-1970s photos by T. Lindsay Baker.
Brenham Waterworks, Washington County.	Built by private company in 1885.	Springs pumped to stand pipe erected in 1885. City bought the water plant in 1894. Purification plant and reservoir were built in 1924. Water supplied from wells.	Box 3, File 59. Hasskarl, Robert A. Jr., *Brenham Texas 1844-1958*, Brenham, Tex.: Banner-Press Publishing Company, 1958, pp. 32-33.
Lampasas Waterworks, Lampasas County.	1885.	Lampasas was founded at site of Hancock Springs and used springs for early water supply. In 1880s supplywas pumped from Sulphur Creek to stand pipe.	Box 9, File 26. *Manual of American Water Works*, 1890, p. 579. Taff, J.A. “Reports on the Cretaceous Area North of the Colorado River.” In *Third Annual Report of the Geological Survey of Texas, 1891*. Austin: Henry Hutchings, State Printer, 1892. pp. 269-397. TLB’s notes give 3 quotes from p. 368 identifying locations where flowing wells occur. Amounts “will be ample for culinary and farm purposes. It will not be sufficient, however, for irrigation unless it be very limited.” See also HB of TX entry “Hancock Springs.”
Victoria Waterworks, Victoria County.	1885.	Water supply from Guadalupe River, later from wells, pumped to stand pipe constructed in 1884. Stand pipe was 105 ft tall and leaned “enough to encourage wagers on its destiny.” It collapsed in 1886.	Box 15, File 85. *Manual of American Water Works*, 1890, p. 584. “Stand-Pipe Accidents and Failures.” *Engineering News*, XXXI, No. 15 (April 12, 1894), pp. 299-300. Includes photo. There are many more such references in the Engineering News of that spring. See No. 14, pp. 276-277; No. 16, pp. 317-318; No. 17, pp. 340-342; No. 18, pp. 358-359; No. 19, pp. 393-395; No. 21, pp. 422-423. TLB (5/3/1974) reports, “includes a discussion of the collapse of the upper portion of the Victoria, Texas, wrought iron water standpipe during a tropical storm on August 20, 1886…” See also HB of TX entry “Victoria, TX.”
Colorado City Waterworks, Mitchell County.	Circa 1885.	Well water pumped to stand pipe.	Box 4, File 30. Site Investigation Summary.
Eagle Pass Waterworks, Maverick County.	Circa 1885.	Rio Grande river water sent through gravel and sand filter and pumped to reservoir.	Box 5, File 56. Water Supply Systems Questionnaire dated June 4, 1971 from water superintendent.
Abilene Waterworks, Taylor County.	Waterworks built 1885-6.	Supplied with water from wells and Lytle Creek pumping to a standpipe.	Box 2, File 6. *Manual of American Water Works*, 1890, p. 571. HB of TX entry “Abilene, TX.”
Goldthwaite Well, Mills County.	1885.	Dam stored 12 surface acres of spring water near railroad tracks. Drought lessened spring output in 1906, so large well	Box 7, Files 36 and 37. Horton, Mrs. M.F. “History of the Gulf, Colorado and Santa Fe Railroad Dam and Hand Dug Well, typescript, 5 pp. Historic

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
		was dug 25 ft in diameter and 50 ft deep. Flowing spring at bottom supplied locomotives until 1915. Acquired by city in 1952 and used for filling city swimming pool and watering county park. Report from 1975 stated that well still supplied city pool, and historic marker was being planned.	Engineering Site Inventory Questionnaire 5/9/1975. Photos of site.
New Braunfels Waterworks, Comal County.	Built by town in 1886.	Originally cooperative venture between city (built Clemens Dam) and cotton mill on river (pumped water into reservoir). Water pumped from Comal River to reservoir. Now, wells supplement supply.	Box 10, File 75. Water questionnaire filled out by Jim T. Hester, NB City Manager. Hass, Oscar, "Provision for City Water Included in Sale for City Lots for Factories," *New Braunfels Zeitung-Chronicle*, December 13 and 20, 1964.
Llano Waterworks, Llano County.	Circa 1886.	Llano River water pumped to tank using water power.	Box 9, File 55. 1971 Water Supply System Questionnaire. *Manual of American Water Works*, 1890, p. 579.
Calvert, Water, Ice and Electric Plant, Robertson County.	1886-1887.	Water supply from artesian well, pumped to nearby stand pipe and reservoir constructed of brick and concrete. By 1910 a pump was needed to extract water from the previously free-flowing well.	Box 3, File 100. National Register of Historic Places Inventory—Nomination Form, prepared by Paul D. Hutchison, History of Engineering Program, Texas Tech University, December 7, 1976. *San Antonio Express*, August 26, 1869, p. 2 noted briefly that Calvert water was the worst in Texas.
Brownwood Waterworks, Brown County.	1886-1887.	Water supply pumped from Pecan Bayou to stand pipe.	Box 3, File 73. *Manual of American Water Works*, 1890, p. 572.
Denison Waterworks, Grayson County.	Built by private company 1886-1887.	Water pumped from Guadalupe River.	Box 5, File 24. *Manual of American Water Works*, 1890, p. 575.
Seguin Waterworks, Guadalupe County.	Built by private company 1886-1887.	Guadalupe River.	Box 14, File 25. *Manual of American Water Works*, 1890, p. 582.
Navasota Waterworks, Grimes County.	1886-1888.	Supply from artesian well, pumped to stand pipe and tank.	Box 10, File 67. *Manual of American Water Works*, 1890, p. 580.
Lockhart Waterworks, Caldwell County.	1887.	Supply from well pumped to tank by windmill for 2 years, then pumped by engine.	Box, File 56. *Manual of American Water Works*, 1890, p. 579.
Paris Waterworks, Lamar County.	Built in 1887 by private company with help from the city.	The fire of 1877 demonstrated need for better fire protection. Water works was joint effort of city and private company. Water supply came from wells a few miles east of the city. After a few years of operation, the city gained ownership of its water system. Lake Gibbons	Box 11, File 33. Neville, A.W., "Paris Installs Water System," in *The History of Lamar County, Texas*, Paris, Texas: North Texas Publishing Company, 1931, p. 217. See HB of TX entry "Lake Gibbons." *Manual of American Water Works*, 1890, p. 581.

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
		constructed on Pine Creek in 1911 as water supply for city.	
Beaumont Waterworks, Jefferson County.	1888.	Beaumont Ice, Light and Refrigerating Company organized in 1888. This company also ran the water supply system. Stand pipe erected in 1888 to store water pumped from Neches River.	Box 2, File 75. Baker, M.N., *Manual of American Water Works*, (New York: Engineering News Publishing Co., 1890), p. 571. Also, Coltharp, J.B, The Story of Electrical Service in Beaumont, 1934, Addendum 1955, typescript, 51 pp. in Box 2, File 72.
Kyle Waterworks, Hayes County.	Circa 1888.	Water originally pumped from Blanco River to storage tanks. Municipal system established 1935, pumping from drilled wells.	Box 9, File 4. 1971 Water Supply Systems Questionnaire. *Manual of American Water Works*, 1890, p. 578-579.
Mexia Waterworks, Limestone County.	Circa 1888.	Water from artificial lake pumped to stand pipe. Lake Mexia constructed on Navasota River in 1960-1961 by Bistone Municipal Water Supply District for municipal water supply.	Box 10, File 14. *Manual American Water Works*, 1890, p. 580.
Sherman Waterworks, Grayson County.	Circa 1888.	Water from gang-wells pumped to stand pipe.	Box 14, File 36. *Manual of American Water Works*, 1890, pp. 582-583.
Weatherford Waterworks, Parker County.	Built by private company circa 1888.	Original supply from large well with tunnels radiating from base. Pumped to elevated reservoir by steam pump. Gravity feed to mains. Weatherford Water, Light and Ice Company sold to Texas Public Utilities Compnay of Fort Worth in 1896. Citizens were dissatisfied with rates charged, so in 1937, they approved bonds to build their own water distribution system. City of Weatherford owns and operates Lake Weatherford. Seven miles east of city, it was built between 1956-1957 on Clear Fork of the Trinity River for water supply and flood control.	Box 16, File 12. *Manual of American Water Works*, 1890, p. 585. Water Supply Systems Questionnaire, 21 June 1971. See also HB of TX entry "Lake Weatherford" and "The Early History" and "First Municipal Utilities" sections of the Utilities page on City of Weatherford website, http;//www.ci.weatherford.tx.us/
Greenville Waterworks, Hunt County.	1889.	Water supply from Cowleach fork of Sabine River, pumping to a reservoir, through a filtering system, and to a stand-pipe. Masonry dam, also. According to the Handbook of Texas, the town's first water works was completed in 1889 and was later purchased by the city.	Box 7, File 65. *San Antonio Express* article of July 10, 1910 reported Greenville's city council ordered the drilling of a new water well to cease at 2900 ft after an equipment breakage at that depth. Water was struck at a depth of 2500 ft, and although not flowing to the surface, casing and a compressor were ordered so water could be pumped to the surface.

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
Panhandle Waterworks, Carson County.	1889.	Supply from local wells.	Box 11, File 28. Site Investigation Summary. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M Press, 1986, p. 296.
Morgan Waterworks, Bosque County.	1889.	Supply from artesian well to tank by gravity.	Box 10, File 43. *Manual of American Water Works*, 1890, p. 580.
Wichita Falls Waterworks, Wichita County.	Built by private company in 1889.	Early water supply from riverbed wells. In 1901, supply impounded behind privately built dam forming Lake Wichita on Holliday Creek. This lake served for municipal water supply, irrigation, and recreation. Purchased by the city of Wichita Falls in 1920, Lake Wichita used for municipal water supply until 1947. Lake Kemp and Lake Diversion supplemented water supply in 1920s. Lake Arrowhead constructed on Little Wichita River in 1966 by the city of Wichita Falls and is now primary municipal water source.	Box 9, File 23, Lake Wichita. Includes leather bound report almost an inch thick entitled "Report on Water Supply for Wichita Falls, Texas." Black & Veatch Consulting Engineers, Kansas City, Missouri, 1926, Copy 4, 179 pp. Detailed work with maps of Wichita Falls water system. Includes section on water consumption and demand (pp. 10-29), water analysis, climatological data, Lake Wichita, Oil well drainage and irrigation, Supply from Little Wichita River, existing waterworks, water rates, cost of producing water, power for pumping water, water treatment, hardness, water softening, chemical costs, plant location, construction costs, distribution systems, operating costs, bibliography, many figures and tables. Valuable, unique document. See also Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, pp.141-144; and HB of TX entries "Kemp, Joseph Alexander," "Lake Arrowhead," and "Wichita Falls, TX." Also, Box 16, File 28, Wichita Falls Waterworks. *Manual of American Water Works*, 1890, p. 586. Water Supply Systems Questionnaire, 1 July 1971.
Marshall Waterworks, Harrison County.	Circa 1889.	Supply from wells.	Box 9, File 108. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M Press, 1986, p. 291.
Terrell Waterworks, Kaufman County.	Circa 1889.	Water supply from two wells, pumped to stand pipe and also direct. Wells 25 ft diameter for 27 ft, then bored 45 ft deeper.	Box 15, File 2. *Manual of American Water Works*, 1890, p. 583.
Cuero Waterworks, DeWitt County.	1889-1890.	Water pumped from Guadalupe River to stand pipe 16 ft in diameter and 105 ft high. Design was for 6 miles of mains and 35 hydrants. Added artesian well in 1910.	Box 4, File 78. *Manual of American Water-Works*, 1890, p. 574. "Water-Works: Southwestern: Cuero, Tex.," *Engineering News*, XXII, No. 49 (7 Dec 1889), p. 552. "Cuero Gives Contract for Pumps. Special Telegram to The Express," *San Antonio Daily Express*, 13 July 1910, p. 12.
Bryan Waterworks, Brazos County.	Built by private	Water pumped from wells to stand pipe and concrete storage	Box 3, File 79. Water Supply Systems Questionnaire dated April 23, 1971.

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
	company 1889-1890.	reservoir.	*Manual of American Water Works*, 1890, p. 572.
Texarkana Waterworks, Bowie County.	Circa 1890.	Worthington pump, pumped to stand pipe. Between 1948 and 1957, Sulphur River was dammed by Corps of Engineers forming what is now called Wright Patman Lake 11 miles SW of Texarkana for flood control and conservation. City diverts annual allocation of water for municipal use.	Box 15, File 5. *Manual of American Water Works*, 1890, p. 584. See also HB of TX entry "Wright Patman Lake."
Big Spring Water System, Howard County.	1892.	Natural springs flow into basin 10 to 20 ft deep and 30 ft across. Used by town and railroad.	Box 3, File 17. Site Investigation Summary.
Castroville Waterworks, Medina County.	Circa 1890.	Water pumped from Medina River to storage tank by rotary pump.	Box 3, File 138. *Manual of American Water Works*, 1890, p. 573.
Galveston Artesian Well, Galveston County.	1892.	City water supply from 13 artesian wells ranging in depth from 825 to 1350 ft deemed unfit for domestic use, so a well was drilled to depth of 3070 ft in unsuccessful attempt to supply city water.	Box 6, File 96. "The Deep Artesian Well at Galveston, Tex." *Engineering News*, XXVIII, No 33 (August 11, 1892), pp. 122-125. Singley, J.A. "Report: Artesian Well Work," Second Report of Progress, Geological Survey of Texas (1891), pp. 78-82.
Galveston Waterworks, Galveston County.	1894.	Previous city efforts to utilize local island well water in 1880 and 1892 failed, so in 1894 thirty artesian wells were drilled on the mainland and connected by cast iron pipe 18.7 miles to Galveston's central business district facility previously constructed for pumping sea water for fire protection. From here the groundwater was pumped to standpipes for distribution.	Box 7, File 15. Thick file summarized in TLB's 1986 *Building the Lone Star*, pp. 112-115.
Cameron Waterworks, Milam County.	Built in 1894 by private company.	Cameron Water, Power and Light Company acquired franchise from city. Water came from Little River to a stand pipe. In 1907 four wells were drilled to supplement supply. In 1911 settling basin constructed to settle mud from river water. Purchased by city through issuance of bonds in 1937.	Box 3, File 104. Water Supply Systems Questionnaire filed by City of Cameron in 1971. Batte, Lelia M., *History of Milam County, Texas*, San Antonio: Naylor Company, 1956, pp. 101-102, 128-129.
Kerrville Waterworks, Kerr County.	1894.	Original water supply pumped from Guadalupe River, later supplemented with artesian wells. Kerrville Ponding	Box 8, File 124. 1971 Water Supply System Questionnaire. See also HB of TX, entries "Kerrville, TX," "Upper Guadalupe River Authority,"

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
		Reservoir built on the Guadalupe in 1919. In 1977, secured water supply contract with the Upper Guadalupe River Authority.	"Guadalupe River."
Bonham Waterworks, Fannin County.	About 1894.	In 1910 deep wells and pump station added to system.	Box 3, File 43. Historic Engineering Site Inventory Questionnaire completed by Mrs. H.D. Swann, July 10, 1975.
Goliad Water and Light Company, Goliad County.	1895.	Water from San Antonio River pumped to water plant which also contained brick-lined well. Foundation on building dated 1895.	Box 7, File 39. Historical Questionnaire dated 24 June 1975.
Ballinger Waterworks, Runnels County.	Late 19^{th} century.	City located at confluence of Colorado River and Elm Creek. Water was pumped into reservoir behind masonry dam.	Box 2, File 54. *Manual of American Water-Works*, 1890. Baker, T. Lindsay, "Ballinger's Early Waterworks System," *Water: Southwest Water Works Journal*, Vol, 56, no. 8 (Nov 1974), p. 24. 1971 photos by Steven R. Rae. Poe, Charlsie, *Runnels Is My County*, San Antonio: Naylor Company, 1970.
Uvalde Waterworks, Uvalde County.	Late 19^{th} century.	Uvalde known as "county of 1,000 springs." Water from wells. Pumps driven by wood fired steam engine.	Box 15, File 72. Water Supply Systems Questionnaire, 1 July 1971. See City of Uvalde website http://www.uvaldetx.com/
Huntsville Waterworks, Walker County.	Circa 1900.	Spring water supplied city until groundwater was tapped around 1900.	Box 8, File 69. Site Investigation Summary.
Henrietta Waterworks, Clay County.	Early 20^{th} century.	Water from surface wells supplemented by Little Wichita River, stored in reservoirs for settling, then pumped to standpipe.	Box 8, File 24. *Engineering News*, LXXIII, No. 2 (June 10, 1915), p. 1129.
Caldwell Waterworks, Burleson County.	1905.	Water supply pumped from drilled and artesian wells to storage tank.	Box 3, File 97. Water Supply Systems Questionnaire dated May 14, 1971.
Coleman Waterworks, Coleman County.	1906.	Water supply pumped from river-fed reservoir.	Box 4, File 27. Water Supply Systems Questionnaire, 5 May 1971.
Sabinal Waterworks, Uvalde County.	1906.	Supply pumped from wells with steam pumps and flowed through wooden water mains wrapped with wire.	Box 12, File 45. Water Supply Systems Questionnaire, 21 June 1971.
Post Waterworks, Garza County.	1907.	Town and waterworks built by Charles William Post, an Illinois native who made his fortune in cereals. Spring water collected in small earthen reservoir. Well water had high dissolved solids content so Ogallala aquifer was tapped a few miles to the west of town and pumped via 6 large windmills to concrete lined	Box 11, File 84. See Baker, T. Lindsay, *Building the Lone Star*, 1986, pp. 195-198.

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
		reservoir.	
Graham Waterworks, Young County.	Circa 1908.	Water pumped from shallow wells using windmills. In 1908 water was pumped from Flint Creek to reservoir and filtering plant. In 1920s Flint Creek was dammed by city to form Lake Eddleman. In 1958 nearby Lake Graham was constructed to supplement water system.	Box 7, File 53. Water Supply Systems Questionnaire, 17 May 1971. See also HB of TX entries "Graham, TX" and "Lake Eddleman."
Brownsville Waterworks, Cameron County.	1908.	In 1931 Brownsville became first waterworks in the United States to use porous tubes or plates for air diffusion water purification system.	Box 3, File 67. Roe, Frank C. "Aeration of Water by Air Diffusion," *Journal of the American Water Works Association*, XXVI, No. 7 (July, 1935), pp. 897-904, includes information on air diffusion system installed at the Brownsville water works in 1931.
Brady Waterworks, McCulloch County.	1908.	Water supply pumped from wells and tributary of San Saba River by gasoline powered pumps.	Box 3, File 49. Water Supply Systems Questionnaire completed by Water Dept Superintendent dated October 15, 1975.
Olney Waterworks, Young County.	1909.	Many merchants had wells or cisterns from founding of town in 1889. Waterworks consisted of 20 ft diameter well with gasoline pump.	Box 11, File 5. Water Supply Systems Questionnaire, 31 May 1971.
Vernon Waterworks, Victoria County.	1909.	Supply from springs and wells. Site called Eagle Springs by Tonkawa Indians as early as 1858.	Box 15, File 82. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, pp. 307-308. See also HB of TX entry "Vernon, TX."
Buffalo Gap Waterworks, Taylor County.	Built in 1910 by railroad company.	Built to supply water for locomotives. System consists of hand-dug well, pumphouse, and stand pipe. Well is 36 feet deep, 21 feet in diameter, and lined with concrete. With the demise of steam locomotives, the town leased the facility for its municipal water supply.	Box 3, File 83. Historic American Engineering Record Inventory, Department of the Interior by T. Lindsay Baker, May 1978, includes small map and photos. TLB interviewed his father, a railway transitman, for this archive. Thick file with photos from mid-1970s.
San Benito Water and Electric Plant, Cameron County.	1910.	Plant operation began in July 1910 with a capacity for supplying water and electric power to at least 5800 people. The operation included a 100 ft tall standpipe.	Box 13, File 23. "New Plant Is in Operation, San Benito Is Proud of Water and Electric Light System, Special Telegram to The Express," *San Antonio Daily Express*, July 16, 1910, p. 6.
Santa Anna Waterworks, Coleman County.	1910.	Municipal water system in 1910.	Box 14, File 12. Site Investigation Summary.
Mineral Wells Waterworks, Palo Pinto County.	Circa 1910.	Crazy Well made town nationally famous in 1880s. Water supply from local river-fed reservoir. Lake Mineral Wells on Rock Creek in Brazos	Box 10, File 25. 1971 Water Supply Systems Questionnaire.

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
		watershed constructed by city 1918-1920. Still provides municipal water supply.	
Austwell Waterworks, Refugio County.	1911.	Built under the direction of Preston R. Austin, rancher and founder of the town. System had mains hollowed from cypress trees and fire hydrants on almost every corner.	Box 2, File 43. Site identified and by T. Lindsay Baker and description provided from HB of TX.
Lubbock Waterworks, Lubbock County.	1911.	Oldest inhabited site in Texas, water supplied from Buffalo Spring in Yellow House Draw. Located over the Ogallala aquifer. Water from Lake Meredith on Canadian River, completed in 1965, flows 160 miles through aqueduct to Lubbock. Supplemented by well water from Bailey County.	Box 9, File 78. Site Investigation Summary. Sparse information. See HB of TX entries “Lubbock Lake National Historic and State Archeological Landmark,” “Lubbock County,” “Canadian River Municipal Water Authority,” “Lake Meredith,” and “Lubbock, TX.” See also City of Lubbock Water Utilities website, http://water.ci.lubbock.tx.us/
Winters Waterworks, Runnels County.	1912.	Water pumped from wells and river-fed reservoir by gasoline pumps and later by electric pumps. City owns Lake Winters, also known as Elm Creek Lake and New Lake Winters, on Elm Creek 5 miles east of town. Lake used for municipal and domestic use. Old Lake Winters is located 2 miles north of the center of town.	Box 16, File 33. 1971 Water Supply Systems Questionnaire. See also HB of TX entry “Lake Winters.”
Midland Waterworks, Midland County.	Circa 1912.	Supply from drilled wells.	Box 10, File 18. Site Investigation Summary. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M Press, 1986, p. 292.
Paducah Waterworks, Cottle County.	Circa 1912.	Supply from hand dug wells pumped for distribution.	Box 11, File 17. Site Investigation Summary. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M Press, 1986, p. 295.
Whitney Waterworks, Hill County.	Circa 1912.	Supply from drilled wells pumped by diesel engine pump to underground reservoir.	Box 16, File 26. Water Supply Systems Questionnaire, July 1971.
Tivoli Waterworks, Refugio County.	1913.	Established by Preston R. Austin. Water supply from gin well, later from two artesian wells with no pumps needed.	Box 15, File 33. Huson, Hobart, *Refugio*, Volume II, Woodsboro, Tex.: The Rooke Foundation, 1955, pp. 321-322.
Rosenberg Waterworks, Fort Bend County.	Circa 1914.	Six drilled wells, each deeper than the previous, supply water pumped to surface and stored in tanks. Wells range in depth from 545 to 1310 ft deep.	Box 12, File 36. Water Supply Systems Questionnaire, 31 May 1971.
Lockney Waterworks, Floyd County.	Circa 1915.	Supply from local wells.	Box 9, File 57. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, p.

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
			289.
Wellington Waterworks, Collingsworth County.	1916.	Sand Springs feed Sand Creek, rising half mile north of town. Public water system pumped by power driven pumps from dug or drilled wells to town via gravity feed pipeline.	Box 16, File 15. Water Supply Systems Questionnaire, 5 June 1971. See also HB of TX entry "Sand Creek."
Crockett Waterworks and Sewage System, Houston County.	Circa 1916.	Town incorporated in 1837, but waterworks not established until approximately 1916. System consists of a 10,750 gallon water tower 125 feet tall, two well sites, an overland concrete pipeline, and sewage disposal area.	Box 4, File 70. Questionnaire completed in 1976 by local historical committee chairperson.
Kenedy Waterworks, Karnes County.	Circa 1916.	Water supply from 5 wells ranging in depth from 431 ft to 650 ft. Pumped to tower and gravity fed to mains.	Box 8, File 122. Water Supply Systems Questionnaire, 28 May 1971.
De Leon Waterworks, Comanche County.	1918.	Water from dug or drilled wells pumped to town.	Box 5, File 16. Water Supply Systems Questionnaire 13 May 1971.
Sweetwater Waterworks, Nolan County.	Circa 1919.	Several dams built for municipal water supply and irrigation. City built Lake Trammell in 1915 on Sweetwater Creek 8 miles south of town for municipal, domestic, and recreational purposes. In 1929 city built Lake Sweetwater SE of town on Bitter Creek for water supply and recreation.	Box 14, File 100. Historical Questionnaire submitted by manager of Pioneer City-County Museum of Sweetwater, 25 July 1975. File contains part of 1948 water supply report and 1976 photos of stand pipe and Lake Trammell dam. See also HB of TX entries "Lake Trammell" and "Lake Sweetwater."
Gorman Waterworks, Eastland County.	Circa 1919.	Water pumped from local wells to storage tower. Later stored in reservoir.	Box 7, File 50. Water Supply Systems Questionnaire, 17 May 1971.
Iowa Park Waterworks, Wichita County.	1920.	Water pumped from wells. In 1964, North Fork of Buffalo Creek was dammed by Wichita County Water Control and Improvement District Number Three to provide water supply for Iowa Park.	Box 8, File 81. Water Supply Systems Questionnaire, 28 May 1971. See also HB of TX, entry "North Fork Buffalo Creek Reservoir."
Slaton Waterworks, Lubbock County.	Circa 1922.	Privately owned wells pumped with windmills. Beginning in 1953, water piped about 160 miles from Lake Meredith on Canadian River as one of 11 members of Canadian River Municipal Water Authority. Other member cities are Amarillo, Borger, Pampa, Plainview, Lubbock, Brownfield, Levelland, Lamesa,	Box 14, File 41. Water Supply Systems Questionnaire, 16 June 1971. See also HB of TX entry "Canadian River Municipal Water Authority."

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
		Tahoka, and O'Donnell.	
Comanche Waterworks, Comanche County.	Circa 1924.	River water pumped to reservoir and then through pipeline to city. In 1925 Lake Eanes was constructed 3 miles south of town on Mercer's Creek. It had a capacity of 1,000 acre-feet and furnished water for the Comanche area. New water system after construction of Proctor Reservoir on the Leon River in the Brazos watershed by Corps of Engineers in early 1960s.	Box 4, File 41. Water Supply Systems Questionnaire dated May 5, 1971. See also HB of TX entries "Lake Eanes," "Comanche, Texas," and "Proctor Reservoir."
San Antonio Waterworks, Bexar County.	1925.	The privately held waterworks changed hands several times as citizens refused to support the facility that was founded in 1878. In 1891 a successful artesian well was drilled that flowed 3 million gallons per day, indicating a readily available long-term supply from the Edwards aquifer. The waterworks was sold to a St. Louis company in 1906 and to Belgian investors in 1909. San Antonio businessmen repurchased the water franchise in 1920. The city denied a rate increase in 1924, but the rate increase was temporarily sustained by a federal court. The water company was purchased by the city for seven million dollars after approval in bond election on April 18, 1925.	Box 13, File 19. TLB compiled 46 item annotated bibliography with water-related articles from the San Antonio newspaper dating back to 1856. Also included are Corner, William, "The Water Works," in San Antonio de Bexar, San Antonio: Bainbridge & Corner, 1890. McLean, Bert J., *The Romance of San Antonio's Water Supply and Distribution*, San Antonio Print Co., 1927. Report of the Water Works Board of Trustees of San Antonio covering the period from 1925 to 1930.
Childress Waterworks, Childress County.	1927.	Water supply from a local river-fed reservoir and from dug or drilled wells using electrical pumps.	Box 3, File 159. Water Supply Systems Questionnaire dated May 13, 1971.
Clyde Waterworks, Callahan County.	1927.	Water supply from local dug or drilled wells pumped to elevated storage tower.	Box 4, File 24. Water Supply Systems Questionnaire dated May 17, 1971.
Woodsboro Waterworks, Refugio County.	Organized before 1928 by local businessmen.	Waterworks organized by Commercial Club, a group of local businessmen, shortly after town's creation. Townsite platted in 1908, awarded contract for electric lights in 1913, and incorporated in 1928. Upon incorporation, waterworks turned over to local government.	Box 16, File 36. Huson, Hobart, *Refugio*, Volume II, Woodsboro, Tex.,: The Rooke Foundation, 1955, p, 308. See also HB of TX entry "Woodsboro, TX."

Table 5.2 Continued

Water Supply	**Date**	**Description**	**Records in Collection**
Archer City Waterworks, Archer County.	1928.	Water supplied from reservoir built in 1927 near town. Carson Lake.	Box 2, File 32. 1971 Water Supply Systems Questionnaire from city water superintendent.
Eagle Lake Waterworks, Colorado County.	1928.	Water supply from dug or drilled wells in immediate vicinity.	Box 5, File 47. 1971 Water Supply Systems Questionnaire.
Devine Waterworks, Medina County.	Circa 1928.	Water supply from numerous local wells pumped to elevated tank.	Box 5, File 32. 1971 Water Supply Systems Questionnaire.
Rotan Waterworks, Fisher County.	Circa 1928.	Originally pumped from local wells with gasoline pumps. In 1963 began piping in treated water from Snyder—20 miles away.	Box 12, File 45. Water Supply Systems Questionnaire, 7 June 1971. See also Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, p. 299.
Groom Waterworks, Carson County.	1929.	Water pumped by windmill. Had horse-drawn tank wagon.	Box 7, File 68. Water Supply Systems Questionnaire 14 June 1971.
Refugio Waterworks, Refugio County.	1930.	Town established in 1831 on Mission River on site of 18th century Spanish mission and even earlier Karankawa village. In 1890s water supply from public courthouse pump or private wells. Two private systems existed. Municipal system established in 1930 after large fire from oil well drilling in 1929.	Box 12, File 17. Site Inventory Sheet. Hutson, Hobart, *Rufugio*. Vol. II, Woodsboro, Tex.: The Rooke Foundation, 1955, pp. 418-419. See also HB of TX entry “Refugio, TX.”
Diboll Domestic Water Distillation System, Angelina County.	1930s	Municipal water supply distilled from water from logging pond. One of three such systems in East Texas in 1930s.	Box 5, File 34. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, p. 278.
Manning Domestic Water Distillation System, Angelina County.	1930s	Municipal water supply distilled from water from logging pond. One of three such systems in East Texas in 1930s.	Box 9, File 94. See Baker, T. Lindsay, *Building the Lone Star*, College Station: Texas A&M University Press, 1986, p. 290.
Crowell Waterworks, Foard County.	Circa 1931.	Originally from local wells, then piped from river to an earthen dammed reservoir and pumped to city.	Box 4, File 75. Water Supply Systems Questionnaire dated May 13, 1971.
Wiergate Domestic Water Distillation System, Newton County.	Circa 1932.		Box 16, File 29. Site Inventory Sheet. Baker, M.N., *The Quest for Pure Water*, New York: American Water Works Association, 1948, p. 360.
Toyah Waterworks, Reeves County.	1934.	Ken Scott, Toyah Independent School District reports, “In early days drinking water was hauled form the Texas & Pacific roundhouse in barrels specially built with tongue and handle for rolling.” Water supply pumped from wells to reservoir. Toyah is Indian word for “flowing water” or “much water.”	Box 15, File 41. June 1971 Water Supply System Questionnaire. Site Inventory Sheet. See also Box 15, File 41: Toyah Artesian Wells; Box 15, File 42: Toyah Hand Dug Oil Wells; Box 15, File 43: Toyah Railway Water System. See also HB of TX entry “Toyah Lake.”

Table 5.2 Continued

Water Supply	Date	Description	Records in Collection
Beeville Waterworks, Bee County.	1946.	Water pumped from wells.	Box 2, File 81. Water Supply Systems Questionnaire, May 14, 1971.
Pearsall Waterworks, Frio County.	Circa 1946.	Water pumped from local well to two storage tanks.	Box 11, File 37. Water Supply Systems Questionnaire, 31 May 1971.

Water Bonds

In an effort to better understand the spread of waterworks and public commitment to this process, I searched for an archive of water bonds. In the state of Texas, one of the duties of the Office of the Comptroller is to register all bonds issued by the State or any of its political subdivisions, including cities. Most bonds are issued for a specific purpose such as schools, waterworks, or street improvements. By going through handwritten records in a general bond index dated 1870 to 1931, I was able to identify approximately fifteen hundred bonds that had been issued by either cities or counties for water-related projects.[225] These are compiled in Appendix E of this dissertation, and include the name of the bond-issuing entity, the bond number (available beginning in 1912), the specific water-related purpose of the bond, and the volume and page number where the bond is recorded. The earliest water-related bonds found were from the 1880s.

[225] *General Bond Index to Volumes 1-34*, 1870-1931, State of Texas Bond Registers and Indexes, Records of the Bond Department, Texas Comptroller's Office General Revenue Volumes. Archives and Information Services Division, Texas State Library and Archives Commission, Austin, TX.

To compare the number of bonds issued in a city with the size of the city, I generated a series of timeslice maps with graduated open circles representing different population, and superimposed solid dots indicating bonds issued for waterworks. The results are displayed in Figures 5.3 through 5.7. Each map is a summary of the bond activity for a decade superimposed upon a map showing incorporated cities as of that census.[226] Cities that issued water bonds prior to a particular timeslice are indicated with a small "×." This cartographic display makes clear a pattern that is hard to discern in the columns and rows of Tables 5.1 and 5.2, namely that waterworks originated in the Texas Urban Triangle and diffused outward from there.

But upon closer inspection, the spread of waterworks does not quite follow settlement patterns of the state. In the first timeslice, Dallas and Fort Worth, at the northern corner of the state's population center had issued waterworks bonds, whereas Austin and San Antonio at the southwestern corner of the Triangle, and Galveston and Houston at the southeastern corner, had not. And yet, San Antonio was the first of these cities to be established. In the 1850 census (the first taken after Texas gained statehood), Galveston (population 4,177) was the largest city in the state, followed by San Antonio (3,488) and Houston (2,396). Austin and Dallas were, at the same time, fledging towns with populations of less than a thousand, and Fort Worth had yet to be incorporated. So, early establishment as a city was not a major factor in municipal involvement in water supply.

[226] *Texas Almanac, 1964-1965*,122-126. Population data is displayed in Appendix C.

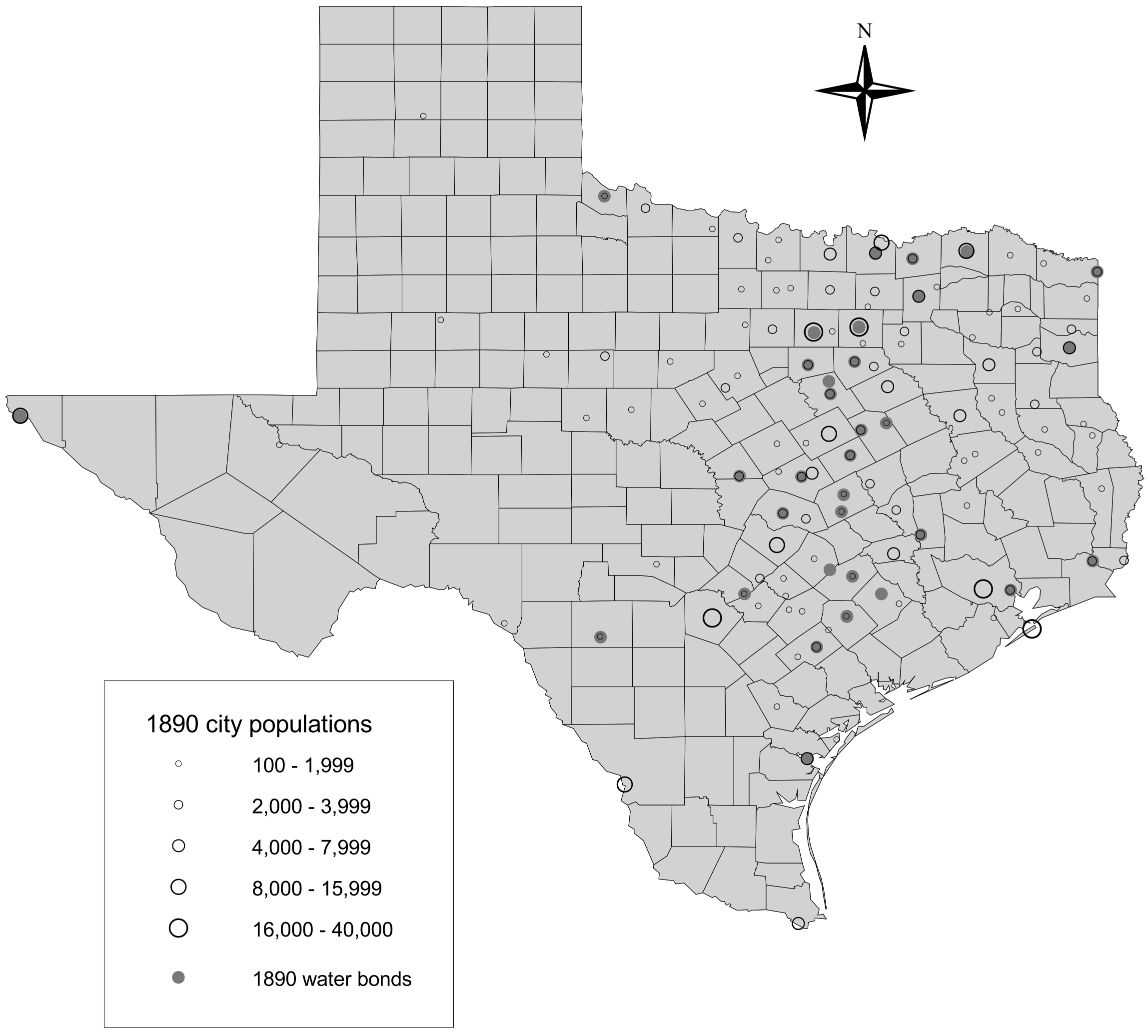

Figure 5.3. 1880 to 1890 Water Bond Timeslice. Municipalities that had approved bonds for waterworks by the year 1890 are indicated with a gray dot.[227] Superimposed are open circles indicating the relative population sizes of incorporated cities and towns using census data from the *Texas Almanac*.[228] Of the largest cities, Dallas and Fort Worth, in north central Texas, and El Paso in far west Texas stand out as having the foresight to approve funds for waterworks. Most of the communities that utilized bonds for municipal funding of waterworks are located in the Blackland Prairie portion of the state, along the present-day Interstate 35 corridor.

[227] The data used to generate this map came from 1,478 separate water-related bonds listed in Appendix E of this dissertation.
[228] *Texas Almanac, 1964-1965*, 122-126.

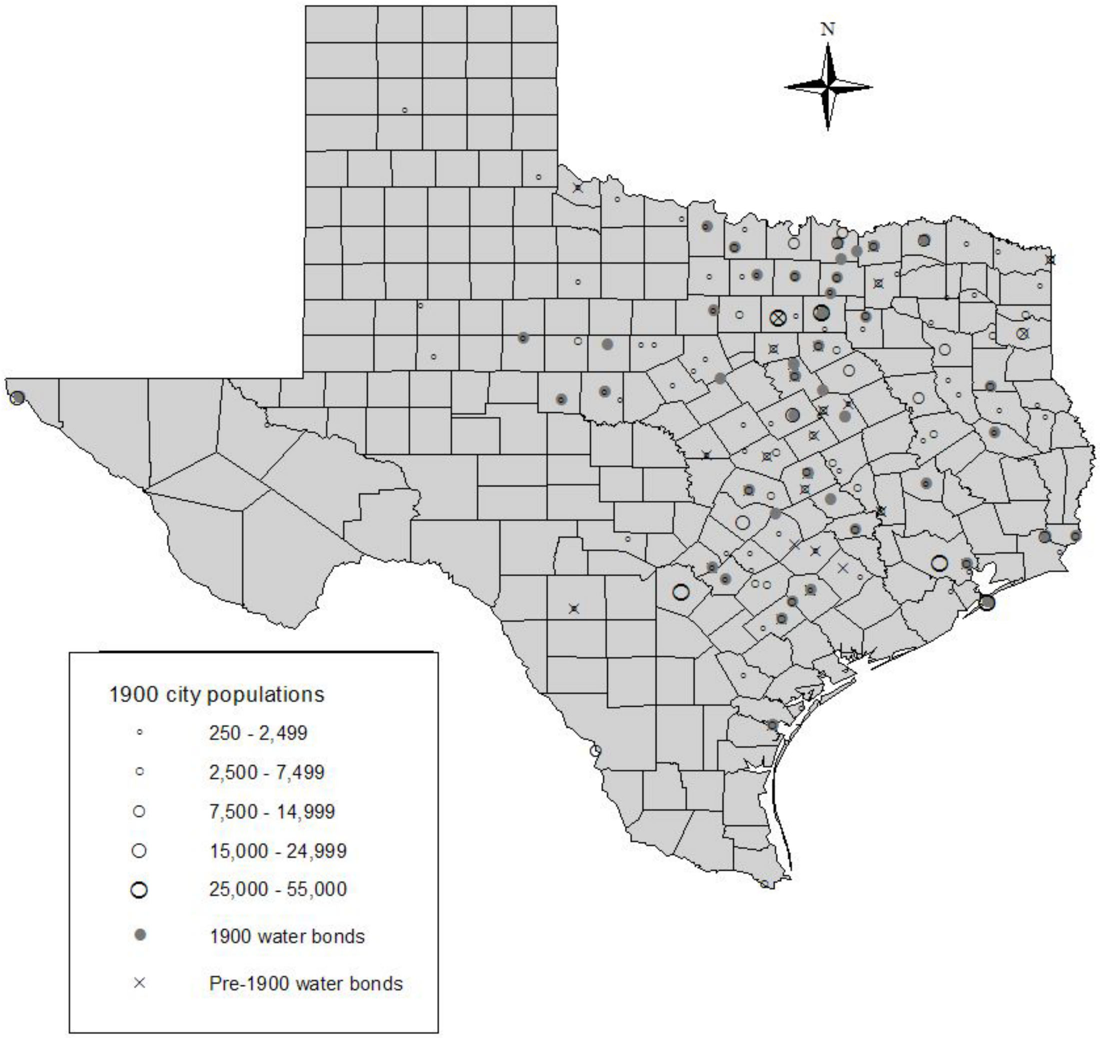

Figure 5.4. 1890 to 1900 Water Bond Timeslice. Municipalities that had approved bonds for waterworks between the years 1890 and 1900 are indicated with a gray dot. Municipalities that had previously approved water bonds are indicated with a small "x." Superimposed are open circles indicating the relative population sizes of incorporated cities and towns using census data from the *Texas Almanac*. Of the major cities, Waco and Galveston passed waterworks bonds during this decade. San Antonio had not yet passed a waterworks bond, but their citizens did approve a sanitary sewer bond during this decade.

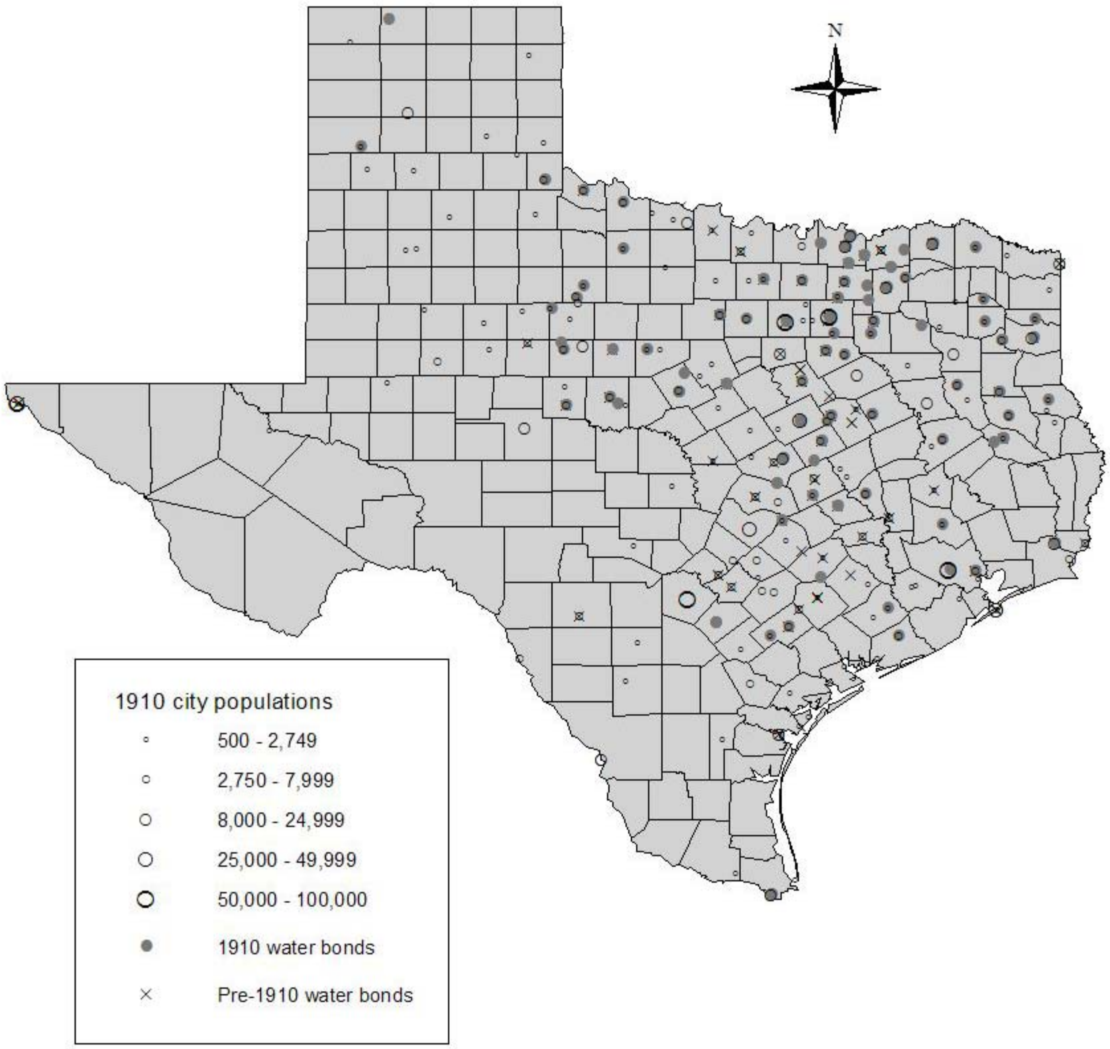

Figure 5.5. 1900 to 1910 Water Bond Timeslice. Municipalities that had approved bonds for waterworks between the years 1900 and 1910 are indicated with a gray dot. The number of communities that passed water bonds in the semi-arid western half of the state increased during the first decade of the twentieth century. Houston was added to the list of major Texas cities to address waterworks through municipal bond funding.

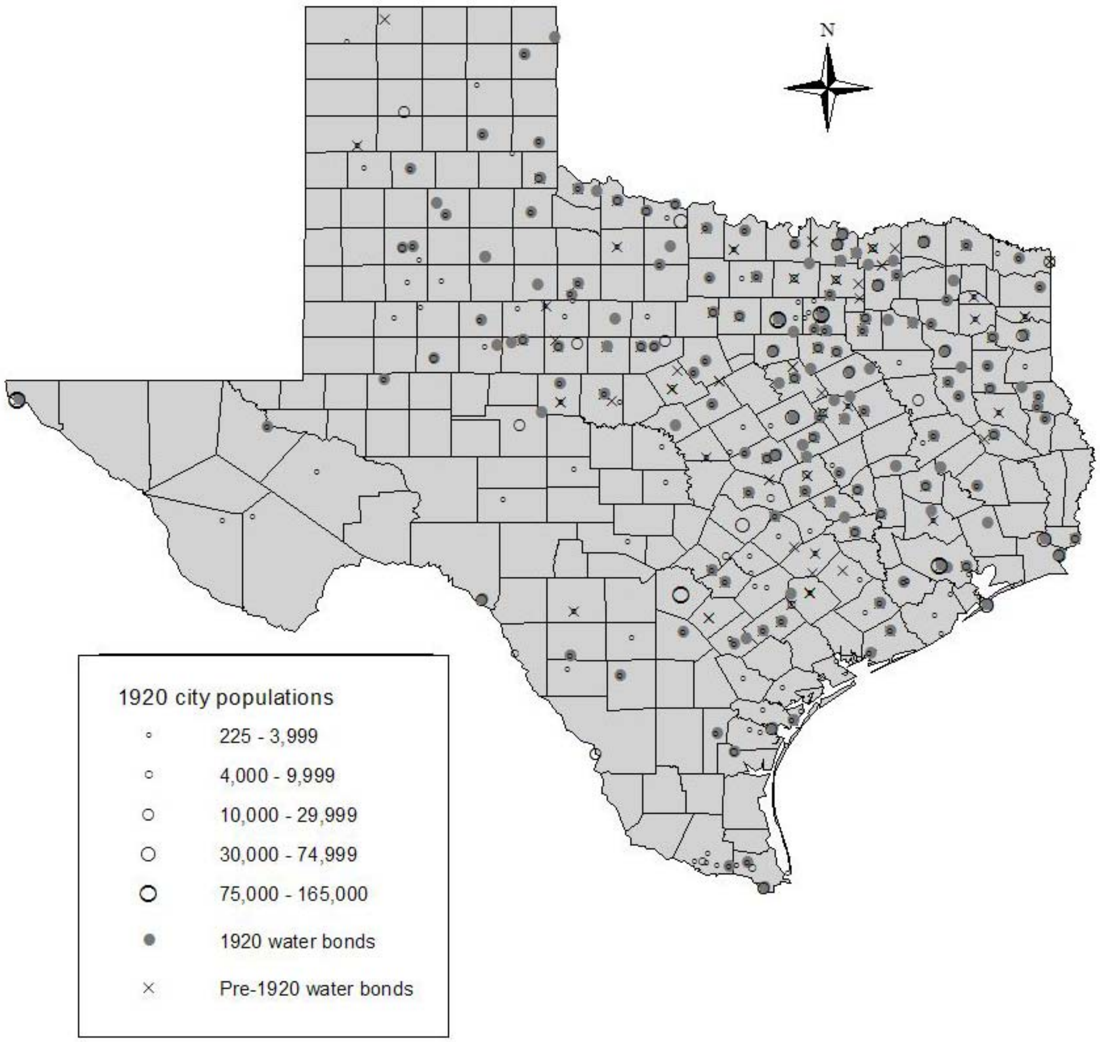

Figure 5.6. 1910 to 1920 Water Bond Timeslice. Municipalities that had approved bonds for waterworks between the years 1910 and 1920 are indicated with a gray dot. There is a noticeable proliferation of municipal water bonds across the state. Austin and San Antonio are conspicuous in their absence of attention to water bonds. Both cities did, however, approve bonds for the construction of sanitary sewers during this decade.

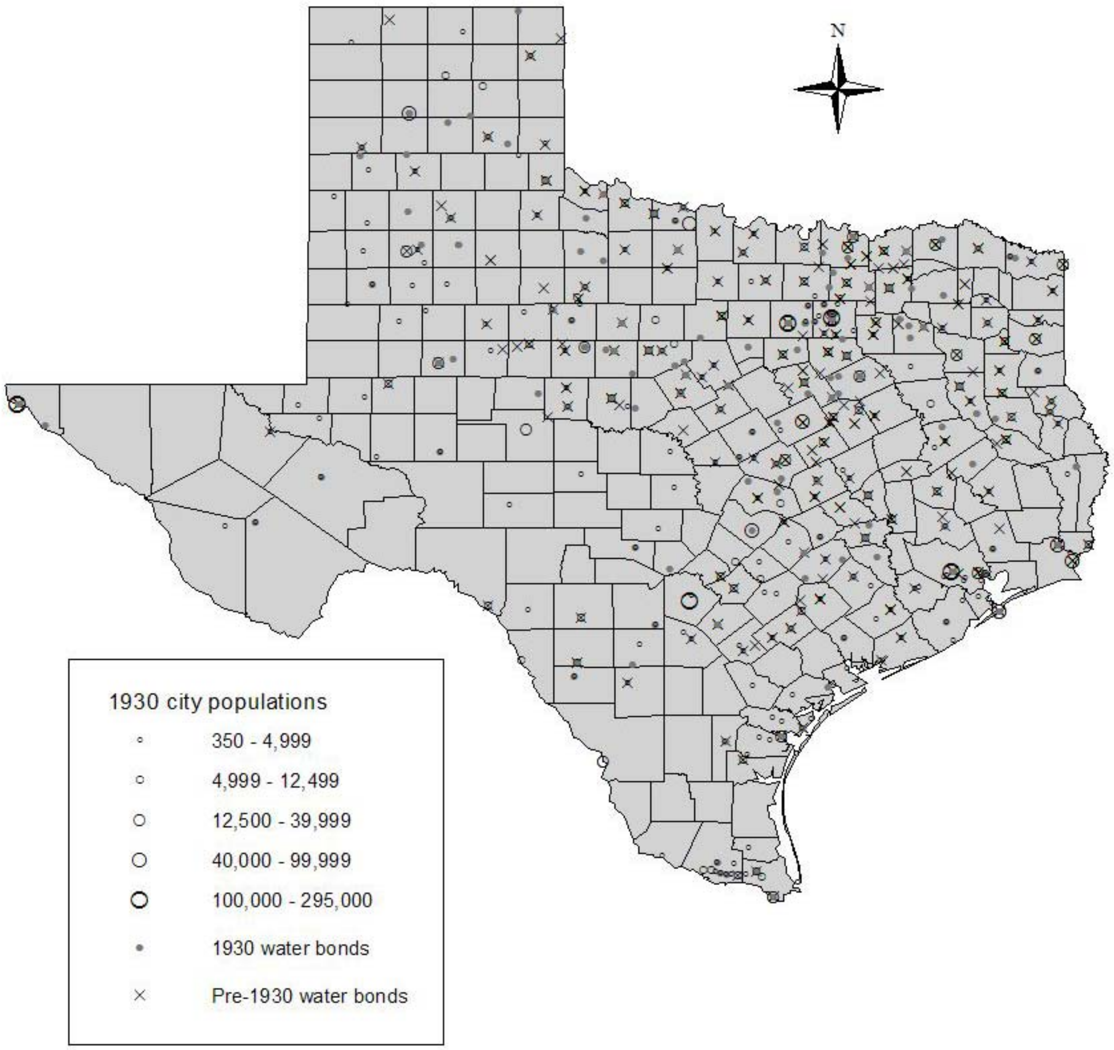

Figure 5.7. 1920 to 1930 Water Bond Timeslice. Municipalities that had approved bonds for waterworks between the years 1920 and 1930 are indicated with a gray dot. Municipalities that had previously approved water bonds are indicated with a small "x." Superimposed are open circles indicating the relative population sizes of incorporated cities and towns using census data from the *Texas Almanac*. Austin passed a waterworks bond during the decade of the 1920s. San Antonio stands out as the lone major city in the state not to have passed a waterworks bond.

By 1890, the two largest cities in the state—Dallas and San Antonio—were a study in contrast when it came to public water supply, as suggested by the timeslice map in Figure 5.3. This contrast grew more apparent over the next several decades. By 1900 Galveston joined the list of major Texas cities that had approved water bonds, while Dallas issued additional bonds. By 1910, Houston issued bonds, as did both Dallas and Fort Worth (again). By 1920, Dallas, Fort Worth, Houston, and even Galveston—devastated though it was by the 1900 hurricane—again issued more water bonds. Austin and San Antonio are conspicuous in their absence. Finally, by 1930, Austin issued water bonds. Yet San Antonio still had not.

One of the most pronounced resistances to change encountered in this dissertation is that of the citizens of San Antonio to investing in a waterworks because they were sitting atop the Edwards aquifer. In 1927, when every other major Texas city had invested in waterworks, the situation in San Antonio was described: "The [San Antonio] waterworks was accepted by the city July 5, 1878, and the LaCoste company prepared to reap the just returns from its enterprise and public-spirited service. To the dismay of the officers and stockholders it was found a most difficult task to overcome the prejudice of the day against new methods and to educate a people reluctant about changing old habits. Where hundreds of consumers were expected tens were the realization…"[229] San Antonio residents did not see a need for waterworks for their water supply.

Why such a difference in how the different cities approached water supply? Was it because culture brought with it different ideas about water? San Antonio's citizens migrated there from the south, where the Spanish acequia system was accepted. Reinforcing this, San Antonio's physical geography suited that system, as it was rife with springs and sat atop the Edwards aquifer which provided flowing water from artesian wells when tapped. Water was plentiful and of excellent quality. Dallas, on the other hand, was settled by immigrants largely from the United States who brought with them ideas about the public waterworks. Dallas also suffered from not being situated on top of an aquifer as prolific as the Edwards. Rather, Dallas was on the banks of the Trinity River. From its early days, Dallas citizens relied upon a combination of spring water, river water, and well water. The active management of clean water was an early necessity, but also a challenge city leaders addressed time and again.

Is this conclusion supported by these maps? It must be admitted that the data collected may not be complete or entirely accurate. I may have overlooked a bond entry through my own error, or because it was not recorded properly in the bond register. Although most bonds listed specific purposes for their funds, there were a few that indicate only "improvements" without designating what kind of improvements were planned. The date of the bonds is only inferred from the volume in which each was

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[229] Bert J. McLean, *The Romance of San Antonio's Water Supply and Distribution* (San Antonio: Water Supply Company, 1927), 6.

recorded. (See Appendix F for a chart indicating which years are recorded in which volumes). This date may have been the date of the bond election, or it may have been the date recorded in the Office of the Comptroller. There was not widespread consistency in recording bonds until 1909 when a more uniform approach was implemented. My approach also does not address the dollar amount attributed to each bond. It is possible one city could issue bonds of small face value, approved during many different elections, while another city could approve larger bonds less frequently. I would argue, however, that in the municipality that held more frequent water bond elections, its citizens were more aware of local water supply issues.

Another possible shortcoming in my analysis is that the timeslice maps indicate only the number of water bonds identified for each city. I did not include sewerage bonds in Figures 5.3 through 5.7, and yet dealing with sewage is integral to a water supply system. Does this analysis seriously underestimate efforts by the early citizens of San Antonio and Austin to plan for their water management? As it might, I made another map of the bond data I had gathered. In it I counted the total number of water, sewer, and fire-related bonds prior to 1931. There were 772 water bonds, 382 sanitary sewer bonds (as opposed to drainage sewers, which were not counted), and 92 bonds for fire equipment. Then I attributed totals to each city and posted the results as three blue graduated dots superimposed over graduated red dots indicating relative population size. The results are shown in Figure 5.8. If a city has had an early history (pre-1931) of at least average water-related bond activity, its blue bond dot obscures its red population dot. The interpretation I am ascribing to this is that its bond activity kept pace with its

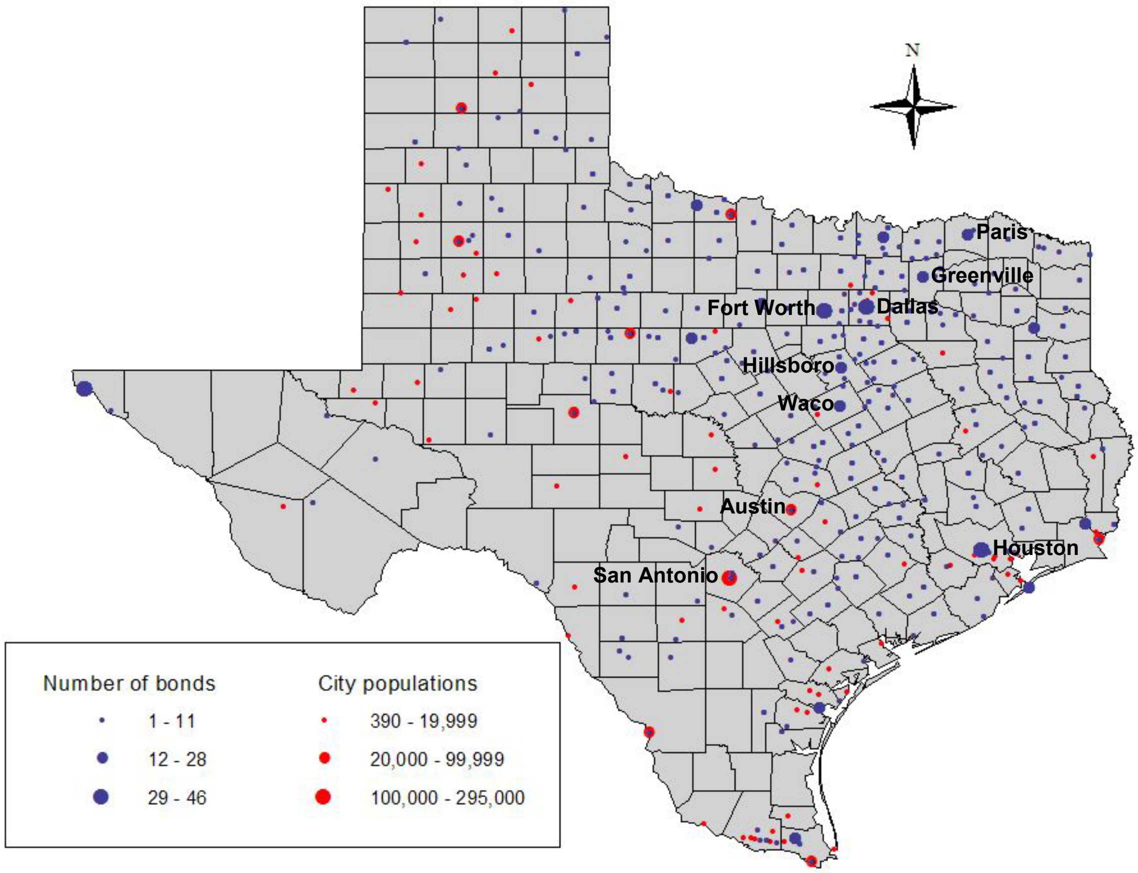

Figure 5.8. Number of Bonds Per City Prior to 1931. Includes the total number of water, sewer, and fire bond elections passed for each city and town as recorded in the General Bond Index to Volumes 1 through 34 of Bond Registers in the archives of the Office of the Comptroller of the State of Texas. The bond data is superimposed over the population data, thereby making the cities with relatively little bond activity appear in red, while those with a higher level of bond activity appear blue. Of the major cities in the state, San Antonio and Austin exhibited less bond activity than did Houston, Dallas, and Fort Worth. San Antonio in particular stands out, having passed only 3 water-related bonds by 1931. Of these three, two were for sewers and one was for fire protection. None were for the waterworks itself. Mid-sized cities such as Waco, Greenville, Mineral Wells, and even Hillsboro had passed more water bond issues than had either Austin or San Antonio.

population. Dallas, Fort Worth, Houston, and Galveston fall into this category, as do many smaller cities and towns. If a city has little or no water-related bond activity relative to its size, then its red population dot is not entirely obscured by its blue bond dot. Once again, San Antonio and Austin fall into this category.

Therefore, even if I did not find all pre-1931 water bonds in my archival search (historical data is imperfect), I believe that Figures 5.3- 5.8 provide strong evidence that some Texas cities historically dealt with water management concerns much more aggressively than others. I have so far painted a broad picture, and each city's waterworks has a unique history, but from the specifics, possibilities for understanding broader habits, uses, attitudes, and approaches are revealed themselves. While a more detailed look at all of the state's waterworks is beyond the scope of this dissertation, a case study of the early history of one water plant is instructive.

Early History of the Waterworks at Bryan, Texas

Consider the case of Bryan, Texas, first settled in 1859 and incorporated by the State Legislature in 1871. The story begins with fire. In June of 1871, fire in downtown Bryan caused $100,000 in damages.[230] Three years later another major fire occurred. *The New York Times* reported, "The sufferers are: McQueen & Davis, loss $20,000; insured for $6,000. A. Kaiser, loss $20,000; insured for $12,000. Frank Clark, loss

[230] "General," *New York Times*, 1 July 1871, p. 4.

$5,000; no insurance. Parker & Flippeus, loss $5,000 to building; insured for $2,500."[231] In 1881, "A fire at Bryan, Texas, Tuesday night, destroyed one of the principal business blocks of the city, including the Post Office and all of its fixtures."[232] "The losses by the fire on Tuesday night at Bryan, Texas, amount to $35,000; insurance, $20,000. M.L. Spring, an old and estimable citizen, perished in the flames."[233] Again quoting *The New York Times*, this time from 1887, "Yesterday afternoon fire broke out in the rear partition of Stuart's drug store, Bryan, Texas. The building, with that occupied by William Koppe as a dry goods house, was consumed, and adjoining property was damaged. The estimated loss is $40,000, which is pretty fully covered by insurance in *15 companies*."[234] When the parsonage of Bryan's Roman Catholic (Italian) church went up in flames, a stiff wind blew sparks that threatened the entire east side of town. "Much property was menaced and housetops were manned by bucket brigades and men with garden hose."[235]

There is no doubt that, from the time of its founding, fire was a significant hazard for residents of the market town of Bryan and to the rural district it served. The establishment of a fire department was a logical response, and this occurred early in the city's history. A group of firefighters calling themselves the "Little Alerts" formed prior to the city's incorporation in 1871, and later that year two more fire companies were organized and manned by volunteers. The city provided firefighting equipment and

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[231] "Losses by Fire," *New York Times*, 8 March 1874.
[232] "Losses by Fire," *New York Times*, 29 September 1881.
[233] "Losses by Fire," *New York Times*, 30 September 1881.
[234] "Losses by Fire," *New York Times*, 11 July 1887. My emphasis.
[235] "The Fire," *Bryan Morning Eagle*, 3 May 1906, p. 2.

maintained a site for a fire station, but it was not until 1921 that the department had its first fulltime employee. The volunteer firefighters were not considered inadequate—to the contrary, their efforts were routinely reported to have been heroic. Devastation from fire continued, however, and the problem was invariably attributed to insufficient water supply and/or low water pressure. During the 1880s, fires in the central business district were fought with a steam fire engine using water from five underground cisterns in the center of Main Street.[236]

The ultimate solution for merchants was, however, to establish a local waterworks. In 1889, five local businessmen (Messrs. J.N. Cole, J.P. Burrough, A.D. McConnico, and Judge J.N. Henderson of Bryan, and L.T. Fuller of Calvert)[237] purchased the existing beer and ice house, along with its water well, from Anheiser Busch of St. Louis, with plans to convert it into the Bryan Water, Ice and Electric Light Co. The new company was granted a twenty-five year franchise from the City Council to supply a network of mains with sixteen hydrants to supply water in sufficient quantity under sufficient pressure for fire and street purposes. [238] This was a public-private partnership in which private interests purchased an existing building with a water well and converted it into a privately owned plant to provide water and street light service to the city. In turn the City Council furnished funds in the form of $18,000 in municipal

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[236] *125 Years of Tradition: Bryan Fire Department, 1871-1997* (Bryan, TX: Bryan Fire Department, 1997).

[237] "The Water Works," *Bryan Weekly Eagle*, 24 October 1889, p. 8.

[238] Bryan City Clerk, Minutes of the City Council, Called Meeting 19 October 1889. A more legible version of the contract was printed in the newspaper, the *Bryan Eagle*, under the headline "Water! Water! The City of Bryan, Party of the First Part, The Water, Ice and Electric Light Company, Party of the Second Part. The Full Text of the Contract," 14 November 1889, p. 1.

bonds as credit to capitalize the new company. The city also agreed to pay a monthly rate for use of the water, and to furnish and maintain fountains to be accessed by the public along the route of the mains.[239] The new owners of the water and light plant, the City Council members, and the general public were united in their optimism that a plan to replace the five cisterns down the middle of Main Street with hydrants connected to the newly converted water plant would solve the problems of low water pressure and inadequate water supply that had so hampered fire fighting efforts in Bryan.[240]

Indeed, the plan might have worked, had it been fully implemented, but a bitter rate dispute during the mid 1890s left both parties dissatisfied with their original agreement. An important component of the political process is response to public criticism. The public was irate. The water company was sued, went into receivership, and emerged with new management—but still enfranchised to provide the city with water and street lights. Pumps not in working order were blamed by the interim water plant manager. By 1897 a new plant manager was hired and the plant was selling bath tubs, lavatories, wash sinks, garden hose, and hose reels in order to try to generate more income. Fires in the central business district remained a serious concern, however. [241]

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[239] Bryan City Clerk, Minutes of the City Council, Called Meeting 29 October 1889, Regular Meeting 4 February 1890.

[240] Bryan City Clerk, Minutes of the City Council, Called Meeting 19 October 1889. "Water! Water!" *Bryan Eagle*, 14 November 1889, p. 1.

[241] Bryan City Clerk, Minutes of the City Council, Regular Meeting 4 February 1890. "Council Meeting: What the City Fathers had to Say About the Waterworks," *Bryan Eagle*, 15 August 1895, p. 1; *"A Crisis Reached," Bryan Daily Eagle*, 19 May 1897, p. 4; "Water Rate Question," *Bryan Daily Eagle*, 21 May 1897, p. 4. "Reached a Show-Down," *Bryan Daily Eagle*, 27 May 1897, p. 4; "New Water Rates," *Bryan Weekly Eagle*, 17 June 1897, p.3. "Advertisement by the Water, Ice, Light and Power Co.," *Bryan Daily Eagle*, 24 March 1897, p. 4.

Once again local businessmen forced the issue. They formed a civic organization called the Business League and appointed a committee charged with encouraging better water and light service for the city. In December of 1905 this committee circulated a petition pressuring the City Council to secure for its citizens ample water and street light service. The City Council's response to the Business League committee's request was—to form another committee to investigate.[242] The following spring the council authorized hiring an expert to examine operations at the water plant and recommend steps to improve operations.[243] A few months later, in October of 1906, Bryan's cotton compress was destroyed by fire. Damage was reported between $125,000 and $150,000 and included burned rail cars loaded with cotton. The fire department and many volunteers responded, but once again it was reported that their efforts were hampered by insufficient water pressure. This was the second time the compress had been destroyed by fire—the first instance being in 1887.[244] The compress was a significant part of the economic engine, not only of Bryan but of the Brazos Valley itself.

In February of 1907, the issue of inadequate fire protection flared up again, because of a visit to Bryan by an official of the Texas Fire Prevention Association. As reported in the *Brazos Pilot*,

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[242] "A Pointed Petition," *Bryan Morning Eagle*, 7 December 1905, p. 2. Bryan City Clerk, Minutes of the City Council, Regular Meeting 18 December 1905.
[243] Bryan City Clerk, Minutes of the City Council, Adjourned Meeting 18 May 1906.
[244] Elmer Grady Marshall, "The History of Brazos County," (Thesis: Austin, TX: The University of Texas, 1937), 208-9. Much of Marshall's information comes from a 1932 interview with H.O. Boatwright, a former president of the First National Bank of Bryan. "Great Fire Disaster," *Bryan Morning Eagle*, 13 October 1906, p. 1.

> Mayor Butler introduced the subject of the present distressingly inadequate water and light service by reading a letter from the Texas Fire Prevention association at Dallas to the effect that unless the matter of fire protection was immediately attended to, the insurance rate would be materially increased on all insured property here, (many of the local insurance agencies have already been instructed to cease writing risks here until this matter is satisfactorily adjusted).

The mayor went on to say that the only solution was to negotiate for a different company to construct and operate a new water and electric light plant. He did not advocate the city taking over operation of the current plant because he did not think the citizens would approve such an undertaking, and furthermore argued that the city did not have the funds to do so. The water plant still had $15,000 in outstanding bonds which the mayor thought the city would then have to pay. This was not possible because the city treasury contained only $4,800. The council's response was to set up another committee to look into the matter. [245]

It is not clear what role the controversy over water service played in the next mayoral election, in April of 1908, but Mayor Butler did not stand for re-election. Instead he was elected a delegate to the Brazos County Democratic convention.[246] No one announced their candidacy for mayor until the day before the election, at which time three men entered the race. The local newspaper endorsed all three candidates as highly qualified, but one candidate, J.T. Maloney, submitted a letter to the newspaper that was published on the front page on Election Day and listed priorities for his administration, should he be elected. This list included improvements to both the fire department and

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[245] "Mass Meeting Largely Attended: Representative Business and Professional Men Unanimous in Condemnation of Present Light and Water Works Service," *Brazos Pilot*, 28 February 1907, p. 2.
[246] "Election Results in Bryan," *Bryan Morning Eagle*, 3 May 1908, p. 1.

the water company to enable local buildings to meet requirements of insurance underwriters. He also called for strict adherence to the contract between the city and the water company. Maloney was elected and served from 1908 to 1912, a pivotal time in the history of Bryan's waterworks because it was during his tenure that the local waterworks went from being a privately owned company to being owned by the city of Bryan.[247]

In one of his first acts as mayor, Maloney endorsed municipal ownership of the water plant. He made the case that even though the city would incur the debts of the water company, enough would be saved by the city in contractual payments to the water company over the course of several years that the purchase would become a viable investment. The city council voted instead to sue the water company, an action that was vetoed by the mayor. It was in the midst of this long-simmering controversy that the *Bryan Morning Eagle* reported, on January 16, 1909, "Fire completely destroyed the Perkins brick building here at 6:30 o'clock this morning… The fire was fought with buckets on account of weak pressure from the fire hydrants. Chief Hamilton stated to the *Eagle* man that had there been the usual pressure he could have confined the blaze to the second floor of the building."[248]

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[247] "To the Voters of Bryan," *Bryan Morning Eagle*, 7 April 1908, p. 1. "City Election Results," *Bryan Morning Eagle*, 8 April 1908, p. 3. "Elections" vertical file at Bryan's Carnegie Library contains a list of Bryan's mayors and their years of service.

[248] "A Business Men's Ticket," *Bryan Morning Eagle*, 7 April 1908. "The Water Problem," *Bryan Morning Eagle*, 25 April 1908. "Some Election Results," *Bryan Morning Eagle*, 3 May, 1908. "Bryan's Water Supply: Mayor Maloney Would Have the City Own Its Waterworks," *Brazos Pilot*, 14 May 1908, p. 7. "A $50,000 Blaze," *Bryan Morning Eagle*, 16 January 1909, p. 2.

Now it is true that the central business district had suffered many earlier fires, and the city council had previously discussed purchasing the water plant, but the destruction of this particular building, housing the First National Bank, Lawrence grocers, a saloon, and the *Bryan Evening Pilot* newspaper, was egregious enough to prompt an immediate response from this particular mayor and city council. Since members of the fire department reported their efforts to fight the fire were thwarted by inadequate water supply, attributed to a lack of proper maintenance at the local privately owned waterworks, Mr. Preston, superintendent of the water company, was immediately summoned before the City Council. He explained that an underground valve was broken at the time of the fire, but had since been replaced. The disgruntled council members established a committee to investigate further. On the same page of the newspaper was a small article entitled "Bond Election Ordered. At a special meeting of the city council it was ordered that an election be held by qualified voters to decide whether or not the City of Bryan shall issue $75,000 in bonds for establishing a water, light and sewerage plant. Election to occur 30 days after publication of ordinance authorizing same."[249] A month later, another downtown fire occurred, this time consuming the fire station, city hall, and opera house.[250] This fire almost certainly guaranteed approval of the bond election for the city's purchase of the waterworks that was held two weeks later.

Indeed on March 2, 1909 an election was held for the purpose of authorizing the issuance of municipal bonds for the purposed of establishing a City of Bryan Water,

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[249] "A $50,000 Blaze," *Bryan Morning Eagle*, 16 January 1909, p. 2. Bryan City Clerk, City Council Minutes, Special meeting, 15 January 1909.
[250] "City Hall Burned," *Bryan Morning Eagle and Pilot*, 20 February 1909, p. 4.

Light and Sewerage Plant. The certified election results were 195 votes in favor and 18 votes against issuance of such bonds. These results set off protracted negotiations between the city and the privately owned waterworks company, culminating in the city's purchase of the existing plant in 1911.[251] Even though the city now owned the water plant, it was decided to build a new waterworks several blocks north of the center of town. Three wells were drilled to a depth of 265 feet on the grounds of the new waterworks, and two much larger cement reservoirs were built for additional storage capacity. The old water plant was decommissioned.[252]

Even after the city took control of the waterworks, the problem with inadequate water supply for fire fighting was not completely resolved. After a Bryan residence fire in 1915, fire marshal John Daly, Jr. reported that the building could have been saved had there been a supply of water. According to Daly this was the second recent disastrous fire due to insufficient water.[253] Citizens' expectations had increased beyond fire protection for the central business district, and the concern was for extending protection to residential areas. The frequency of water company complaints registered in the minutes of the city council decreased after Daly's complaint—suggesting that although the problem had not be eliminated, it had become manageable. The response to the challenge had been to organize locally to attack the problem—first, with several businessmen combining resources to buy a site that included a water well, and coming to an agreement with the city council to provide water for fire protection. When this

[251] Bryan City Clerk, Minutes of the City Council, 12 March 1909.
[252] Sanborn Insurance Map of Bryan, Texas, June 1912.
[253] "Another Bad Fire in Bryan," *Bryan Daily Eagle and Pilot*, 15 August 1914, p. 6.

system proved to be less than satisfactory, again it was a group of businessmen organizing to apply pressure on the city council for relief from increasing insurance rates. At the heart of the process was a series of committees. The businessmen established a group called the Business League and appointed a committee of five members charged with securing better water and light service for the city. The City Council addressed routine business as well as special problems through the appointment of committees comprised of from one to three members. Sometimes the committees were authorized to study the problem and take action, at other times they were instructed to report back to the council at large for further deliberation.

So in 1889 Bryan's city council granted a franchise to the Bryan Water, Ice and Electric Light Company to provide a water system for the city. A generally troublesome relationship ensued between the city and its water company for the next twenty years, but a network of water mains and hydrants was put into place that completely changed how water was delivered to the city. All parties learned from the experience, and in 1911 a new water plant was built and put into operation by the city with the consent of its citizens. Fire was not eliminated, but it was thereafter manageable and not catastrophic. In the process, how people used water changed. Maybe even more important, their perception of water was altered. The Bryan waterworks' early history puts a specific face to the generalizations inferred about the establishment of waterworks in late nineteenth and early twentieth century Texas. It also suggests that there were a myriad of changes occurring in the artifacts, sociofacts, and mentifacts of the water supply system and, by extension, to water use itself. These thoughts are explored in the next section.

Changing Landscape and Water Use

The construction of waterworks as a response to fire marked the transition from the agrarian water use regime to the waterworks regime. If this represents a new approach to water use, then there should be a significant manifestation of change within the water supply system. Using Dodgshon's ideas about inertial aspects of a cultural landscape, I should be able to find indications of a tipping point related to the appearance of waterworks around which the water supply landscape could no longer flow. The water supply network should *look different*. Sanborn Insurance Maps provide visual evidence of that difference. The earliest Sanborn map of Bryan is from July 1885, and its legend states flatly that Bryan's water facilities are "not good."[254] There is no public water system to describe. Instead, the few blocks that comprise Bryan's central business district contain a myriad of cisterns and wells shown on the map in Figure 5.9. The second Sanborn map for Bryan was issued in 1891, shortly after a waterworks was established.[255] The water supply network has changed dramatically. Most of the wells and cisterns are gone, replaced by a grid of water mains and hydrants, shown on the map in Figure 5.10. The new water system may not have been working as well as Bryan's

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[254] Sanborn Insurance Maps, *Texas 1876-1970*, Digital, "Bryan, Texas, July 1885" (Ann Arbor, MI: Bell & Howell Information and Learning, c2001) http://sanborn.umi.com./ (accessed March 12, 2007).
[255] Sanborn Insurance Maps, *Texas 1876-1970*, Digital, "Bryan, Texas, May 1891" (Ann Arbor, MI: Bell & Howell Information and Learning, c2001) http://sanborn.umi.com./ (accessed March 12, 2007).

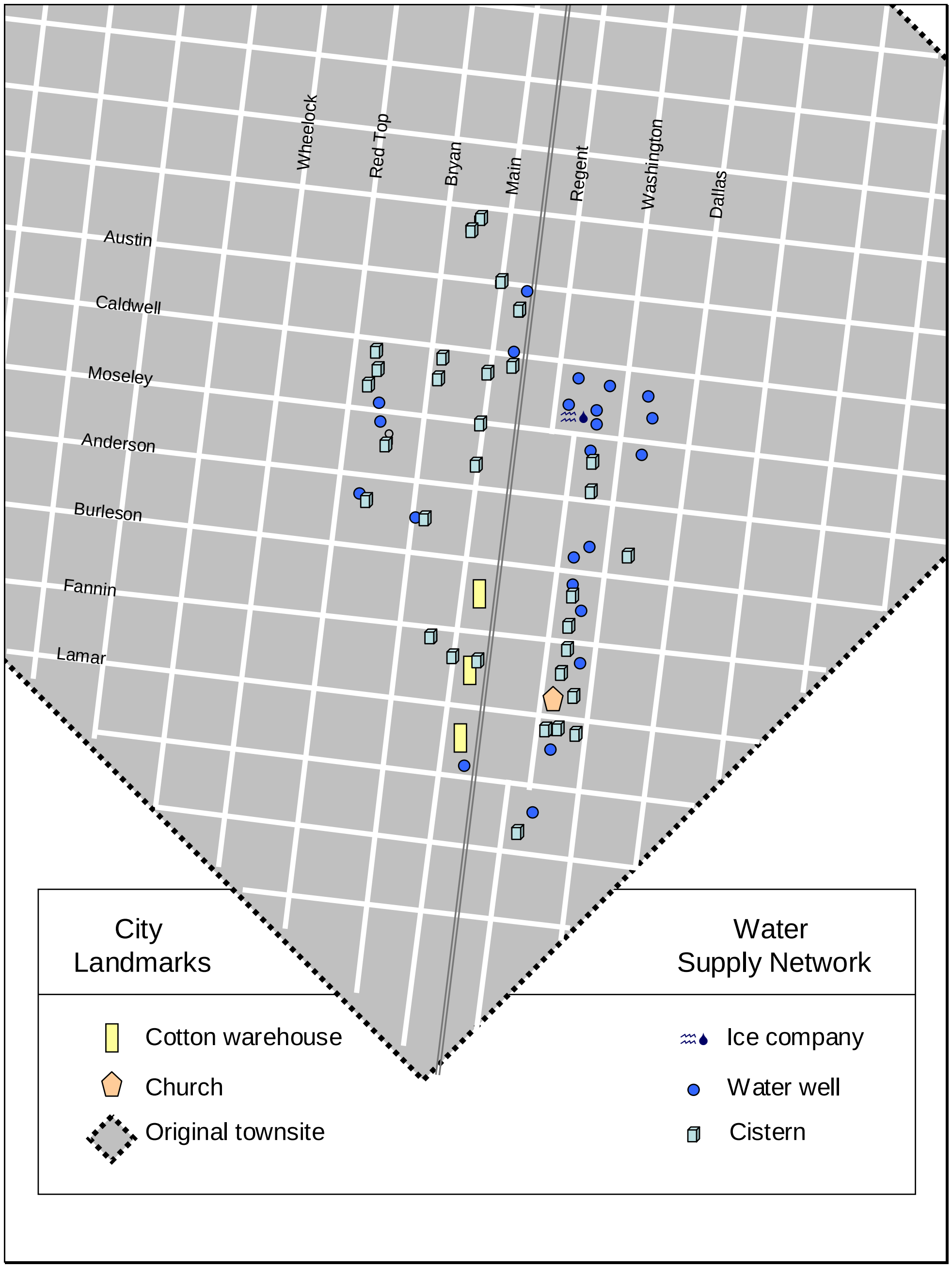

Figure 5.9. Water Supply Network for Bryan, Texas in 1885. Water supply was from individual wells and cisterns scattered throughout the central business district. The public supply was from 5 cisterns located down the middle of Main Street. The rest of the wells and cisterns were provided by individual citizens and merchants for their businesses.

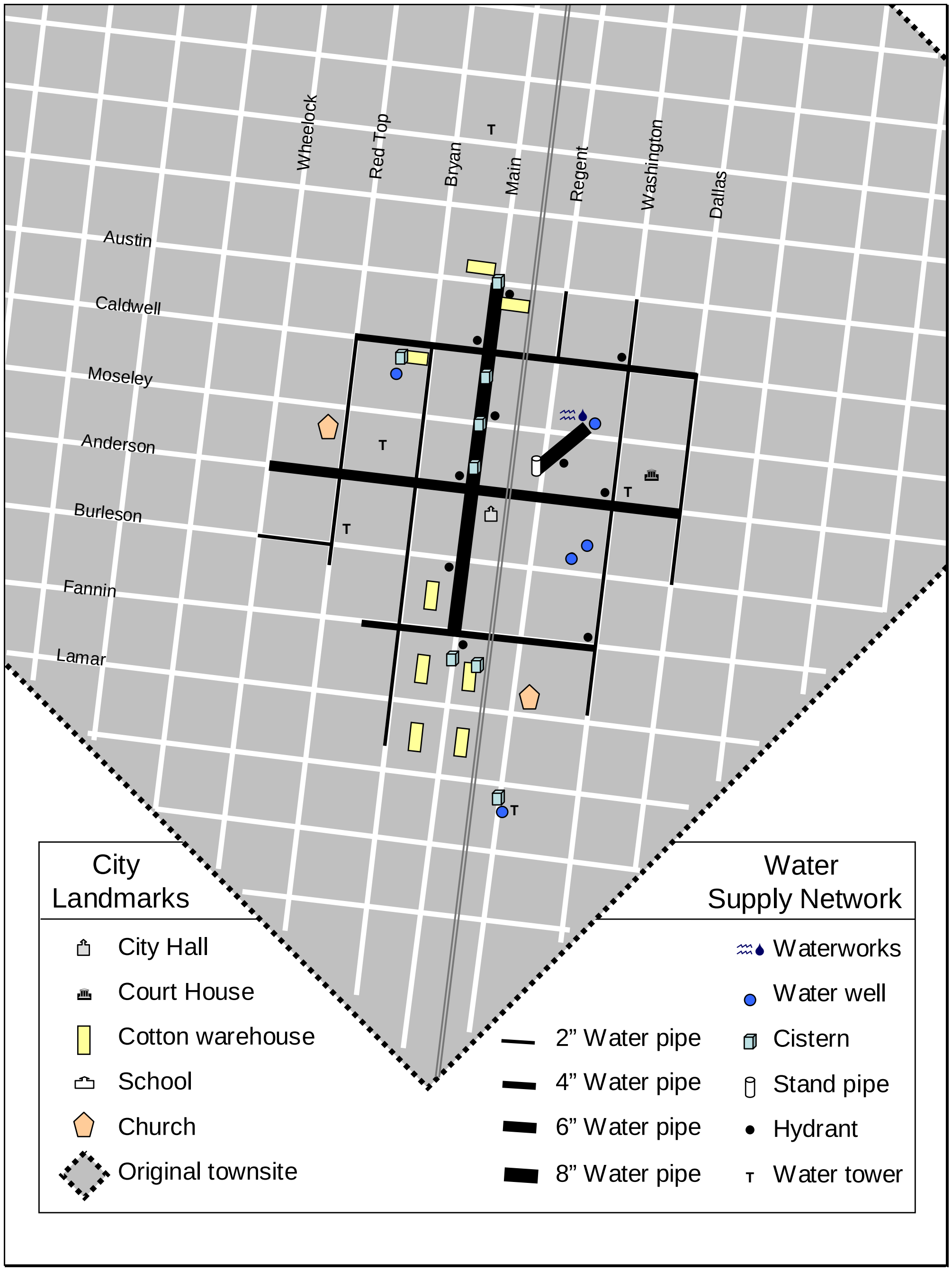

Figure 5.10. Water Supply Network for Bryan, Texas in 1891. The local waterworks had been established a year and a half earlier. Bryan now had a network of water mains, a standpipe, and hydrants that supplied well water throughout the central business district.

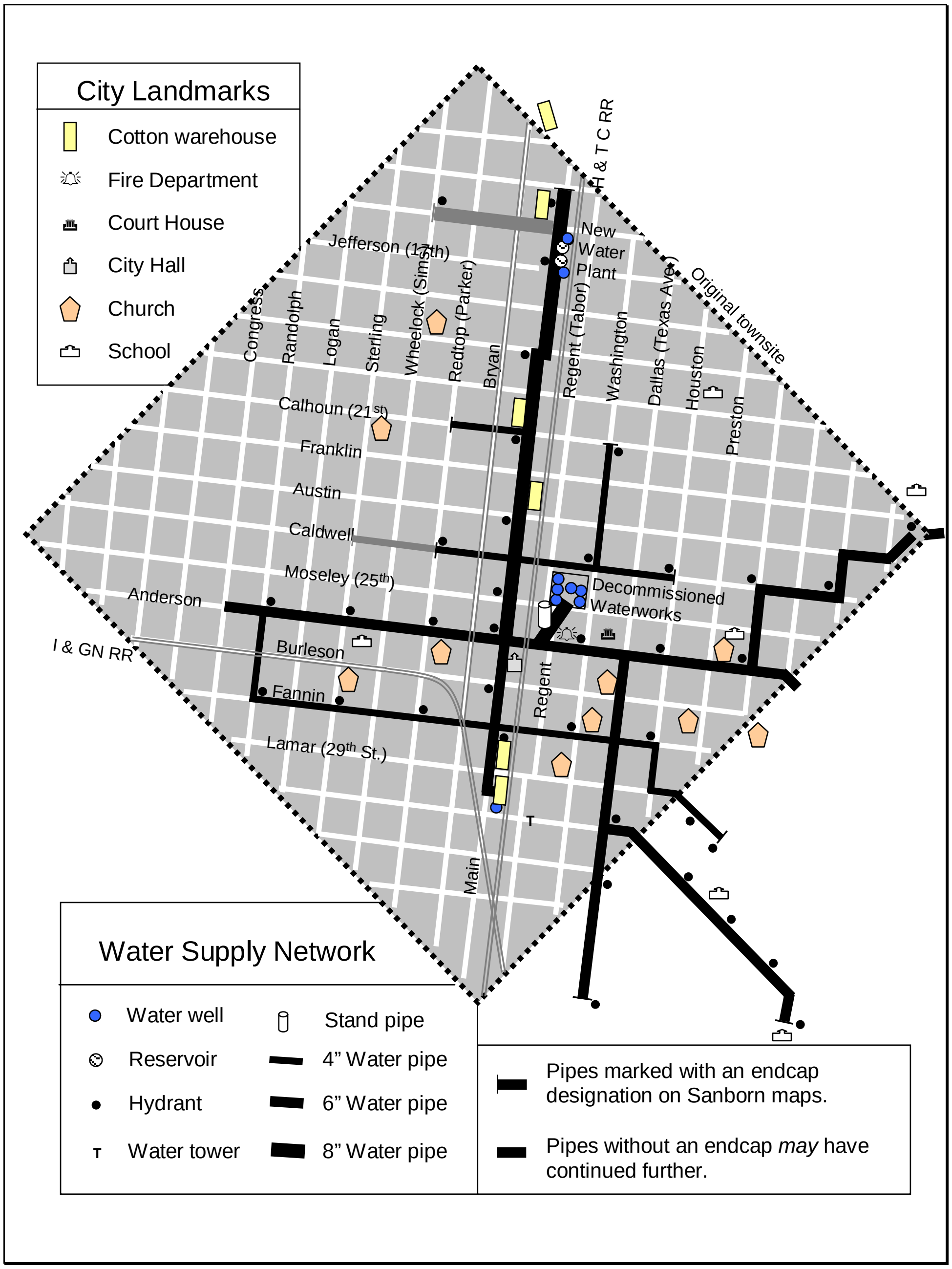

Figure 5.11. Water Supply Network for Bryan, Texas in 1912. Bryan's water supply network remained largely unchanged from 1891 until the city purchased the waterworks in 1911. A new waterworks plant was built to the north of the central business district, and the network of mains was extended out of the central business district to the east and southeast into a residential neighborhood.

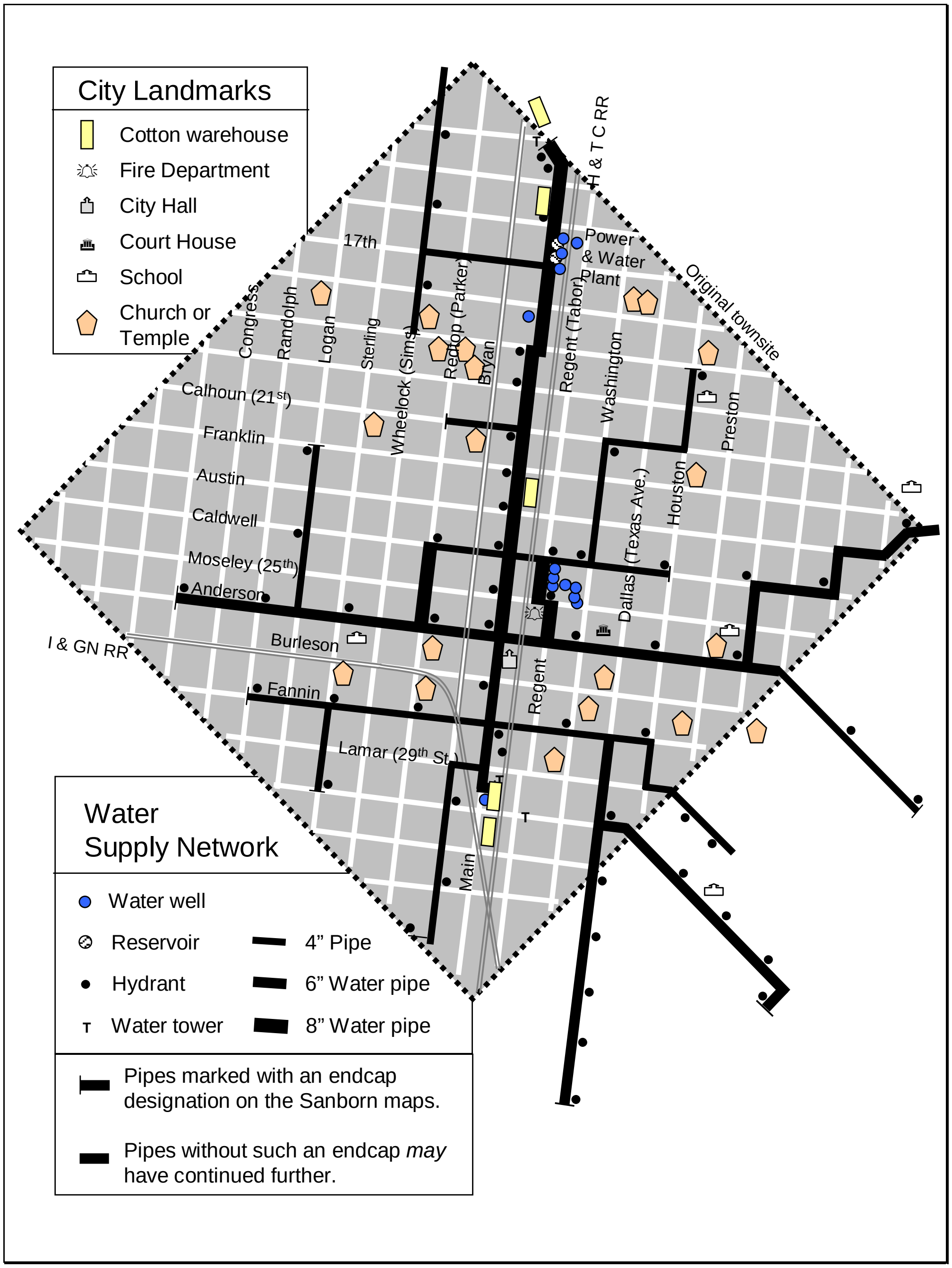

Figure 5.12. Water Supply Network for Bryan, Texas in 1925. The city has expanded its network of mains in all directions, just as its city limits were extended beyond the boundary of this map. The city is expanding toward the Agricultural and Mechanical College of Texas, now Texas A&M University, four miles to the south.

citizens would have liked, but there was certainly a distinct change in the landscape of its water supply. Sanborn maps issued for Bryan in 1896, 1901, and 1906 show relatively little change from the water distribution system represented in the 1891 map. Major changes occurred after the city purchased the original water plant in 1911 and immediately built a new waterworks at the north end of town. The changes are reflected in the June 1912 Sanborn map used to make Figure 5.11.[256] With the shift from private to public ownership, the appearance of the water supply system changed, although not as pronounced as with the introduction of the first water plant in 1889. By 1912, the old waterworks in the center of town was decommissioned, a new waterworks was supplied by new wells, water was stored in two new cement reservoirs, and the water main network was expanding, particularly to the south and east. The Agricultural and Mechanical College of Texas, today Texas A&M University, was located four miles to the south at College Station, and Bryan was expanding in that direction. Finally, for comparison purposes, I have included a map of Bryan's water supply network in 1925.[257] The city had by that time owned and operated its waterworks for more than a decade. Some growth in the system can be seen in Figure 5.12, but the water supply system remained largely unchanged from that represented in the previous map.

[256] Sanborn Insurance Maps, *Texas 1876-1970*, Digital, "Bryan, Texas, June 1912" (Ann Arbor, MI: Bell & Howell Information and Learning, c2001) http://sanborn.umi.com./ (accessed March 12, 2007).

[257] Sanborn Insurance Maps, *Texas 1876-1970*, Digital, "Bryan, Texas, July 1925" (Ann Arbor, MI: Bell & Howell Information and Learning, c2001) http://sanborn.umi.com./ (accessed March 12, 2007).

If Figures 5.9 through 5.12 do not persuade my reader that a fundamental change occurred in the water supply network associated with the opening of a waterworks, then possibly a summary table of waterworks specifications will. In Table 5.3 data about Bryan's water facilities from 1885 to 1925 is compiled from the legends of each Sanborn Insurance Map issued during this time period. This table indicates a fundamental change between no water system in 1885, and a water network only six years later with three miles of mains, 18 triple hydrants, 3 deep wells, a standpipe, pumps, and water pressure measured at 40 psi (increasing to 150 psi in case of fire). The next most obvious shift occurred between 1906 and 1912 when the number of hydrants almost doubled, the number of deep wells increased, storage capacity was increased for the first time since the inception of the waterworks, and the original pumps were replaced.

Table 5.3 and the maps in Figures 5.9 through 5.12 are strong evidence that the establishment of a waterworks in a Texas town altered the built environment. But if the built environment changed that dramatically, what about organizational and institutional elements in the cultural environment? Did they, too, overcome their inertial forces? By considering the case of Bryan specifically, and the story of Texas waterworks more generally, I would argue that they did.

Table 5.3. Water Facilities for Bryan, Texas Compiled from Sanborn Insurance Maps. Bryan's water facilities in 1885 were summed up by Sanborn in two words, "Not good." In 1889 a privately owned waterworks opened. When the second set of Sanborn maps for Bryan were published in 1891, the central business district was served by a 3 mile network of pipes and hydrants. Over the next 20 years, this network expanded slowly to the north along the rail line and to the southeast, upgrading 2 inch pipe to larger diameter water mains. In 1911, the city bought the waterworks and began major upgrades in supply, distribution, and pressure.

Sanborn Map	Miles of Mains	Number of Hydrants	Water Source	Water Storage	Delivery System	Water Pressure	Population	Ave. Daily Consumption
1885	0	0	Rain	5 cisterns			3,300	
1891	3	18 triple hydrants.	3 "deep" wells.	Stand pipe, 12'x100' w/ capacity of 85,000 gal.	2 Smith-Vaile duplex pumps, combined capacity of 1,000,000 gal/24 hrs.	40 psi. Can be increased to 150 psi.	3,500	
1896	3	18 triple.	1 deep well pump, water from 2 wells.	Stand pipe.	2 Smith-Vaile duplex pumps, same as 1891.	30 psi average. Direct pressure in case of fire.	4,000	
1901	3.5	18 triple.	1 deep well pump, water from 2 wells.	Stand pipe.	2 Smith-Vaile duplex pumps, same as 1891.	30 psi average. Direct pressure in case of fire.	4,500	
1906	4	19 triple.	1 deep well, water from 3 wells.	Stand pipe.	2 Smith-Vaile duplex pumps, same as 1891.	30 psi average. Direct pressure in case of fire.	4,600	
1912	4	36 triple, 3 double.	Three 6" wells, 265 ft deep.	2 concrete reservoirs and 85,000 gal stand pipe.	Gravity and direct pressure. 3 Lawrence 4" centrifugal pumps (250 gal/min).	45 lbs domestic pressure & 100 lbs direct fire pressure.	4,500	65,000 gal.
1925	6.5	64 triple, 3 double.	1 deep well & shallow wells.	2 reservoirs, w/ capacity of 240,000 gals each.	Direct pressure. 3 8" vortex pumps (250 gal/min, each) & 1 fire pump (150 gal/min).	90 psi at corner of 26th & Main for both domestic and fire pressure.	7,500	3,500,000 gal.

185

Certainly the organizational elements of a water system changed from the self-sufficiency of individual family units and merchants during the agrarian regime once waterworks were established. As the turbulent early history of Bryan's water plant demonstrates, the transition to water management by someone else was a traumatic one. Designing an efficient way to organize a waterworks, figuring out how to betterimplement that often contentious public-private partnership so prevalent in the early years of so many of Texas's waterworks, was a turbulent process. It was during the waterworks regime that many of today's public utilities developed their operating procedures. I think it is clear that organizational inertias from the agrarian water use regime were overcome and that water management was significantly altered by the introduction of waterworks. But what about Dodgshon's institutional inertias?

Changes in the ideas we carry around in our head about water supply and management are more difficult to quantify. Institutional ideas did change from the agrarian to the waterworks regime, but the change is more subtle than in organization or the built environment. During the agrarian regime water was perceived as abundant, although it was something that had to be provided for on a daily basis in every household, on every farm, plantation, or ranch, and in every business. It required attention daily by many different people across society. By introducing waterworks, the perception that water was abundant was reinforced, but acquiring it was no longer a daily chore. Instead, almost as an afterthought to fire protection, water became available from the tap. And the moment this happened, the moment someone outside the household was responsible for obtaining water, the perception of water was altered. Not only was water abundant; it was taken for granted. It was also wasted. This notice was posted by Bryan Water, Light & Power Company in the Bryan newspaper in 1902:

> Notice. Patrons of the Bryan Water, Light & Power Co., who continue the useless and extravagant waste of water, by turning it on and permitting it to run without holding the hose in the hand, (as required) for hours at a time and frequently all night depriving those on the same line from getting water for domestic purposes—will without further notice be cut out, if caught violating the rules again. We did hope that parties would stop wasting the water without being forced to use harsh means. Parties violating the rules would be surprised, yes, indignant if they were presented with a bill for the amount of water they use. Those who have meters running are exempt from this notice but will be expected to pay for all the water used. No person will be furnished with water to sprinkle—who does not use a meter. One dollar will be charged for cutting off, and one dollar for turning on.[258]

What was perceived as scarce during both the agrarian and waterworks regimes was capital. This accounts for a variety of different public-private partnerships because cities did not have the funds to establish and run waterworks on their own. Although I found records of 772 water bonds passed in Texas prior to 1931, cities were concerned about their ability to generate enough revenue to construct their own waterworks. During the early part of the Waterworks regime, bond money was used to purchase hydrants and hoses rather than to construct waterworks themselves. Cities contributed to monthly waterworks expenditures through monthly fees paid from taxes. Private companies contributed employees, property, and capital.

Now, what does this have to do with patterns of water use? During the waterworks regime water was increasingly used effectively for fighting fires. Sewerage systems were installed in cities, usually a few years after the establishment of the

[258] "Notice," *Bryan Morning Eagle*, 19 June 1902, p. 3.

waterworks. This is a topic on which a great deal more research could be done, but one which is beyond the scope of this dissertation. Water's use in power generation shifted from steam to hydroelectric. Water was used for irrigation as pump technology developed.[259] Irrigation became the single largest consumptive water use in the state, but the majority of irrigation in Texas was done from the Ogallala aquifer, outside the main study area of this dissertation. But the most significant aspect of this waterworks regime was simply reinforcement of the institutional inertia that water was not only abundant, but with the advent of waterworks, water was taken for granted.

When did the waterworks regime begin? Because the most critical element of the transition to the waterworks regime was in the mind of the user, it happened as soon as the newness of having access to tap water wore off. It has been well documented in this chapter that waterworks were established in Texas during the late nineteenth and early twentieth centuries in Texas, but it has also been documented that the early waterworks did not function as hoped, planned, or advertised. It seemed to take on the order of twenty years to put an effective waterworks into operation. For that reason an approximate date of 1900 may be assigned to mark the end of the transitional crisis and the start of the dam and levee regime.

[259] See Donald E. Green, *Land of the Underground Rain: Irrigation on the Texas High Plains, 1910-1970* (Austin, TX: University of Texas Press, 1973).

CHAPTER VI

THE DAM AND LEVEE REGIME

Flooding Along Texas Rivers

The need to mitigate the effects of floods and drought fundamentally reorganized Texans' way of thinking about water and led to a third water regime. The challenge was to control sudden, unexpected over-abundance and undersupply of water in the landscape.[260] During the agrarian regime, the family or plantation unit responded to floods in a self-sufficient way. A typical agrarian regime response was described by Dilue Harris as she recounted her family's first summer in Texas:

> By the 15th of June [1833], the Brazos and Colorado rivers overflowed, and the water extended from the Brazos to Buffalo Bayou. The crops were all lost. Not corn enough was raised to feed the people, and no cotton was raised that year. No boat came during the year. David Harris sent a schooner loaded with lumber to Tampico, Mexico, which brought back dry goods, but no provisions. It was many days before we got any flour. Soon times became hard. The steam mill was closed down, running only one day in the week to grind corn. That threw the men out of work, as sawing timber was the only branch of industry in the place. There was some corn raised on Buffalo Bayou and the Bay, but the main dependence of the people was on the Brazos farmers. They, the planters, didn't raise bread to feed their negroes. Father concluded to move. He rented a farm near Stafford's Point, about fifteen miles from Harrisburg on the Brazos.[261]

The Harris family had been in Texas only three months when they experienced wide-ranging consequences of Brazos River flooding and decided to settle elsewhere. It

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[260] "Brazos River Improvement," *Dallas Morning News*, 25 July 1899, p. 3 contains a letter from H. C. Eldridge to the Honorable Eugene Williams, chairman of the Brazos River Improvement Committee in which Eldridge recounts the repeated devastation from rising flood waters on the Brazos dating back to 1841. He suggested harnessing the river by storing flood waters in abandoned beds of the river so that the water could later be released for "irrigation and fish breeding."
[261] Harris, *Reminiscences*, 6.

was a simple solution, but a solution far less feasible by the end of the agrarian regime, when settlements and economic livelihoods were established. These inertial elements in the landscape made moving less of an option and the need to manage, rather than avoid, flood waters more necessary.

Meanwhile, the Brazos Valley had become an important supplier to the world cotton market. By the 1870s Texas had become the dominant cotton state, and it was on the fertile soil of the Brazos flood plain where some of the most prolific cotton production occurred.[262] Cotton production began around the Spanish missions and expanded rapidly after Austin's colony was established in the Brazos Valley in 1821. The number of acres planted in cotton increased, except during the Civil War period, until after the turn of the twentieth century. Cotton production rose steadily through about 1904, then began to fluctuate wildly around the levels of the early 1900s because of the boll weevil.[263] It has been estimated that Texas produced more than 180,000,000 bales by the mid-1920s, enough to clothe fifteen to twenty percent of the world's population. Almost half the population of Texas was estimated to be dependent upon cotton for their livelihood as late as 1934.[264]

Thus it was here that the devastation of flooding intensified, as both cotton production and population in the Brazos River valley increased during the latter half of

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[262] Peter J. Hugill, "The Macro-Landscape of the Wallerstein World-Economy: "King Cotton" and the American South," *Geoscience & Man*, 25 (30 June 1988): 77-84; Texas State Historical Association, *Handbook of Texas Online*, entry "Cotton Culture," http://www.tsha.utexas.edu/handbook/online/ (accessed March 10, 2007).
[263] Peter J. Hugill, *Cotton in the World-Economy: Geopolitics and Globalization Since 1771* (forthcoming).
[264] *Texas Almanac and State Industrial Guide* (Dallas, TX: A.H. Belo Corporation, 1936), 237.

the nineteenth century. Loss of the cotton crop had consequences beyond that of individual plantations. The floods of 1854, 1885, 1899, 1913, and 1921 were devastating to those who worked the Brazos River bottoms and to merchants, manufacturers and professionals in the towns that supplied them. By 1900, more than seven million acres was devoted to cotton production, most of it in the Brazos River Valley. When the Brazos was flooded during peak growing season in 1899, Texas was the leading cotton producing state in the country, producing 3,143,000 bales the preceding season. The total U.S. mill-grade cotton crop for the year was 11,180,000 bales, with Mississippi being the second ranking producer at 1,776,000 bales. The total output of mill-grade cotton for the *world* was only 12,200,000 bales in 1898.[265] Clearly cotton was the lifeblood of the Texas economy, particularly in the Brazos Valley, and when cotton planters sent petitions to the legislature demanding that something be done about flood control, the legislators were understandably disposed to listen.[266]

The response to flooding of prime cotton land was the construction of levees. The earliest levees were designed to protect a feature such as a barn by diverting water with a well-placed berm. Locally constructed levees were in place along parts of the Brazos and Trinity Rivers by the end of the agrarian regime, but they were no match for the river at flood stage.[267] Information on the nineteenth century levees is sketchy. They were constructed at the direction of individual landowners for the protection of specific

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[265] *World Almanac and Encyclopedia, 1900,* Vol. VII, No. 76 (New York: The Press Publishing Company, January 1900), 194-195.
[266] Shirlireed Walker, "Brazos and Navasota Rivers," in *Brazos County History: Rich Past—Bright Future,* ed Glenna Fourman Brundidge (Bryan, TX: Family History Foundation, 1986), 60-64.
[267] Walker, "Brazos and Navasota Rivers," 60-64.

elements of the landowner's property, as indicated by civil engineer W.F. Martin's criticism of this common practice:

> In the location of levees a general consideration of the public benefits to be derived from them should have first place. It has been too often true that local property holders receive the first consideration, and the alignment is such as to surround almost every cow-pen or horse-lot in its path. This results in sharp angles which give rise to increased cost of construction and maintenance and to enhanced exposure to injury. The levee should be as nearly parallel to the river as possible without too great a sacrifice of good alignment. Sharp angles are to be severely condemned, and all intersecting tangents should be connected by curves flat enough to admit the operation of a railroad on the crest.[268]

From this description it is clear that such levees were not continuous along extended stretches of the river, but were, rather, designed to alter the flow of flood waters around features of value in the landscape. Even though little is preserved from these first private levees, it is clear that individual property owners worked to protect their property from river flooding.

In 1908, farmers in southern Brazos County organized the construction of a levee on the east bank of the Brazos using the Griggs drainage law passed by the Thirtieth Legislature in 1907 as their enabling legislation.[269] Prior to that time, no legislative approval was necessary, but levees were built by private citizens. A three and a half mile section of levee had already been built on the John Rogers property in southern Brazos County that was intact and incorporated into the l908 levee.[270] In 1913, the State

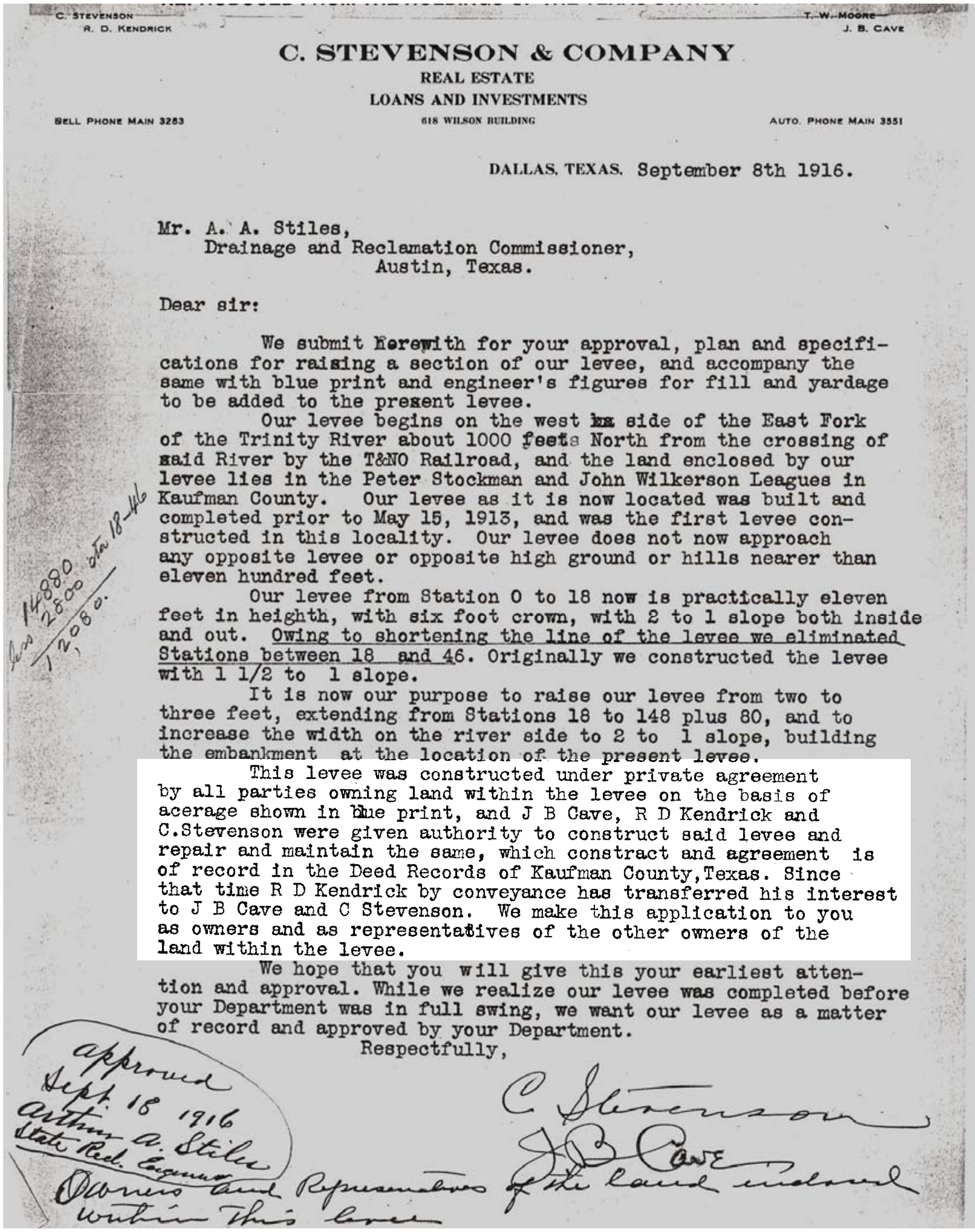
[268] W.F. Martin, "A System of Levees for the Brazos River Below Waco," (Civil Engineering Thesis: Austin, TX: The University of Texas, 1904), 9.
[269] *Gammel's Laws of Texas*, Vol. 13, General Laws of the State of Texas Passed at the Regular Session of the Thirtieth Legislature Convened at the City of Austin, January 8, 1907, pp, 78-91.
[270] "Brazos Farmers Building A Levee. Eight Thousand Acres Are To Be Protected From Overflow," *Dallas Morning News*, 27 August 1908, p. 19.

placed a Reclamation Engineer in charge of levees,[271] but some individual landowners still designed, constructed, maintained, and modified their own levees. This is evident in a 1916 letter from property owner C. Stevenson to the State Reclamation Engineer asking for the State's approval for a modification Mr. Stevenson planned to make to a levee on his property along the Trinity River (See Figure 6.1). The State's approval was not required since his levee had been in place prior to the Burges-Glasscock Act of 1913, but Mr. Stevenson wanted to have the consent of the State Reclamation Engineer on record anyway. The only government involvement in this particular levee at the time the letter was written, in 1916, was a handwritten stamp of approval from the State Reclamation Engineer acknowledging the landowner's personal flood control modification.[272]

Although such efforts by private citizens were still being carried out as late as 1916, the shift from purely private ventures to some form of government involvement in flood control was already gaining momentum in Texas. The flood of July 1899 was particularly devastating and influential. In his civil engineering thesis, written in 1904, W.F. Martin described the flooding: "In the late spring of 1899 occurred one of the most destructive floods, perhaps, in the history of the Brazos. At that time it was from 5 to 15 or 20 miles wide nearly all the way from its mouth to Waco, covering between one and two million acres to a depth varying from 5 to 30 feet, the larger part of which had

[271] The Burges-Glasscock Act established the Board of Water Engineers in 1913. Texas State Historical Association, *Handbook of Texas Online*, entries "Texas Water Commission" and "Levee-Improvement Districts," http://www.tsha.utexas.edu/handbook/online/ (accessed March 12, 2007.

[272] State Reclamation Engineer, "Kaufman County 1916 LID #10 Stevenson C et al. Correspondence CR," Texas State Library and Archives Commission.



C. STEVENSON
R. D. KENDRICK
T. W. MOORE
J. B. CAVE

C. STEVENSON & COMPANY
REAL ESTATE
LOANS AND INVESTMENTS
BELL PHONE MAIN 3283
618 WILSON BUILDING
AUTO. PHONE MAIN 3351

DALLAS, TEXAS. September 8th 1916.

Mr. A. A. Stiles,
Drainage and Reclamation Commissioner,
Austin, Texas.

Dear sir:

We submit herewith for your approval, plan and specifications for raising a section of our levee, and accompany the same with blue print and engineer's figures for fill and yardage to be added to the present levee.

Our levee begins on the west side of the East Fork of the Trinity River about 1000 feets North from the crossing of said River by the T&NO Railroad, and the land enclosed by our levee lies in the Peter Stockman and John Wilkerson Leagues in Kaufman County. Our levee as it is now located was built and completed prior to May 15, 1913, and was the first levee constructed in this locality. Our levee does not now approach any opposite levee or opposite high ground or hills nearer than eleven hundred feet.

Our levee from Station 0 to 18 now is practically eleven feet in heighth, with six foot crown, with 2 to 1 slope both inside and out. Owing to shortening the line of the levee we eliminated Stations between 18 and 46. Originally we constructed the levee with 1 1/2 to 1 slope.

It is now our purpose to raise our levee from two to three feet, extending from Stations 18 to 148 plus 80, and to increase the width on the river side to 2 to 1 slope, building the embankment at the location of the present levee.

This levee was constructed under private agreement by all parties owning land within the levee on the basis of acerage shown in blue print, and J B Cave, R D Kendrick and C.Stevenson were given authority to construct said levee and repair and maintain the same, which constract and agreement is of record in the Deed Records of Kaufman County,Texas. Since that time R D Kendrick by conveyance has transferred his interest to J B Cave and C Stevenson. We make this application to you as owners and as representatives of the other owners of the land within the levee.

We hope that you will give this your earliest attention and approval. While we realize our levee was completed before your Department was in full swing, we want our levee as a matter of record and approved by your Department.

Respectfully,

C. Stevenson
J B Cave
Owners and Representatives of the land enclosed within this levee

Approved Sept. 18 1916
Arthur A. Stiles
State Recl. Engineer

14880 sta 18-46
less 2800
12080

Figure 6.1. Letter Indicating Private Ownership of River Levee. The highlighted paragragh in this letter from property owner C. Stevenson documents the role that individual property owners initially assumed for the design, funding, and construction of levees for the protection of their personal property, and the handwritten note circled in the lower left hand corner signifies the State's unnecessary approval for the project. From the files of the State Reclamation Engineer, in the collection of the Texas State Library and Archives Commission.

growing crops."[273] The front page headline of the *Bryan Eagle* read, "A Terrible Flood. Nothing Like it Known for Years---Heavy Damages to Bridges, Fences, Crops and Land. Fifty Foot Rise on Brazos. All Other Water Courses on a Rampage---Trains Tied Up by Washouts and Business Suspended." Transportation infrastructure was rendered inoperable as railroad bridges around the state were washed out. Roads were so covered with quicksand and debris that horses had to be dug out of the mire.[274] Because the 1899 Brazos flood occurred in July, the entire cotton crop was destroyed, and it was too late in the growing season to replant. [275]

The flood of 1899 overwhelmed the patchwork system of individually built levees along the Brazos. The response was to consider a system of levees that was larger, more continuous and that would demand more extensive financial resources. Martin's statement that, "If such a system of levees shall ever be constructed, it will have to be done little by little, perhaps by counties largely,"[276] suggests that levee funding had, until that point, been provided by individual landowners. Further response to flooding would turn to the governor for help. Again in 1899, Bryan officials reported that, "Parties here communicated with the governor at Austin yesterday with a view to having the state executive make application to the authorities for aid for the flood

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[273] Martin, "A System of Levees for the Brazos River," 3.
[274] "A Terrible Flood. Nothing Like it Known for Years---Heavy Damages to Bridges, Fences, Crops and Land. Fifty Foot Rise on Brazos. All Other Water Courses on a Rampage---Trains Tied Up by Washouts and Business Suspended." *Bryan Eagle*, 6 July 1899, p. 1. In "Floods" vertical file of the Carnegie Library, Bryan, Texas; "Bryan Is Isolated. The Flood Situation is the Worst Ever Known in that County," *Dallas Morning News*, 3 July 1899, p. 2.
[275] "Brazos River Floods," *Dallas Morning News*, 5 July, 1899, p. 2;
[276] Martin, "A System of Levees for the Brazos River," 161.

sufferers in the Brazos, many persons in the flood district who were dependent upon their crops or labor for subsistence now being left without means of support."[277] Initial steps were even taken toward federal involvement. Martin reported that, "In the summer of 1900 the United States Geological Survey made a complete map of the river from its mouth up to Waco, a distance of 424 miles."[278] He went on to suggest, "Because the project would be too extensive and too costly to be undertaken all at one time if sections or intervals of the system were constructed by individuals or counties and proved a sufficient protection against inundation, it would be possible to invoke state and perhaps national aid to effect a completion of the system."[279] This, in fact, happened, although not before several decades passed.

Addressing Flooding with a Change in Scale

Organization at the scale of the federal government takes time, and inertial elements for negotiating such a change were not yet in place. A change in the scale of water management from the household level to the town had been accomplished through local organization and division of labor, as illustrated in Chapter V, and these attempts to solve the vexing problem of fire in the state's central business districts caused the transition from the agrarian regime to the waterworks regime. The solution involved making water available under pressure from the tap, and when this occurred, water was perceived not only as abundant, but also taken for granted. By the early twentieth

[277] "Request for Aid," *Bryan Eagle*, 13 July 1899, p. 5.
[278] Martin, "A System of Levees for the Brazos River," 3.
[279] Martin, "A System of Levees for the Brazos River," 161-162.

century the urgent need for a change in water management with regard to flooding and drought forced a similar change.

A significant response occurred at the State level in 1904. The Texas Constitution of 1876 had specifically prohibited the State from funding water projects by prohibiting the issuance of State bonds for water or reclamation projects.[280] During the late nineteenth century, limited programs for navigation improvement, drainage, and flood control could be authorized by special assessment at the county level, but this quickly proved inadequate to the magnitude of the problem. In 1904, a State constitutional amendment was passed that allowed the creation of special districts to oversee levee, navigation, and drainage projects. This amendment provided for the first public development of the State's water resources, and established water districts as the primary controlling government entity.[281]

In 1908, the Brazos again overflowed.[282] A series of articles in the *Dallas Morning News* made the point that flooding on the Brazos, Trinity, and Colorado rivers was no longer an unusual event; rather, it was unusual if a year went by *without* flooding. Many different solutions were proposed—building levees, increasing the width of the channels where the rivers flowed into the Gulf of Mexico, connecting rivers

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[280] Baker, *Building the Lone Star*, 142.
[281] Texas State Historical Association, *Handbook of Texas Online*, entry "Water Agencies and Programs," http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007). The wording of the amendment itself can be found here: "Have Three Changes: Text of the Proposed Amendments to Constitution of the State of Texas," *Dallas Morning News*, 6 November 1904, p. 6. The water amendment was ratified in an election held November 8, 1904. See "Constitutional Amendments, *Dallas Morning News*, 11 November 1904, p. 9; "Constitutional Amendments," *Dallas Morning News*, 12 November 1904, p. 3.
[282] *Dallas Morning News*, "Brazos Near Flood Stage," 16 May 1908, p. 10; *Dallas Morning News*, "Crest of Brazos Passes," 16 May 1908, p. 11; *Dallas Morning News*, "Fury of Flood at Waco," 16 May 1908, p. 3.

through a series of canals and reservoirs to store excessive runoff, and straightening the rivers so that water could exit the flood plain more quickly[283]—but it was the levee that seemed to hold the most promise to those in the midst of cotton country. In both Brazos and Burleson Counties, the scale of levee construction increased, from individual landowners funding levees along their personal river frontage to formal organizations with taxing authority and the goal of providing a significant measure of flood protection via more organized levee construction. In the next section, one such levee project is explored.

Burleson County Improvement District No. 1

The devastation caused by the Brazos flooding in the summer of 1899 has already been noted. In Burleson County the cotton crop was virtually destroyed. According to the *Caldwell News Chronicle*, the newspaper in Burleson's county seat,

> The following planters suffered a total loss of all crops: J.W. Moore, 2000 acres; W.S. Mial, 800 acres; Newsome Estate, 1,000; H. Kernole, 250; G.W. Smith, 400; Mrs. White, 2600; J.O. Chance 3000; Wm. Koppe, 3500; T.L. Botte, 3500; W.A. Bell, 800; J.W. Colter, 600; Bell Durham, 300; Oscar Seward, 300; J.W. Johnson, 275; A.M. Clay, 2000; Tony[,] Tom and Jim Jones, 400; Jim Dallas, 400; and numerous smaller holders, 2500 acres." Mitt and John Parker saved about half of the 5000 acres they had in cultivation; Dan Sims saved 200 acres of corn and 200 acres of cotton out of 1300 and Ewing and Bell saved half of their 200 acres.[284]

[283] Alonzo Wasson, "Texas Flood Losses May be Prevented," *Dallas Morning News*, 25-29 August 1908, p. 1.

[284] Bernadette Speckman and Caressa Inman, "The Brazos River Levee," undated typescript (Caldwell, TX; Burleson County Historical Society, c. 1976), p. 3, from the files of the Burleson County Historical Museum.

When the Brazos flooded again in May of 1908, most of these same cotton producers banded together to implement flood control measures stronger than those they had already undertaken individually. [285] They organized with the intent of building a continuous levee to protect 48,000 acres on the west bank of the river. Six men owned 30,000 of these acres; the rest was reportedly owned by fifty-five men.[286] A committee represented by major landowners J.E. Butler, James O. Chance, E.J. Fountain, and John K. Parker was chosen to petition the Burleson County Commissioners' Court to appoint an engineer to survey the proposed levee district. The petition was presented to the Court on July 14, 1908, and conditional approval to begin the project by hiring an engineer to survey the district was granted by the Commissioners a month later. The landowners provided funding for a district engineer until voters could approve bond money for the project.

It was recognized that although the Texas Constitution had been amended in 1904 to allow for the "improvement of rivers, creeks and streams to prevent overflows,"

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[285] With the exception of the Newsome Estate and H. Kernole, all of the 1899 property owners listed from the *Caldwell News Chronicle* quote above are included on the 1911 map of the Burleson County Improvement District No. 1 (See Plate 1), although the amount of acreage attributable to each landowner may vary. See also "Propose to Build Levee Thirty Miles in Length; Brazos Bottom Farmers Meet for Action at Bryan," *Dallas Morning News*, 31 May 1908, p. 29.

[286] Alonzo Wasson, "Burleson County Fighting Floods: Steps Taken by Brazos River Farmers to Protect Lands from Overflow. Drainage Act Insufficient," *Dallas Morning News*, 2 September 1908, p. 1. This suggests that no women were landowners in this area, yet a check of Nagle's 1911 map of the Burleson County Improvement District (See Plate 1) shows eleven women as landowners: Mrs. Gaynor-200 ac, Mrs. Lamplet/J.W. Dallas-no acreage total listed, but tract is estimated to be about 500 ac; Mrs. Kocourek-52 ac, Mrs. Bettis-126 ac, Mrs. Woods-1287 ac and Mrs. Woods-360 ac, Mrs. Anderson-105 ac, Dr. Holt or Mrs. Gillespie-181 ac, Lula E. Cole-380 ac, Annie Johnson-264 ac, Ida Shepard-264 ac, and Ella Call-264 ac. Assuming 50-50 ownership in the two cases that appear to be jointly owned by both a man and a woman, then women owned approximately 3642 acres within the Improvement District, or 20% of the 18,000 acres not controlled by the 6 largest landowners, called "planters" in the *DMN* article. Eleven women out of fifty-five "men" also represent 20% of the non-planter population of landowners in the District.

the only statute enabling such action was specifically related to drainage, not overflow. Concern over legal ramifications of possible damage to adjacent or downstream property due to river flow changes caused by a levee resulted in the urging of legislators to adopt a statute specifically authorizing improvements to prevent overflows.[287] This concern was overcome during the next session of the state legislature, when two improvements to the Griggs Drainage Act of 1907 were signed into law. One bill, sponsored by Representatives Lively, Buchanan, and Cox, established a State Levee and Drainage Board consisting of the Governor, Attorney General, and Commissioner of the General Land Office. This board was authorized to fill the new position of State Levee and Drainage Engineer. The second bill, sponsored by Representatives Buchanan, Davis, and Meeks, gave Commissioners' Courts authority to create improvement districts for the purpose of controlling overflow.[288]

With passage of this legislation resolving the legality of levee districts, W.S. Mial presented the signatures of fifty Burleson County landowners requesting the formation of a special levee district to the Burleson County Commissioners' Court on April 20, 1909. Although most of the landowners resided in the city of Bryan in adjacent Brazos County, Mial himself lived within the proposed levee district.[289] The

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[287] Alonzo Wasson, "Burleson County Fighting Floods: Steps Taken by Brazos River Farmers to Protect Lands from Overflow," *Dallas Morning News*, 2 September 1908, p. 1.

[288] "New Bills in Texas House: Two Measures Offered Look to Protection of Lands from Overflow and Provide for Certain Surveys," *Dallas Morning News*, 10 February 1909, p. 2; "Drainage and Levee Work in the Hands of a Board: They to Employ Engineer to Devise Plans for Work," *Dallas Morning News*, 14 February 1909, p. 5; "Reclaiming Texas Lands," *Dallas Morning News*, 24 February 1909, p. 6; "New Bills in Texas Senate," *Dallas Morning News*, 25 February 1909, p. 2.

[289] See "Propose to Build Levee Thirty Miles in Length; Brazos Bottom Farmers Meet for Action at Bryan," *Dallas Morning News*, 31 May 1908, p, 29 for reference to the fact that an organizational meeting

request was granted on May 22, 1909, and the Burleson County Improvement District No. 1 was established. Civil engineer J.C. Nagle, professor of engineering at the nearby Agricultural and Mechanical College of Texas, was immediately appointed to the position of District Engineer.[290] Nagle filed a report on May 31, 1909 calling for the construction of a 27 mile long levee. This was to be eight feet in height, with a slope of 2 to 1 on the river side, and 3 to 1 on the land side, and was to be built 200 to 1000 feet from the west bank of the river using 1,100,000 cubic yards of earth. The estimated cost of the levee was $210,320.00, plus $5,000 for the right-of-way and an estimated $8,412.80 per year for maintenance. The engineer's report was approved July 2, 1909. On July 26 of that year, in a vote of 175 to 0, Burleson County voters approved the issuance of 40 year bonds, at a rate of 5% interest, in an amount not to exceed $215,320.00 for the construction of the levee. W.S. Mial, A.L. Ewing, and R.S. Newsome were appointed drainage commissioners of the newly funded Burleson County Improvement District No. 1.[291]

This district covered fifty thousand acres and included most of the flood plain within the county. At the north end of the flood plain, only a small amount of the Parker

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for the levee occurred in Brazos County rather than in Burleson County because many of the affected landowners lived in Bryan. See Nagle's map of the Improvement District No. 1 in Plate 1 for the location of Mial's house near the southern corner of his 1172 acre tract.

[290] Speckman and Inman, "Brazos River Levee," 4-7. See also Burleson County Clerk, *Minutes of the County Commissioners' Court*, Vol. G, 20 April 1909, pp. 374-386; "A. & M. College News," *Dallas Morning News*, 22 August 1909, p. 8.

[291] Record of Organization: Burleson County Improvement District No. 1. Compiled by State Reclamation Engineer from Comptroller's records in Summer of 1913. From the collection of the Texas State Library and Archives Commission.

acreage was included, and at the south end of the flood plain the Clay tract was excluded. Several other large tracts, belonging to Gregg, Sims, Moore, Oldham, and Vidacardi were also excluded, although, excepting Vidacardi, all of these men owned tracts in the district.[292] To fund the district, property owners were levied $1.85 per $100 valuation on their land.[293] A map of the levee and Burleson County Improvement District No. 1 is shown in Figure 6.2. A more detailed map by District Engineer J.C. Nagle, including landowner information and acreage amounts, is included as Plate 1.[294]

The landowners of Burleson County were particularly vulnerable because of the unusual width of the Brazos flood plain in their county. The Brazos River is bounded by bedrock valley constrictions 125 km upstream from Burleson County at Waco, and 75 km downstream from Burleson County at Hempstead. Between these two cities, the river's flood plain widens to a width of 12.8 km as it flows between Burleson and Brazos Counties. An estimated 8500 years ago the Brazos went from a competent meandering stream to an underfit meandering stream with a narrow channel that occasionally changed its course rapidly. The channel's width at Burleson County today is only 150 meters. The two most recent channel avulsions are dated at 500 and 300 yr B.P.[295] At Burleson County, the channel is incised along the eastern edge of the flood plain leaving the Burleson side of the river vulnerable both to flooding and to a redirection of the

[292] See Plate 1.
[293] Speckman and Inman, "Brazos River Levee," 8.
[294] J.C. Nagle, "Map of Improvement District No. 1, Burleson County, Texas," collection of the Texas State Library and Archives Commission.
[295] Michael R. Waters and Lee C. Nordt, "Late Quaternary Floodplain History of the Brazos River in East-Central Texas," *Quaternary Research* 43 (1995): 311-319.

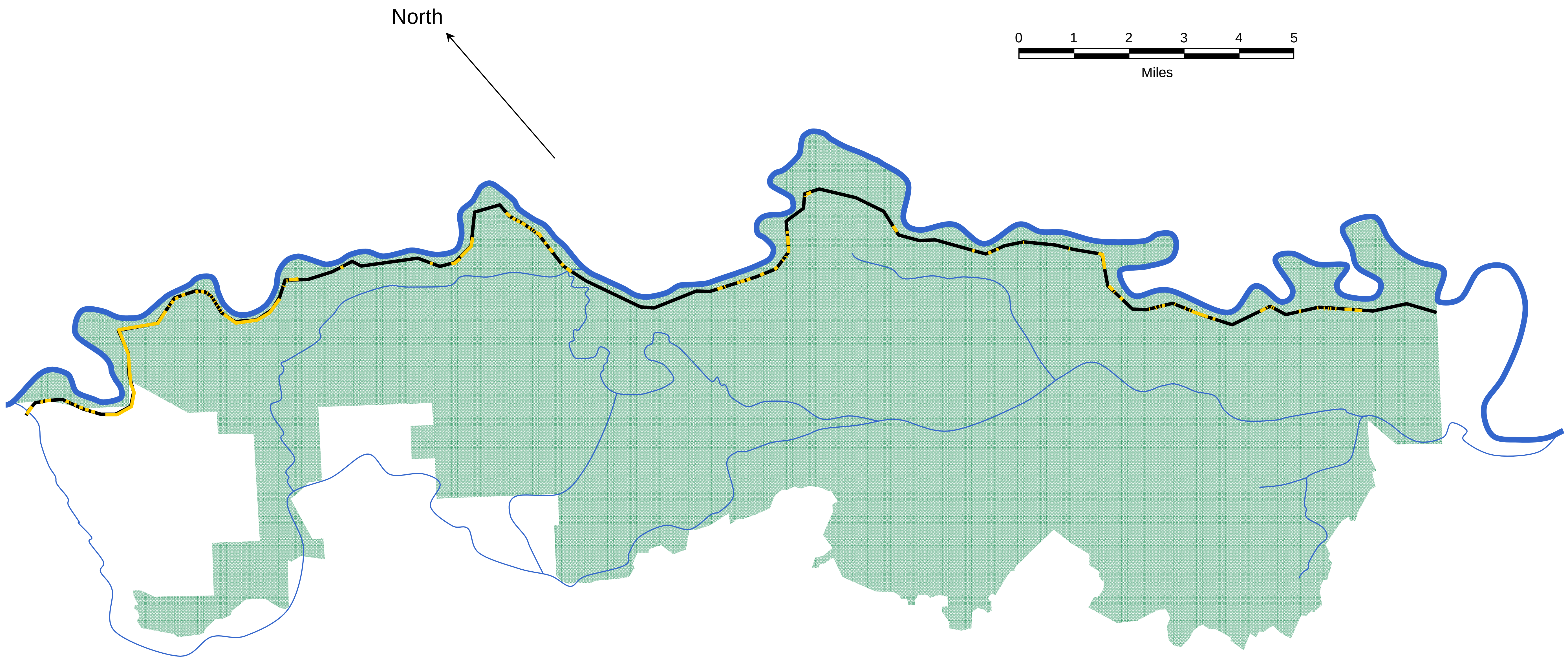

Figure 6.2. Burleson County Levee. The Burleson Improvement District No. 1, shown in green, was established by order of the county's Commissioners' Court in May 1909 after receiving a petition for its establishment signed by 50 landowners within the district. The district covered 79 square miles in the Brazos bottoms in eastern Burleson County. A 26-mile long levee, shown in black, was constructed along the west bank of the Brazos River in 1910, under the direction of a civil engineer. In December of 1913, major flooding washed over the top of much of the levee, breeching or partially washing out the levee at the locations shown in yellow. The levee was repaired, widened, and raised in height by three feet in 1914, only to be damaged again in the flood of 1921. The Brazos River flows from left to right on this map. This figure was compiled from a 1911 map of the Improvement District (See Plate 1), five 1914 profiles of the levee (See Plates 2, 3, 4, 5, and 6), and J.C. Nagle's 1914 Engineer's Report to the Commissioners of Burleson County Improvement District No. 1, all from the collection of the Texas State Library and Archives Commission.

river's course. The plan of the levee was to pin the river to the eastern limit of its flood plain between a man-made levee on its west bank and a natural topographic rise on its east bank. This is illustrated in the shaded relief map in Figure 6.3.

The Memphis, Tennessee firm of Stansell and Roach was hired to construct this levee[296] for a contract price of $178,000. The contract specified that no local labor could be hired without permission of the landowner upon whose land the laborer resided.[297] This effectively precluded the use of local labor in the construction of the levee. Instead, the contractors moved trainloads of men and equipment from Memphis, Tennessee to Bryan, Texas at the end of February 1910 in preparation for levee construction. One of the trains was fourteen cars long and hauled ninety laborers brought from Mississippi to Memphis and then on to Texas. Another train brought the contractors and bosses directly from Memphis. Their equipment included a twenty-seven team outfit, two large grading outfits, one hundred eight mules, ten road wagons, large plows, seventy-five scrapers, one hundred tents, cots and bedding for one hundred twenty-five, and several blacksmith shops. It took about a week to haul all the supplies from Bryan and set up the levee camp along the west bank of the Brazos in Burleson County.

[296] Burleson County Historical Marker located on the east side of Highway 50, 1.3 miles south of State Highway 21 in Burleson County, Texas.
[297] Speckman and Inman, "Brazos River Levee," 8. See also Burleson County Clerk,"Specifications for Construction," in Minutes of the County Commissioners' Court, Volume G, 1910, pp. 473-477.

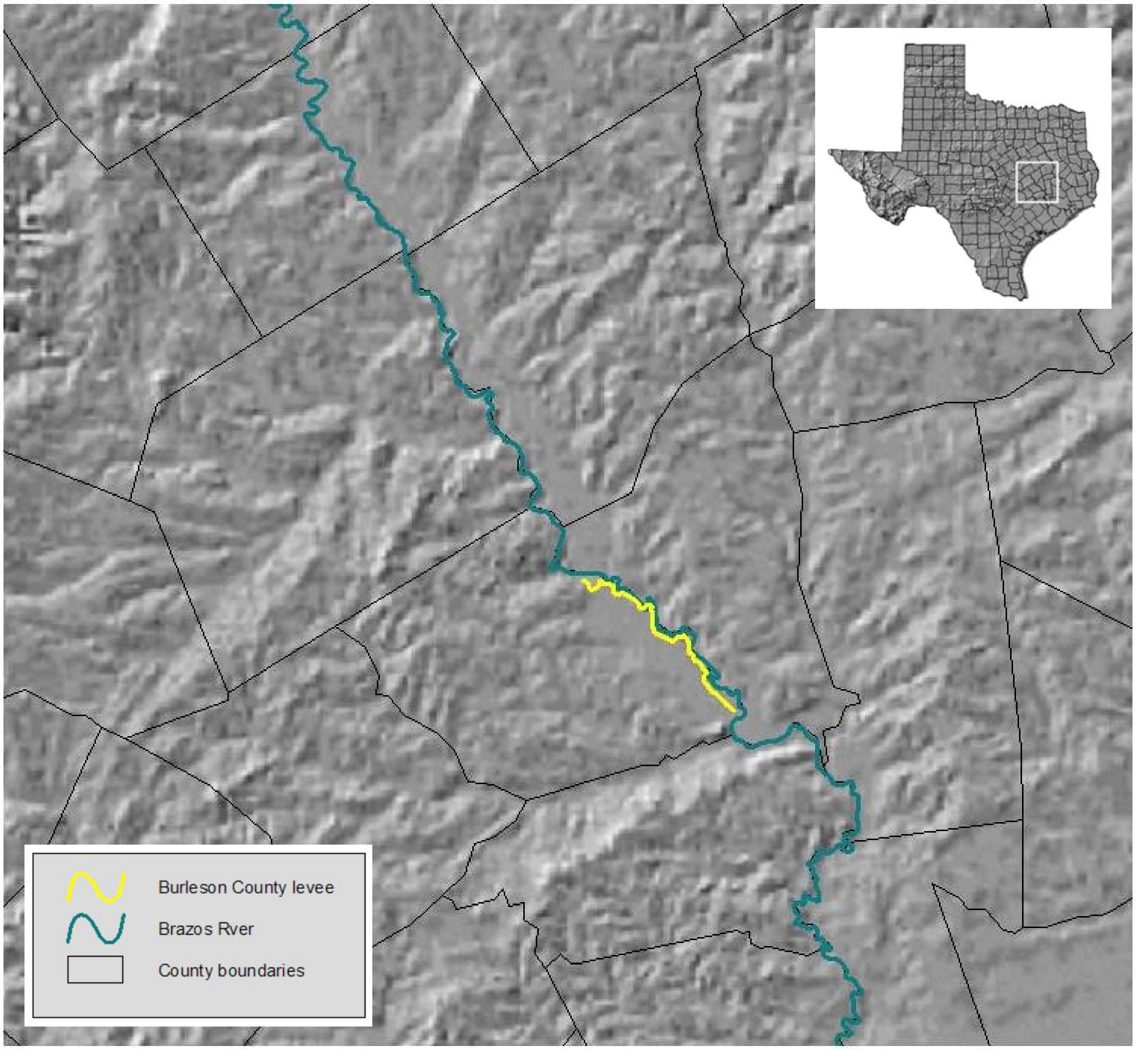

Figure 6.3. Brazos Valley Shaded Relief Map. The flood plain of the Brazos Valley widens through east central Texas. The Brazos River flows along the western edge of its flood plain until reaching Burleson County where it abruptly crosses its 5 mile wide flood plain to its eastern edge. From there it hugs the eastern side of the flood plain for most of the length of Brazos County. The Burleson County levee built in 1910 is shown in yellow. Its function was to keep the river pinned to the eastern edge of the flood plain, thereby preventing major flooding in the prolific cotton growing river bottom that comprised the eastern 20% of the county. The northern end of the levee, where the river crosses the floodplain, received the most significant damage in the first major test of the levee during the flood of December 1913. Hillshade and river shapefiles used to construct this figure are from of the Texas Water Development Board. The levee was digitized from 7.5 minute USGS topographic sheets and from the February 1911 Map of Improvement District No 1, Burleson County (See Plate 1.)

A glimpse into living conditions in the levee camp during 1910 can be gleaned from the collection of ballads and folk songs meticulously recorded by John A. Lomax and his son Alan Lomax.[298] Laborers were black and overseers were known for their harshness, in peonage conditions not far removed from slavery. Wages were low, and often withheld. A bell rang to call the men to breakfast well before dawn. They harnessed their mules and worked until the overseer finally allowed them to stop, often after dark,[299] as described in selected excerpts from the Levee Camp "Holler."

> We git up in the morning' so dog-gone soon,
> Cain' see nothin' but de stars an' moon.
> Um—m, cain' see nothin' but de stars an' moon.
>
> I looked all over de whole corral,
> An' I couldn't fin' a mule wid his shoulder well.
>
> Runnin' all aroun' de whole corral, Lawdy-Lawdy-Lawd,
> Tryin' to git de harness on Queen an' Sal.
>
> Cap'n, cap'n, what's de matter wid you?
> Ef you got any Battle-Ax, please, suh, give me a chew.
>
> Heered a mighty rumblin' down 'bout de water trough,
> Mus' been de skinner whoppin' hell out de walkin' boss.
>
> Cap'n got a 44 an' he try to play bad,
> Take it dis mornin' ef he make me mad.
>
> Cap'n, cap'n, will you sen' me some water?
> Ain' had none since dis long mornin',
>
> Lawd, de cap'n call me an' I answered, "Suh."
> "Ef you ain' gonna work, what you come here fuh?"

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[298] John A. Lomax and Alan Lomax, *American Ballads & Folk Songs* (New York: MacMillan, 1934) especially Chapter II: "The Levee Camp," 43-53.
[299] John Cowley, "Shack Bullies and Levee Contractors: Bluesmen as Ethnographers," *Journal of Folklore Research* 28, Nos. 2/3 (1991): 135-162.

> Cap’n, cap’n, doncha think it’s mighty hard?
> Work me all day on ‘lasses an’ lard, oh, Lawd.
>
> I got a clock in my stomach an’ a watch in my head,
> I’m a-getting’ superstitious ‘bout my hog an’ bread.
>
> I look at de sun an’ de sun look high,
> I look down on de boss-man an’ he look so sly.
>
> “Boss man, boss man, cain’ you gimme my time?’
> An’ de boss man say, “One day behin’.”
> Ask Cap’n George did his money come,
> Said, “De river too foggy, de boat won’ run.”[300]

To alleviate boredom and escape drudgery, the men bought liquor from the company store and roamed the camp at night, fighting viciously with razors. These drunken brawls impeded the men’s ability to report for work before dawn, so the contractor hired a boatload of women from Memphis, brought them to the Brazos river levee camp, and turned them loose.

> The two groups of men and women had never seen each other until they met on the river bank in Texas where the white levee contractor gave them the opportunity presented to Adam and Eve – they were left alone to mate after looking each other over. While her man built the levee, each woman kept his tent, toted the water, cut the firewood, cooked, washed his clothes and warmed his bed. [301]

The despair of the women living on the levee under these conditions was encapsulated in the blues song reluctantly sung for folk music collector John Lomax by a woman named Dink, only after she was plied with a bottle of gin from the local company store. Her sorrowful song was that of deep loneliness, despair, and unrequited love.

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[300] Lomax and Lomax, *American Ballads*, 43-52.
[301] Lomas and Lomax, *American Ballads*, 193.

Some folks say dat de worry blues ain' bad,
It's de wors' ol' feelin' I ever had.

Git you two three men, so one won't worry you min';
Don' they keep you worried and bothered all de time?

I wish to God eas'-boun' train would wreck,
Kill de engineer, break de fireman's neck.

I'm gwine to de river, set down on de groun',
Ef de blues overtake me, I'll jump overboard and drown.

Ef trouble was money, I'd be a millioneer,
Ef trouble was money, I'd be a millioneer.

My chuck grindin' every hole but mine,
My chuck grindin' every hole but mine.

Come de big *Kate Adam* wid headlight turn down de stream,
An' her sidewheel knockin'; "Great-God-I-been-redeemed."

Ef I feels tomorrow like I feels today,
Stan' right here an' look ten-thousand miles away.

My mother tol' me when I was a chil',
'Bout de mens an' whisky would kill me after while.

Ef I gets drunk wonder who's gwine carry me home,
Ef I gets drunk, wonder who's gwine carry me home.

I used to love you, but, oh, God damn you, now,
I used to love you, but, oh, God damn you, now.

De worry blues ain' nothin' but de heart disease,
De worry blues ain' nothin' but de heart disease.

Jes' as soon as de freight train make up in de yard,
Some poor woman got an achin' heart.

Tol' my mother not to weep an' mo'n—
I do de bes' I can, kase Ise a woman grown.

I flag de train an' it keep on easin' by,
I fold my arms, I hang my head an' cry.

When my heart struck sorrow, de tears come rollin' down,
When my heart struck sorrow, tears com rollin' down.

Worry now an' I won't be worry long,
Take a married woman to sing de worry song.

Ef I leave here walkin', it's chances I might ride,
Ef I leave here walkin', it's chances I might ride.[302]

Lomax later inquired about Dink and learned that she had died. [303]

In spite of the human toll, levee construction proceeded almost on schedule. Various news reports indicated the project was scheduled to be completed either by September 1st or by October 1st of 1910, a total construction interval of only four or five months.[304] Actual construction took several months longer than this, although at the end of September 1910 engineer James C. Nagle estimated the project would be completed by the middle of November that same year. It was, in fact, completed before the end of December 1910, as noted in the Engineer's Report of 1914.[305]

It was not long before the levee was tested. It had been thought both by those who proposed and those who designed the Burleson levee that the river would never again flood to the extent it had during the Great Flood of 1899. To this end the new levee was built two feet higher than the 1899 flood stage. But in December 1913, the Brazos rose four feet higher than it had in 1899. Because the flood occurred during

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[302] Lomax and Lomax, "Dink's Blues," in *American Ballads*, 193-194.
[303] John A. Lomax, *Adventures of a Ballad Hunter* (New York: Macmillan, 1947), 275.
[304] "Big Levee Project in Burleson County: Contract Let to Reclaim Thousands of Acres of Rich Land," *Dallas Morning News*, 25 February 1910, p. 1; "To Protect Fine Lands," *Dallas Morning News*, 25 February 1910, p. 1; "Grading Outfits Arrive: Special Trains Reach Bryan with Equipment for Levee Work," *Dallas Morning News*, 28 February 1910, p. 11.
[305] J.C. Nagle, Engineer's Report Submitted to the Commissioners of the Burleson County Improvement District No. 1, 26 May 1914, from the collection of the Texas State Library and Archives Commission.

winter, it did not destroy the cotton crop; however, it did wash away the cotton seed for the next season. It also washed away countless people and almost all livestock living in the Brazos Bottoms.[306] Furthermore, the levee itself is blamed for many of the flooding deaths because it held as the river rose, thereby providing a false sense of security to many in the flood plain who did not evacuate as the river began rising. It was not until the river went over the top that the levee was breached. Post-flooding assessment by District Engineer Nagle concluded that thirty percent of the levee was damaged and could be repaired for an estimated $100,000.[307] Assessment of the damage is detailed in the Engineer's Report Nagle sent to the Board of Commissioners of the Burleson County Improvement District No. 1 in May of 1914.[308] Included with this report were five levee profiles surveyed to locate damage from the flooding.[309] This damage information has been compiled and is presented in yellow along the crest of the levee in Figure 6.2. Damage at the northern end of the levee was heavy, particularly around a sharp meander known as Moelhman Slough.[310] This section of the levee not only abuts a sharp

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[306] For more detailed response to the flooding see "Flood Conditions Are Worst Ever Known," *Bryan Weekly Eagle*, 11 December 1913, p. 3; "Loss in Texas $4,000,000: Death Toll in Brazos and Trinity River Floods Is Fifty-Three," *New York Times*, 7 December 1913, p. 21; "Texas Flood Loss Calls for Relief," *New York Times*, 14 December 1913, p. 4; "Further Relief Work for Flood Sufferers," *Bryan Weekly Eagle*, 25 December 1913, p. 1; "Thanks Returned for Flood Relief," *Bryan Weekly Eagle*, 25 December 1913, p. 3; "Sumners Says We Need Help," *Bryan Weekly Eagle*, 8 January 1914.

[307] "J.C. Nagle to Inspect Flood District," *Bryan Weekly Eagle*, 25 December 1913, p. 3; "Confidence in Levees Cause of Flood Loss: Waters Break Over Top of Highest Man-Made Dikes: Twenty-Seven-Mile Levee Near Bryan Held Secure for a Time, but Is Damaged $100,000," *Dallas Morning News*, 22 December 1913, p. 2.

[308] J.C. Nagle, "Engineer's Report to the Board of Commissioners of Burleson County Improvement District No. 1, 26 May 1914, from the collection of the Texas State Library and Archives Commission.

[309] See Plates 2 through 6 of this dissertation. Plate 2 begins at the north end of the levee and each subsequent plate moves to the southeast.

[310] United States Geological Survey, "Tunis Texas" 7.5 Minute Topographic Sheet, 1962, photorevised 1989.

meander, but is also where the levee ran perpendicular to the river channel and was, therefore, subject to the full brunt of the downstream force of the river overflow as it funneled from the wide flood plain north of the levee into the narrow channel between the levee and the high eastern bank of the river.[311] Furthermore, at mile two, the levee actually created a trap for water coming downstream and may have added to river scour at that location. This is, in fact, the vicinity where the first levee break occurred.[312] The repair plan submitted by Nagle called for moving the levee several hundred feet back from the river and eliminating the sharpest corner of the levee just before mile 3,[313] but did not entirely remove this switchback from the levee plan—most likely because flood protection of as much of the Brazos Bottom land as possible was the goal of the levee.

In spite of its catastrophic failure, confidence in the levee as an appropriate form of flood control, and in the soundness of its design and construction methods, remained high. The source of this confidence may be traced to Mayor Scott of Navasota, a town east of the Brazos River a few miles downstream from the Burleson Improvement District, who was quoted as saying the levee held until water washed over its crest. The editors of the *Dallas Morning News* published this opinion:

> Mayor Scott's testimony is valuable to the cause of flood prevention. It proves, as we have said, the feasibility of providing absolute protection against

[311] See Figure 6.3. The most levee damage occurred where the river was moving across the flood plain from its location along the west bank upstream to its position along the east bank where the levee was built.
[312] "Confidence in Levees Cause of Flood Loss," *Dallas Morning News*, 22 December 1913, p. 2 reported that the first break was near Stone City. Texas State Historical Association, *Handbook of Texas Online*, entry "Stone City, Texas," http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007) reports that Moseley's Ferry was in the area near Stone City. Moseley's Ferry was also at the north end of the Burleson Levee.
[313] See dashed line representing proposed 1914 levee near Mile 3 on Plate 1.

> those ordinary and numerous floods that, in the aggregate, do more damage in the course of ten years than did this last flood. And it proves that we may even protect ourselves against such floods as we have recently suffered, a repetition of which will not, in all likelihood, occur in a generation, if at all. There is nothing in the experience of the last month to embarrass the cause of flood prevention. There is much, on the contrary, to promote that cause. The levees that broke ought to be repaired and made higher, and where there are no levees now, levees ought to be built, and in accordance with plans which will subordinate the question of cost to the requirements of engineering science.[314]

The washouts were repaired and the crest of the levee raised three feet.[315]

In spite of its inability to provide reliable flood control, the Burleson County levee has left its imprint on the landscape. The location of the levee is accurately recorded on the 1:24,000 Tunis, Chances Store, Wellborn, and Clay 7.5 minute topographic sheets, and on the 1:100,000 Bryan, Texas and Brenham, Texas 30 minute by 60 minute quadrangles, although the relief of the levee is not indicated by contours at either scale. To this day, the Burleson County tax appraisal records contain acreage classified as "levee."[316] In 1978, a historical marker commemorating the levee was placed along State Highway 50 where the levee is closest to a public highway. A remnant of the levee is less than one hundred yards from the marker, but is barely discernable because it has been plowed over and planted with crops. To the north of the marker along the north side of Moelhman Slough, a private road has recently been graded along the crest of the levee. Much of the levee remains relatively undisturbed. The original levee can be seen crossing County Road 277, formerly Batte's Ferry Road,

[314] "The Recent Flood and the Levees," *Dallas Morning News*, 24 December 1910, p. 10.
[315] See Plate 2, Profile of A Protection Levee Along the Brazos River, January 1914, from the collection of the Texas State Library and Archives.
[316] Burleson County Tax Appraisal Records, Map Room of the Burleson County Courthouse, 2006.

Figure 6. 4. Land Side of Original Burleson County Levee. View to the northeast on County Road 277, formerly Batte's Ferry Road. The levee is from mile 20 of the improvement project in a location that is largely intact from its original construction. The levee is 3 to 4 feet high. There is more vegetation on the river side of the levee than on the land side of the levee because water collects in the slightly lower borrow pit on its river side. The river is 750 feet beyond the levee. The original plan specified the levee would be constructed "on the west bank of river at a distance of 200 to 1000 feet in order to cut off bends and avoid caving banks."[317] Photo by the author.

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[317] Burleson County Improvement District No. 1, Record of Organization, created July 26, 1909 and compiled by State Reclamation Engineer from Comptroller's records in Summer of 1913, p. 1. From the Collection of the Texas State Library and Archives Commission.

Figure 6.5. River Side of Repaired Burleson County Levee. The earthen levee was constructed of soil dug from a borrow pit immediately adjacent to the levee and on its river side. At this location in mile 10 of the levee, the borrow pit is overgrown with vegetation that is distinct from the scrub brush and mesquite in the foreground. The borrow pit was originally 3 to 4 feet deep,[318] but is now 1 to 2 feet deep. The levee can be seen along the horizon, immediately behind the treeline that has grown up on its river side. Photo by the author.

[318] See Plate 2, Profile of a Protection Levee Along the Brazos River in Burleson Co. Improvement District No. 1, by J.C. Nagle, Improvement Engineer. January, 1914.

in Figure 6.4. The Brazos River is seven hundred fifty feet beyond the levee in this photograph. The river side of the levee, somewhat overgrown with trees, can be seen in Figure 6.5. Also visible is the borrow pit, the source of the earth used to build the levee. This borrow pit is several feet deep and runs the length of the levee on the river side. A cross-section of the levee and its borrow pit can be seen in Plate 2. In aerial photographs of the levee, the borrow pit is often filled with water.[319] In Figure 6.5 the borrow pit is filled uniformly with woody, spreading vegetation, identified as *sesbania drummondii*, growing to a height of four to five feet. This vegetation is clearly distinct from the scrub brush and mesquite on the flood plain adjacent to the borrow pit. *Sesbania* occurs in moist or wet soils in low lying areas near water.[320]

Although remnants of at least half the levee remain, it is breached at miles 4, 9, 13 to 15, 18, 22, and 24. The breach at mile 9 is the largest. There the river has changed course by almost a mile since 1911 (see Figure 6.6), and is about to change course again between points C and D. During the flood of 1913, the levee washed out east of point B. By 1916 the levee was repaired, after voters approved a reconstruction bond by a vote of 112 to 2.[321] By 1920, mile 9 was again in need of repairs because of the encroaching river bank, [322] and major flooding in September 1921 again destroyed the levee, flooding

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[319] See, for example, the Brazos County, Texas aerial photographs collection in the Evans Library of Texas A&M University with holdings from 1940, 1979, 1982, 1988, and 1994.
[320] Geyata Ajilvsgi, *Wildflowers of Texas* (Bryan, TX: Shearer Publishing, 1984), 184-185.
[321] Burleson County Historical Society, *Astride the Old San Antonio Road: A History of Burleson County, Texas* (Dallas, TX: Taylor Publishing Company, 1980), 43.
[322] See letter from J.C. Nagle to Major Arthur A. Stiles, State Reclamation Engineer, dated March 13, 1920 and District Engineer's Report from J.C. Nagle to the Board of Supervisors of the Burleson County Improvement District Number One, also Dated March 13, 1920. Both are from the collection of the Texas State Library and Archives Commission, Austin, TX.

Figure 6.6. Levee Breach at Mile 9. This is the largest of the Burleson levee breaches. The wide light green line represents the approximate channel of the river in 1910. The thin white line is the estimated location of the original levee. Both are taken from Nagle's 1911 map in Plate 1. The levee is still in place today from point A to point B and from C to D. The dark area lining the northern side of the trace of the levee between A and B and to the right of C is the borrow pit. Between B and C, the levee has been completely washed away by the river meander which has advanced to the right (southeast) almost a mile since the levee was first constructed in 1910. Satellite image is from Google Earth.

all 55,000 acres of the Burleson County Improvement District.[323] For all of their efforts, the landowners and residents of the Brazos flood plain in Burleson County were left with an ineffective flood control system, and debt that lasted until 1963.[324] It was time to think about flood control in a new way.

Addressing Flooding Through Water Conservation

By changing the scale of water management from household to local scale, and then from local to state scale, the possibilities for flood control expanded from diversion berms around individual features to levees that utilized civil engineering expertise and experienced Mississippi River levee construction contractors. Managing water at this scale held out the promise that entire watersheds could be managed, not just for flood control, but also for water conservation.

In 1902, the Brazos River Improvement Association was organized by D.C. Giddings of Brenham and Leonard Tillotson of Sealy for the purpose of Brazos flood control. This organization worked for the 1904 passage of the Texas Constitutional Amendment allowing the State's participation in water management projects, and endorsed the topographic mapping of watersheds in order to determine the best approach to flood control. In 1915, the Brazos River and Valley Improvement Association was formed by a group of Waco businessmen in conjunction with D.C. Giddings and Ward

[323] "Ten Lives Lost Outside of San Antonio and Taylor," *Dallas Morning News*, 13 September 1921, p. 5.
[324] Texas Historical Commission, "Brazos River Levee," Burleson County Historical Marker, 1978. Text of marker is available in Burleson County Historical Society, *Astride the Old San Antonio Road: A History of Burleson County, Texas* (Dallas, TX: Taylor Publishing Company, 1980), 121.

Templeman of Navasota to organize a regional approach to flood control in the Brazos Valley. Texas historian Kenneth Hendrickson reported the organizational meeting was held September 15, 1915, but that there was no evidence the Association's second meeting, planned for October 12-13th of that same year in Bryan, Texas, was ever held.[325]

I found evidence to the contrary. The Association did meet in Bryan, as scheduled. Fifty men from Waco under the leadership of W.W. Seley traveled to Bryan to meet with representatives from Marlin, Hearne, Bryan, Brenham, Navasota, Richmond, Angleton, Freeport, Hempstead, Bellville, Sugerland, Corsicana, and Calvert. Topics on the program included "Cost of Protection Levees and Their Effect Upon Land Values Along the Brazos River" by J.C. Nagle, and several presentations concerning river navigation as a way to promote trade and commerce. Water conservation was not listed on the program, but the general tenor was that citizens of the Brazos Valley should work together to secure resources of the federal government for the economic development of the watershed.[326] This Association is credited with influencing the passage of the Conservation Amendment to the Texas Constitution in 1917, [327] which allowed for the conservation of storm waters for beneficial uses such as irrigation and

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[325] Hendrickson, *Waters of the Brazos*, 12-14.
[326] "Brazos River and Valley Improvement Association: Permanent Organization formed at Bryan, Texas October 12-13, 1915 for the Prevention of Overflows and Promotion of Navigation, Proceedings of the Meeting, with Statistical Data From Various Authorities," from the collection of the Center for American History, University of Texas at Austin. "Program for Brazos Improvement Meeting: Fifty Waco Men to Leave for Bryan Monday Night," *Dallas Morning News*, 10 October 1915, Part 1 Page 6; "Discuss Improvement of Brazos at Bryan: Well-Known Men Deliver Addresses on Subject," *Dallas Morning News*, 14 October 1915, p. 2.
[327] Hendrickson, *Waters of the Brazos*, 14.

power generation. According to James Hays Quarles, secretary to the Board of Water Engineers, the birth of the conservation movement in Texas is attributable to the Brazos River Improvement Association's W.W. Seley, who began his work for the Association by encouraging protection via levees, but soon decided that conservation needed to come before protection.[328]

Support for conserving flood water, rather than protecting flood plains by means of a levee, received some of its earliest support in Texas from rice farmers. Rice farming came to southeast Texas from Louisiana by the 1880s, [329] and then moved west along the coast to the Lower Colorado River Valley, where a large-scale irrigation system was in place at Eagle Lake by 1899. [330] Rice growers pushed for legislation establishing the position of a State Engineer who would head a commission to develop, conserve, and appropriate water, and work with the federal government to design efficient irrigation systems.[331] In 1913, the Legislature re-wrote Texas water law and passed the Irrigation Act.[332]

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328 George McQuaid, "Conservation Plans Follow the Streams: Amendment to be Vitalized Built on Theory That Water Should Be Saved and Used," *Dallas Morning News*, 16 February 1918, p. 5.
329 Texas State Historical Association, *Handbook of Texas Online*, entry "rice culture," http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).
330 Baker, *Building the Lone Star*, 69.
331 George McQuaid, "Conservation of the Flood Waters: Movement to Store All Excess Rainfall of Texas for Irrigation Purposes: Coast Country Begins: Rice Growers of Matagorda County Urge Plan to Save Waters of Flood Time for Use When Needed," *Dallas Morning News*, 23 February 1911, p. 3; "Effective Control of Texas Irrigation: Texas Welfare Commission Indorses [sic.] Paper of Engineer W.L. Rockwell, For State Engineer, Urges Creation of That Office and of Commission; Also Co-operation with Federal Government," *Dallas Morning News*, 10 October 1912, p. 7.
332 Texas Water Development Board, *The Texas Water Plan* (Austin, TX: Texas Water Development Board, 1968), II-27.

By 1919, water engineers were advocating a shift in flood control strategy from protection by way of levees to conservation in reservoirs. In an address at the University of Texas, J.C. Nagle, back at the Agricultural and Mechanical College of Texas as Dean of Engineering at after his positions as District Engineer for the Burleson County Improvement District and then as chairman of the State Board of Water Engineers,[333] advocated the conservation of water by the impoundment of runoff for use in irrigation, generation of electricity, and municipal water supplies. Nagle argued that the economic benefits of capturing flood waters and releasing them gradually for beneficial use greatly outweighed the cost of a levee capable of withstanding flooding the magnitude of which had been experienced in the Brazos Valley in 1899 and 1913.[334] T.U. Taylor, dean of engineering at the University of Texas at Austin, had a similar idea. He expressed the opinion that the control of flooding could be accomplished by a combination of an expanded levee system and impoundments of flood waters for irrigation.[335] The State Reclamation Engineer, Arthur A. Stiles, in 1922 envisioned reclamation of the Brazos Valley through a combination of levees and "flood control works." By this he meant municipal reservoirs designed to impound water for domestic use, working in combination with water tanks constructed by railroads, farmers, and ranchers to

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[333] "Discuss Improvement of Brazos at Bryan: Well-Known Men Deliver Addresses on Subject," *Dallas Morning News*, 14 October 1915, p. 15.
[334] "Water Conservation Appeals to Texas: Nagle Tells University Men of Great Work That Awaits in Texas Streams. Preventing Overflows: Waste Is Seen in Allowing Storm Waters to Run Off and in Methods of Irrigating," *Dallas Morning News*, 11 May 1919, Sec: Part Two p. 2.
[335] "Control of Floods Big Issue in Texas: Much Already Is Accomplished Toward Reclamation of Lowlands," *Dallas Morning News*, 2 December 1922, Sec: One p. 3.

collectively reduce runoff, conserve water, and reduce flooding. Stiles' plan envisioned construction of reservoirs at a local scale. [336]

Others, though, were looking to expand the scale of flood water management, if for no other reason than to draw from a wider base to pay for the project. Funding in Texas had been by the property owners, usually though ad valorem taxes. The State had been prohibited from issuing bonds under its Constitution until 1904. Individual property owners tried to shoulder the burden, but flood control was a project too large in scope. By expanding the size of improvement districts to the scale of an entire watershed such as the Brazos, the financial burden was spread, and the economic benefits of flood control were realized by many. Thus, while some such as John Wesley Powell had advocated for watershed management of water resources for scientific reasons, in Texas organizing the management of the Brazos by its watershed was done for funding reasons because this engaged the largest number of taxpayers allowed under the state's constitution.[337] And because financing was a serious problem, impounding flood water that could be used to generate a salable product such as electricity or water for irrigation had growing appeal. Texans also started looking to the federal government for assistance.[338] When the Brazos River Conservation and Reclamation District was

[336] "Stiles to Attend Meeting in Bryan: Steps to Be Taken by Citizens for Flood Prevention," *Dallas Morning News*, 7 June 1922, Sec: One p, 5.

[337] A.D. Jackson, "Brazos River Body to Control Floods: Reclamation Association to Regulate Run-Off of Storm Waters. Many Are Joining: Counties in Watershed Half-Way Up Stream Expected to Be Members of Organization," *Dallas Morning News*, 7 July 1922, Sec: One p. 12.

[338] "Brazos River Flood Control Body Formed: Many Points Are Represented at Meeting Held in Waco. Seek Federal Air: Twelve Reservoirs and Four Hydro-Electric Plants in Project," *Dallas Morning News*, 26 August 1927, Sec: Part 1 p. 1.

founded in 1929, its primary function was flood control, but water allocation was also a consideration.[339] As predecessor to the Brazos River Authority, the first river authority in Texas—and in the nation[340]—its founding was a significant milestone in Texas' water management, whether its organizational motivation was scientific or economic.

Another significant expansion in the scale of water management for flood control took place at this same time. The first federal involvement in a Texas water project was with a dam on the Red River between Texas and Oklahoma near the city of Denison. Some wanted the project in order to increase navigation on the Red to connect North Texas to the Mississippi River, even going so far as to suggest connecting the Red River Improvement Project to Dallas via a shallow canal. But for most, the Denison Dam was viewed as a flood control project. This was significant in that it marked a shift from a federal flood control policy based upon levees, known as the Jadwin Plan, to a flood control policy utilizing reservoirs.[341] It also introduced the U.S. Army Corps of Engineers to flood control projects in Texas.[342] At the Twenty-Fifth annual Rivers and Harbors Congress in Washington, D.C., in December of 1929, almost every presentation urged the adoption of flood control by reservoirs rather than by levees. The appeal of reservoirs had clearly been growing for more than a decade because of the idea that water could then be conserved for beneficial purposes, in addition to providing a measure of relief from flood waters. But it was also a reaction to numerous levee

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[339] "Flood Control Meeting Called: Brazos River Association Will Plan Its Work," *Dallas Morning News*, 12 July 1929, Part 1 p. 3.
[340] Hendrickson, *Waters of the Brazos*, 14-16.
[341] "The Denison Plan," *Dallas Morning News*, 28 October 1929, Part 2 p. 14.
[342] See Appendix H.

failures, both in Texas and along the Mississippi. As Senator Elmer Thomas of Oklahoma said at the Rivers and Harbors Congress, "the levee plan of flood control is not a success. The experience of fifty years demonstrates the truth of this statement." [343]

Even after this fundamental change from levees to reservoirs in flood control, the influence of the levee was still visible. Because elevation change along Texas rivers is relatively gradual,[344] most reservoirs in the state are impounded with earthen dams. These dams have a shape similar to the earlier levees, as can be seen in Figure 6.7. Diagram A is a cross section of the Burleson County levee constructed to a height of seven feet in 1910, and rebuilt to a height of ten feet in 1914. It has a slope of three to one on the river side and two to one on the land side. Its crest is eight feet wide. This levee ran parallel to the river and was designed to channel flood water downstream. Diagram B is from a portion of that same levee designed to stop the flow of water across the Old River Slough channel, rather than simply channeling flood water downstream. It has a slope of three to one on both sides of its ten foot crest. Diagram C is from the dike along the side of the Somerville Reservoir, constructed in the mid-1960s in Burleson County. Its purpose is the same as that of the levee, to channel flood water downstream. It is not exposed to water, except under flood conditions. Although larger in every dimension than the levee in Diagram A, its shape is similar with slopes on both sides of

[343] Mark T. Goodwin, "Flood Control By Reservoirs Plan Favored: Red River Project Aired at Rivers and Harbors Congress Meeting," *Dallas Morning News*, 11 December 1929, p. 1.
[344] The Brazos River, for example, rises from the confluence of the Salt Fork and the Double Mountain Fork at an elevation of 1500 ft above sea level, nine hundred river miles to its mouth. Its descent decreases from an initial 3.5 ft/mi down to 0.5 ft/mi as it approaches the Gulf of Mexico. See Hendrickson, *Waters of the Brazos*, 1.

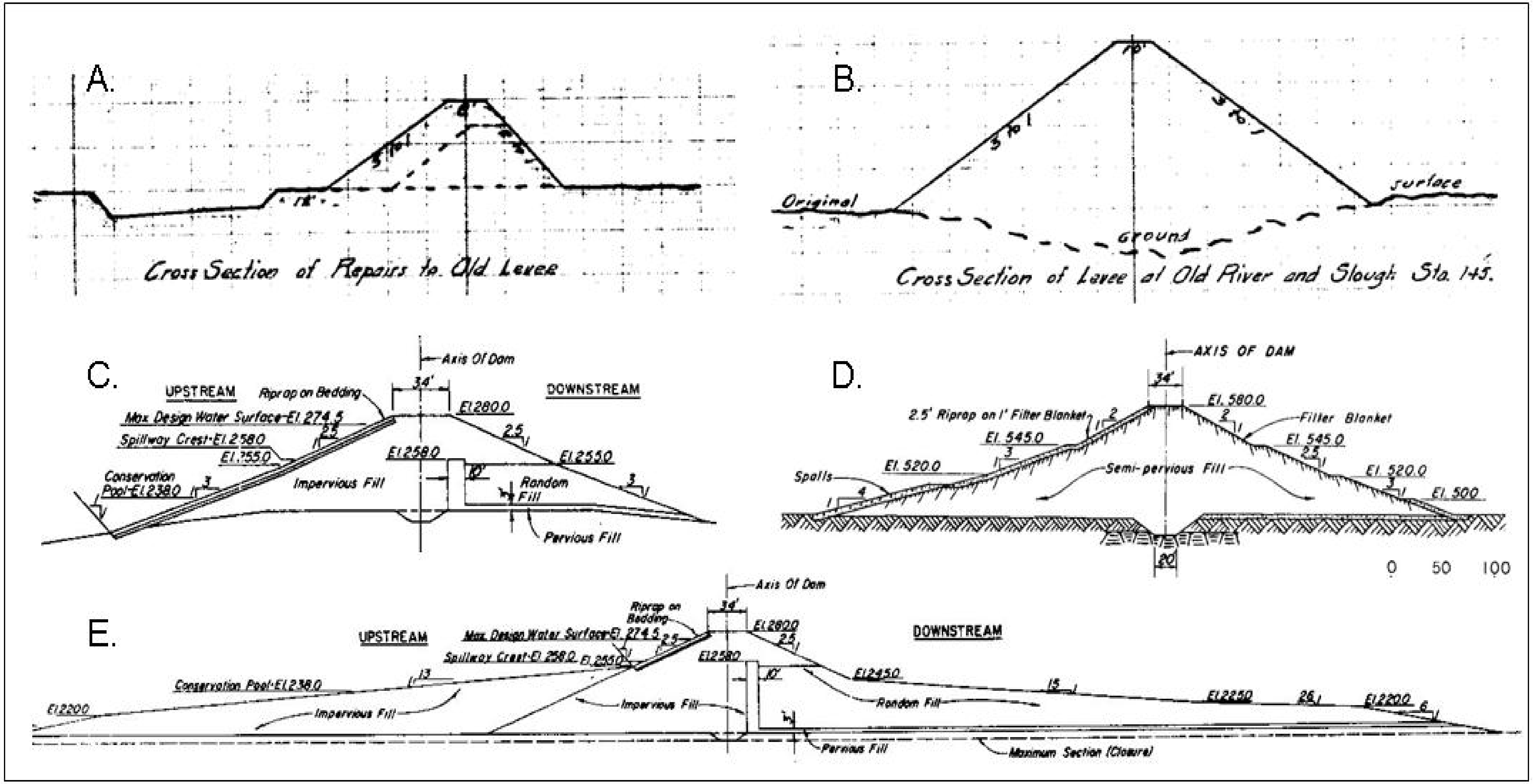

Figure 6.7. Comparison of Early 20th Century Levee to Mid-20th Century Earthen Dam. The basic design of early 20th century Texas levees and mid-20th century earthfill dams is similar. Technological advancements between the two are in soil science, the equipment used for construction, and in the scale of the project. **A**: Cross-section of Burleson County levee. Dashed line is 1910 levee and solid line shows the larger size of the repaired 1914 levee and its relationship to its borrow pit—the source of the soil for construction of the levee. This is designed to channel flood water downstream. **B**: Cross-section of same Burleson County levee in section designed to obstruct water flow as levee crosses Old River. **C**: Cross-section of dike embankment constructed in mid-1960s at Lake Somerville, also in Burleson County. As with the levee above it in A, this dike embankment is used only under flood conditions to channel water. It is larger, but with similar proportions to its earlier counterpart. **D**: Cross-section of the earthfill dam completed in 1951 at Lake Whitney. This dam's function is similar to that of the levee above it in B, except for the scale. The Lake Whitney dam is built across the main-stem of the Brazos River. **E**: Cross-section of the earthfill embankment dam across Yegua Creek at Lake Somerville between Burleson and Washington Counties. Just as with B and D above it, Somerville's dam is designed for constant water impoundment. Although its slopes are wider, having a slope of 15:1 in places as opposed to 2.5 or 3:1 in the earlier structures, its basic design is similar. Diagrams A and B are from Plate 2, from the Texas State Library and Archives Commission. Diagrams C, D, and E are from Dowell, C.L. and R.G. Petty, *Engineering Data on Dams and Reservoirs in Texas, Part II*, Report 126 (Austin: Texas Water Development Board, 1971), 12-18.0-B and 12-29.0-B. Drawings are not to scale.

three to one at its base and two and a half to one near its crest. The Lake Whitney dam in Diagram D was built in 1951 across the main stem of the Brazos. It impounds water on a much larger scale than the levee across Old River illustrated in Diagram B, but is designed with similar proportions. Its sides have variable ratio slopes, ranging from between four to one at the base of the impounding side, to two to one near the crest of the impounding side and three to one at the base of the downstream side, to two to one near the crest of the downstream side. It, too, has a flat crest. Its sides are reinforced with riprap. The main dam at Lake Somerville (See Diagram E) is noticeably wider than the dam at Lake Whitney, built fifteen years earlier, even though the Somerville dam impounds Yegua Creek, a tributary of the Brazos, and Lake Whitney impounds the Brazos River itself.

Although their shapes are remarkably similar, there are distinct technological advances that distinguish the newer earthfill dams from the earlier levees. The first is improved construction materials as a result of advancements in soil science.[345] In Figure 6.7 Diagram A, the soil used to build the levee came from the borrow pit on the construction site between the river and the newly created levee. It is represented by the forty foot wide and two to three feet deep pit in the cross section. The levee was constructed by moving earth from the base of the levee to its crest, an average distance of seventy-five feet (See Plate 2). The soil used for construction was the most convenient soil, but not necessarily the most appropriate in terms of its physical

[345] Peter J. Hugill, *Cotton in the World-Economy: Geopolitics and Globalization Since 1771* (forthcoming).

properties. By the time the earthfill dams were constructed, it was recognized that soil mechanics and soil permeability needed to be engineered into the design to lower the risk of dam failure.[346] This is hinted at in Figure 6.7, where impervious, semi-pervious, and random fills are specified for different parts of the earthfill dam. The second technological advancement is in construction techniques.[347] The levees were constructed by laborers using mule powered scrapers; the dams were constructed with diesel-powered earth moving equipment.

There are now over two hundred dams in Texas with the capacity to impound more than five thousand acre-feet of water, more than ninety percent of which are earthfill. See Table 6.1 for specifications on the dams' lengths, elevations, heights, top widths, latitude and longitude of each dam's center point, the stream or river impounded, name of the associated reservoir, completion date, estimated cost, and type of spillway noting whether overflow is controlled or uncontrolled. Controlled overflow is typically by gates, frequently rotating tainter gates.

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[346] Hugill, *Cotton in the World-Economy* (forthcoming).
[347] Hugill, *Cotton in the World-Economy* (forthcoming).

Table 6.1. Dams on Texas Reservoirs Designed to Impound More than 5,000 Acre-Feet of Water. The majority of these dams are earthfill construction with both an embankment to impound water and a spillway for overflow that is either controlled or uncontrolled. Flow is controlled by means of gates that can be raised or rotated to control the rate at which water moves downstream. Some reservoirs also have an emergency spillway for overflow greater than can be handled through the gates. The year listed is the year the dam was completed. The latitude and longitude coordinates are for the center of each dam and have been listed in decimal degrees. The dam and reservoir name, date, length, elevation of the top of the dam, coordinates, and stream supplying the impounded water are courtesy of the Texas Water Development Board. Latitude and longitude data not provided by the Texas Water Development Board were extracted from Google Earth. Dam type, height, width of the top of the dam, spillway type, and cost estimates are from Dowell, C.L., and R.G. Petty, *Engineering Data on Dams and Reservoirs in Texas, Parts I, II, and III*, Report 126, Austin: Texas Water Development Board, 1971. This information is supplemented by websites maintained by the U.S. Army Corps of Engineers, the Brazos River Authority, and the Lower Colorado River Authority.

Dam Name	Reservoir Name	Year	Dam Type	Dam Length (Ft)	Dam Top Elev (Ft)	Dam Height (Ft)	Top Width (Ft)	Dam Latitude	Dam Longitude	Spillway	Stream	Est Cost ($)
Addicks Dam	Addicks Reservoir	1948	Earthfill	61,166	123	49	Varies	29.7917	-95.6233	5 concrete conduits w/ vertical slide gates	South Mayde Creek	5,248,200
	Alan Henry Reservoir	1994		4,150	2,263			33.0700	-101.0500		South Fork of the Double Mtn Fork Brazos River	
Aloca Dam	Alcoa Lake	1952	Earthfill	5,430	475	50	15	30.5750	-97.0483	Concrete w/ 2 tainter gates	Sandy Creek	
	Alders Reservoir							29.9267	-94.7900		Big Caney Creek	
Anzalduas Diversion Dam	Anzalduas Channel Dam	1960		524	106			26.1370	-98.3340		Rio Grande River	
	Aquilla Lake	1983		11,800	583			31.9133	-97.2083		Aquilla Creek	
Town Bluff Dam	B A Steinhagen Lake	1951	Paved earthfill	6,698	95	45	25	30.7667	-94.1500	Concrete ogee w/ 6 tainter gates	Neches River	8,749,000
Bardwell Dam	Bardwell Lake	1965	Earthfill	15,400	460	82	20	32.2778	-96.6167	Broadcrested weir	Waxahachie Creek	
Barker Dam	Barker Reservoir	1945	Earthfill	71,900	115	36.5	Varies	29.7700	-95.6467	5 concrete conduits w/ vertical slide gates	Buffalo Bayou	4,530,000
Baylor Creek Dam	Baylor Lake	1950	Earthfill	3,383	1,829	66	16	34.4767	-100.3717	Open channel cut	Baylor Creek	

Table 6.1 Continued

Belton Dam	Belton Lake	1954	Earthfill	5,524	662	192	30	31.0833	-97.4833	Broadcrested weir	Leon River	13,804,000
Benbrook Dam	Benbrook Lake	1950	Earthfill	9,130	747	130	20	32.6500	-97.4333	Ogee w/ notch	Clear Fork Trinity River	12,000,000
Bivins Dam	Bivins Lake	1927	Earthfill	1,600	3,640	48	20	35.0367	-102.0267	Earth w/ riprap	Palo Duro Creek	117,268
Brady Creek Dam	Brady Creek Reservoir	1963	Earthfill	8,400	1,783	104	36	31.1400	-99.3917	Drop inlet	Brady Creek	1,075,600
Brandy Branch Dam	Brandy Branch Cooling Pond	1983		3,560	351			32.4300	-94.4850		Brandy Branch	
Brazoria Dam	Brazoria Reservoir	1954	Variable height levee	40,000	35	16 ft average	14	29.0683	-95.5283	Box type concrete structure thru levee	N/A	1,500,000
	Bryan Utilities Lake	1974		20,000	373			30.7083	-96.4517		Unnamed Tributaries Brazos River	
Umbarger Dam	Buffalo Lake	1938	Earthfill	882	3,662	37	15	34.9217	-102.1000	Concrete ogee	Tierra Blanca Creek	
Caddo Dam	Caddo Lake	1968	Earthfill		176	36	30	32.6944	-94.0500	Broadcrested weir	Cypress Bayou	3,173,609
Calaveras Creek Dam	Calaveras Lake	1969	Earthfill	6,000	498	70	24	29.2783	-98.3050	Concrete ogee w/ 5 tainter gates	Calaveras Creek	19,650,000
Camp Creek Dam	Camp Creek Lake	1949	Earthfill	1,855	325	49	15	31.0617	-96.2867	Drop inlet	Camp Creek	116,000
Canyon Dam	Canyon Lake	1964	Earthfill	6,830	974	224	20	29.8500	-98.2000	Broadcrested uncontrolled	Guadalupe River	20,795,000
Country Club Dam	Casa Blanca Lake	1951	Earthfill	5,000	467	76	20	27.5333	-99.4483	Excavated channel	Chacon Creek	
	Cedar Bayou Generating Pond	1972		21,750	10			29.7550	-94.8183		Cedar Bayou	
Cedar Creek Dam	Cedar Creek Reservoir Colorado	1977		15,259	401			29.9157	-96.7361		Cedar Creek	
Joe B. Hogsett Dam	Cedar Creek Reservoir Trinity	1966	Earthfill	17,539	340	91	20	32.1400	-96.0800	Concrete chute w/ 8 tainter gates 6 mi upstream	Cedar Creek	20,500,000
Champion Creek Dam	Champion Creek Reservoir	1959	Earthfill	6,800	2,109	114	20	32.2817	-100.8600	Cut channel	Champion Creek	
	Choke Canyon Reservoir	1982		18,504	241			28.4850	-98.2450		Frio River	
Coffee Mill Dam	Coffee Mill Lake	1938	Earthfill	3,680	507	27	16	33.7350	-95.9500	Concrete weir	Coffee Mill Creek	
	Coleto Creek Reservoir	1980		19,300	120			28.7233	-97.1500		Coleto Creek	

Table 6.1 Continued

	Cox Lake / Raw Water Lake / Recycle Lake	1956			10			28.6608	-96.5440		Cox's Creek	
Delta Dam	Delta Lake	1939	Earth dike	63,360		17		26.4300	-97.9367	None.		
Robert Lee Dam	E V Spence Reservoir	1969	Earthfill	21,500	1,928	140	21	31.8950	-100.5150	Drop inlet	Colorado River	9,315,000
Eagle Lake Dam	Eagle Lake	1900	Earthfill	5,300		6		29.5706	-96.4017	Concrete structure w/ stop logs	Moores Branch	
Eagle Mountain Dam	Eagle Mountain Lake	1932	Earthfill	4,800	682	85	25	32.5200	-97.2800	Concrete ogee w/ gates	West Fork Trinity River	3,637,000
	Eagle Nest Lake / Manor Lake	1949						29.2207	-95.5893		Brazos River	
Ellison Creek Dam	Ellison Creek Reservoir	1943	Earthfill	4,000	280	48.5	18	32.9183	-94.7250	Concrete & natural embankment	Ellison Creek	
Fairfield Dam	Fairfield Lake	1969	Earthfill	4,350	322	77	25	31.8183	-96.0417	2 tainter gates at end of dam	Big Brown Creek	2,600,000
Farmers Creek Dam	Farmers Creek Reservoir	1960	Earthfill	3,720	847	77	20	33.8833	-97.6517	2 level 3 section uncontrolled	Farmers Creek	1,100,000
Forest Grove Dam	Forest Grove Reservoir	1980		3,886	376			32.2270	-95.9629		One Mile Creek	
	Gibbons Creek Reservoir	1981						30.6100	-96.0617		Gibbons Creek	
Laneport Dam	Granger Lake	1979	Earthfill	16,320	555	115	30	30.7033	-97.3000	Ogee uncontrolled	San Gabriel River	52,300,000
Grapevine Dam	Grapevine Lake	1952	Earthfill	12,850	588	137	28	32.9500	-97.0500	Ogee	Denton Creek	11,753,000
Greenbelt Lake	Greenbelt Lake	1968	Earthfill	5,800	2,686	110	20	35.0017	-100.8933	Drop inlet	Salt Fork Red River	1,800,000
	Gulf Coast Water Authority Reservoir	1948			25			29.4400	-94.9850			
Hords Creek Dam	Hords Creek Lake	1948	Earthfill	6,800	1,939	91	24	31.8500	-99.5667	Broadcrested uncontrolled	Hords Creek	2,857,000
Houston County dam	Houston County Lake	1966	Earthfill	1,250	277	63	20	31.4067	-95.6050	Drop inlet & broadcrested weir	Little Elkhart Creek	500,000
Hubbard Creek Dam	Hubbard Creek Reservoir	1962	Earthfill	15,150	1,208	112	20	32.8283	-98.9633	Drop inlet & broadcrested weir	Hubbard Creek	7,697,089
Fish Creek Dam	Hubert H Moss Lake	1966	Earthfill	1,460	740	93	17 to 40	33.7733	-97.2133	Drop inlet	Fis Creek	671,000
	Imperial Reservoir	1915						31.2617	-102.8467		Imperial Ditch	

Table 6.1 Continued

Roy Inks Dam	Inks Lake	1938	Concrete gravity	1,458	919	96.5	16.5	30.7300	-98.3850	Uncontrolled gravity section of dam	Colorado River	2,079,738
International Amistad dam	International Amistad Reservoir	1969	Earthfill & concrete	32,000	1,152	254	35	29.4333	-101.0583	Ogee crest on concrete section w/ 16 tainter gates	Rio Grande River	61,021,000
International Falcon Dam	International Falcon Reservoir	1954	Earthfill & concrete	26,294	323	153	35	26.5583	-99.1500	Concrete ogee w/ 6 wheel type gates	Rio Grande River	46,065,000
Compartment levees	J D Murphree Wildlife Impoundment	1964	Earth levees	211,200	5	4 to 6 ft	8	29.8028	-94.1917	None.		600,000
Cooper Dam	Jim Chapman Lake	1991	Earthfill	28,072	465	73	20	33.3356	-95.6361	Ogee w/ 5 gates	South Sulphur River	
	Joe Pool Lake	1991		24,200	565			32.6450	-96.9933		Mountain Creek	
Johnson Creek Dam	Johnson Creek Reservoir	1961	Earthfill	2,530	296	60	20	32.8400	-94.5483	Drop inlet	Johnson Creek	338,000
Abilene Dam	Lake Abilene	1921	Earthfill	5,040	2,024	61	16	32.2350	-99.8883	Masonry and natural earth uncontrolled	Elm Creek	212,000
Amon G. Carter Dam	Lake Amon G Carter	1956	Earthfill	2,540	938	71	20	33.4683	-97.8650	Drop inlet	Big Sandy Creek	320,046
Anahuac Dam	Lake Anahuac	1954	Earthfill	5,900	9	10	8	29.7756	-94.6875	Part of levee, uncontrolled	Turtle Bayou	N/A
Lake Arlington Dam	Lake Arlington	1957	Earthfill	6,482	572	83	24	32.7217	-97.1983	Drop inlet	Village Creek	3,833,710
Lake Arrowhead Dam	Lake Arrowhead	1966	Earthfill	15,900	944	62	25	33.7617	-98.3500	Concrete ogee weir	Little Wichita River	12,500,000
Lake Athens Dam	Lake Athens	1963	Earthfill	3,000	453	67	20	32.2050	-95.7233	Drop inlet	Flat Creek	361,000
Tom Miller Dam	Lake Austin	1939	Concrete gravity overflow	1,590		85		30.2950	-97.7867	Concrete ogee w/ 9 tainter gates	Colorado River	3,479,309
	Lake Ballinger / Lake Moonen	1984			1,702			31.7584	-100.0434		Valley Creek and Quarry Creek	
Balmorhea Dam	Lake Balmorhea	1917	Earthfill	4,000	3,192	46		30.9583	-103.6717	Right end of dam	Sandia Creek	121,710
Bastrop Dam	Lake Bastrop	1964	Earthfill	4,000	458	85	20	30.1550	-97.2917	Concrete ogee weir w/ 2 tainter gates	Spicer Creek	2,107,000
Fort Sherman	Lake Bob Sandlin	1978	Earthfill	5,650	349	69	25	33.0750	-95.0017	Concrete ogee w/ 4 tainter gates	Big Cypress Creek	16,104,000
Timber Creek Dam	Lake Bonham	1969	Earthfill	4,860	584	70	18.5	33.6517	-96.1300	Drop inlet	Timber Creek	500,000

Table 6.1 Continued

Bridgeport Dam	Lake Bridgeport	1931	Earthfill	2,040	874	130	16	33.1400	-97.5000	Channel to concrete ogee with 8 vertical gates	West Fork Trinity River	2,316,000
Brownwood Dam	Lake Brownwood	1933	Earthfill	1,580	1,450	120	21	31.8383	-99.0017	2 concrete conduits	Pecan Bayou	
Buchanan Dam	Lake Buchanan	1938	Multiple concrete arch, gated & gravity	10,987	1,025	145.5	Varies	30.7517	-98.4183	3 sections w/ tainter gates	Colorado River	10,397,475
Cherokee Dam	Lake Cherokee	1948	Earthfill	4,000	295	45	20	32.3617	-94.6050	Concrete structure	Cherokee Bayou	658,182
Williamson Dam	Lake Cisco	1923	Concrete slab & buttress	1,060	1,529	133.5		32.4400	-98.9833	Concrete uncontrolled	Sandy Creek	1,500,000
Upper Pecan Bayou Ws Site 7 Dam	Lake Clyde	1970	Earthfill	3,950	1,889	63	20	32.3133	-99.4700	Concrete tower	North Prong Pecan Bayou	270,000
Coleman Dam	Lake Coleman	1966	Earthfill	3,200	1,740	90	20	32.0300	-99.4650	Drop inlet	Jim Ned	1,227,648
Colorado City Dam	Lake Colorado City	1949		4,800	2,090			32.3183	-100.9000		Morgan Creek	
Conroe Dam	Lake Conroe	1973	Earthfill	11,300	212	82	20	30.3567	-95.5600	Concrete ogee w/ 5 tainter gates	West Fork San Jacinto River	28,857,000
Wesley E. Seale Dam	Lake Corpus Christi	1958	Earthfill & concrete	5,980	106	75	Varies	28.0417	-97.8650	Concrete section w/ 23 gates w/ screw hoists	Nueces River	21,936,000
Lake Creek dam	Lake Creek Lake	1952	Earthfill	1,860	410	50	20	31.4567	-96.9867	Concrete section w/ 2 tainter gates	Manos Creek	N/A
Crook Dam	Lake Crook	1923	Earthfill	3,100	484	38	17	33.7283	-95.5667	Uncontrolled concrete weir	Pine Creek	250,000
Franklin County Dam	Lake Cypress Springs	1971	Earthfill	5,230	395	74	44	33.0567	-95.1400	Drop inlet	Big Cypress Creek	1,270,000
Gonales Creek Dam	Lake Daniel	1948	Earthfill	2,655	1,295	60	18	32.6483	-98.8683	Drop inlet & natural ground	Gonzales Creek	363,000
	Lake Davis	1959						33.5248	-99.7417		Dutchman Creek	
Lake Diversion Dam	Lake Diversion	1924	Earthfill	4,120	1,074	55	16	33.8200	-98.9367	Concrete ogee	Wichita River	
Dunlap TP-1 Dam	Lake Dunlap	1928	Earthfill w/ concrete spillway	2,000	590	41		29.6533	-98.0667	Floating crest w/ 3 roof-weir gates	Guadalupe River	
	Lake Electra	1950		4,500				33.9750	-99.0233		Camp Creek	

Table 6.1 Continued

Lake Fork Dam	Lake Fork Reservoir	1980		12,410	420			32.8067	-95.5400		Lake Fork Creek	
Fort Phantom dam	Lake Fort Phantom Hill	1938		3,740	1,650			32.6278	-99.6683		Elm Creek	
North Fork (San Gabriel River) Dam	Lake Georgetown	1982	Rock fill, impervious core	6,947	861	162	40	30.6750	-97.7250	Broadcrested weir	San Gabriel River	22,900,000
	Lake Gilmer	1999		2,550	329			32.7624	-94.9800		Kelsey Creek	
Gladwater Dam	Lake Gladewater	1952	Earthfill	1,203	312	48	16	32.5550	-94.9583	Concrete structure	Glade Creek	137,004
H-4 Dam	Lake Gonzales (H-4)	1931	Earthfill w/ concrete spillway	5,100	345	42		29.4950	-97.6250	Floating crest w/ 2 roof-weir gates	Guadalupe River	
Graham Dam	Lake Graham	1958	Earthfill	4,300	1,093	80	20	33.1167	-98.6133	Cut in natural ground	Flint and Salt Creeks	486,490
De Dordova Bend Dam	Lake Granbury	1969	Ambursen-type concrete and earthfill	2,200	707	84	17	32.3733	-97.6883	Ogee weir w/ 16 tainter gates	Brazos River	7,800,000
Halbert Dam	Lake Halbert	1921	Earthfill	2,780	375	49	16	32.0733	-96.4033	Concrete uncontrolled	Elm Creek	
	Lake Hawkins	1962	Earthfill	1,265	363	58	20	32.6117	-95.2517	Drop inlet	Little Sandy Creek	
Wood County Dam No. 2	Lake Holbrook	1962	Earthfill	3,100	387	49	20	32.6850	-95.5517	Drop inlet	Keys Creek	
Lake Houston Dam	Lake Houston	1954	Earthfill	12,097	62	65	Varies	29.9200	-95.1317	Concrete slab & buttress w/ 2 tainter gates	San Jacinto River	14,850,000
Colorado River Dam	Lake J B Thomas	1952	Earthfill	14,500	2,280	105	28	32.5833	-101.1350	Drop inlet	Colorado River	1,452,877
Buckner Dam	Lake Jacksonville	1957	Earthfill	2,700	438	72	16	31.9083	-95.3083	Drop inlet	Gum Creek	675,000
Lake Kemp Dam	Lake Kemp	1923	Earthfill	8,890	1,183	115	28	33.7550	-99.1450	Cut channel	Wichita River	
Lake Kickapoo Dam	Lake Kickapoo	1945	Earthfill	8,200	1,062	62	16	33.6633	-98.7783	Concrete ogee	North Fork Little Wichita River	3,500,000
Kiowa Dam	Lake Kiowa	1970	Earthfill	2,400	712	42	20	33.5533	-97.0117	Concrete ogee weir	Indian Creek	637,570
Kirby Dam	Lake Kirby	1928	Earthfill	4,200	1,795	50	20	32.3850	-99.7283	Masonry and natural earth uncontrolled	Cedar Creek	180,000
Kurth Dam	Lake Kurth	1961	Earthfill levee	8,600	206	37	16	31.4500	-94.7000	Drop inlet	Angelina River	2,500,000

Table 6.1 Continued

Leon Dam	Lake Leon	1954	Earthfill	3,700	1,398	90	20	32.3600	-98.6750	Drop inlet	Leon River	585,800
Sterling C. Robertson	Lake Limestone	1978		9,100	380			31.3250	-96.3200		Navasota River	
Livingston Dam	Lake Livingston	1969	Earthfill	14,400	145	100	24	30.6333	-95.0083	Ogee w/ 12 tainter gates	Trinity River	
Alvin Wirtz Dam	Lake Lyndon B Johnson	1951	Concrete & earthfill	5,491	835	118	26	30.5550	-98.3383	Concrete ogee w/ 9 tainter gates	Colorado River	9,725,934
Max Starcke Dam	Lake Marble Falls	1951	Concrete	860		98.8		30.5567	-98.2567	Ogee w/ 10 roof-weir gates	Colorado River	6,768,395
Abbott Dam (TP-3)	Lake McQueeney	1928	Earthfill w/ concrete spillway	1,900	543			29.5933	-98.0400	Floating crest w/ 3 roof-weir gates	Guadalupe River	
Sanford Dam	Lake Meredith	1965	Earthfill	6,410	3,011	200	40	35.7000	-101.5533	Drop inlet	Canadian River	18,587,000
Bistone Dam	Lake Mexia	1961	Earthfill	1,645	462	50	20	31.6433	-96.5783	Concrete ogee	Navasota River	312,000
Mineral Wells Dam	Lake Mineral Wells	1920	Earthfill	1,650	874	73.9		32.8167	-98.0417	Concrete	Rock Creek	
Murvaul Dam	Lake Murvaul	1958	Earthfill	8,300	280	46	10	32.0333	-94.4200	Concrete broadcrested weir	Murvaul Bayou	1,600,000
	Lake Nacogdoches	1977		4,350	303			31.5883	-94.8267		Bayou Loco	
Nasworthy Dam	Lake Nasworthy	1930	Earthfill	5,480	1,884	50	20	31.3883	-100.4783	Concrete ogee w/ 15 tainter gates	South Concho River	376,600
Ferrells Bridge Dam	Lake O the Pines	1958	Earthfill	10,600	277	97	30	32.7650	-94.4967	Concrete chute	Cypress Creek	13,405,475
	Lake Olney / Lake Cooper	1935		2,508	1,155			33.4417	-98.7817		Mesquite Creek	
Blackburn Crossing Dam	Lake Palestine	1905	Earthfill	5,720	364	75	20	32.0550	-95.4383	Concrete ogee weir	Neches River	15,822,000
Palo Pinto Creek Dam	Lake Palo Pinto	1964	Earthfill	1,255	898	96	22	32.6467	-98.2683	Concrete ogee	Palo Pinto Creek	707,200
Cleburne Dam	Lake Pat Cleburne	1964	Earthfill	4,900	753	78	25	32.2883	-97.4167	Uncontrolled concrete ogee & excavated channel	Nolan River	1,316,000
Lake Pauline Dam	Lake Pauline	1905		4,500	1,496			34.2500	-99.6717		Wanderer's Creek and Groesbeck Creek	
Wood County Dam No. 1	Lake Quitman	1962	Earthfill	2,500	413	42	20	32.8583	-95.4333	Drop inlet	Dry Creek	
Rockwall-Forney Dam	Lake Ray Hubbard	1969	Earthfill	12,500	450	68	22	32.8017	-96.5067	Concrete ogee w/ 14 tainter gates	East Fork Trinity River	26,100,000

Table 6.1 Continued

	Lake Ray Roberts	1987		15,250	665			33.3567	-97.0367		Elm Fork Trinity River	
Rita Blanca Dam	Lake Rita Blanca	1939	Earthfill	2,880	3,880	75	26	36.0250	-102.4983	Uncontrolled concrete & natural channel	Rita Blanca Creek	
Stamford Dam	Lake Stamford	1953	Earthfill	3,600	1,437	78	24	33.0717	-99.5600	Excavated channel and concrete shaft	Paint Creek	289,365
Striker Creek Dam	Lake Striker	1957	Earthfill	2,400	309	42	25	31.9350	-94.9750	Concrete ogee w/ 4 tainter gates	Striker Creek	1,750,000
White Oak Creek Dam	Lake Sulphur Springs	1973	Earthfill	6,232	474	44	20	33.1733	-95.6100	Concrete ogee w/ 4 vertical gates	White Oak Creek	1,611,000
Sweetwater Dam	Lake Sweetwater	1930	Earthfill	2,600	2,129	50	20	32.4428	-100.3033	Concrete ogee	Bitter and Cottonwood Creeks	346,000
Iron Bridge Dam	Lake Tawakoni	1960	Earthfill	29,560	454	85	23	32.8117	-95.9000	Uncontrolled concrete ogee	Sabine River	19,000,000
Palmetto Bend Dam	Lake Texana	1981		41,712	55			28.8900	-96.5783		Navidad River	
Denison Dam	Lake Texoma	1944	Earthfill	15,200	670	165	40	33.8183	-96.5700	Ogee	Red River	78,000,000
Mansfield Dam	Lake Travis	1942	Concrete gravity, earth & rock fill	7,098	750	266	20	30.3917	-97.9067	Concrete ogee uncontrolled	Colorado River	27,700,578
Whitehouse Dam	Lake Tyler	1967	2 Earthfill dams	4,708	390	50	20	32.2117	-95.1717	Concrete weir & chute	Prairie Creek	1,610,000
Waco Dam	Lake Waco	1965	Earthfill	24,618	510	140	20	31.5840	-97.2020	Concrete ogee w/ 14 tainter gates	Bosque River	49,407,000
Decker Creek Dam	Lake Walter E Long	1967	Earthfill	6,390	563	83	20	30.2850	-97.5967	Concrete ogee weir w/ 2 tainter gates	Colorado River	4,602,974
South Prong Dam	Lake Waxahachie	1956	Earthfill	3,800	542	66	18	32.3417	-96.8050	Concrete weir	South Prong Creek	
Weatherford Dam	Lake Weatherford	1957	Earthfill	4,055	914	75	20	32.7717	-97.6750	Drop inlet	Clear Fork Trinity River	
Whitney Dam	Lake Whitney	1951	Concrete gravity & earthfill	17,695	584	159	34	31.8662	-97.3713	Ogee w/ 17 tainter gates	Brazos River	41,795,000
Lake Wichita Dam	Lake Wichita	1901	Earthfill	6,250	988	23	20	33.8450	-98.5383	Uncontrolled	Holiday Creek	350,000
Wood County Dam No. 4	Lake Winnsboro	1962	Earthfill	2,570	437	44.5	20	32.8867	-95.3450	Drop inlet	Big Sandy Creek	

Table 6.1 Continued

	Lake Winters / New Lake Winters	1983		5,200	57			31.9393	-99.8699		Elm Creek	
Lake Worth Dam	Lake Worth	1914	Earthfill	3,200	606	50	≤ 40	32.7917	-97.4150	Concrete	West Fork Trinity River	
Lavon Dam	Lavon Lake	1953	Earthfill	18,860	514	81	30	33.0330	-96.4690	Ogee w/ 12 tainter gates	East Fork Trinity River	12,500,000
Lewis Creek Dam	Lewis Creek Reservoir	1969	Earthfill	12,836	274	54	18	30.4300	-95.5433	Concrete ogee w/ 2 tainter gates	Lewis Creek	3,685,150
Lewisville Dam	Lewisville Lake	1955	Earthfill	32,888	560	125	20	33.0500	-96.9633	Ogee	Elm Fork Trinity River	21,971,000
Loma Alta Dam	Loma Alta Lake	1963	Earth dike			18	18	25.9800	-97.3861	Concrete ogee uncontrolled	Rancho Viejo Floodway	
	Lost Creek Reservoir	1991			1,029			33.2426	-98.1196		Lost Creek	
Lower Running Water Draw WS Site #2	Lower Running Water Draw WS SCS Site 2 Dam	1977									N Fork Running Water Draw	
Lower Running Water Draw WS Site #3	Lower Running Water Draw WS SCS Site 3 Dam	1982		2,382							N Fork Running Water Draw	
Mackenzie Dam	Mackenzie Reservoir	1974	Earthfill	3,280	3,126	174	20	34.5433	-101.4367	Concrete ogee, discharge chute & flip bucket	Tule Creek	2,636,390
Martin Lake Dam	Martin Lake	1974	Earthfill	6,875	322	61	20	32.2717	-94.5517	Concrete ogee & chute	Martin Creek	
Medina Dam	Medina Lake	1913	Gravity concrete structure	1,580	1,076	164	25	29.5400	-98.9333	Cut through rock	Medina River	2,739,300
Millers Creek Dam	Millers Creek Reservoir	1974	Earthfill	9,250	1,355	75	20	33.4233	-99.3683	Uncontrolled drop inlet	Millers Creek	1,205,000
	Mitchell County Reservoir	1991						32.2778	-101.1000		Beals Creek	
Monticello Dam	Monticello Reservoir	1973	Earthfill	3,200	352	54	40	33.0800	-95.0433	Concrete ogee w/ 4 tainer gates	Blundell Creek	4,500,000
Mountain Creek Dam	Mountain Creek Lake	1936	Earthfill	8,200	467	47	16	32.7317	-96.9433	Concrete ogee w/ 6 tainter gates	Mountain Creek	940,000
	Mud Lake NO 4	1974			55			28.6669	-96.5434		Cox's Creek	
	Mustang Lake East/Mustang Lake West	1969						29.2950	-95.1883		Chocolate/Mustang Bayou	

Table 6.1 Continued

	Natural Dam Lake	1989						32.2183	-101.6250		Sulphur Springs Draw	
Navarro Mills Dam	Navarro Mills Lake	1963	Earthfill	7,570	457	81.7	20	31.9500	-96.7000	Ogee w/ 6 tainter gates	Richland Creek	9,598,000
Terrell Dam	New Terrell City Lake	1955	Earthfill	4,900	514	45	≥ 14	32.7283	-96.1733	Concrete chute, 9-24" pipes	Muddy Cedar Creek	169,900
North Fork Buffalo Creek Dam	North Fork Buffalo Creek Reservoir	1964	Earthfill	4,645	1,056	47	14	33.9867	-98.7517	Drop inlet	North Fork Buffalo Creek	542,880
North Lake Dam	North Lake	1957	Earthfill	7,146	515	65	12	32.9467	-96.9700	Concrete uncontrolled	South Fork Grapevine Creek	550,000
	O C Fisher Lake	1951	Earthfill	40,885	1,964	128	20	31.4667	-100.4833	Ogee uncontrolled	Concho River	16,200,000
	O H Ivie Reservoir	1989						31.5028	-99.6669		Colorado River	
Oak Creek Dam	Oak Creek Reservoir	1952	Earthfill	3,800	2,014	95	36	32.0400	-100.2500	Cut channel	Oak Creek	411,000
	Palo Duro Reservoir	1991		3,800	2,943			36.3633	-102.6333		Palo Duro Creek	
Pat Mayse Dam	Pat Mayse Lake	1967	Earthfill	7,080	489	96	32	33.8550	-95.5533	Excavated channel	Sanders Creek	9,000,000
	Peacock Site 1A Tailings Reservoir	1983		2,000	435			32.9700	-94.6800		Tr-Peacock Creek	
	Pinkston Reservoir	1977						31.7050	-94.3633		Sandy Creek	
Morris Sheppard Dam	Possum Kingdom Lake	1941	Ambursen-type, buttress w. flat-slab deck & earthen dike	2,740	1,024	189	14.8	32.8700	-98.4250	Gated-controlled ogee weir w/ 9 roof-weir gates	Brazos River	7,000,000
Proctor Dam	Proctor Lake	1963	Earthfill	13,460	1,206	86	30	31.9717	-98.4767	Ogee w/ 11 tainter gates	Leon River	14,450,000
	Prudential Reservoir	1976		4,900				28.8200	-95.5033		Tr-Kellers Creek	
Randell Dam	Randell Lake	1909	Earthfill	1,385	628	70	24	33.8017	-96.5800	Concrete section	Shawnee Creek	
Red Bluff Dam	Red Bluff Reservoir	1936	Earthfill	9,230	2,856	102	25	31.9017	-103.9100	Concrete ogee w/ 12 tainter gates	Pecos River	2,600,000
	Red Draw Reservoir	1985						32.2300	-101.3750		Red Draw	

Table 6.1 Continued

Richland-Chambers Dam	Richland-Chambers Reservoir	1987		31,000	330			31.9500	-96.1417		Richland Creek	
River Creat Levee	River Crest Lake	1953	Earthfill circular dike	14,770	335	23	10	33.3883	-95.1467	Gate-controlled	Sulphur River	
Sam Rayburn Dam	Sam Rayburn Reservoir	1965	Earthfill	19,430	190	120	42	31.0500	-94.0667	Broadcrested weir	Angelina River	63,290,000
San Esteban Dam	San Esteban Lake	1911	Concrete pier & deck (Ambursen)	400		68		30.1668	-104.0288	None.	Alamito	62,000
Santa Rosa Dam	Santa Rosa Lake	1929	Earthfill	2,400	1,178	41	15	33.9400	-99.2600	Concrete weir	Beaver Creek	88,338
Sheldon Dam	Sheldon Reservoir	1943	Earthfill	32,208	55	10	10 to 12	29.8533	-95.1500	Concrete slab	Carpenters Bayou	
Smithers Lake Dam	Smithers Lake	1957	Earthfill	3,000	71	18	12	29.4800	-95.6300	Concrete ogee w/ 3 tainter gates	Dry Creek	
Somerville Dam	Somerville Lake	1967	Earthfill	20,210	280	80	20	30.3167	-96.5167	Ogee uncontrolled	Yegua Creek	21,700,000
N/A	South Texas Project Reservoir	1981		65,509	66			28.7433	-96.0583		Colorado River	
Squaw Creek Dam	Squaw Creek Reservoir	1977						32.2883	-97.7600		Squaw Creek	
Stillhouse Hollow Dam	Stillhouse Hollow Lake	1968	Earthfill	15,624	698	200	42	31.0167	-97.5167	Broadcrested weir	Lampass River	20,100,000
	Sulphur Springs Draw Storage Reservoir	1993		7,113							Sulphur Springs Draw	
Toledo Bend Dam	Toledo Bend Reservoir	1969	Earthfill	11,200	185	112	25	31.1783	-93.5667	Ogee weir w/ 11 tainter gates	Sabine River	70,000,000
Longhorn Dam	Town Lake	1960		760	460			30.2504	-97.7136		Colorado River	
Tradinghouse Creek dam	Tradinghouse Creek Reservoir	1968	Earthfill	7,600	456	60	20	31.5533	-96.9800	Concrete ogee w/ 2 tainter gates	Tradinghouse Creek	
Trinidad Levee	Trinidad Lake	1925	Earthfill	12,000	287	20	15 to 20	32.1105	-96.0920	Part of levee w/ 1 tainter gate	Trinity River	
	Truscott Brine Lake	1983		16,080	1,513			33.7983	-99.8366		Bluff Creek	
Twin Buttes Dam	Twin Buttes Reservoir	1963	Earthfill	42,450	1,991	134	30	31.3767	-100.5167	Uncontrolled ogee weir	South Concho River, Spring Creek, and Middle Concho River	20,687,000

Table 6.1 Continued

Twin Oak Dam	Twin Oak Reservoir	1982		7,800	414			31.2000	-96.4633		Duck Creek	
Upper Nueces Dam	Upper Nueces Lake	1948	Earthfill	550		60	20	28.7783	-99.8283	Concrete, uncontrolled	Nueces River	225,000
Valley Acres Dam	Valley Acres Reservoir	1947	Earth levee	28,300	73	15	12	26.2483	-97.8900	None.		
Valley Dam	Valley Lake	1961	Earthfill	2,770	618	55	20	33.6450	-96.3583	Natural ground	Brushy Creek	
Victor Braunig Plant Dam	Victor Braunig Lake	1962	Earthfill	9,647	516	80	18	29.2400	-98.3717	Concrete ogee w/ 2 tainter gates		4,700,000
Wallisville Dam	Wallisville Lake	1999	Earthfill	16,725	10		10 to 12	29.9444	-94.7756		Trinity River	24,500,000
Swauano Creek Dam	Welsh Reservoir	1975		4,610	335			33.0433	-94.8333		Swauano Creek	
Al O'Brien Dam	White River Lake	1963	Earthfill	3,300	2,395	84	30	33.4567	-101.0667	Drop inlet	White River	980,062
White Rock Dam	White Rock Lake	1911	Earthfill	2,100	469	40	20	32.8150	-96.7250	Broadcrested uncontrolled	White Rock Creek	
William Harris Dam	William Harris Reservoir	1947	Rectangular-shaped levee	39,600	45	12	8 to 10	29.2293	-95.5307	None	N/A	86,400
Texarkana Dam	Wright Patman Lake	1954	Earthfill	18,500	286	106	30	33.3050	-94.1600	Concrete chute	Sulphur River	35,048,603

Major Texas Reservoirs

The story of the reservoirs impounded by the more than two hundred dams identified in Table 6.1 is much too long to be told this dissertation. There are, however, some generalizations about Texas reservoirs that are pertinent to my argument. When and where reservoirs were built, for what purpose, and by whom, offers insights not only into patterns of water use, but also into perceptions of water evident from the way water was managed. Identifying factors contributing to historical change in water management is a desired outcome of this work. To this end I gathered data on each of the two hundred twenty Texas reservoirs with a capacity of greater than five thousand acre feet and organized this information into a table presented here as Appendix H.[348] Five thousand acre-feet is the standard used by the Texas Water Development Board in defining a major reservoir in the State.[349] I have then sub-divided the reservoirs into three categories: smaller ones with a capacity of less than 100,000 acre-feet (identified with regular type font), large reservoirs with a capacity greater than one million acre-feet

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[348] There are 209 such reservoirs according to the Texas Water Development Board. Appendix H includes 220 reservoirs. For a more accurate historical perspective, I have included reservoirs that have been expanded significantly or no longer exist. See Surface Water section of the Texas Water Development Board website for the starting point of this appendix, http://www.twdb.state.tx.us/home/index.asp (accessed March 11, 2007). It has been synthesized with data collected from the Brazos River Authority, "Reservoirs Authority Lakes," http://www.brazos.org/ (accessed March 11, 2007); the Lower Colorado River Authority, "Dams and Lakes," http://www.lcra.org/water/dams.html (accessed March 11, 2007); the Upper Colorado River Authority, "Lake Storage Levels," http://www.ucratx.org/ (accessed March 11, 2007); and the United States Army Corps of Engineers, "Fort Worth Division, Lakes & Recreation Info," http://www.swf.usace.army.mil/ (accessed March 11, 2007).

[349] Louis L. McDaniels, *Conservation Storage Reservoirs in Texas: Some Aspects and Chronology of Surface-Water Resources Development*, Bulletin 6404 (Austin, TX: Texas Water Commission, 1964); C.L. Dowell, *Dams and Reservoirs in Texas: Historical and Descriptive Information*, Bulletin 6408 (Austin, TX: Texas Water Commission, 1964); Cleo Lafoy Dowell and Seth Darnaby Breeding, *Dams and Reservoirs in Texas: Historical and Descriptive Information*, Report 48 (Austin, TX: Texas Water Development Board, 1967).

(identified with bold and italic font), and those in between (identified with simply a bold font). This reservoir size distinction, too, is based upon Texas Water Development Board classification. The data is presented in chronological order by the date of completion of each reservoir. I have organized reservoirs by date and by owner. The bulk of this data is from the Texas Water Development Board, but their owner information pertains to the present controlling authority.[350] I have supplemented this by listing the original owner in parenthesis, when I have been able to find such data. Because of conflicting claims, overlapping authorities, and vagueness in the historical record, some of this information is uncertain. Regardless, it is included here because the origin of the project matters in the context of change. I am interested in not only where and when reservoirs appeared upon the landscape, but also in the entity that caused them to appear.

I have used timeslice maps to analyze how reservoirs spread across the state. Records are available from 1900 to the present. I have divided this interval into four slices, 1900 to 1929, 1930 to 1954, 1955 to 1980, and 1980 to 2005. There are not enough data points to warrant finer resolution. The first slice is five years longer than the rest, but there was less activity then, and in spite of the longer window, this is reflected in the maps. There was a major drought in Texas in the early 1950s, and I did not want this event to be temporally located in the middle of a timeslice.

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[350] Texas Water Development Board, "Surface Water," http://www.twdb.state.tx.us/ (accessed March 10, 2007).

I also organized the original owners of the reservoirs into four categories: local, regional, federal, and non-government because it has become increasingly clear to me that scale matters in terms of water management. Local reservoirs are those owned by a municipality or a county. If one agency with a strong community visibility had jurisdiction over decision making, I considered that ownership to be local. Regional ownership involves either a multi-county effort or a State project. At the heart of the regional concept is the idea that multiple local government entities had to work to organize a regional effort to construct the reservoir. There is a caveat, in that multi-county also implies county populations large enough to bring divergent stakeholders into the decision making process. This can be difficult to quantify, but when two or three very low population counties in West Texas joined forces, I considered this to be a local effort. The third ownership category is federal. This includes both federal and international reservoirs. Because the Rio Grande is on the international border between Texas and Mexico, there are several internationally controlled reservoirs related to Texas. Most of the federal reservoirs in Texas fall under the auspices of the U.S. Army Corps of Engineers (30), but the U.S. Bureau of Reclamation (4), the U.S. Fish and Wildlife Service (2), the U.S. Federal Works Administration (1), the U.S. Forest Service (1), and the International Boundary and Water Commission (2) are also represented (See Appendix H). Because of overlapping responsibilities, there are conflicting claims between agencies. In such cases I identify the agency with primary responsibility for managing the reservoir. The remaining reservoirs fall outside government ownership and are classified as non-government. These are owned by utility companies, industry, or private individuals. My interpretation about ownership of any one individual reservoir may be questioned, but I do not believe this affects my generalizations.

The first timeslice representing reservoirs completed between 1900 and 1929 is presented in Figure 6.8. Each timeslice is represented as four separate maps, according to the scale of ownership of the reservoir: either non-government, local, regional/state, or federal. This first set of maps shows there were relatively few reservoirs completed in comparison with later time intervals, and that the ownership was non-government and local. The earliest surviving reservoir in the state is Eagle Lake, with a capacity of 9,600 acre-feet, completed in the Lower Colorado watershed in 1900 by William Dunovant for rice irrigation, and now owned by the Lower Colorado River Authority. A relatively large private reservoir, Medina, Lake with a capacity of 254,000 acre-feet, was also constructed for irrigation in south central Texas. The largest reservoir constructed during this period was Lake Kemp, with a capacity of 319,600 acre-feet, built by the city of Wichita Falls. There were no regional/state or federal reservoirs completed, although preliminary work was underway by the Tarrant County Water and Improvement District in a multi-county project to construct Lake Bridgeport and Eagle Mountain Lake in north central Texas, and Lake Texoma, on the northern border of Texas was in the initial planning stages. Lake Austin was the first major reservoir in the state, impounding 49,300 acre-feet of the Colorado River behind a masonry dam in 1893, but it is not included in this timeslice. It failed in 1900, was partially rebuilt in 1915, but failed again that same year. It was again rebuilt in 1939, and this reservoir is intact today.

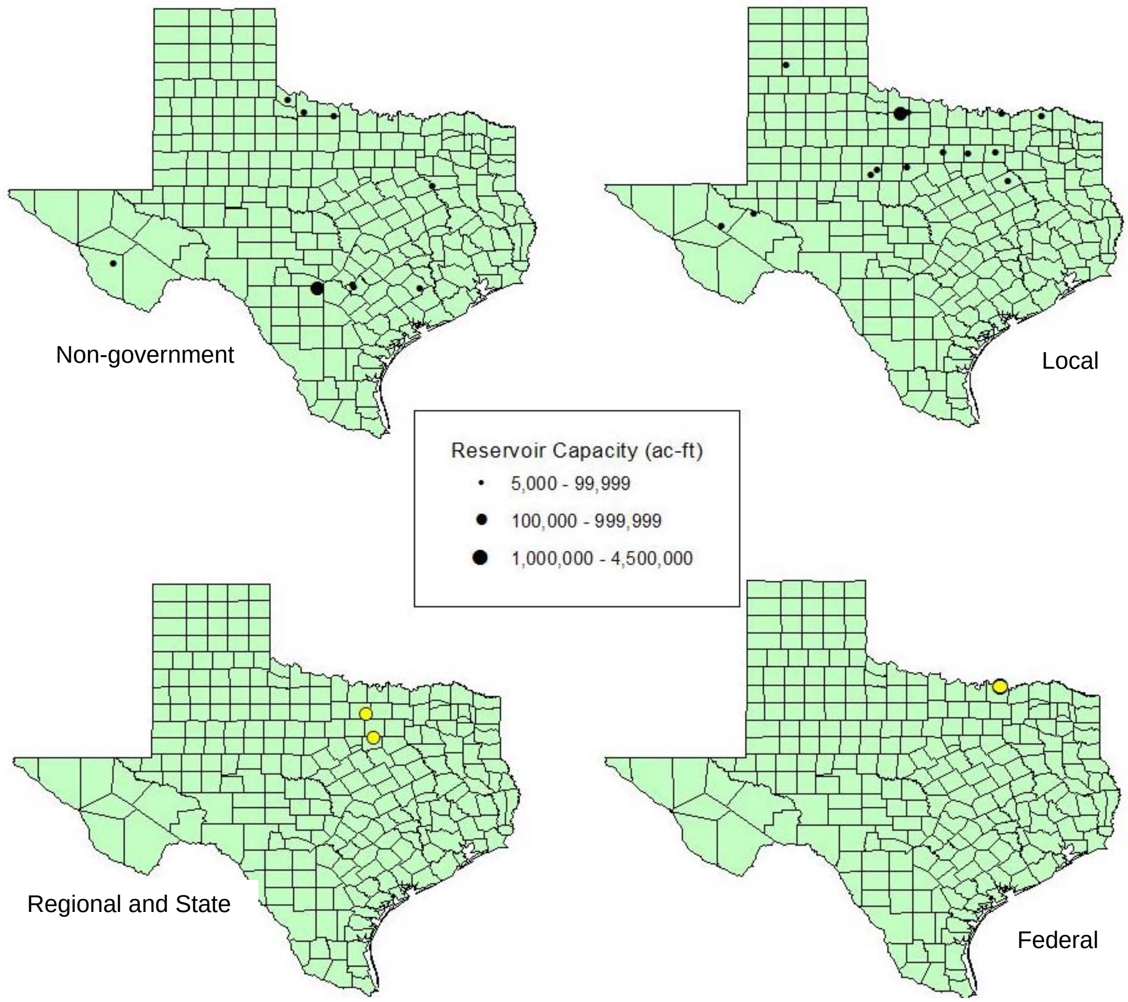

Figure 6.8. Reservoirs Completed Between 1900 and 1929. Reservoirs completed during this period were built by local governments or local businessmen for local use. The first dams for hydroelectric power were constructed in Texas in 1928. The largest non-government reservoir was an irrigation project. No regional, state, or federal dams were completed, but organizational efforts were underway for regionally and federally funded reservoirs designed for flood control at the locations marked with yellow dots. At the regional level, Tarrant and Wise Counties worked together to plan Eagle Mountain Reservoir and Lake Bridgeport, "uniting efforts toward controlling the flood waters of the West Fork of the Trinity River and conserving them for constructive purposes."[351] The first federal reservoir was Lake Texoma, on the Red River between Texas and Oklahoma. Construction on its dam did not begin until 1939, but in 1928, the United States War Department surveyed the river to consider the feasibility of constructing a dam across the Red River in connection with Mississippi River flood control.[352] Data from the Texas Water Development Board.

[351] "Wise, Tarrant, Unite in Control of Floods," *Dallas Morning News*, 25 October 1925, Section 1, p.9.
[352] "Soundings to Be Made On Red River for Dam," *Dallas Morning News*, 10 February 1929, Sec. 1, p. 3.

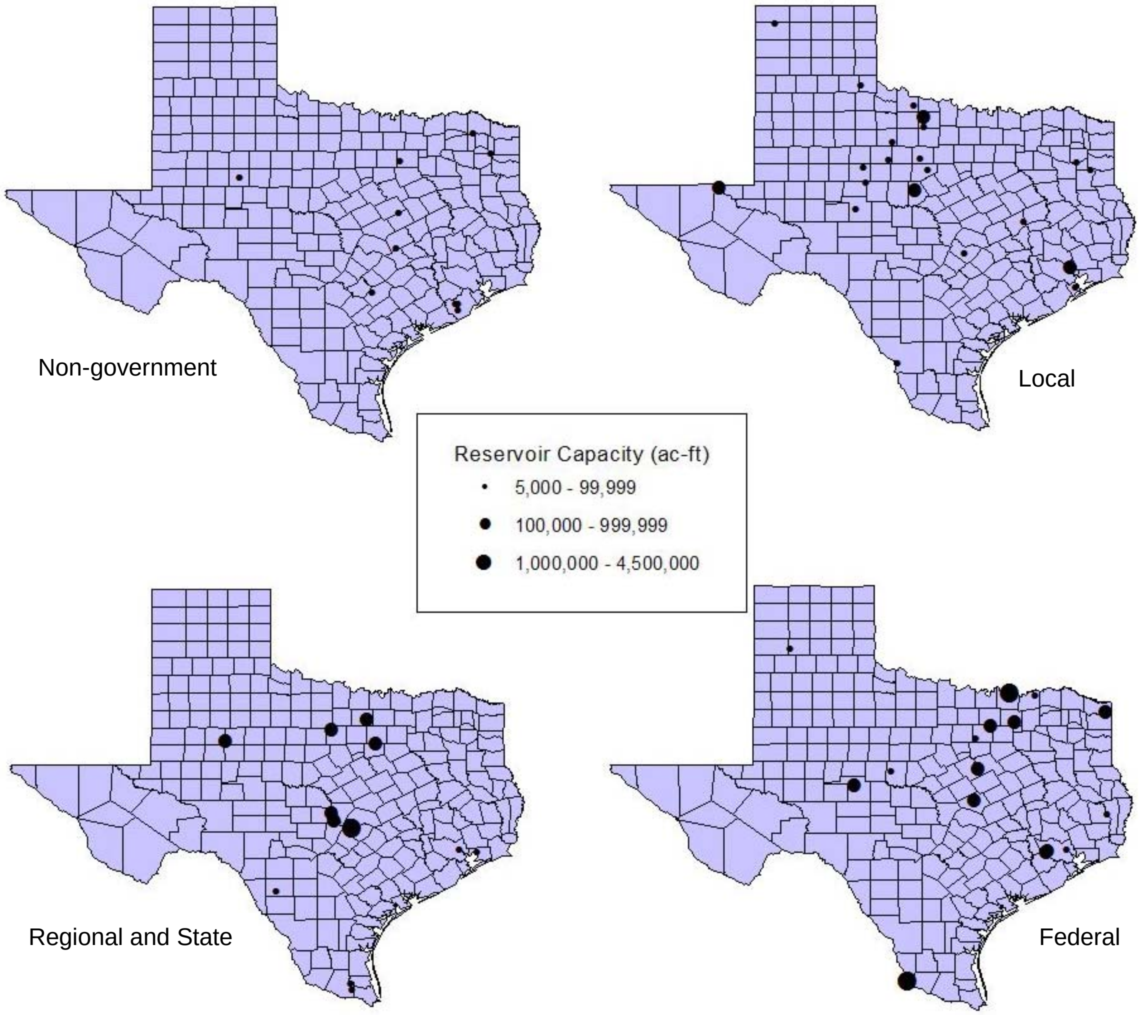

Figure 6.9. Reservoirs Completed Between 1930 and 1954. The scale of reservoir construction increased once the state and federal governments were involved. At the state level during the 1930s, reservoirs were justified for flood control and for hydroelectric power. Lake Texoma was the first large federal reservoir and was completed in 1944. Most of the large federal reservoirs in this map were constructed during the last five years of this timeslice, and all were justified, at least partially, on the basis of flood control. Data from the Texas Water Development Board.[353]

[353] See Appendix H.

The second timeslice, representing reservoirs completed between 1930 and 1954, is shown in Figure 6.9. The most striking differences between this and Figure 6.8 are the number of large-scale reservoirs built and the amount regional/state and federal involvement. The predecessor agency to the first state river authority, the Brazos River Reclamation and Conservation District, was organized in 1929. The decade of the 1930s saw the establishment of a number of other river authorities in Texas (See Table 6.2). In 1933, the Tennessee Valley Authority was created as the first federal river authority with goals similar to those of the Texas river authorities, although at a larger scale because the Tennessee River is larger than Texas rivers and flows across state boundaries. At the State level during the 1930s, reservoirs were justified for flood control and for hydroelectric power. The U.S. Army Corps of Engineers' involvement in the construction of large Texas reservoirs burgeoned during the latter part of this interval. Corps of Engineers' reservoirs were all justified, at least partially, on the basis of flood control (See Appendix H).

The third timeslice, representing reservoirs completed between 1955 and 1979, shows that non-government and local reservoirs constructed during this interval were numerous, but small in capacity when compared with those built by the state and federal government (See Figure 6.10). The smaller reservoirs tended to have a specific purpose such as cooling for a utility company or supplementing a municipal water supply, whereas the larger reservoirs were multi-purpose. The construction of federal flood control reservoirs waned after the completion of the International Amistad Reservoir on the border with Mexico. This may be due to the physiography of Texas not affording an

Table 6.2. Regional River Authorities in the State of Texas. Much of the surface water in the state is controlled through regional river authorities, based in large part upon watersheds. The Brazos River Authority, the Lower Colorado River Authority, and the Upper Colorado River Authority are involved in the construction, ownership, and management of some of Texas' largest reservoirs. A majority of the river authorities were established during the 1930s. Even when the river authorities are not listed as the owners of a reservoir in Appendix F, they are frequently involved in water allocation from reservoirs across the state. The San Antonio River Authority and the Brazos River Authority were renamed in 1953.[354]

Established	River Authority
1929	Brazos River Authority
1934	Lower Colorado River Authority
1935	Upper Colorado River Authority
1935	Central Colorado River Authority
1935	Guadalupe-Blanco River Authority
1935	Nueces River Authority
1937	San Jacinto River Authority
1937	San Antonio River Authority
1939	Upper Guadalupe River Authority
1939	Lower Concho River, Water, and Soil Conservation Authority
1949	Angelina and Neches River Authority
1949	Sabine River Authority
1955	Trinity River Authority
1959	Lavaca-Navidad River Authority
1959	Red River Authority

[354] Data synthesized from the Texas State Historical Association, *Handbook of Texas Online*, http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).

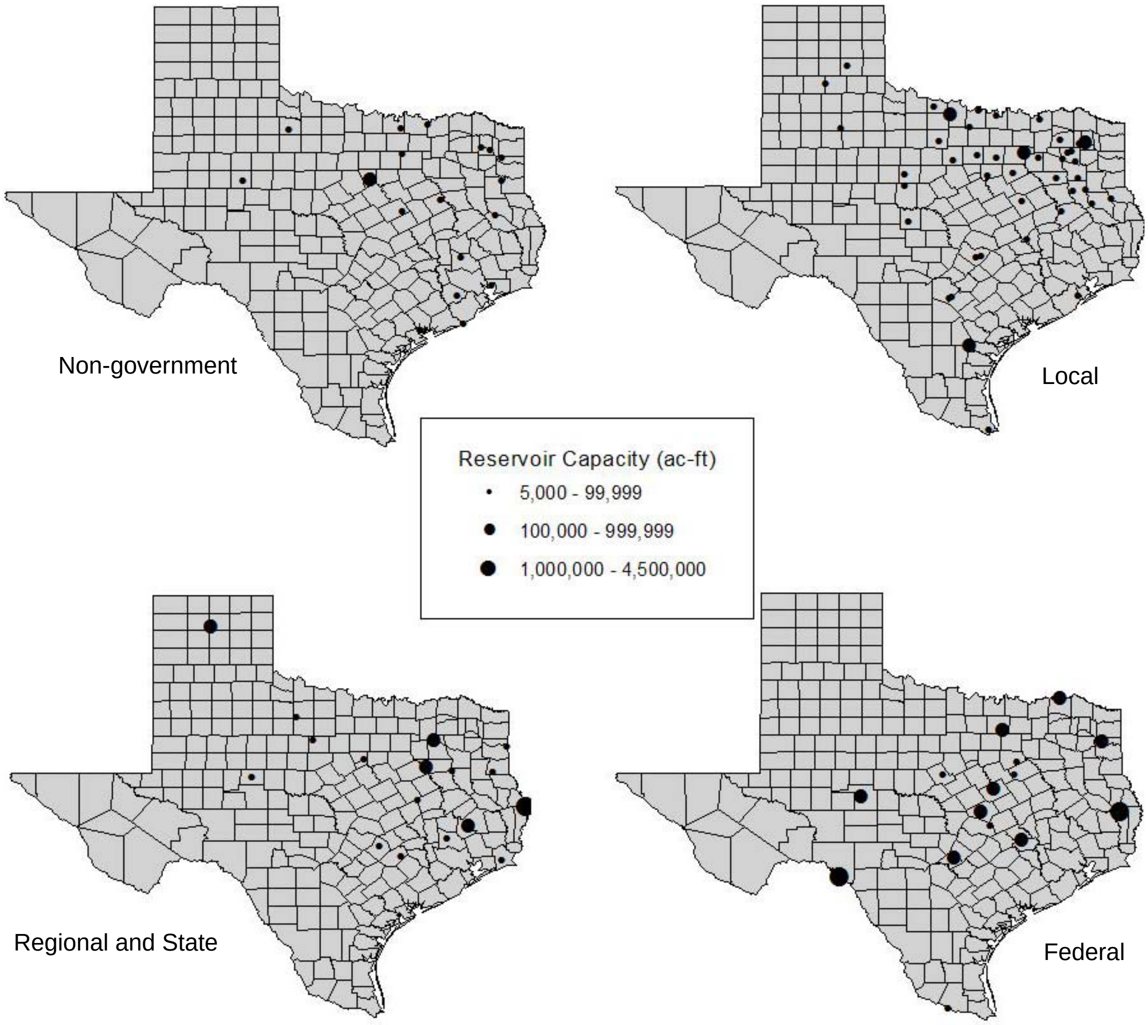

Figure 6.10. Reservoirs Completed Between 1955 and 1979. The non-government and local reservoirs completed during this timeslice were numerous, but small in capacity when compared with those built by the state and federal governments. The only mid-sized non-government lake is an impoundment on Squaw Creek associated with Comanche Peak Nuclear Power Plant in the Brazos watershed. The construction of federal flood control reservoirs waned after the completion in 1969 of the International Amisted Reservoir on the border with Mexico. Data from the Texas Water Development Board.[355]

[355] See Appendix H.

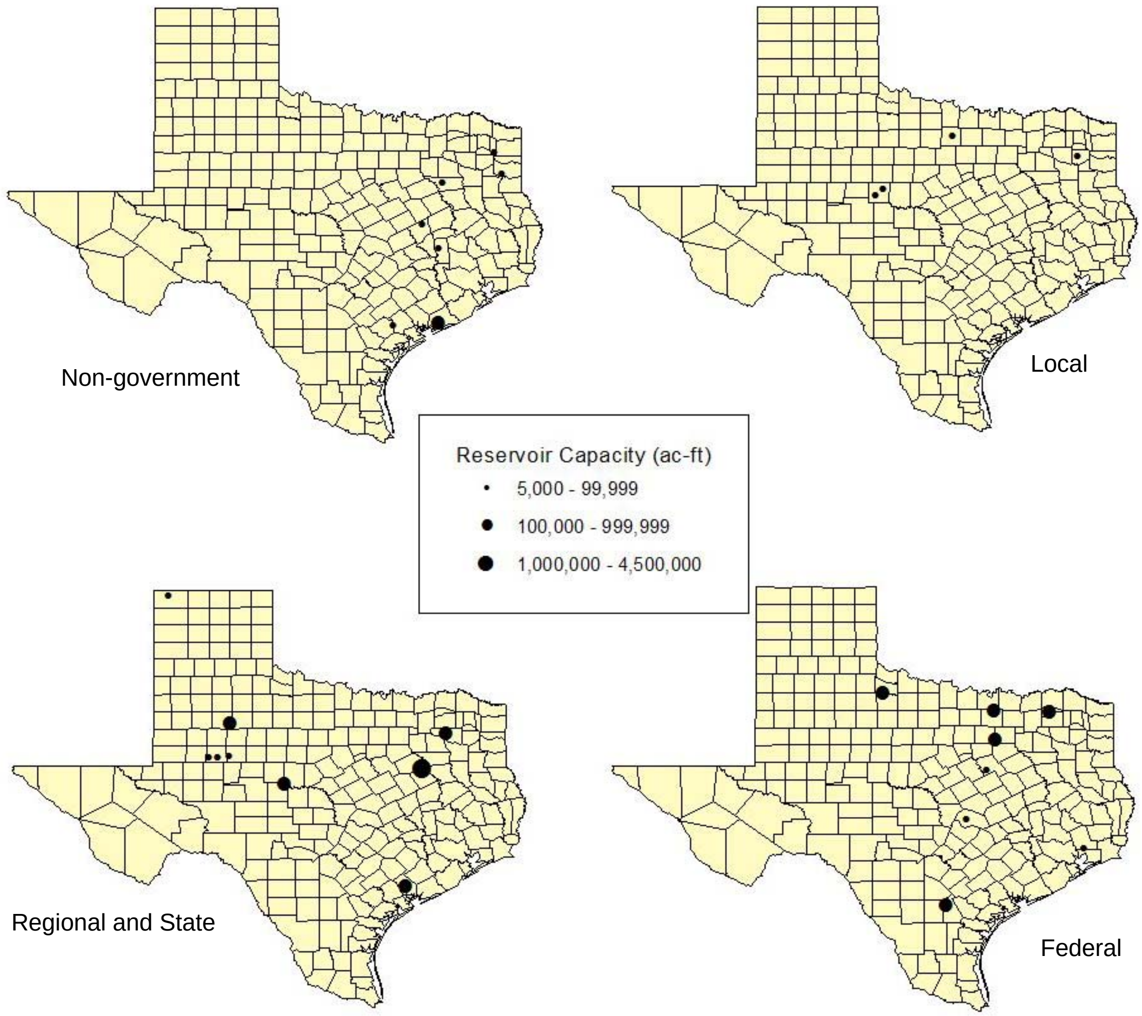

Figure 6.11. Reservoirs Completed Between 1980 and 2004. Reservoir construction by any entity, at any scale, slowed. The largest reservoirs completed were the Richland-Chambers Reservoir built by the Tarrant Regional Water District and O.H. Ivie Lake by the Colorado River Municipal Water District. Data from the Texas Water Development Board.[356]

[356] See Appendix H.

abundance of obvious natural damsites. The state is lacking in topographic relief in comparison to other western states. Without natural canyons within which to store water, a dam in many parts of Texas would impound water over a large surface area to only a relatively shallow depth. That, combined with high summer temperatures would lead to high amounts of evaporation from shallow lakes.

The fourth timeslice representing reservoirs completed between 1980 and 2004 shows that reservoir construction by any entity, at any scale, slowed when compared with the second and third intervals (See Figure 6.11). The largest reservoirs completed were the Richland-Chambers Reservoir, built by the Tarrant Regional Water District, and O.H. Ivie Lake, built by the Colorado River Municipal Water District. Local and non-government reservoir construction slowed to the lowest level of the century. Local construction of reservoirs almost came to a halt.

The reservoir data illustrated in the timeslice maps in Figures 6.8 through 6.11 is summarized in Table 6.3. The table indicates that the number of reservoirs completed increased steadily during each of the first three intervals, and then dropped off significantly. The capacity figures are shown to give an idea of scale, but should not be taken as completely comparable data. This is a compilation of data from several sources, and the capacity of a reservoir can be measured in different ways. Conservation storage capacity is the volume of water that can be conserved in a reservoir and then removed for use elsewhere. Dead storage capacity is the amount left in the bottom of the reservoir after the conservation volume has been removed. Capacity can also include flood water impoundment. For some of the reservoirs there is calculated capacity data a

Table 6.3. Texas Reservoirs with Capacity of Greater than 5,000 Acre-Feet. The total number of reservoirs built are grouped in intervals corresponding to the same periods used in the previous timeslice maps. Reservoir construction in Texas peaked during the interval from 1955 to 1979, both in terms of the number of reservoirs completed and in their total volume. There is a pronounced difference between the size of non-government and local reservoirs as compared with those constructed by either the state or federal government. The reservoirs are organized by the type of entity that funded and subsequently owned each reservoir upon its initial construction. The non-government category consists primarily of utilities with a few private individuals and corporations also represented. The local category includes cities and counties. Regional/state includes reservoirs constructed by multi-county or state agencies, usually river authorities. Finally federal includes all reservoirs funded primarily with federal funds. In Texas, this usually involved the U.S. Army Corps of Engineers. Capacity refers to the original conservation storage capacity of the reservoir, when and if a distinction has been made between that and the total capacity of the reservoir. Data from the Texas Water Development Board and predecessor agency.[357]

Number of Reservoirs	**1900-1929**	**1930-1954**	**1955-1979**	**1980-2004**	**Totals**
Non-government	9	11	17	7	44
Local	14	23	45	5	87
Regional/State	0	11	18	10	39
Federal	0	16	14	8	38
Total	23	61	94	30	208
Capacity					
Non-government	333,290	476,165	523,045	351,582	1,684,082
Local	499,899	822,733	2,349,498	48,118	3,720,248
Regional/State	0	3,859,585	11,086,483	2,857,530	17,803,598
Federal	0	8,769,796	8,161,047	2,240,889	19,171,732
Total	833,189	13,928,279	22,120,073	5,498,119	42,379,660
Average	36,226	228,332	235,320	183,271	
Average Capacity					
Non-government	37,032	43,288	30,767	50,226	
Local	35,707	35,771	52,211	9,624	
Regional/State		350,871	615,916	285,753	
Federal		548,112	582,932	280,111	

[357] Texas Water Development Board, "Surface Water," http://www.twdb.state.tx.us/ (accessed March 10, 2007) and Dowell, C.L., *Dams and Reservoirs in Texas: Historical and Descriptive Information*, Bulletin 6408 (Austin, TX: Texas Water Commission, 1964).

and then surveyed capacity data obtained years after the reservoir was impounded. Even if all reservoir capacities were measured accurately and consistently, they are in constant state of change because siltation diminishes capacity.[358] Finally, capacity is plotted in Figure 6.12 as a cumulative amount by decade across the twentieth century. Because of the unknown quantity of siltation that has occurred, and because some reservoirs have been dredged, this graph does not reflect actual storage capacity in 2000, but rather the sum of the original estimated conservation storage of major reservoirs. The actual volume is not as important as the shape of the graph, showing a sharp rise in capacity from 1960 to 1970, with a marked slowing in the latter part of the century.

The Tipping Point to the Dam and Levee Regime

This regime began with the demand for flood control after the flood of 1899 which caused property damage of more than nine million dollars through the heart of the cotton growing region along the Brazos River.[359] The initial response was the construction of levees, first by private landowners and then by districts organized at the county level. A significant step was taken in the late 1920s when flood control moved beyond levees to conservation of flood waters for later beneficial use, usually defined ineconomic terms. This led to an era of dam construction for the impoundment of flood

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[358] Texas Water Development Board, "Surface Water," http://www.twdb.state.tx.us/ (accessed March 11, 2007). Conservation storage capacity before surveying was the figure available for the majority of the reservoirs, so this was generally the capacity figure used to make Table 6.3. For some of the older reservoirs, no distinction was made between different types of capacity.

[359] Texas State Historical Association, *Handbook of Texas Online*, entry "Brazos Flood of 1899" http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).

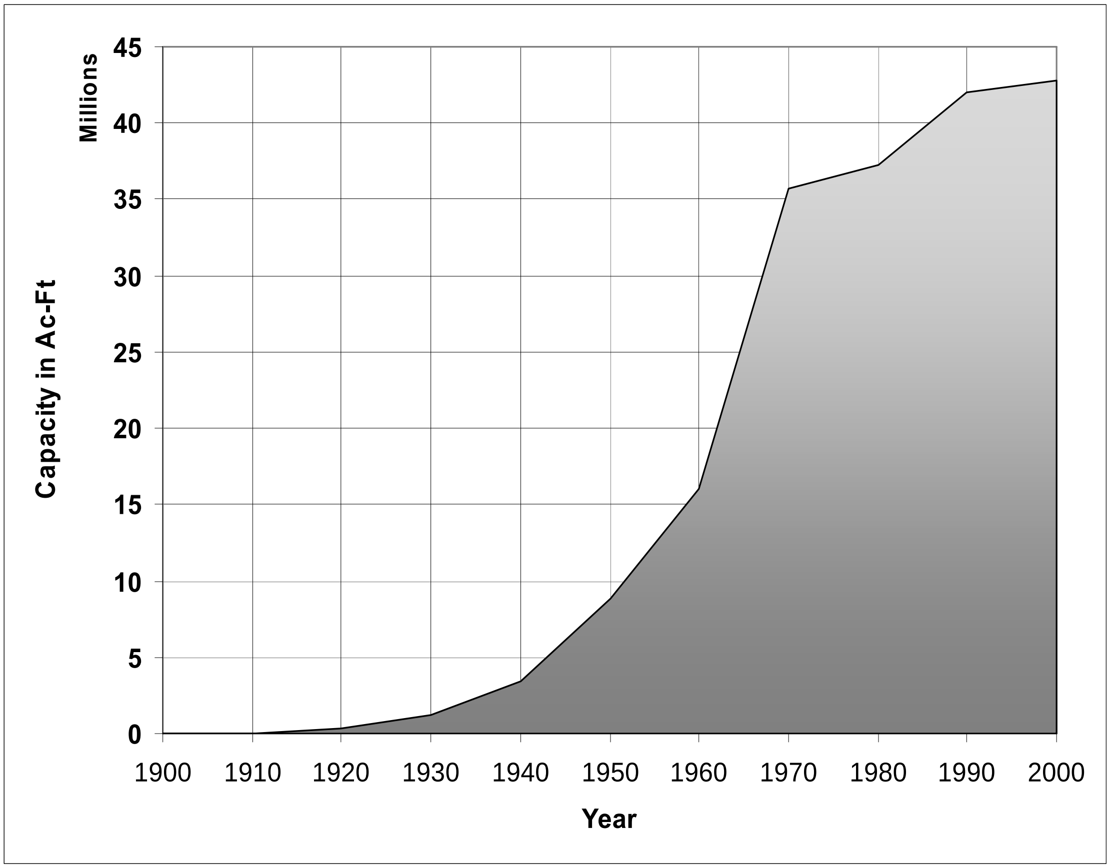

Figure 6.12. Conservation Storage Capacity of Texas Reservoirs Larger than 5,000 Acre-Feet. This does not reflect actual storage capacity as surveyed, but rather is the sum of the original estimated conservation storage of reservoirs larger than 5,000 ac-ft. The actual storage capacity also contains dead storage plus flood storage, but is then reduced by siltation within the reservoirs. For these reasons, the actual volume should be interpreted with caution. This graph is shown here to illustrate the high volume of surface water impounded in Texas during the decade following the severe Drought of the 1950s. Data is from the Texas Water Development Board.[360]

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[360] See Appendix H.

water in reservoirs. The scale at which flood control projects were implemented then increased, from individual property owners to local improvement districts in the first quartile of the century, to large-scale reservoirs managed at the state and federal level during the second and third quartiles of the twentieth century. Surface water management during the regime was seriously challenged by the Drought of the 1950s.

Before considering the significant impact of this drought, we must first consider the changing demography of the state and its implications for water supply. The population of the United States was growing at a rate faster than that of the rest of the world, and the population of Texas was growing at a rate faster than that of the United States. Texas' population had been rural from its inception, hence the independent nature of its population with regard to water use during the agrarian regime. Market towns were established to support the largely cotton- based economy. The 1940 census was the last in which the population of Texas was predominantly rural, and by 1950, a major demographic shift was underway and the state's population was concentrating in cities.[361] The population shift was significant enough for some to question the adequacy of their water supply. This is why the Texas Board of Water Engineers in cooperation with the United States Geological Survey undertook a comprehensive examination of public water supplies in the state during the latter half of the 1940s.[362] An

[361] Stuart McGregor, "Why Texans Think Less of Drouth," *Dallas Morning News*, 29 April 1952, Sec: Part III p. 2. Includes a graph "Population of Texas, Urban and Rural, 1870-1950" and asserts that rural populations are more sensitive to drought than their urban counterparts.

[362] See Texas Board of Water Engineers, *Public Water Supplies in Eastern Texas, Volumes I , II: Anderson-Harris Counties*, M214 (Austin, TX: Texas Board of Water Engineers, 1945); W.L. Broadhurst, R.W. Sundstrom, and J.H. Rowley, *Public Water Supplies in Southern Texas*, M215 (Austin,

unprecedented series of regional water planning sessions was held across Texas in 1948 that set the precedent for involving some segments of the public, mostly prominent businessmen, in aspects of water planning.[363] The need for planning for future water supplies was reported in this 1949 article from the *Dallas Morning News*,

> "A lot of Texas towns are going to be left high and dry if the people do not take more interest in future water supplies," E. V. Spence of Austin, Texas Interstate Compact Commissioner, said in Dallas Monday. "The growth of a community stops when its water supply ceases to meet the overall demand, and many Texas towns already have outgrown their present sources," he told the Dallas Branch of the American Society of Civil Engineers at Hotel Adolphus. *"Human nature being what it is, the public is not too concerned about water as long as it flows freely from the faucet," he observed.* "But it takes time to finance and build dams and reservoirs. For that reason, Texans should support vigorously a statewide water development and conservation program."[364]

And just as this was happening, Texas was beset with drought. During the first half of the 1950s, all parts of Texas suffered from a well-documented lack of rain. According to the *Handbook of Texas*, this was the most catastrophic drought to affect all parts of the state,[365] although this is now at least partially in dispute from Malcolm Cleaveland's research for the Guadalupe-Blanco River Authority. Cleaveland agrees that the Drought of the 1950s is the worst drought in "the observed climatic data," but

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TX: Texas Board of Water Engineers, 1946); W.L. Broadhurst, R.W. Sundstrom, and D.E. Weaver, *Public Water Supplies in Western Texas*, M216 (Austin, TX: Texas Board of Water Engineers, 1949); R.W. Sundstrom, W.L. Broadhurst, and Mrs. B.C. Dwyer, *Public Water Supplies in Central and North-Central Texas*, M213 (Austin, TX: Texas Board of Water Engineers, 1947).

[363] Coastal Area Water Conference at Houston on October 20, 1948; South Texas Water Conference at Corpus Christi on August 13, 1948; West Texas Water Conference at Big Spring on January 20, 1948; East Texas Water conference at Tyler on May 21, 1948; Central Texas Water Conference at Waco on July 8, 1948. Proceedings from these conferences are listed on p. 108 of the Texas Water Development Board's June 1992 Publication Catalog as Miscellaneous reports M059A-E, respectively.

[364] "Future Water Supply Importance Stressed," *Dallas Morning News*, 6 December 1949, Sec: III p. 3. The emphasis is my own and typifies attitudes of the waterworks regime.

[365] Texas State Historical Association, *Handbook of Texas Online*, entry "droughts," http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).

argues that in the period dating back to 1648, droughts of greater magnitude have been identified by tree ring analysis. Cleaveland rates a drought in early eighteenth century as the worst in the last 350 years, when considering durations of three, four, five, or ten years.[366] Nevertheless, it is clear from the academic literature,[367] government reports,[368] the popular press,[369] and even an award-winning novel,[370] that the Drought of the 1950s made an indelible impression upon Texans.

As this chapter has documented, the roots of the dam and levee regime extend as far back as at least the turn of the twentieth century and are entangled with flood control in order to protect the cotton economy during a period when water was perceived as plentiful. The Drought of the 1950s shattered Texans' long-held perception that water was an abundant resource. There was an institutional shift in Texans view of water, and for the first time in Texans'. Agriculture and livestock were particularly hard hit. In

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[366] Malcolm K. Cleaveland, "Extended Chronology of Drought in the San Antonio Area," revised March 30, 2006, http://www.gbra.org/ (accessed March 12, 2007). See especially page 5 and Table 4: Twenty droughts of 1-5 and 10-year lengths in order of severity in the reconstruction of climatic division 7 (S. Central) Feb. – June total precipitation (inches), 1648-1995.
[367] David W. Stahle and Malcolm K. Cleaveland, "Texas Drought History Reconstructed and Analyzed from 1698 to 1980,) *Journal of Climate*, Volume 1, Issue 1 (January 1988): 59-74. Tree rings from post oaks were used to reconstruct the Palmer Drought Severity Index for each June in large regions of North and South Texas for an interval of almost 300 years. See Figure 2, p. 63 for a graph of the drought. See also Rana K. Williamson, "The Heat from the Forge: Aspects of the Seven Year Drought of the 1950s," (Ph.D. Dissertation: Fort Worth, TX: Texas Christian University, 1993).
[368] Robert F. Riggio, George W. Bomar, and Thomas J. Larkin, *Texas Drought: Its Recent History, 1931-1985* (Austin, TX: Texas Water Commission, 1987); R.L. Lowry, Jr., *A Study of Droughts in Texas* (Austin, TX: Texas Water Commission, 1959).
[369] Todd H. Votteler, "Drought: Drought Is a Normal Condition in Texas. The Great Drought of the 1950s May Have Been Just a Taste of What's to Come," *Texas Parks & Wildlife*, July 2000.
[370] Elmer Kelton, *The Time It Never Rained* (New York: Forge, 1973). Winner of the Spur Award Western from the Writers Association and the Western Heritage Award from the National Cowboy Hall of Fame. Kelton noted about this drought, "For parts of West Texas the ordeal lasted a full seven years. Though some would argue that it was not the most devastating drouth they had ever seen, it was by all odds the longest in memory." p. vii.

urban areas, the impact was not as immediate, but was felt nevertheless. As the state's economy suffered, so did its urban areas. And when water supplies, literally, almost completely evaporated, the urban public was awakened to a water crisis. In Dallas, Bachman Lake completely dried up. Lake Dallas was at only eleven percent of capacity by the end of 1952, and it represented a critical element of the city's water supply. About the same time the Army Corps of Engineers issued a report estimating that the city had only a four month supply of water unless it could tap a new source.[371] In rural parts of the state, the drought adversely affected the agricultural economy and way of life. Even in the cities, the drought made an economic impact as municipal leaders worried about securing emergency water supplies.

One small but very human example is illustrated in Figure 6.12, which is a *Dallas Morning News* photograph of Joe Emerton filling a 55-gallon tank from his water truck. Mr. Emerton made a living during the Drought by delivering water to people whose wells had gone dry in Dallas County. He purchased twelve hundred gallons of water at a time for ninety-six cents from the City of Cockrell Hill and delivered it to more than two hundred customers for one cent per gallon. He was assisted by his wife and nine of his eleven children.[372]

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[371] Robert B. Fairbanks, *For the City as a Whole: Planning, Politics, and the Public Interest in Dallas, Texas, 1900-1965* (Columbus, OH: The Ohio State University Press, 1998), 186-7; Texas State Historical Association, *Handbook of Texas Online*, entry "Drought." "Drought," Vertical file, Center for American History, University of Texas at Austin (accessed August 30, 2005).

[372] "Wells Go Dry: Drouth Helps Business for Water Truck," *Dallas Morning News*, 30 March 1951, Sec: Part I p. 11.

—Dallas News Staff Photo.

Joe Emerton, who sells water to folks all over Dallas County but especially in Eagle Ford, is pictured here filling a 55-gallon tank for a customer.

Figure 6.13. Putting an Enterprising Face on the Drought of the 1950s. This man made a living during the Drought by delivering water to people whose wells had gone dry in southwest Dallas County. He purchased 1,200 gallons of water for 96 cents from the City of Cockrell Hill and delivered it to more than 200 customers for one cent per gallon using a 1,250 gallon water trucked owned by R.H. Pallette. He was assisted by his wife and nine of his eleven children.[373]

[373] "Wells Go Dry: Drouth Helps Business for Water Truck," *Dallas Morning News*, 30 March 1951, Sec: Part I p. 11.

Newspaper headlines stoked the unease of the populace then, but now provide an indication of the pervasive effects of the drought.[374] But one of the best indications of the change in perception of water is, ironically, fictional! Elmer Kelton began the

[374] Roy Roddy, "Cotton Planting Time Finds Dallas Area Dry," *Dallas Morning News*, 2 April 1950, Sec: Part 1 p. 13; Walter Robinson, "Farmers Hoping For Soaking Rain: Needed to Save Crops, *Dallas Morning News*, 13 April 1950, Sec: Part 1 p. 1; Joe Belden, "Texas Poll: Water, Soil Conservation Top Problem," *Dallas Morning News*, 15 May 1950, Sec: Part II p. 4; Walter Robinson, "Long Drouth Sears Area's Countryside," *Dallas Morning News*, 10 December 1950, Sec: Part IV p. 1; "Low Water Levels Reported in Texas Rivers and Wells," *Dallas Morning News*, 11 February 1951, Sec: Part I p. 7; "Drouth Relief Meeting," *Dallas Morning News*, 23 February 1951, Sec: Part I p. 7; "Texas Water At Low Point On April Check," *Dallas Morning News*, 13 May 1951, Sec: Part I p. 7; "Texas Drouth Area Widens," *Dallas Morning News*, 9 August 1951, Sec: Part III p. 6; "Lake Deserts Boathouse: Man With Deep Water Well Rates High in Corsicana," *Dallas Morning News*, 12 August 1951, Sec: Part I p. 9; "County Hits New High on Water Consumption," *Dallas Morning News*, 9 August 1951, Sec: Part III P. 3; "115 Degrees and No Water: Old-Timer Would Hark Back to Heat Waves of 1909-10," *Dallas Morning News*, 11 August 1951, Sec; Part III p. 1; "Food Off Farms Cut By Drouth," *Dallas Morning News*, 16 August 1951, Sec: Part III p. 1; "Prayer for Rain Due At North Dallas Church," *Dallas Morning News*, 17 August 1951, Sec: Part III p. 14; "Temple [Texas] Water May Be Gone In Ten Days," *Dallas Morning News*, 29 August 1951, Sec: Part I p. 17; "Drouth Causes Threat of New Raise on Milk," *Dallas Morning News*, 4 September 1951, Sec: Part III p. 1; "Drouth Sends Cattle Pouring Into Markets," *Dallas Morning News*, 5 September 1951, Sec: Part I p. 4; Roy Roddy, "Farmers Giving Up After Crop Failures," *Dallas Morning News*, 5 September 1951, Sec: Part I p. 4; Dawson Duncan, "Water Shortage Brings Special Session Pleas," *Dallas Morning News*, 6 September 1951, Sec: Part I p. 5; "Tenant Farming In Texas Declines," *Dallas Morning News*, 7 September 1951, Sec: Part III p. 2; Thomas Turner, "Rain-Making Tryout Nears in Central Texas," *Dallas Morning News*, 12 November 1951, Sec: Part I p. 5; Roy Roddy, "West Texans Fight To Survive Drouth," *Dallas Morning News*, 7 February 1952, Sec: Part I p. 1; Roy Roddy, "Lake Dallas Shrinking From Drouth and Silt," *Dallas Morning News*, 17 February 1952, Sec: Part IV p. 1; Wayne Gard, "Texas Honey Crop Pinched by Drouth," *Dallas Morning News*, 5 March 1952, Sec: Part III p. 2; "Big Cats Seined As Drouth Shrinks Lake to Mudhole," *Dallas Morning News*, 13 July 1952, Sec: Part II p. 5; "Drouth Employed as Theme Of Freestone Fair's Parade," *Dallas Morning News*, 21 September 1952, Sec: Part I p. 19; "Unique Way Found To Beat Drouth," *Dallas Morning News*, 2 November 1952, Sec: Part I p. 1, contains front page photo of ice delivery man spreading 12,000 pounds of ice shavings on his front yard; "Drouth Affects Even the Wets [Moonshiners]," *Dallas Morning News*, 9 November 1952, Sec: Part III p. 16; Robert E. Baskin, "Drouth Damage—III: Farmers Assisted By Outside Jobs," *Dallas Morning News*, 25 November 1952, Sec: Part I p. 6; Walter C. Hornaday, "Drouth Raises Party Tempers," *Dallas Morning News*, 8 July 1953, Sec: Part III p. 2; "Ike to Visit Texas Friday on Drouth," *Dallas Morning News*, 10 July 1953, Sec: Part I p. 1; "Dams Will Combat Floods, Drouth," *Dallas Morning News*, 21 February 1954, Sec: part Viii p. 4 with photo of construction at Garza-Little Elm dam; Dawson Duncan, "A&M Allowed to Buy Hay for Drouth Areas," *Dallas Morning News*, 29 July 1953, Sec: Part III p. 12; Robert Alexander, "Tree to Withstand Drouth Is Studied," *Dallas Morning News*, 19 November 1953, Sec: Part III p. 15; Richard M. Morehead, "Drouth Called Texas' Worst," *Dallas Morning News*, 13 October 1956; Stuart McGregor, "Longest Drouth in Texas History," *Dallas Morning News*, 6 July 1956; Stuart McGregor, "Now's the Time to Solve Drouth," *Dallas Morning News*, 23 September 1956; Stuart McGregor, "When Will This Drouth End?" *Dallas Morning News*, 29 August 1956; Allen Duckworth, "Water Bond Plan Rushed to Senate," *Dallas Morning News*, 30 January 1957.

introduction to *The Time It Never Rained*, his highly regarded novel about the Drought of the 1950s, with this: "During the long Texas drouth of the 1950s a joke—probably already as old as the state—was told again and again about a man who bet several of his friends that it never would rain again, and collected from two of them. Indeed, it seemed the rain was gone forever."[375]

Under these conditions it is hardly surprising that dams were now touted for water supply rather than flood control or hydroelectric power generation. Grapevine and Garza-Little Elm dams were planned to increase not only the water supply for Dallas, but to add to the perception of water abundance for the city. Dallasites were told, "When Grapevine and Garza-Little Elm dams are complete, Dallas can swell its population to 1,200,000 and still have plenty of water for them all—even if it doesn't rain for five consecutive years." [376] There was still the problem that the State could not go into bonded indebtedness to build reservoirs. An attempt to revise the State Water Code in 1951, and allow for a $200,000,000 revolving loan fund for reservoir construction, did not pass the legislature. A Constitutional Amendment was necessary before the state could authorize a state bond issue for reservoirs.[377] This was finally accomplished in 1957 through an amendment that also created the Texas Water

[375] Kelton, *The Time It Never Rained*, vii.
[376] Walter Robinson, "2 Dams to Store Water for a City of 1,200,000," *Dallas Morning News*, 19 November 1950, Sec: Part IV p. 1. For perspective, the population of Dallas in 1950 was 434,462.
[377] Dawson Duncan, "Water Shortage Brings Special Session Pleas," *Dallas Morning News*, 6 September 1951, Sec: Part I p. 5.

Development Board. The Board's original function was to provide loans for reservoir construction that could not be funded by other means.[378]

Another indication of this drought's impact on the psyche of Texans is reflected in the interest by Walter Prescott Webb in a conference on water conservation organized by the President of Southwest Texas State Teachers College at San Marcos on July 20, 1954. Webb served as moderator and urged the State to become more involved in the role of conservation of surface water, asserting that leadership in this realm had been abdicated to federal and local governments.[379] What is striking is not that a conference was held with the central theme of water conservation—after all the State was several years into a significant drought—but rather that concern had spread beyond public works officials to the leading historian in the state. Webb argued that drought was a reoccurring phenomenon in at least half the state, and that Texans should embrace a plan that "looks forward to mitigating the rigors of the next drought by saving the water of the fat wet years for use in the lean dry ones."[380] He felt so strongly about the need for water conservation that he took a government report by engineers from the U.S. Bureau of Reclamation[381] and rewrote it hoping to present the ideas in a form the general public would fine more engaging. In it Webb wrote,

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[378] Texas State Historical Association, *Handbook of Texas Online*, entry "Texas Water Development Board," http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).
[379] "Texas' Water Waste Discussed at Meet," *Dallas Morning News*, 21 July, 1954, Sec: Part I p. 18.
[380] Walter Prescott Webb, *More Water for Texas: The Problem and the Plan* (Austin, TX: The University of Texas Press, 1954), v.
[381] Bureau of Land Management Austin Area Planning Office, *Water Supply and the Texas Economy: An Appraisal of the Texas Water Problem* (Washington, DC: Department of the Interior Bureau of Reclamation, U.S. Government Printing Office, 1953).

> As a result of several successive years of moisture deficiency, people have become water conscious, and all sorts of plans are being suggested for doing something about it. Many of these plans have merit, but any plan that promises quick relief through human agency is a fraud. A good rain is the only quick solution to the problem of the drought, and nature has as yet not yielded the secret of making rain. Unfortunately a good rain washes away more than the drought; it washes away much of man's interest in providing for the next one, and it washes the supports from under those who know that another dry cycle is coming and who urge their fellows to make ready for it.[382]

One final indication that the Drought precipitated Texans' views on the scarcity of water comes in government reports and new legislation. Periodic reports on water use began to emerge from various government agencies. The USGS has issued water use reports every five years since 1950. The more recent USGS reports contain a historical summary section of "Trends in Water Use."[383] Texas water agencies have issued water use reports irregularly 1961.[384] Most of the Texas water use data is incorporated into the State's water plan—*Water for Texas*—first issued in 1968, revised several times, and now issued every five years. The earliest water plan I can find for the state was published in March 1938 by the Texas Planning Board and is entitled *Development of Texas Rivers: A Water Plan for Texas*. In spite of its title it is not a comprehensive water plan, but rather the proceedings of a state-wide ground water conservation conference of the Water Resources Committee of the Texas Planning Board. Another early water plan for the state came from the U.S. Department of the Interior Bureau of Reclamation in 1953 at the behest of then Senator Lyndon B. Johnson in 1949. This was the plan that

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[382] Webb, *More Water for Texas*, v.
[383] United States Geological Survey, *Water Use in the United States*, Washington, DC, http://water.usgs.gov/watuse/ (accessed March 11, 2007).
[384] Texas Board of Water Engineers, *Historical Ground-Water Used by Municipalities for the Years 1955 Through 1959 for Selected Areas in Texas* (Austin, TX: Texas Board of Water Engineers, 1961).

caught Walter Prescott Webb's attention and led to his 1954 *More Water for Texas*. This plan called for the construction of a canal parallel to the Gulf Coast and approximately seventy-five miles inland extending all the way from Louisiana to Mexico. Its purpose was to irrigate and to transport water from the more humid eastern part of the state to the more arid western parts of the state at an estimated cost of one billion dollars. Texans had long perceived their financial capital to be scarce and their interest in federal involvement low, so this project never gained traction.

A Constitutional amendment in 1957 created the Texas Water Development Board and provided allocation of State funds as loans for the construction of reservoirs. Shortly after its creation, the agency issued its first water report to the State Legislature.[385] In May 1961 the agency published its first water plan for the state.[386] Even though this had a time horizon of less than twenty years, it indicates a significant change in perception for a state recovering from a drought in which some communities' water supplies had dwindled to a few months' worth of water. The agency's function expanded into that of the central water planning agency for the state.[387] A flurry of preliminary and regional water plans were published in 1966,[388] but the State's long

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[385] Texas Water Development Board, *Texas Water Resources Planning at the End of the Year 1958: A Progress Report to the Fifty-Sixth Legislature,* P02 (Austin, TX: Texas Water Development Board, December 1958).
[386] Texas Water Development Board, *Plan for Meeting the 1980 Water Requirement of Texas,* P03 (Austin, TX: Texas Water Development Board, May 1961).
[387] Texas Water Development Board, *Texas Water Planning—A State Responsibility*, P06 (Austin, TX: Texas Water Development Board, October 1964).
[388] Texas Water Development Board, *Water for Texas: A Plan for the Future (Preliminary),* P07 (Austin, TX: Texas Water Development Board, May 1966); Texas Water Development Board, *Preliminary Plan for Proposed Water Resources Development in* various river basins, P08-P30 (Austin, TX: Texas Water Development Board, 1966).

awaited and first official water plan, written by Texans for Texans, was announced in 1968 and adopted by the State Legislature in 1969.[389] Much was made by State politicians that this was a Texas plan and not a federal plan for water management. It was also significant in that it was designed to put Texas in a better position to weather another severe drought, even in light of significant population growth, for the next fifty years. The plan was extended an additional ten years in 1977[390] and amended in 1984, 1990, 1992, 1997, and 2002.[391]

The first Texas Water Plan of 1968 may have been the most ambitious. It not only called for the impoundment of surface water, but also incorporated the Bureau of Reclamation's plan to import water from the Mississippi River and transport it across Texas via canals. It called for the manipulation of surface water using the resources of both the State and federal governments at a grand scale. The average annual runoff of fresh water in Texas between 1924 and 1956 was estimated to be 39,000,000 acre-feet. More than fifty new reservoirs were proposed.[392] The Texas Water Plan was designed to conserve as much of this run-off as possible, plus to import what was advertised as a

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[389] Texas Water Development Board, *The Texas Water Plan*, P32 (Austin, TX: Texas Water Development Board, 1968); preceded by Texas Water Development Board, *Texas Water Plan Summary*, P31 (Austin, TX: Texas Water Development Board, 1968).
[390] Texas Water Development Board, *Continuing Water Resources Planning and Development*, 2 volumes, P34 (Austin, TX: Texas Water Development Board, May 1977).
[391] Texas Water Development Board, *Water for Texas: Planning for the Future*, 2 volumes, P36 (Austin, TX: Texas Water Development Board, 1984); Texas Water Development Board, *Water for Texas: Today and Tomorrow – 1990*, GP-5-1 (Austin, TX: Texas Water Development Board, 1990; Texas Water Development Board, *Water for Texas: Today and Tomorrow – 1992* (Austin, TX: Texas Water Development Board, 1992); Texas Water Development Board, *Water for Texas* (Austin, TX: Texas Water Development Board, 1997); Water for Texas – 2002, GP-7-1 (Austin, TX: Texas Water Development Board, 2002).
[392] Texas Water Development Board, *The Texas Water Plan* (Austin, TX: Texas Water Development Board, 1968), Plate 3.

negligible amount (five percent) of the Mississippi's run-off.[393] This was a plan born in the scarcity of drought, and had it been put to the voters a decade earlier, it might have been approved. But the cost was high, both in terms of dollars and environmental impacts, and by 1968 memories of the drought were fading. The water importation plan was defeated in a low-turnout 1969 statewide bond election, largely on the basis of opposition in Houston, where a newly founded chapter of the Sierra Club had campaigned vigorously for its defeat.[394] This defeat is indicative of a changing attitude toward water that would eventually give rise to a fourth water regime. The hard edge of drought was tempered, but not forgotten for several decades.

Dam and Levee Regime Summation

The challenge of fire in the central business districts and flooding in prime cotton producing acreage demanded a response at a scale larger than the individual, family, or plantation. In each new water regime, citizens organized to bring more assets to bear in attempting solutions to recurring problems of water management. Both challenges involved moving from self-sufficiency to an organized division of labor. Both required investing resources beyond those available to individuals. As new ways of supplying

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[393] Texas Water Development Board, *The Texas Water Plan* (Austin, TX: Texas Water Development Board, 1968), II-15.

[394] Bret Wallach, "Big State, Slow Learner," in *At Odds with Progress* (Tucson, AZ: University of Arizona Press, 1991), 164-187, especially p. 180. See also John Graves, "Texas: 'You Ain't Seen Nothing Yet.'," in *The Water Hustlers*, by the editors of the Sierra Club (San Francisco: Sierra Club, 1971), 15- 129 for a much more complete description of the Sierra Club's successful opposition to the Bureau of Reclamation's plan, known as the Texas Water System, to import water from the Mississippi River to semi-arid West Texas and the Rio Grande Valley.

and managing water emerged, the self-sufficient patterns of water use characteristic of the agrarian regime went by the wayside.

Local organization sufficed to address the vexing problem of fire in the central business districts of Texas' towns and cities, but trying to manage the destruction from flooding and multi-year droughts by capturing and conserving runoff required more resources than local communities could provide. The challenge was recognized early in the settlement process, but it took time for Texans to put in place elements with which to address the challenge. Certainly the State constitutional amendment adopted in 1904, allowing State funds to be used for water management projects, was an important step. So, too, were the lessons learned from such groups as the Burleson County Improvement District and dam building projects under the auspices of government agencies in other parts of the United States during the 1930s and 1940s. Ultimately, though, it was the transition from a dispersed rural population to a more concentrated urban population, occurring coincident with the Drought of the 1950s, that changed Texans' perception of water, from that of an abundant resource that was taken for granted to that of a scarce resource whose conservation required a different and more comprehensive management strategy that could not be implemented at the scale of local government. Thus, the emphasis in this third water regime was on management of surface water, which in Texas occurred first in the form of levees and then as reservoirs impounded by earthfill dams, that were organized, constructed, and managed at the scale of regional river authorities, the federal government via the U.S. Army Corps of Engineers, and finally the State through the adoption, partial implementation, and amendment of the Texas Water Plan.

By the end of the twentieth century, however, the dam and levee regime was supplanted by a fourth water regime. Groundwater re-emerged as a significant source of non-irrigation water at a scale well beyond that of supplying a household, as in the agrarian regime, or a local waterworks, as in the waterworks regime. With enthusiasm for dam construction waning, the dam and levee regime was replaced by the groundwater regime.

CHAPTER VII

THE GROUNDWATER REGIME

Reservoir construction in Texas peaked during the 1960s, and then dropped off rather abruptly. Why? In his classic Texas narrative, *Goodbye to a River*, written in the late 1950s, John Graves takes a nostalgic three week canoe trip down a stretch of the Brazos scheduled to be inundated by the construction of four new dams. He accepted the proposed dams as necessary simply because water was necessary. The folks who moved to nearby Fort Worth and Dallas needed water, and dams represented progress toward securing a water supply after the severe 1950s drought. As Graves explained,

> "Bitterness? No, ma'am . . . In a region like the Southwest, scorched to begin with, alternating between floods and drouths, its absorbent cities quadrupling their censuses every few years, electrical power and flood control and moisture conservation and water skiing are praiseworthy projects. More than that, they are essential. We river-minded ones can't say much against them—nor, probably, should we want to. Nor, mostly, do we. . . . … When someone official dreams up a dam, it generally goes in. Dams are ipso facto good all by themselves, like mothers and flags. Maybe you save a Dinosaur Monument from time to time, but in-between such salvations you lose ten Brazoses. . . ."[395]

Written just after the Drought of the 1950s, Graves's views capture both the attitudes about the scarcity of water and the necessity for conserving surface water that are so characteristic of the dam and levee regime. But this attitude has not persisted to the present. With the passage of time, memories of the drought have faded and the urgency of conserving surface water diminished. It is certainly not that water is once again perceived as abundant—consider the efforts that went toward adopting and amending the

[395] John Graves, *Goodbye to a River* (Houston, TX: Gulf Publishing Company, 1960), 8-9.

Texas Water Plan over the past forty years—but the urgency with which Texans pursued reservoir construction in the state after 1970 has certainly diminished.

Failure to implement the 1968 water plan is an indication of a shift in attitude toward water in Texas, and suggests the possibility that Texans have moved beyond the dam and levee regime.[396] This is illustrated in Figure 7.1. The reservoirs that exist are shown in blue. Those relatively few shown in yellow were proposed in the 1968 plan and are still proposed in the 2002 plan. The red reservoirs are those proposed in the 1968 water plan, but almost forty years later still have not been constructed.[397]

It is clear from today's perspective that the plan to capture surface water runoff proposed in the 1960s was overly ambitious. Because so many of these once planned-for reservoirs were not and almost certainly will not be constructed, I argue Texas has moved beyond the dam and levee regime. Was the planned construction of more than forty additional major reservoirs an over-reaction to the Drought of the 1950s? Did the fifty year Texas Water Plan reassure Texans that their water supply was guaranteed, at least for their lifetimes? Were all the best reservoir sites already impounding water? Did Texans sense the ephemeral nature of their reservoirs because of the high silt content of their sluggish rivers? Was there a new awareness of the environmental and

[396] Todd H. Votteler, "Water Boondoggles: The Biggest Little Water Plan in Texas," *Texas Parks & Wildlife* (January 2001).

[397] The 1997 and 2002 State Water Plans recommended 8 new reservoirs for additional water supplies between now and 2050. Planning groups have recommended 14 new major reservoirs in their 2006 Regional Water Plans. See, Texas Water Development Board, *Draft –Water for Texas – 2007* (Austin, TX: Texas Water Development Board, August 2006), 11, http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/vol%20I_draft.pdf, (accessed October 2006).

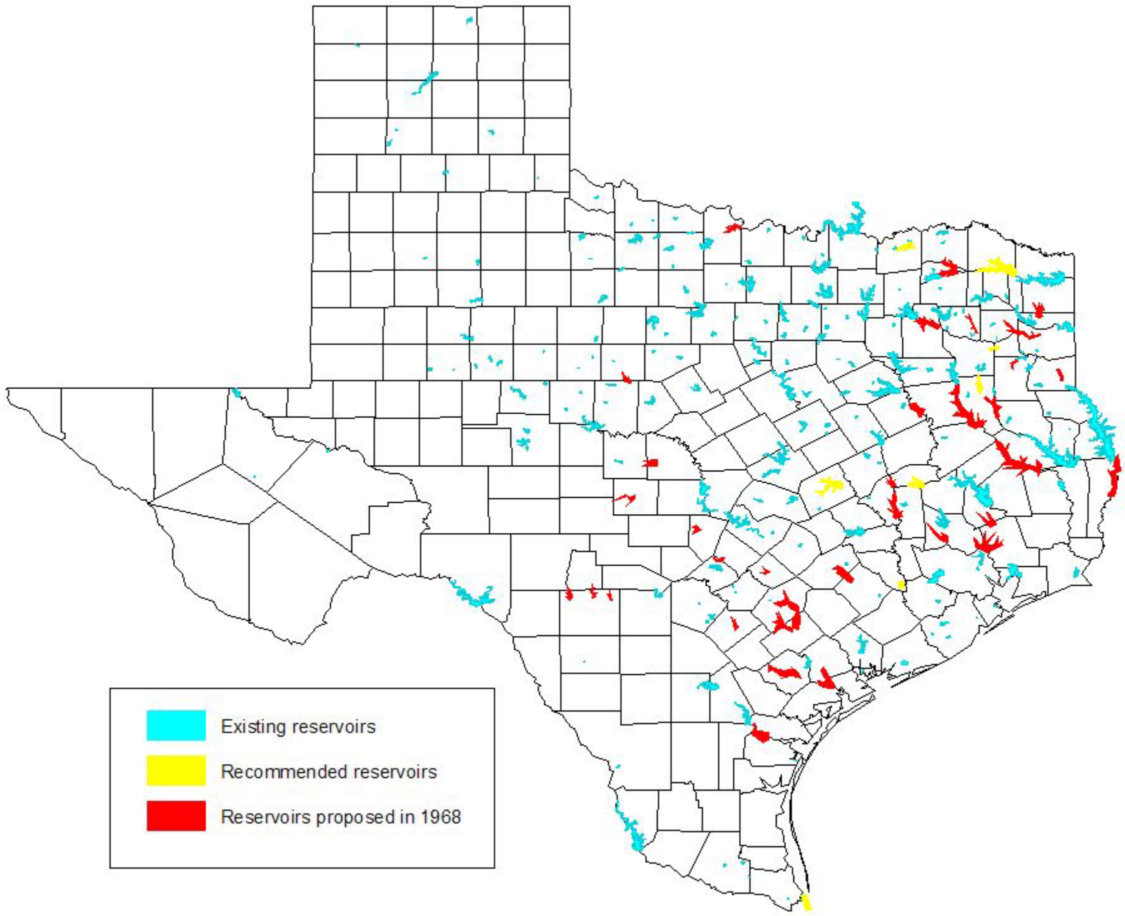

Figure 7.1. Existing and Proposed Reservoirs. Ideas on the conservation of surface water in the state's rivers has changed since the first official Texas Water Plan was issued in 1968. Interest has waned in conserving surface water in reservoirs. The reservoirs shown in red were proposed in the 1968 plan, but have not been built, nor are they included in the 2002 Texas water plan.[398] The locations shown in yellow are included as recommended sites for new reservoir construction in the 2002 plan. The three largest of these recommended sites were included in the original 1968 plan, although the western-most of the three has been shifted to the east by half a county. Most of the smaller 2002 recommended sites were not part of the 1968 Texas Water Plan.[399] Data is from the Texas Water Development Board.

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[398] Texas Water Development Board, *The Texas Water Plan* (Austin, TX: Texas Water Development Board, 1968), IV-9 to IV-59 and Plate 3.
[399] GIS shapefiles for existing and recommended reservoirs are from the Texas Water Development Board.

social consequences of dam construction? Or was technology trusted as the tool that would allow for better filtration, cycling, and recycling of water supplies? All of these are contributing factors, but in this chapter I argue that drought in 1996, causing six billion dollars in agricultural losses,[400] resulted in new legislation that, in combination with a landmark court decision, marks the tipping point to a new water regime. According to the Texas Water Development Board, the signing into law of Senate Bill 1 in June of 1997, "was in response to the extensive drought of 1995-96 and established an entirely new approach to water management and planning in Texas. By 1996, it was clear to most Texans the state was especially vulnerable to drought, and that existing water supplies could not meet current demands during these conditions, let alone the demands of a growing population."[401]

Although reservoir construction slowed significantly by 1970, it was another quarter of a century before this tipping point occurred. Even as Texans adjusted to their new-found perceptions of the scarcity of water during the second half of the twentieth century, the groundwork was being laid for another shift in the cultural landscape of water. In this impending shift, the inertia to be overcome was organizational—Texas water law. One of the byproducts of the civil upheavals of the 1960s was an increased awareness of the environment. The Water Resources Planning Act, the Water Quality Act, the Land and Water Conservation Fund Act, the Highway Beautification Act, the

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[400] Texas Water Development Board, "The Drought in Perspective, 1996-1998," 1999 http://www.twdb.state.tx.us/data/drought/DroughtinPerspective.asp (accessed March 11, 2007).
[401] Texas Water Development Board, *Water for Texas: Summary of Regional Water Plans, February 1, 2001* (Austin, TX: Texas Water Development Board, 2001), 1.

Endangered Species Act, the Clean Water Act, and the Wild and Scenic Rivers Act were all signed into federal law during the latter half of the 1960s.[402] A new element had certainly been added to institutional ideas about water at the national level, and this in turn raised awareness of Texas water law. Concerns about water *quantity* were augmented with increasing concerns for water *quality*.

Texas Water Law

Law is a powerful form of cultural inertia. Significant influences brought from Spanish, Mexican, and Anglo law have interwoven to form Texas water law. Spanish law established community controlled water supplies in the acequias of San Antonio and El Paso in which authorization was required for access to water. When Mexico won its independence from Spain in 1821, Spanish water law was continued in what is now Texas. In 1836, the Republic of Texas declared its independence from Mexico and four years later adopted English common law, including the doctrine of riparian rights granting private water rights to property owners adjacent to a river or stream. Drought in the 1880s prompted the Texas Legislature to amend its water laws in 1889, 1893, and 1895 to reflect prior appropriation laws recognizing earliest claims to water use as precedent setting and continuing. This is summarized by the phrase “first in time, first in right.”

[402] See Appendix A.

This prior appropriation rule was common in the semi-arid western United States, and the riparian system was common in the more humid eastern United States. Texas incorporated some of both with its judicially adopted riparian rights and legislatively created prior appropriation rights.

In 1967, the Legislature passed the Water Rights Adjudication Act, consolidating surface water claims into one system. The State claimed all surface water that made its way into a river or stream, and extraction of surface water from these sources now requires a permit from the State. Although both surface water and groundwater are linked through the hydrologic cycle, groundwater was at the same time subject to a different set of laws derived from the English common law of "absolute ownership." This gives the owner of the property above the groundwater the right to pump groundwater to the surface and either use it or sell it as private property, with few exceptions. Absolute ownership is frequently referred to as the "rule of capture." Whatever groundwater the property owner can capture and bring to the surface belongs to the property owner, although it does not belong to the property owner while it is still in the subsurface.[403]

Observations about the inertial nature of Texas water law, particularly with respect to groundwater, were made by Otis Templer in 1978,

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403 Kaiser, *Handbook of Texas Water Law*. See also Olen Paul Matthews, *Water Resources, Geography and Law* (Washington, DC: Association of American Geographers, 1984), especially map of surface water law, p. 41 and map of type of groundwater law, p. 7. See also Otis W. Templer, "Texas Ground Water Law: Inflexible Institutions and Resource Realities," *Ecumene* 10 (April 1978): 6-15; and Otis W. Templer, "Texas Surface Water Law: The Legacy of the Past and Its Impact on Water Resource Management," *Historical Geography* Vol. 8, No. 1 (1978): 11-20.

> The significance of water rights and water law is sometimes overlooked by geographers in their studies of natural resource use and management. Though the impact of these legal institutions which regulate water resource allocation is not always readily apparent, they can be of great importance in controlling the efficient management of water resources. Primarily, they serve as absolute constraints on the way in which both water and land are used, now and in the past. Once established in the law by statute, common law or customary practice, these systems *tend to resist change and are especially difficult to replace or modernize*. As competition for limited water supplies increases, the water rights systems inherited from the past sometimes hamper desirable water resource management reforms, and perhaps nowhere is this more evident than in Texas. Thus the study of water rights institutions should be of immediate concern to geographers interested in water resources. Almost forty years ago the late Derwent Whittlesey perceptively noted that, "Laws flagrantly unsuited to regions where they operate ultimately destroy the resource which they govern." The significance of these slowly-evolving water law institutions and the impact they can have on water resource use and management are clearly shown in the example provided by Texas ground water law.[404]

Incorporating Dodgshon's ideas on inertial elements in the cultural landscape with Templer's assertions that water law is clearly a significant inertial force leads to the conclusion that a significant change in water law could not be implemented without overcoming significant resistance. In 1997, Texas water law *was* significantly amended by the passage of Senate Bill 1.

New Legislation and a State Supreme Court Decision

With the passage of Senate Bill 1 by the 75th Legislature in 1997, the water planning process in the state Texas water law was overhauled. Adjusting to mandates of the bill itself has proven to be the challenge precipitating a new water regime. The first challenge was that the bill severely restricted interbasin transfers of surface water, and

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[404] Templer, "Texas Ground Water Law," 7. My emphasis.

this forced consumers to turn to groundwater to plug gaps in water supply. Second, the challenge was that the bill allocated more surface water to ensure adequate freshwater flows from the state's rivers and streams into bays and estuaries. Finally, the bill completely overhauled the State's water planning process and required a significant amount of public participation at the local and regional level, the idea being to develop a grassroots plan that was updated every five years. In order to accomplish this, the state was divided into sixteen regional water planning groups, roughly aligned within watersheds, comprised of stakeholders from eleven specified interest groups who were appointed by the Texas Water Development Board. Each group was then charged with constructing its own regional water plan with intermediate (thirty year) and long term (fifty year) objectives encompassing projected demand by type of water use, sources of supply, and any necessary construction or enabling legislation recommended to accomplish the plan. Patterns of water use by category, projected supply, and projected demand under drought conditions were built into the plan. Drought conditions were to be assumed. Then each regional plan had to be coordinated into one statewide plan. The intent was to get significant local involvement in a comprehensive statewide water planning process. Should this fail, however, the Texas Water Development Board was charged with filling any missing pieces in the overall plan.[405] There were other provisions in Senate Bill 1, but I believe the changes identified above, taken as a whole, created a significant challenge that demanded a change in how water had previously

[405] Texas Water Development Board, *Water for Texas – 2002*, 1-14.

been managed and perceived in Texas. Unlike in the third water regime, Texans could no longer rely upon their government to ensure their water supply simply by capturing surface runoff.

A year after the passage of Senate Bill 1, litigation alleging damage to previously existing rural water wells by a bottled water company reached the Texas Supreme Court. In a decision commonly referred to as the Ozarka case, plaintiffs accused Ozarka of pumping so much water from their shared aquifer that the plaintiffs' wells went dry. The Court agreed with the plaintiffs that it was likely their wells had been harmed by the pumping of Ozarka, but ruled under precedent set in the 1904 case of Houston & Texas Central Railway, Co. v. East, that Ozarka had not broken the law by extracting a large quantity of groundwater from under property it owned. The 1904 case confirmed the precedent of the common law of absolute ownership, commonly referred to as the rule of capture, which grants surface owners the right to extract groundwater from the subsurface and use it without retribution, regardless of any harm this may cause their neighbors.

The plaintiffs in the Ozarka case had asked the Court to change the law, but the justices declined to do so at the time of their ruling in 1999, citing a preference for legislative action over judicial decree. The Court's ruling acknowledged that reasons for adopting the rule of capture in 1904 were no longer valid—that it would be practically impossible to administer laws concerning something as uncertain as underground water, and that such regulation would be to the detriment of progress in the State—but the Court interpreted the 1997 Senate Bill 1 as an indication that the Legislature recognized change was necessary in the State's water law, and wanted to give the new statutes a chance to work.[406]

The combination of Senate Bill 1 and the Ozarka decision brought groundwater into a more prominent role in the State's water planning. With new limitations placed upon the interbasin transfer of surface water and the requirement for each water supplier to have a fifty year plan based upon a worst case drought scenario, groundwater was increasingly considered as a significant source to augment long term water supply. This was necessitated not only by Senate Bill 1's increased restrictions on movement of surface water, but also by the demographic projection of continued increase in population in counties in and around metropolitan areas.[407] The use of groundwater for irrigation from the Ogallala aquifer in the Panhandle was already the highest consumer of water in the State, and groundwater was the source of choice for many of the State's early waterworks. Although groundwater was the principle water source for Houston until 1954, and the Edwards aquifer remains practically the sole source for San Antonio today, historically groundwater use has been local.[408] Now, it is increasingly apparent

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[406] Ronald A. Kaiser, ed., *Course Reader - RENR 662: Environmental Policy Law* (College Station, TX: Notes & Quotes, Spring 2003), 292-299 contains opinion delivered by Justice Craig T. Enoch for a unanimous Court, in Bart Sipriano, Harold Fain, and Doris Fain, Petitioners v. Great Spring Waters of America, Inc. a/k/a Ozarka Natural Spring Water Co. a/k/a Ozarka Spring Water Co. a/k/a Ozarka, Respondents, No. 98-0247, Supreme Court of Texas, 1999 Tex. LEXIS 49; 1999 Tex. Sup. J. 629; 1 S.W.3d 75, November 19, 1998, Argued and May 6, 1999. See also "Dateline Texas: State Justices Rule on Water 'Ownership'," *Houston Chronicle*, 9 May 1999, Sec: State, p. 2

[407] Texas Water Development Board, *Water for Texas – 2002*, 6, 25-30.

[408] Laura Wimberley, "The 'Sole Source:' A History of San Antonio, South Central Texas, and the Edwards Aquifer, 1890s-1990s," (History Dissertation: College Station, TX: Texas A&M University, 2001). See also John M. Donahue, "Water Wars in South Texas: Managing the Edwards Aquifer," in *Water, Culture, & Power*, edited by John M. Donahue and Barbara Rose Johnston (Washington, DC: Island Press, 1998), 187-208.

that groundwater may be relied upon to supply much more than just local demand. Infrastructure for the transportation of groundwater is being developed, but not without controversy.[409]

Groundwater Districts

With the Ozarka case confirming the right of a landowner to extract all the water he or she could pump, and then transport it without any of the restrictions that encumbered surface water as a result of Senate Bill 1, it suddenly appeared possible that large cities like Houston, San Antonio, and Dallas might very well seek to siphon off the groundwater from beneath smaller cities and rural counties. The response to the perceived threat of the movement of large amounts of groundwater across the state was the sudden proliferation of groundwater conservation districts. Although largely unprotected and unregulated, local management of groundwater has been allowed under state law for more than half a century. In 1949 Governor Beauford H. Jester signed the Underground Water Conservation Districts Act.[410] Local districts could be created, if confirmed by local vote, for the purpose of an orderly development and wise use of groundwater. The first such district was the High Plains Underground Water Conservation District No. 1. It was delineated by the State Board of Water Engineers in March of 1951, and confirmed by voters on September 19, 1951. In 1985 the law was

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[409] See, for example, "Texas Legislature gets comprehensive blueprint for future water supply to state," *Victoria Advocate*, 16 January 2005 in which citizens of Victoria are concerned about plans of the Lower Guadalupe Water Supply Project to transfer groundwater from the area around Victoria to San Antonio beginning in 2012.

[410] W. M. Thornton, "Water Bill Is Signed By Jester," *Dallas Morning News*, 3 June 1949, Sec: I, p. 7.

amended, adding the provision that the Texas Water Commission could initiate the formation of a groundwater district. Previous to this a district could be created only in response to petition from the voters. In the 1985 refinement, the district still had to be confirmed by local vote, but a no vote could jeopardize state funding for water projects. The intent of the districts was to encourage water conservation and protect water quality. Well spacing could be regulated and permits for new wells required. No attempt was made to limit production from private wells.[411] Senate Bill 1 in 1997 and Senate Bill 2 in 2001 contain further encouragement for the local establishment of groundwater districts as specified in Chapter 36 of the Texas Water Code. Their establishment can now be initiated by the Legislature, by petition from landowners, by the Texas Commission on Environmental Quality, or by annexation into an existing district, Regardless of how initiated, all groundwater districts must be confirmed locally.[412]

The first phase of groundwater district establishment in Texas was confined largely to the Panhandle and High Plains. These districts are indicated in blue on Figure 7.2. A second wave of groundwater districts spread across much of the western half of the state after a 1985 amendment allowing the Texas Water Development Board to recommend the establishment of such districts. These are indicated in green on Figure 7.2. After the passage of Senate Bill 1, and with further encouragement from Senate Bill 2 in 2001, groundwater districts have been organized across much of the rest of rural

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[411] Kaiser, *Handbook of Texas Water Law*, 32-34. See also the High Plains Underground Water Conservation District No. 1, "About Us," http://www.hpwd.com/about_us.asp (accessed 15 November 2007).

[412] Bruce Lesikar, Ronald Kaiser, and Valeen Silvey, *Questions about Groundwater Conservation Districts in Texas* (College Station, TX: Texas Cooperative Extension, [2002]), 13-26.

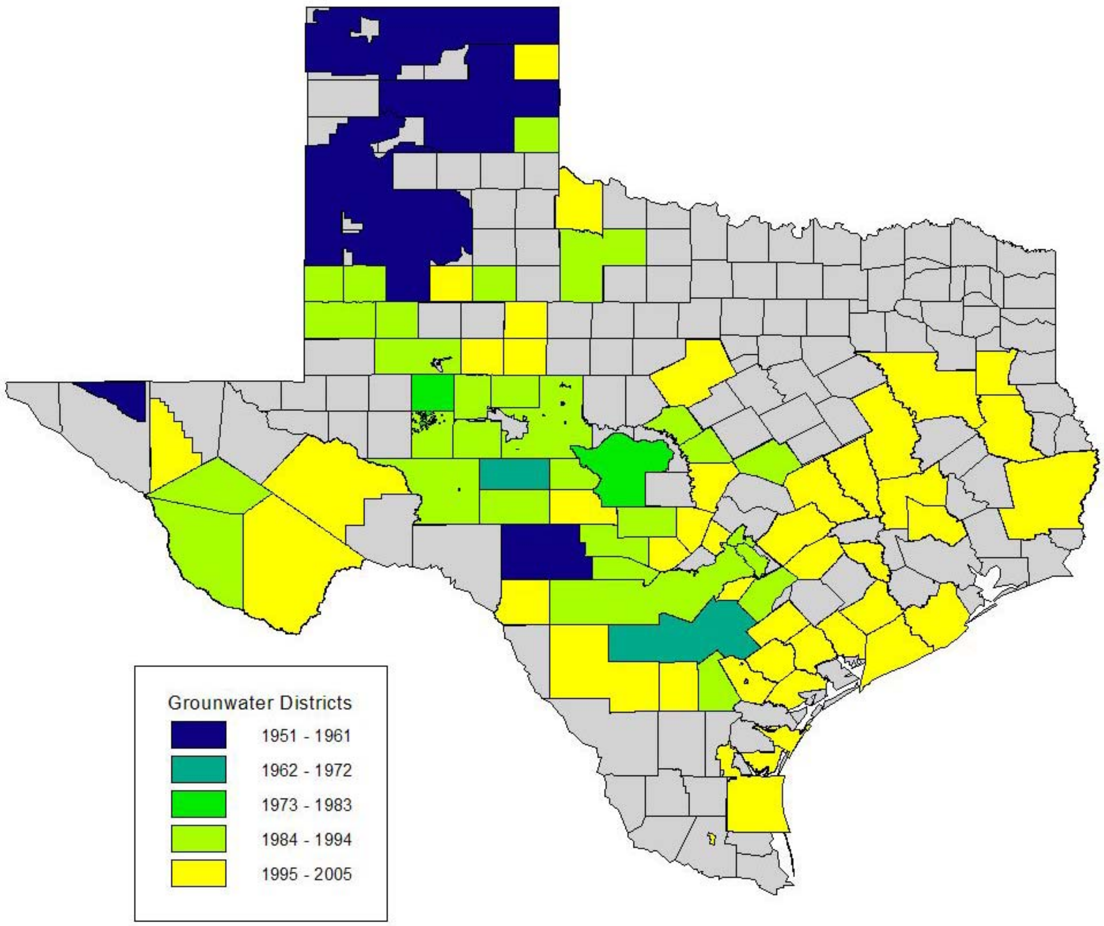

Figure 7.2. Groundwater Districts as of November 9, 2005. This map is grouped by the date each groundwater district was established by the legislature and contains both confirmed and proposed districts. The districts must be confirmed by voters in their districts after being established by the legislature. In the case of multi-county districts, each county votes on whether or not to join the district. The first groundwater district in Texas was established in the Panhandle of Texas in 1951 as a result of legislation passed in 1949. It has only been recently, however, that the districts have spread to other parts of the state. While many groundwater districts follow county lines, not all do. Rural landowners have become increasingly concerned about groundwater being sold to other parts of the state and many have viewed groundwater districts as a vehicle for regulating such transfers. Data from the Texas Water Development Board.[413]

[413] Data is from the Texas Water Development Board, "Mapping," http://www.twdb.state.tx.us/mapping/gisdata.asp (accessed March 11, 2007).

Texas. The most recently created groundwater districts are shown in yellow on Figure 7.2. The establishment of these districts is being encouraged by the Legislature as the vehicle of choice for changing Texas groundwater law by allowing—but not mandating—local control over groundwater withdrawals.

Analysis and Interpretation

Lewis Mumford observed that humankind's influence on its landscape was a most visible demonstration of its relationship with the land. The shift of cultures from rural to urban increased the value of land for its resources, and at the same time raised the potential for its abuse.[414] This neatly encapsulates the setting for the fourth water regime in Texas—the groundwater regime—as groundwater's status in the more humid parts of the state moves from a condition of being either ignored or taken as a given property right, to becoming a commodity. The potential for abuse occurs because groundwater was still unregulated at the end of the dam and levee regime. The rather abrupt transition to a new water regime is the effort to regulate groundwater in the face of long-held institutional inertias opposing such regulation.

Groundwater is distributed broadly beneath much of the state, particularly the more populous eastern half and the High Plains. The state's population, on the other hand, is both concentrating and increasing in the corners of the Texas Urban Triangle. The widespread distribution of groundwater is illustrated in the Texas Water

[414] Lewis Mumford, "The Renewal of the Landscape," in *The Brown Decades: A Study of the Arts in America, 1865-1895*, chapter 2 (New York: Harcourt, Brace and World, 1931), 26-48.

Development Board's Major Aquifers of Texas map, reproduced here as Figure 7.3, and the population shift from a rather widespread distribution across the eastern half of the state in the nineteenth century to a concentration in its largest urban centers today can be seen in a series of maps from the Texas State Data Center in Figure 7.4. Senate Bill 1 has made it clear that groundwater will have to be transported in order for all of the state's water planning regions to devise legislatively required long term water plans. The Texas Supreme Court has made it clear that it expects Texas groundwater law to be revised even though it reaffirmed the rule of capture from the 1904 precedent setting case. Senate Bill 2 of 2001 is another indication of the Legislature's intent to empower local groundwater districts to serve as the first step in the possible regulation of groundwater withdrawals. Representative Lois Kolkhorst of Brenham has pointed out that this is an issue dividing the Texas Legislature, not along party lines but as rural Texas versus urban Texas, with urban representatives clearly in the majority.[415]

This coming to terms with the transport of groundwater from rural to urban Texas is the reason this fourth water regime is labeled the groundwater regime. Water is not yet a commodity in the sense of a commodity traded on the Chicago Board of Trade. It does not yet have a value that fluctuates with perceived supply and demand. Nor is there a mechanism in place for establishing such value. But it is something that is absolutely necessary, that is in supply in rural Texas, and that is in demand in urban Texas. Groundwater therefore has the makings of a commodity.

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[415] Lois Kolkhorst, Personal Communication, Groundwater district advocacy meeting in Hearne, TX, 2003.

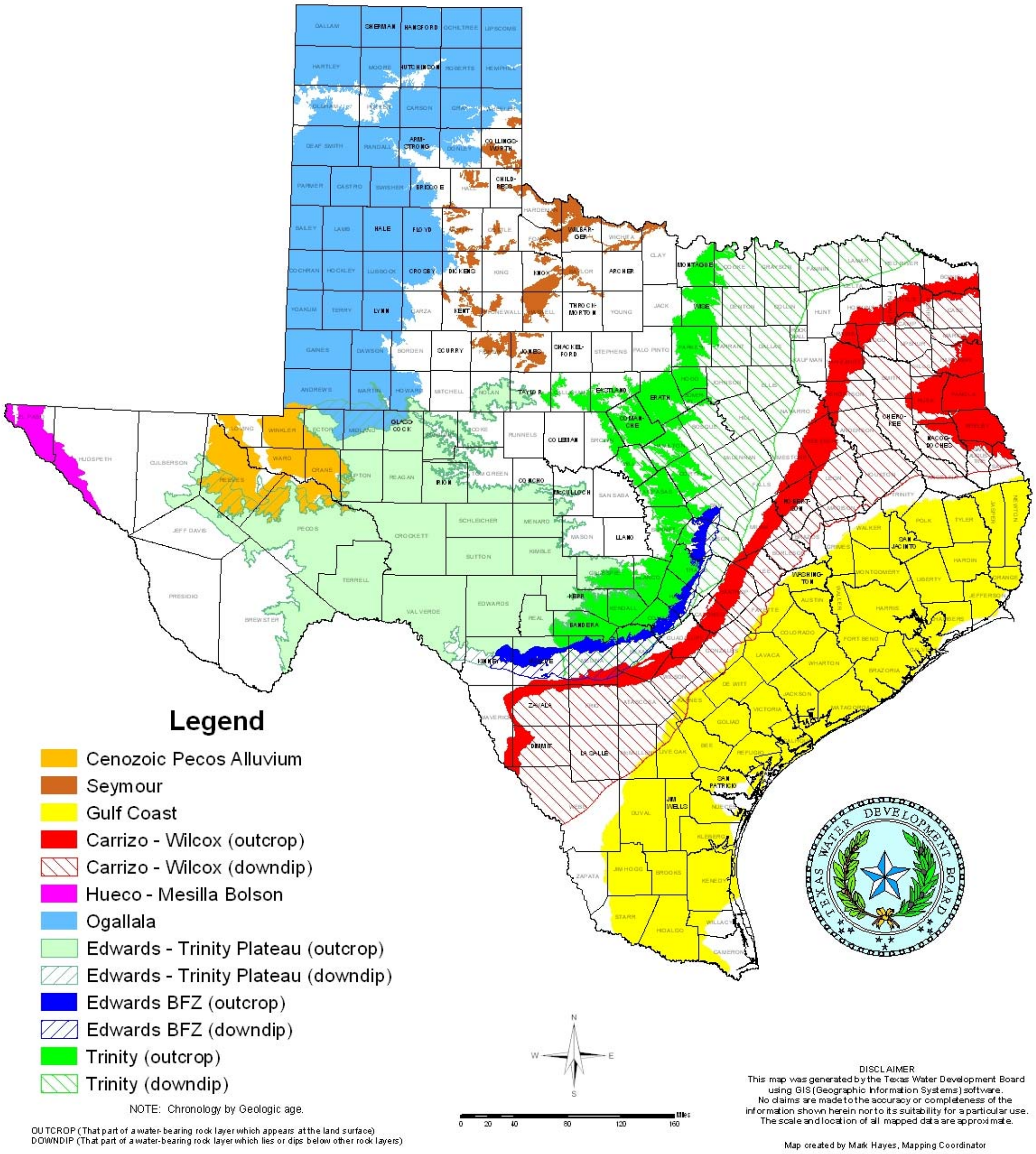

Figure 7.3. Major Aquifers of Texas. There are nine major aquifers and twenty-one minor aquifers in the state. The Ogallala in the High Plains contains the most water. Gulf Coast is the second largest aquifer, followed by the Carrizo-Wilcox and Trinity aquifers. From the Texas Water Development Board.[416]

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[416] Texas Water Development Board, "Major Aquifers of Texas," http://www.twdb.state.tx.us/mapping/maps/jpg/aqu_maj_8x11.jpg (accessed March 11, 2007).

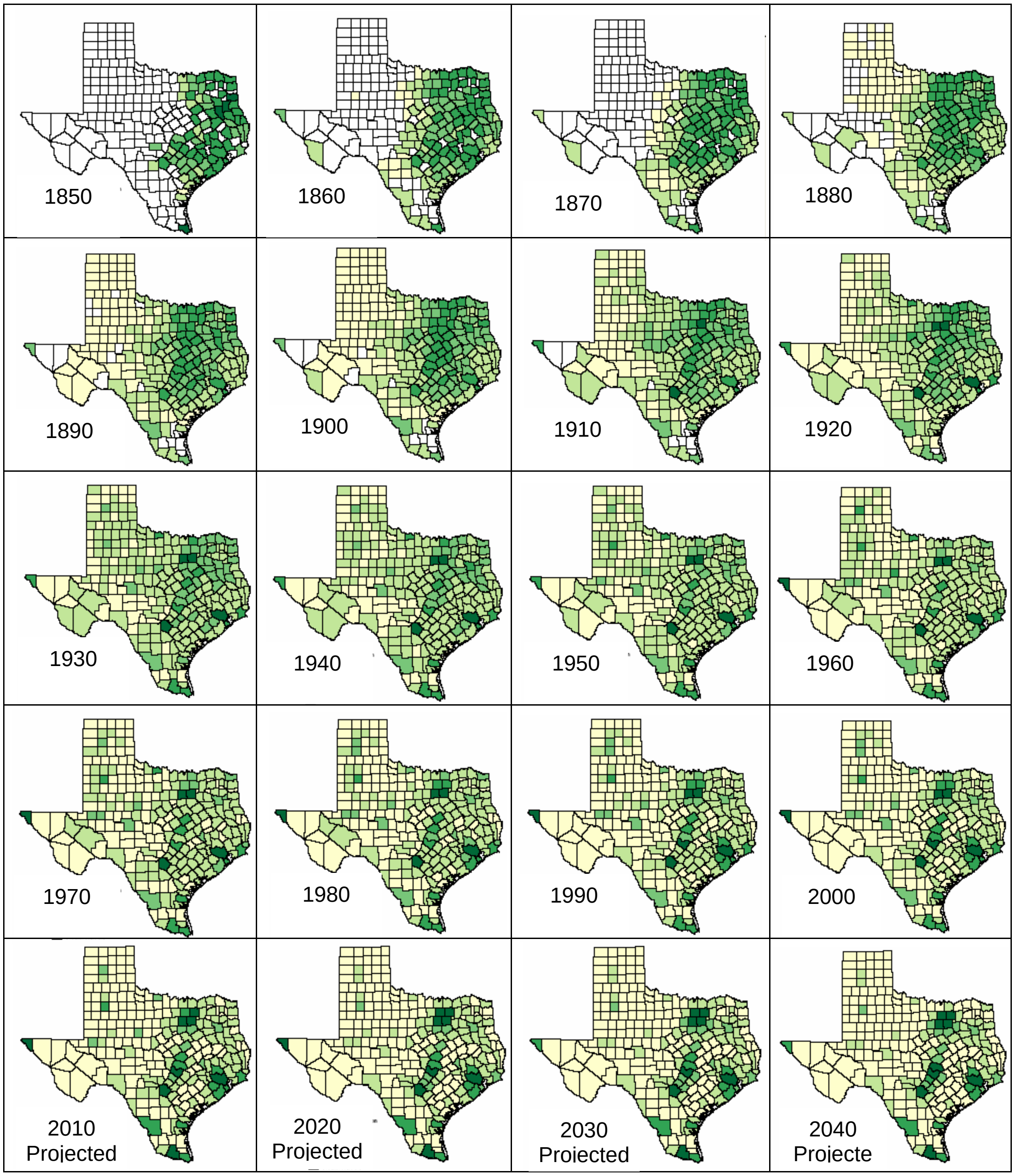

Figure 7.4. Migration of Texas' Population. The rural population of the 19th century has concentrated at the corners of the Texas Urban Triangle and in the southern Rio Grande valley. Dark green indicates counties with greater than 3 percent of the state's population. Medium green: counties with ½ to 3 percent of the population. Pale green to white: counties with less than ½ percent of the population.[417]

[417] Texas State Data Center, "Population Growth of Texas Counties as a Percent of State Population," (San Antonio, TX: Texas State Data Center, 2006), http://txsdc.utsa.edu/ (accessed March 11, 2007).

Texans have long held ideas on the material value of natural resources within their command. When considering early nineteenth century Anglo settlement, Doughty noted,

> What people saw in the three natural regions of Texas were objects having material and functional significance, rather than biological and ecological value. Landscapes appeared as discreet units of so much valuable timber, or acres of fertile soils and pasture, or areas abounding with game animals, not as environments containing systems of life with linkages that sustained the character and structure of the biological communities that composed them. People made simple inventories of resources as material, immediately functional, commodities. They drew up lists of commodities—items supplying food, clothing, and utensils, and items that could be bartered or traded.
>
> Stephen F. Austin's 1821 exploration of East Central Texas typifies this pattern of thought. He regarded woodlands as so much variable quality timber; streams would supply water for irrigation; prairies would become fields; deer were so much meat… In other words, Austin as an empresario looked first at what was materially useful and capable of sustaining settlement on his land grant.[418]

Texans views on the pumping of groundwater as a resource to be sold for profit may also have been shaped by the development of the petroleum industry. Through the concept of mineral rights, rural Texas landowners have learned to deal with the extraction and sale of oil and gas from beneath their property. These mineral rights are either sold or specifically withheld from sale along with the surface rights to property. The Texas Railroad Commission and well established legal precedent strictly regulate the interface between rural property owners and the oil and gas industry. Any reservoir of oil and gas in a reservoir beneath a landowner's property belongs to the landowner. Detailed

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[418] Robin Doughty, "Settlement and Environmental Change in Texas, 1820-1900," *Southwestern Historical Quarterly* (1986): 426.

regulations protect this commodity from being aggressively pumped out by a nearby well, thereby depleting a reservoir that could extend under the property of several different landowners. With these organizational and institutional inertias in place, rural Texans have both a well established mechanism and a personal understanding in place for dealing with a valuable resource in the subsurface. Many believed that this concept of mineral rights and their incumbent regulations also applied to the groundwater beneath their property. After all, farmers and ranchers have long drilled water wells or even converted dry oil and gas wells into water wells for domestic use, livestock, and irrigation. This common belief is mistaken, however. Groundwater is not included in the mineral rights when a piece of land is bought or sold. Nor is it regulated by the rules of the Texas Railroad Commission. Nor is Texas groundwater law even remotely similar to Texas oil and gas law. Texas property owners do not even own the groundwater beneath their property.

That groundwater is not bound up within property owners' mineral rights was emphasized by the Texas Supreme Court's decision in the Ozarka case. If it had been petroleum in the common reservoir underlying both Ozarka's pumps and the plaintiff's wells, the plaintiffs would have had legal recourse. But the fact that it was an underground reservoir filled with groundwater meant that laws regulating the extraction of minerals did not apply.

Groundwater districts have proliferated because under current state law, they are the means for regulating groundwater extraction. Regulations vary from district to district, but must apply uniformly to those within each district. Districts may not prohibit the export of groundwater, but can regulate its export. Regulations have to consider the case of rural landowners who might want to sell some of their groundwater to a city in need of a greater water supply such as San Antonio, as well as the possibility that the San Antonio Water System might itself purchase the tract next door and begin pumping large volumes from the aquifer.

This tension between rural landowners' freedom to pump groundwater at their discretion and the desire for protection from unregulated pumping by a larger pump next door has captured the attention of rural Texans. The Texas Cooperative Extension in conjunction with the Texas Agricultural Experiment Station and the Texas Water Resources Institute offered a series of conferences in 2003 designed to help landowners and newly founded groundwater district board members understand water management issues. The topic generating the most interest was the sale of groundwater and implications of exporting groundwater from a rural district to a metropolitan area.[419] In preparation for the May 28, 2003 conference in this series, eighty-three groundwater districts and related agencies were contacted to ascertain whether groundwater rights

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[419] Texas Water Resources Institute, *Buying, Selling and Exporting Groundwater: Implications for Groundwater Conservation Districts*, TWRI-219 (College Station, TX: Texas Cooperative Extension, May 28, 2003). Topics and speakers included "The Status of Groundwater Sales in Texas" by Ronald Kaiser, professor at Texas A&M University; "Groundwater Transactions: Byers Perspective" by Russell Johnson, Attorney and Adjunct Professor at Texas State University; "Purchasing Groundwater for Export: The Kinney County Proposal" by Lynn Sherman, president of Water Texas; "Model Lease of Groundwater Rights" by Ned Meister, Director for Regulatory Activities of the Texas Farm Bureau; "Protecting Your Land and Water in a Sales/Lease Agreement," by Sandra Burns, Attorney-Mediator from Dallas; "Regulation of Exportation of Underground Water," by Doug Caroom, Attorney from Austin; "High Impact Permit to Produce Water Upon Designation of Destination Users," by C.E. Williams, General Manager of the Panhandle Groundwater Conservation District; "Export Fees: A Groundwater District Limits and Uses," by Jace Houston, General Counsel for the Harris-Galveston Coastal Subsidence District; and "Secrets for Negotiating Texas Groundwater Leases," by Judon Fambrough, Attorney with the Real Estate Center at Texas A&M University.

were being leased, sold, or even transported out of the district. Responses were tabulated from seventy agencies with thirty indicating that groundwater was being leased, seventeen that groundwater was being transported from the district, and eight more indicating that it was only a matter of time before groundwater would be exported from their districts.[420]

By the establishment of groundwater districts, even though both local and voluntary, Texans are fundamentally changing concepts of groundwater ownership, management, and property rights. Scale is basic to this change. Rather than instituting uniform revisions to Texas water law, and in spite of the directive from the Texas Supreme Court to find a remedy to injustices caused by the Rule of Capture, the Legislature has decided to encourage the creation of groundwater districts with the authority, but not the duty, to regulate groundwater within the bounds of each district. Decisions on how, or even whether, to regulate groundwater are, therefore, to be made locally. Landowners have historically constituted a powerful presence in a state born of an agrarian economy, and the possibility of groundwater regulation by these districts has the potential to reduce landowners' freedoms and property values.

Giordano has argued that in managing common resources, the primary issue is in establishing rights rather than exclusive access, but that the scale at which these rights

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[420] Ronald Kaiser, "Texas Groundwater Marketing and Exporting," in *Buying Selling and Exporting Groundwater*, TWRI-219 (College Station, TX: Texas Water Resources Institute, 2003), 4 and table following.

are granted is critical.[421] The transition from groundwater as a property right to groundwater management in Texas would seem to be a case in point. In this fourth water regime rural Texas landowners are making a difficult choice of protection over freedom. In doing so, they are ceding personal water control to some level of their government in order to establish an orderly procedure for controlling conditions for access to a resource. But that control has been vested in a local authority with local stakeholders, thereby easing the angst because of the relatively small shift of the scale. The advantage is, of course, that this protects their groundwater against an entity that could buy the land next door and install a large pump. Although no longer at the scale of an individual landowner, Giordano suggests that by leaving the management of a common resource at a smaller scale, it leaves incentive to preserve that resource that might not manifest itself if access were granted at a larger scale.

Worster has argued, on the other hand, that whatever entity controls the water in a semi-arid region, controls the society that lives there. He laments the loss of the pioneering spirit of the American West as its settlers routinely traded independence for a more secure water supply.[422] Although the choice rural Texans have made in establishing groundwater districts is a choice not atypical of others in the semi-arid American West, the security they are protecting may be more their property value than their water supply. The perception among landowners is that water has a value and that groundwater rights are and should be an integral part of the value of their property.

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[421] Mark Giordano, "The Geography of the Commons: The Role of Scale and Space," *Annals of the Association of American Geographers* 93, no.2 (2003): 367.
[422] Worster, *Rivers of Empire*, 333.

Although water rights have long been a part of the value of land in the semi-arid American West, this is a new concept to rural Texans who have taken their groundwater for granted, particularly in the more humid eastern half of the state. Even in the western half of the state where water has always been valued, it has only recently been thought of by landowners in terms of something that might be bought and sold.[423] It is this shift in attitude toward the management of groundwater that has brought me to conclude that Texas has entered upon a fourth water management regime. The exact character of this regime remains as of yet indistinct, however the apparent movement toward a perception of groundwater as a resource in important ways comparable to oil and gas makes the title of groundwater regime appropriate.

Summary of Groundwater Regime

The transportation of groundwater from rural to urban Texas would require a change in scale in delivery infrastructure and organization not currently in place. Such a change in scale of the water delivery system has been explored by geographers elsewhere, and has inevitably been contentious.[424] A change in the scale of water supply would require overcoming all three types of inertia described by Dodgshon. But interest

[423] The continuing sage of T. Boone Pickens to market water from the Ogallala aquifer in Roberts County is a case in point. See, for example, Brad Reagan, "Pickens Says Study Backs Water Pipe," *Wall Street Journal*, 17 May 2000, T1, T3.

[424] See, for example, Matthew Gandy's discussion of the importation of water to New York City from the Delaware and Catskill watersheds in *Concrete and Clay: Reworking Nature in New York City*, (Cambridge, MA: The MIT Press, 2002): 19-75; and Blake Gumprecht's depiction of the struggles to import water from Owens Valley to Los Angeles in *The Los Angeles River: Its Life, Death, and Possible Rebirth* (Baltimore, MD: The Johns Hopkins University Press, 1999), 104-106.

in leasing groundwater rights, in regulating groundwater extraction, and in transporting groundwater across the state combine to suggest that perceived municipal water shortages can be addressed by developing a water regime in which rural Texans sell groundwater to their urban counterparts. This fourth water regime is in its early stages, but spurred by the enabling legislation of Senate Bill 1 in 1997 requiring statewide involvement in water planning every five years, Texans are now forced to reconsider their water usage and make adjustments in a fifty year water plan on a regular basis. Prodded by the Ozarka decision, the Legislature continues to encourage local regulation of groundwater production where no such regulation had previously existed. The landowner's freedom to extract groundwater is being replaced by local controls designed to protect the aquifer. Water is now thought of as a resource to be bought and sold, as a property right and property value enhancer. Water is still perceived as scarce, but not in the same way as in the dam and levee regime. Concerns for water quantity have been supplanted by concerns about water quality and its role in the natural environment. Rather than technical solutions that conserve surface water, the emphasis is on legislation and regulation, accompanied by a shift in scale in the proposed movement of groundwater. Bottom line—water is becoming a commodity.[425]

[425] See, for example, Peter H. Gleick, et al. *The New Economy of Water: The Risks and Benefits of Globalization and Privatization of Fresh Water* (Oakland, CA: Pacific Institute, 2002), especially "The Water Crisis: Perceived and Real," 2; "Privatization," 3; "Commodification," 3-4; "Privatization of Water," 21-27.

CHAPTER VIII

CONCLUSION

Alan Baker has succinctly commented, “the best work in historical geography has always situated specific studies within their general contexts and it has always engaged general ideas to illuminate particular past geographies.”[426] This is certainly what I have tried to do. Using archival data, I have engaged the concepts of resistance to change, crisis, perception, and scale to explore water use in nineteenth and twentieth Texas—a time and a place that was experiencing significant change. I have relied heavily on Dodgshon’s work suggesting that change had to overcome inertial elements in the cultural landscape to repeatedly reorganize water use into four water regimes since Anglo settlement. I have in each case identified the tipping point from one regime to the next as a crisis that was responded to by an increase in the scale of a particular aspect of water management, and I have noted the role of perception, both in identifying each tipping point and in defining each regime.

Summary of Four Water Regimes

Robert Dodgshon has suggested there are three different kinds of resistance to change: inertias of the built environment, organizational inertias, and institutional inertias. Each has a geographic component that is place-specific. These place-specific

[426] Baker, *Geography and History*, 212.

inertias resist change, and cause change, when it occurs, to follow the form of punctuated equilibrium rather than continuous adaption.

The first water regime was the agrarian regime. The founding of the Republic of Texas in 1836 opened the doors to Anglo migration and settlement, both from the southern United States and from Europe. These immigrants brought with them ideas that water was plentiful and could be had for no cost from a river or stream during migration, or from a natural spring, cistern, or shallow hand-dug well after settlement. In the agrarian society they built, the majority lived in a rural setting where each family or plantation unit was self-sufficient in terms of its water supply and water management. Water was perceived as abundant, although use was limited by the need for someone from the family or plantation to fetch and haul water daily.

The second water regime was the waterworks regime. The crisis that precipitated this regime was the need for fire protection in the central business districts of market towns. The response was to build local waterworks. These generally began in Texas in the last two decades of the nineteenth century as private ventures with franchise agreements with local governments. By the early twentieth century many of the waterworks came under municipal control. Water was still perceived as abundant, but the perception of water changed once it became available from the tap because it was also taken for granted. The shallow wells and cisterns characteristic of the agrarian regime were replaced by a network of mains and hydrants. Individual family units and businesses no longer provided their own water, and water supply was taken for granted. This transition took place suddenly in a location, although its spread from town to town across the state took several decades. The transition entailed a change in scale of water supply from self-sufficiency to local control.

The third water regime was the dam and levee regime. The twofold crisis defining this regime were the long-standing need for flood control to protect the state's cotton economy and the Drought of the 1950s, which occurred just as Texas was making a demographic shift from predominantly rural to predominantly urban settlement. Controlling flooding was an immediate water management concern, first attempted with levees, then with the construction of dams to preserve flood water runoff for beneficial purposes. Construction of reservoirs for conservation of surface water caused the scale of surface water management to increase significantly, as both the State and federal governments assumed significant roles. The Drought of the 1950s marked the first time in history that Texans perceived water as scarce.

The fourth water regime is the groundwater regime. Drought in the 1990s caused an estimated six billion dollars in damages to the state's agricultural economy in 1996,[427] and prompted legislative overhauling of the Texas Water Code in 1997. Senate Bill 1, in conjunction with the Ozarka judicial ruling in 1999, together put a new emphasis on groundwater in a new state-wide water planning scenario. This significantly alters the scale at which groundwater is managed by creating groundwater districts across much of rural Texas. There are new tensions and complementarities between rural and urban Texas, as rural landowners begin to view groundwater as a commodity to be sold to their

[427] Texas Water Development Board, "The Drought in Perspective, 1996-1998," Austin, TX, http://www.twdb.state.tx.us/data/drought/DroughtinPerspective.asp (accessed March 11, 2007).

urban counterparts. The perception of water today is that there is not enough *unpolluted* water where it is needed, and just where it is needed is a source of much debate. Concern about reserving water for wetlands, for habitat, for sustaining flows of rivers and springs, has been added to the debate through court decisions.

These are the four water regimes in Texas since the time of Anglo settlement. In order to make sense of them, one has to understand powerful factors in the cultural landscape, social organization, and environmental perception of Texans, which together prevented gradual and continuous change in water management. A significant aspect of this dissertation has been to identify factors that worked to resist change with regard to water use and ultimately resisted change in how water has been perceived and managed.

Resistance to Change

The first of Dodgshon's inertias, that of the built environment, has long been recognized by geographers. Elements of the built environment constitute the "structure" that Sauer described in his morphology of landscape.[428] Peirce Lewis recognized this when he wrote, "our human landscape—our houses, roads, cities, farms, and so on—represents an enormous investment of money, time, and emotions. People will not change that landscape unless they are under very heavy pressure to do so."[429] Historian Frederic Maitland's famous reference to the Ordnance Survey maps as "a marvellous

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[428] Carl Sauer, ""The Morphology of Landscape," In *Land and Life: A Selection from the Writings of Carl Ortwin Sauer*, edited by John Leighly (Berkeley, CA: University of California Press, 1963 [1925]): 315-351, especially 342-343.
[429] Lewis, "Axioms for Reading the Landscape," 15.

palimpsest" also recognizes the presence of enduring artifacts of the past in present-day landscapes.[430] More subtle resistance comes in the form of Dodgshon's institutional inertias, or ideas embedded within a culture. This, too, has been well explored by geographers.[431] A portion of Peirce Lewis's "historic" axiom encompasses all of Dodgshon's inertias when he admits, "We are a good deal more conservative than many of us would like to admit."[432]

This conservatism, which geographers call geographic inertia, is an inescapable aspect of geographic phenomena. One of the most pronounced resistances to change encountered in this dissertation is that of the citizens of San Antonio to investing in a waterworks because they were sitting atop the Edwards aquifer. San Antonio residents did not see a need for waterworks for their water supply. So, both in theory and in practice, resistance to change is a powerful factor in the history of water use and management.

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[430] Referenced by such historical geography classics as H.C. Darby, "On the Relations of Geography and History," in *Historical Geography: A Methodological Portrayal*, edited by D. Brooks Green, 34-45 (Savage, MD: Rowman and Littlefield, 1991), 42, originally published in *Transactions of the Institute of British Geographers* 19 (1953): 1-11; and W.G. Hoskins, "The Reclamation of the Waste in Devon, 1550-1800," *Economic History Review* 13, No. 1/2 (1943): 81.

[431] See the work of David Lowenthal, for example, "Age and Artifact," in *The Interpretation of Ordinary Landscapes: Geographical Essays* (New York: Oxford University Press, 1979), 103-128; and David Lowenthal, "Geography, Experience, and Imagination," *Annals of the Association of American Geographers* 51 (1961): 241-260, also Yi-Fu Tuan, "Perceptual and Cultural Geography: A Commentary," *Annals of the Association of American Geographers* 93, No. 4 (2003): 878-881.

[432] Lewis, "Axioms for Reading the Landscape," 22-23.

Role of Crisis

I have relied upon Carville Earle's description of some form of crisis as the catalyst for innovation that results in the tipping point from one water regime to the next. Many others have written similarly about the role of crisis. Robert Nisbet writes that, "wars, catastrophes, invasions, and the like, … far from being obstacles to progress, were in fact precipitators of it by virtue of their shaking man out of natural torpor and galvanizing him into adaptation and invention." [433] Peirce Lewis once again lends his support, "most major cultural change does not occur gradually, but instead in great sudden historic leaps, commonly provoked by such great events as wars, depressions, and major inventions."[434]

Time and again, it has been observed that it takes a crisis to shake a society from complacency into action, and as we have seen this has certainly been the case with regard to water management. The point is simply that it takes a crisis such as flooding, not just a sensible idea such as not wasting groundwater, to get the public's attention. Such is the significant role of crisis in water regimes.

Unintended consequences

Geographers have long recognized that there are unintended consequences of human actions upon the environment.[435] Ian Simmons noted that human alterations of their environment fell into two categories: "those which were deliberate and those which

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[433] Robert Nisbet, *The Making of Modern Society* (Washington Square, NY: New York University Press, 1986), 24.
[434] Lewis, "Axioms for Reading the Landscape," 23.
[435] See, for example, "Incidental Effects of Human Action" in George Perkins Marsh, *Man and Nature* (Seattle, WA: University of Washington Press, 2003 [1864]), 456-459.

were accidental," and called the former "environmental management" and the latter "environmental impacts."[436] Alan Baker reiterates this notion, "I have repeatedly emphasized that human activities often had unintended environmental consequences. Such surprises often stemmed from the incomplete or inappropriate appraisal of environments by those exploring them and by those exacting their livelihoods from them."[437]

There have been unintended consequences to each of the new water regimes. In the case of the construction of waterworks to provide better fire protection for central business districts, water was made available to the public from hydrants, and eventually from the tap in homes. This changed water from a resource with high variable costs to a resource with high fixed and low variable costs. It was just there at the turn of the faucet. This did not encourage judicious use of the resource. The construction of levees and dams to manage surface water had its own set of unintended consequences. The levees provided a false sense of security from flooding that led to catastrophe when they failed. Dams impounded surface water, significantly reducing flooding[438] and providing water supplies.[439] Yet dams also reduced the spread of nutrients across flood plains during flooding because they eliminated the flooding. Their construction altered not

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[436] I.G. Simmons, *Changing the Face of the Earth: Culture, Environment, History* (Oxford, UK: Blackwell, 1989), 378.
[437] Baker, *Geography and History*, 100.
[438] Anne Chin and Jean Ann Bowman, "Changes in Flow Regime following Dam Construction, Yegua Creek, South-Central Texas," in *Water for Texas*, edited by Jim Norwine, John R. Giardino, and Sushma Krishnamurthy, 166-177 (College Station, TX: Texas A&M University Press, 2005), compare high pre-dam and low post-dam annual peak flows on Brazos tributary in Figure 6, page 173.
[439] See Appendix H.

only river water discharge, but also sediment deposition and transport. Estuaries and shorelines have become sediment starved. Riparian zones and channel configurations downstream from dams have been affected, not to mention the environmental consequences of the inundation of the reservoirs themselves. The response to Senate Bill 1 in 1997, legislation that mandates new regional water planning across the state every five years at the grassroots level, has had the unintended consequence of putting more emphasis on groundwater to fill future water supply needs. This has led to the establishment of numerous groundwater districts in rural Texas and begun the process of re-addressing the Rule of Capture of property owners' groundwater rights. Eventually the challenge or crisis that proved to be the tipping point to each new water regime was solved, but each time with unintended consequences.

Role of Perception

The importance of perception in defining each water regime has increased as this dissertation progressed. I began with an observation from Donald Worster that "Americans' Eurocentric heritage values land and takes water for granted."[440] This describes Texas settlers. They also tended to settle in the eastern half of the state, east of the thirty inch annual isohyet,[441] so water was seldom a problem for them. During the

[440] Worster, *Rivers of Empire*, 191.
[441] Walter Prescott Webb, *The Great Plains* (Waltham, Massachusetts: Blaisdell, 1931). Much of this classic is based upon Webb's observations about the differences between frontier settlement in woodlands versus frontier settlement in the Great Plains, where water was scarce. Webb put the dividing line at the 98th parallel.

waterworks regime, water was still perceived to be abundant, but as we have seen, the labor demand that regulated consumption in the agrarian regime was also removed.

A major change in the perception of water occurred with the Drought of the 1950s. For the first time, water was perceived as scarce in the more heavily populated eastern portion of the state. Historian Walter Prescott Webb became so concerned about Texas' water supply during the early part of the Drought of the 1950s that he took a government water plan for Texas and rewrote it with the hopes that his version would attract a more wide-spread and receptive audience.[442]

The crisis precipitated by the Drought of the 1950s was serious enough to set off a series of water-related responses in reaction to both the reality and the perception that water was scarce. The Texas Constitution was amended to establish the Texas Water Development Board, for the first time water use data was collected by both the state and federal governments, the first state-wide water plans were made that included the construction of numerous dams to conserve surface water in reservoirs for beneficial use, headlines about the drought were a common occurrence, and people like Professor Webb were speaking to their fellow citizens about long-term water planning. With the transition to the groundwater regime, water is still perceived as scarce, but it is a more nuanced scarcity. It is a scarcity of clean, pure, *unpolluted* water, where it is needed, which is, increasingly, in urban areas and in the natural environment itself.

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[442] Webb, *More Water for Texas*, v-vi.

Role of Scale

Scale comprises the final aspect of the definition of a water regime. Just as some form of a crisis marks the transition from one regime to another, so, too, is each new regime characterized by an increase in the scale of water management. This reminds me of Tony Wrigley's analysis of how human energy needs have been met by expanding the scale at which energy supplies are secured, from that of a tree whose energy was received from the sun over the course of several decades to that of petroleum whose energy was received from the sun millions of years ago.[443] Wrigley argues persuasively that with population increase, an enormous scale change (in time) is required to supply the corresponding increase in energy budget.

I have argued that with each new water regime, the scale at which water is managed has also increased. During the agrarian regime, family units, plantations, and businesses were self-sufficient in their water supply. During the waterworks regime, this changed and water became available at a hydrant or through the tap from a local source. In the dam and levee regime, runoff of surface water was collected in reservoirs and stored for beneficial use, for irrigation, water supply, and flood control. Now in this fourth regime, groundwater is beginning to be regulated at a scale beyond that of the individual property owner, and there is an increasing realization of the logic in

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[443] E.A. Wrigley, "Meeting Human Energy Needs: Constraints, Opportunities, and Effects," in *Environments and Historical Change: The Linacre Lectures 1998,* edited by Paul Slack (Oxford, UK: Oxford University Press, 1999), 76-95.

modifying water law to recognize the interconnected nature of groundwater with surface water through the hydrologic cycle.[444]

Additional Research

Because this dissertation cuts such a wide swath across human geography, it suggests a great many opportunities for additional research. Here are just a few. In considering differences between historical ecologists and environmental historians, Alan Baker notes that they "bring to their studies of the relationships between peoples and their environments different questions, different preconceptions, different knowledges and different skills, but together they advance our collective understanding of those relationships."[445] The topic I have treated could certainly be considered from a different theoretical perspective, particularly political ecology and political economy—especially the groundwater regime. In addition to studying the commodification of Texas groundwater with respect to conceptual ideas in the literature, there are specific case studies that would make an interesting analysis. For example, Jerry Patterson, commissioner of the Texas General Land Office, struck a raw nerve in 2003 when he proposed the sale of groundwater from public lands in far West Texas. The sale of oil and gas from this same acreage has long supported the Permanent School Fund, but the

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[444] Glennon, *Water Follies, 1-12*.
[445] Baker, *Geography and History*, 79.

idea of selling groundwater from an area where water is in short supply has generated heated debate.[446]

There is much in the literature today about the privatization of water.[447] This, too, is in its infancy in Texas, and is specific to groundwater. For example, the Brazos Valley Water Alliance was organized in 2000 to assemble a block of acreage with water rights in order to negotiate the sale of groundwater from the Carrizo-Wilcox aquifer in Robertson, Burleson, and Brazos Counties to potential municipal and industrial users.[448] Part of the justification for the proliferation of groundwater districts in recent years has been prevention of unregulated sale of large quantities of groundwater to satisfy the unquenchable thirst of Texas cities. San Antonio, because of its reliance on the Edwards aquifer, and Houston, with its subsidence problem from excessive withdrawals from the Gulf Coast aquifer, are in need of new long-term water supplies. Both are looking to the Carrizo-Wilcox as potential sources.[449] There is also an effort by T. Boone Pickens to orchestrate the sale of groundwater from the Ogallala aquifer to a municipal buyer.[450]

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[446] Ralph Blumenthal, "West Texans Sizzle Over a Plan to Sell Their Water," *New York Times*, 11 December 2003, A22. See also, Associated Press, "Officials Say Water Mining Plan Is Costly," *Bryan/College Station Eagle*, 12 February 2004, A9.
[447] See, for example, Peter H. Gleick et al., *The New Economy of Water: The Risks and Benefits of Globalization and Privatization of Fresh Water* (Oakland, CA: Pacific Institute, 2002).
[448] Brazos Valley Water Alliance, L.P., "The Alliance Update," vol. 2, no. 1 (February 2004).
[449] Laura Hipp, "Liquid Assets: Water-Rich Brazos Valley Attracts Thirsty Marketers," *Bryan/College Station Eagle*, 28 July 2002, A1, A7, A8.
[450] Brad Reagan, "Pickens Says Study Backs Water Pipe," *Wall Street Journal*, 17 May 2000, T1. See also, Scott Parks, "Water Investors Eye Liquid Assets: Demand Creates a Market for Aquifer Rights in Texas," *Dallas Morning News*, 21 May 2000, 1A, 20A-21A; and Betsy Blaney, "Oil Baron Set to Drill for Water in W. Texas," *Bryan/College Station Eagle*, 16 May 2002, A9.

This is particularly controversial because the aquifer is already being steadily depleted by irrigation.[451]

Themes of environmental justice and environmental equity certainly apply with respect to access to fresh water supplies. In Texas this is a serious health concern in the colonias along the Rio Grande and has received attention both from academia[452] and government agencies.[453] It is undoubtedly one of the largest scale and most serious water-related problems in the state. The historical environmental equity of water supplies could be mapped at local scales and compared across socio-economic classes. Craig Colten has examined this for New Orleans,[454] but I find no such studies for Texas cities.

The role of scale in water management and a specific study of Texas water policy are interrelated concepts worthy of closer examination. Water management is today both increasing and decreasing in scale. The decision by the 1999 Texas Supreme Court reaffirmed the Rule of Capture but mandated that the State's groundwater extraction law be changed. Groundwater extraction needed to be regulated in some way, but the Court

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[451] Elizabeth Brooks and Jacque Emel, "The Llano Estacado of the American Southern High Plains," in *Regions at Risk: Comparisons of Threatened Environments*, edited by Jeanne X. Kasperson, Roger E. Kasperson, and B.L. Turner II (Tokyo: United Nations University Press, 1995), 255-303.

[452] See, for example, Peter M. Ward. *Colonias and Public Policy in Texas and Mexico: Urbanization by Stealth* (Austin, TX: The University of Texas Press, 1999), especially "Chapter 3, Servicing No Man's Land: Ambivalence versus Commitment in the Texas-Mexico Colonias," 131-164; Rebecca Dolhinow, "Caught in the Middle: The State, NGOs, and the Limits to Grassroots Organizing Along the US-Mexico Border," *Antipode* 37, no. 3 (June 2005): 558-580.

[453] Texas Water Development Board, *Economically Distressed Areas Program Status Report* (Austin, TX: Texas Water Development Board, 2006); Texas Water Development Board, *Water and Wastewater Needs Survey of Economically Distressed Areas, December 1996 Update* (Austin, TX: Texas Water Development Board, 1996).

[454] Colten, *An Unnatural Metropolis*, especially Chapter 3: "Inequity and the Environment," 77-107.

wanted the Legislature to determine the specifics. The Legislature, on the other hand, decided to allow the regulations to be determined at the local level, if at all. Senate Bill 1 now requires a new state-wide water plan to be submitted to the Legislature every five years, but also requires that it be constructed in small pieces integrated into sixteen regional water plans by private citizens representing specifically defined stakeholders. So, the plan is both state-wide as well as local. It would be interesting to examine this in light of geographic theory, particularly to the "tragedy of the commons."[455] As water legislation is increasingly conceived at the scale of the state, water policy continues to be implemented largely at the local level. This poses the potential for inconsistent administration of water regulations and water policy that may not fit local conditions. Nor has the divide between the physical sciences and social sciences been adequately bridged, using Baker's metaphor. This has been noted by Christopher Lant.[456] This study constitutes an effort to begin an integration of many limited aspects of water use, water policy, water law, hydrology, and climatology into a human geography of water for a specific place. Matthew Gandy has explored this disconnect between state regulations and local water bureaucrats in New York City,[457] but the issue of scale in water management is one that geographers have not yet explored in Texas. And, according to Katherine Hirschboeck, there has been little engagement by geographers in

[455] Mark Giordano, "The Geography of the Commons: The Role of Scale and Space," *Annals of the Association of American Geographers* 93, No. 2 (2003): 365-375.
[456] Christopher Lant, "The Changing Nature of Water Management and Its Reflection in the Academic Literature,"*Water Resources Update* 110 (1998): 18-22.
[457] Matthew Gandy, "Restructuring New York City's Water Supply," *Transactions of the Institute of British Geographers* 22 (1997): 338-358.

hydrology, and she sees scale as geographers' logical and rightful contribution to academic discussion.[458]

There is also more detailed work that could be done on water bonds. More complete studies could be made on individual cities, including compiling the amount of each bond with specific dates. In particular, the bond history of San Antonio needs to be examined in comparison with that of the other major cities in the state. Much of this dissertation has focused on management of water supply. A similar study could be made of water treatment and sewage disposal. The sewage treatment plant constructed by the city of Paris, Texas in 1897 was acclaimed as the first sewage treatment plant in the South.[459] How and why did that happen?

The imprint of the U.S. Army Corps of Engineers on the Texas landscape and economy has been significant, but almost no work has been published on this subject.[460] This branch of the government has been more involved with the construction of more dams in Texas than any other state or federal agency. Their involvement is complex, as I discovered when trying to tabulate the data in Appendix H. There are conflicting claims between various state and federal agencies as to which was involved with each

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[458] Katherine K. Hirschboeck, "A Room with a View: Some Geographic Perspectives on Dilettantism, Cross-Training, and Scale in Hydrology," *Annals of the Association of American Geographers* 89, No. 4 (1999): 696-706.

[459] T. Lindsay Baker, "Paris Sewage Plant," Historic American Engineering Record, Department of the Interior, April 1978. From the archives of the Center for Historic Preservation and Technology, 1833-1995 in the Southwest Collection, Texas Tech University, Lubbock, TX.

[460] D. Clayton Brown, *Rivers, Rockets and Readiness: Army Engineers in the Sunbelt: A History of the Fort Worth District, U.S. Army Corps of Engineers, 1950-1975* (Fort Worth, TX: Fort Worth District, U.S. Army Corps of Engineers, 1979); and Brian Lenny Miller, "Intern Experience with the San Antonio Area Office of the U.S. Army Corps of Engineers Fort Worth District" (Civil Engineering Dissertation: College Station, TX: Texas A&M University, 1991).

reservoir. I suspect they are all true to some extent, and that many different agencies and entities were involved in the planning, construction, and ownership of the reservoirs, dams, and water impounded in each reservoir. Craig Colten has worked with the Corps of Engineers in New Orleans to document aspects of their involvement with the Mississippi River levees, but no such effort has been undertaken with respect to Texas reservoirs, most of which fall under the auspices of the Fort Worth District of the Corps of Engineers.

Where do these ideas lead? I have argued for the existence of four water regimes in Texas since the time of Anglo settlement in the early nineteenth century. The fourth regime has just begun. Will there be a fifth? I think it is likely that there will, and I think it will involve desalination, the roots of which could be explored now. As patterns and perceptions of water use have changed, with each new regime there has been a corresponding change in the scale of water management. I think this will continue. The next increase in scale may well involve utilizing seawater, which Texas has in abundance. This will require technological advances as well as overcoming organizational inertias involved with establishing new supply networks in the built environment. The Texas Water Development Board has completed seventeen desalination studies since 1992 with several more feasibility studies underway. Their efforts include both seawater desalination, particularly near Corpus Christi and

Brownsville, as well as desalination of brackish groundwater, which is available below potable water in the subsurface across much of the state.[461]

In Closing

This dissertation examines how and why water use has changed, in a particular place and during a particular period. This is a topic largely unexplored in the literature of historical geography. My conclusion is that water use change follows a pattern of punctuated equilibrium, rather than continuously adaptive change, and happens only when forced. I do not break new theoretical ground, but rather apply concepts already in the literature—particularly Dodgshon's ideas on the geography of change—to an examination of patterns of water use.

I bring several new archival sources and several new topics to the literature. The *Journal* of Pleasant B. Watson is heretofore unpublished and was not available to scholars until recently acquired by the Star of the Republic Museum. I have used travelers' accounts and diaries from the migration and settlement period of Texas to ascertain how water was used and perceived in an earlier period—something I do not think has been done before. I offer an example of how municipal water bond data can be examined in light of regional variations in attitudes about water. To my knowledge, nowhere in the literature of historical geography has anyone utilized municipal bond

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[461] See, for example, Bureau of Economic Geology, *A Desalination Database for Texas* (Austin, TX: Texas Water Development Board, 2006); Turner, Collie, and Braden Inc., *Large Scale Demonstration Desalination Feasibility Study: City of Corpus Christi, Texas* (BHP Engineering & Construction, Inc., November 2004); Texas Water Development Board, "Desalination," http://www.twdb.state.tx.us/iwt/desal.asp (accessed March 11, 2007).

data, certainly not Texas water bond data. Sanborn insurance maps are long a favorite of historical geographers, but I do not know of anyone who has used them to map the expansion of a network of water mains in Texas. This dissertation includes the first published history both of the waterworks in Bryan, Texas and the construction of the levees in Burleson County. Nowhere in the academic literature can I find anything about the levees of Burleson County, even though they were the largest construction project in the South at the time they were built. I conducted a survey of all of the groundwater districts in the state to find out local issues of most concern and to identify areas already exporting groundwater. I also attended numerous grassroots meetings to better understand the debate involving groundwater districts. Throughout, I continue a recent trend of finding new ways to use GIS techniques in historical geography.

With regard to my conclusions, the most important influence on water use, as I see it, is the scale at which the resource is managed in conjunction with the perception of its abundance or scarcity. Increasingly Texans are locating in urban areas and drawing their water from farther away, either in actual distance or in terms of technological and organizational frontiers traversed. Of all the changes recognized in this study, the two most important were the change to tap water, and later the perception that water was scarce. The next step function of change, the next water use regime, may well result from a technological and organizational breakthrough—such as large-scale desalination—and this would inaugurate a fifth water regime.

The last word goes to my advisor's advisor, Don Meinig who wrote, "Finally, I would like to emphasize that this is very much an exploratory essay and not a definitive analysis. ... no more than expressions of ideas and a stimulus to thought and not as definitive depictions of actual patterns … one hopes … that it will be read as a geographer's contribution to the general and continual interest in what it is that makes Texas such a remarkable and singular place."[462] And then again from Meinig, "One is not proving anything, or solving problems, or refining theory, or providing detailed answers from the past to guide the present into the future. One can hope to provide a perspective, a way of looking at things, a help in making sense out of something far too vast to 'explain'—at best, perhaps, to provide the basis for a meditation."[463]

[462] Meinig, *Imperial Texas*, 9.
[463] Alan Baker quoting Meinig in *Geography and History*, 224.

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APPENDIX A

TIMELINE OF SELECTED EVENTS RELEVANT TO

TEXAS WATER HISTORY

Date	Event	Scale
1519	Spaniard Alonzo Alvarez de Pineda mapped entire Gulf Coast & founded short-lived colony at mouth of Rio de las Palmas, probably the Rio Grande.	Global
1534-1535	Panfilo de Narvaez shipwrecked with crew of 400 on FLA coast in 1528. Only a few survived the winter including Cabeza de Vaca who was shipwrecked again on TX coast in 1534. Marched SW along TX coast, NW through Mexico, back through central TX, to Mexico again.	Global
1541	Coronado went through TX Panhandle on journey to Kansas in search of gold.	Global
1542	DeSoto went from Florida west to Mississippi Valley looking for gold. He died in 1542 and Luis de Moscoso de Alvarado took over his expedition. Tried to go to overland to Mexico, may have made it as far as Trinity River in Houston County before giving up. Went down river to coast near Beaumont, sailed to Panuco, Mexico.	Global
1684-1687	LaSalle landed on Gulf of Mexico, set up fort at head of Matagorda Bay, TX, explored toward the Rio Grande, then was heading back to Mississippi when murdered near Navasota, TX in 1687.	Global
1716	Captain Domingo Ramon and Canadian trader Louis Juchereau de St. Denis led expedition of 75 to East Texas. Constructed presidio and 4 missions near present-day Nacogdoches, TX.	Global
1718	Martin de Alarcon led expedition that founded presidio and mission at San Antonio.	Regional
1719	French chased Spaniards out of East TX as the two countries fought in Europe.	Global
1721	Spaniards established military presence on Gulf of Mexico near site of LaSalle's abandoned fort. Spaniard's named it Espiritu Santo.	Global
1731	Civilian settlement at San Antonio. 16 families from Canary Islands.	Global
1750s	Spanish settlement along Rio Grande, including near Laredo.	Regional
Nov 1762	Spain acquired Louisiana from France.	Global
1776	United States declared independence.	Global
1789	French Revolution.	Global
1801	First public waterworks in the United States established at Philadelphia, Pennsylvania.	National
1803	Louisiana Purchase from France made the area immediately east of Texas a territory of the United States.	Regional
1804-1815	Napoleon was emperor of France and conquered much of Western Europe before defeats in Russia in 1812 and Waterloo in 1815.	Global
Apr 30, 1812	Louisiana became 18th state in the United States.	National
1813	Spanish Cortes' colonization law required special permission for Americans to settle within 52 miles of the border between New Spain and American territory.	Regional
1819	Panic of 1819 caused financial ruin for Moses Austin in Missouri.	National
1821	Moses Austin received Spanish permission to settle 300 American Catholic families in Texas. This transferred to his son Stephen F. Austin after Moses death later in 1821.	State
1821	New Spain won independence from Spain and became Mexico.	Global
1821	Spanish water law continued to form the basis for Mexican water law.	State
Nov 13, 1821	Robert Millican family from Missouri were the first permanent settlers in present Brazos County, TX.	

Date	Event	Scale
1823	Mexican Empressario Act authorized land grants for new settlers in Texas.	State
1824	First lands grants in present Brazos County were issued.	Regional
1826	A series of wars ended Spanish rule in South America.	Global
Apr 6, 1830	Mexican law prohibited further emigration from the United States to Texas. Austin got exemption for his colony and DeWitt's.	Regional
1831	Michael Faraday converted mechanical motion into electrical current.	Global
1833	Major flooding on the Brazos River between Washington and Navasota.	State
1834	Repealed law of Apr 6, 1830 that had prohibited US residents from settling in TX.	Regional
1836	Republic of Texas declared independence from Mexico	State
1836	Republic of Texas kept Mexican and Spanish water laws.	State
1837	Panic of 1837 created widespread economic depression in the United States.	National
1840	Republic of Texas adopted riparian rights water law based upon English common law.	State
1842	Major flooding on the Brazos River. Overflow was more than 6 miles wide between Washington and Navasota.	State
1842	Steamboat navigation on Texas rivers became a reality as the side-wheeler Mustang docked at Washington.	State
1845-1849	Potato Famine in Ireland.	Global
1846	Texas became 28th state in the Union.	National
1848	The Brazos Steam Association was formed to encourage navigation between Washington and the Gulf of Mexico. They purchased two boats for this purpose.	State
1848	Revolutions in Europe	Global
1852	First State of Texas water legislation. County boards established to regulate irrigation works jointly owned by individuals.	State
1854	A canal was built between the Brazos River and the Port of Galveston.	State
1854	Long summer drought.	State
1854	Flood on Brazos River as high as later flood of 1913.	State
1856	First windmill in the United States.	National
1856	Judicial recognition of riparian rights in Texas.	State
1861	Texas voted to secede from the Union and joined the Confederacy.	National
July 2, 1862	President Abraham Lincoln signed the Morrill Land Grant Act donating public land to colleges to promote agricultural and mechanical studies.	National
1864	George Perkins Marsh's *Man and Nature* published.	National
April 1865	Civil War ended.	National
1867	Houston & Texas Central railroad reached Bryan, TX.	State
1867	Yellow Fever hit the Brazos River valley town of Millican, causing survivors to move to Bryan.	Local
March 1870	Texas readmitted to the Union.	National
1870	Col. J.S. Thrasher proposed transporting water from Sweetwater Lake 5 miles to the city of Galveston. Aldermen rejected his plan.	Local
1874	Canal companies were granted free access to rivers and streams for irrigation.	State
1875	Canal companies were granted land for the construction of canals and ditches for navigation and irrigation.	State
1875	Austin waterworks founded by private company.	Local
1876	Dallas waterworks	Local
1878	Edison invented the light bulb and established the Edison Electric Light Company.	Global
1878	John Wesley Powell authored Report on the Lands of the Arid Region of the United States.	National
1878	Waco waterworks built by private company.	Local
1879	Houston waterworks begun by private company.	Local
1879	U.S. Geological Survey established.	National

Date	Event	Scale
1881	Congress declared that no federal money could be used to protect from flooding or for any purpose other than to deepen, straighten or clear river channels.	National
1882	Fort Worth waterworks founded by private company.	Local
1882	El Paso waterworks founded by private company.	Local
1883	San Marcos waterworks. Built by private company to pump water from San Marcos River to town of San Marcos.	Local
1885	Significant flood on Brazos	Regional
1885	November 13th fire destroyed 40 city blocks in Galveston.	Local
1885	Abilene waterworks supplied from wells and from Lytle Creek.	Local
1886	New Braunfels waterworks used water pumped from Comal River.	Local
1887	City of Galveston began drilling system of artesian wells for fire protection, domestic, and industrial use.	Local
March 1888	Congress authorized an irrigation survey under the direction of J.W. Powell.	National
1888	Decade of drought began that moved settlement line in US eastward including depopulation trend of Llano Estacado in TX.	National
Spring 1889	2000 people drowned when the Johnstown Dam broke in western Pennsylvania.	National
1889	Irrigation Act of 1889 established Doctrine of Prior Appropriation for surface water in arid part of the state. Streams became property of the state to be used for beneficial purposes. Amended in 1913, 1917.	State
1889	Bryan Water, Inc. & Electric Light Co., Inc. was contracted to furnish water for the city of Bryan.	Local
1890	Bryan waterworks est. about 1890. Local well water stored in standpipe. Distributed to citizens by gravity.	Local
1890	Navasota waterworks est. about 1890. Water from artesian well was pumped to standpipe.	Local
1891	National Irrigation Congress established.	National
1893	2nd Intl Irrigation Congress convened in Los Angeles. J.W. Powell proclaimed there was enough water to irrigate no more than 12% of western US land.	Intl
1893	International depression began that effectively stopped investment in Western US irrigation systems.	US and UK
1894	Oil discovered in Corsicana, TX while drilling for water.	State
1895	Galveston municipal waterworks brought water from mainland to the island.	Local
1895	Irrigation Act of 1889 was amended expanding the list of beneficial uses for water appropriation to include mining, milling, construction of waterworks, and stock raising. "First in time" rule was adopted.	State
1895	The first large hydroelectric plant in the United States began generating power at Niagra Falls.	Regional
1899	River and Harbor Act established means of prohibiting pollution of navigable waterways.	National
June 30, 1899	Great Flood of 1899 on Brazos.	State
Feb 1900	Sewage disposal plant completed at A&M College, now TAMU.	Local
Sept 1900	Hurricane at Galveston killed more than 6,000 people—the worst natural disaster in U.S. history.	National
1901	Oil discovered at Spindletop near Beaumont, TX.	State
June 1, 1902	President Theodore Roosevelt signed the Reclamation Act—often Called the Newlands Act.	National
1902	The Brazos River Impoundment Association is established by leaders from towns and counties along the river. Its purpose was to control flooding, but funding was an obstacle.	State
1904	Texas constitution was amended to authorize public development of water resources.	State

Date	Event	Scale
1904	Texas Supreme Court decision in Houston & Texas Central Railway Co. v. East established principle of Absolute Ownership of groundwater. Known as rule of capture.	State
1904	City of Waco purchased 1878 waterworks from private company.	Local
1905	Derby Dam diverted half Truckee River 30 miles east of Reno for irrigation project. First Reclamation project to open.	National
1905	Rivers and Harbors Act of 1905 included allocation for Trinity River improvements in Dallas as well as a lock and dam system between Waco and Washington on the Brazos.	National and state
1906	Treaty between the United States and Mexico appropriated water from the Rio Grande upstream from Fort Quitman, Texas (Hudspeth County, east of El Paso) for irrigation.	Regional
1907	Extensive flooding on the Ohio River	Regional
May 21, 1908	Reported that flood on Brazos the previous Monday endangered iron bridge at Jones ferry in western Brazos Co.	Local
1908	President Theodore Roosevelt held a White House conference on conservation for the nation's governors.	National
1909	Fire destroyed Bryan's city hall, fire department and all city minutes from prior to 1891.	Local
1909	Sewer system installed to serve Bryan's central business district.	Local
1910	El Paso waterworks purchased from private company by city.	Local
1910	White Rock Dam, earthen dam constructed across White Rock Creek in Dallas County between 1910 and 1911 to create reservoir for Dallas waterworks.	Local
1911	Lubbock waterworks	Local
1911	City of Bryan purchased the electrical distribution system from Bryan Water, Inc. and Electric Light Company for $7,650.	Local
1911	Warren Act stimulated private irrigation by allowing the sale of surplus government water.	National
1912	Public Health Service Act designed to protect drinking water by setting allowable levels for contaminants of disease.	National
1912-1913	Flooding in Ohio and Mississippi River valleys	National
1913	The Doctrine of Prior Appropriation was extended by legislation to the entire state (Irrigation Act of 1889).	State
1913	State Board of Water Engineers was created by Burges-Glasscock Act. Duties included supervising the appropriation of water rights.	State
1913	Sewage disposal plant was installed to serve the western part of the city of Bryan, TX.	Local
1913	First auto truck was purchased for the Bryan fire department.	Local
Dec 3-4, 1913	Extensive flooding along Brazos, Colorado Guadalupe and Trinity Rivers. Destroyed the lock and dam system authorized by the Rivers and Harbors Act of 1905, ending plans for a transportation network on the Brazos River. Killed at least 177 people and caused major property damage.	State
1913	Decision to dam Hetch Hetchy Valley in Yosemite National Park for a water supply for the city of San Francisco.	National
1914	Reclamation Extension Act gave Congress more oversight of reclamation projects and project extensions.	National
1915	The Brazos River and Valley Improvement Association was established in Waco for flood control. Needed funding.	State
1916	National Defense Act authorized the president to select a site for a hydroelectric dam and nitrate plants for the production of fertilizer. Woodrow Wilson chose Muscle Shoals.	National
1917	Flood Control Act of 1917 was the first federal law appropriating money for river improvements other than navigation. Focused on Mississippi and Sacramento Rivers.	National

Date	Event	Scale
1917	“Conservation amendment” of the Texas constitution was passed. This established the state’s right to regulate and conserve natural resources including water. Flood prevention became a duty of the state.	State
1920	Federal Water Power Act authorized the Federal Power Commission to issue licenses for the development of hydroelectric power.	National
1921	Major Texas flooding.	State
1922	Boulder Dam Bill introduced by Rep. Swing and Sen. Johnson. Approved in 1928.	National
1923	William Mulholland proposed an aqueduct from the Colorado River to Los Angeles for that city’s water supply.	Regional
1923	Texas legislature allocated funds for an analysis of flood problems on all the rivers in Texas. Controlling the Brazos was deemed necessary.	State
1925	Olmos Dam built by city of San Antonio between 1925-1926 for downtown business district flood protection.	Local
1925	Rivers and Harbors Act of 1925	National
1926	Secretary of Commerce Herbert Hoover, “True conservation of water is not the prevention of use. Every drop of water that runs to the sea without yielding its full commercial returns to the nation is an economic waste.”	National
1926	The Texas Supreme Court determined riparian rights applied only to ordinary flow and underflow of rivers.	State
1927	Metropolitan Water District created by California legislature for Los Angeles area water supply.	Regional
1927	Mississippi River flood.	Regional
1928	Flood control Act of 1928 with major benefits to the Deep South. Flood control on Mississippi River.	National
1928	Congress authorized funds for Boulder Dam. Pisani calls the year 1928 “a turning point in national water policy.”	National
1929	The Brazos River Conservation and Reclamation District, predecessor to the Brazos River Authority, was established under Article XVII, Section 59 of the Texas Constitution to “conserve, control, and utilize to beneficial service the storm and flood waters of the Brazos River and its tributary streams.”	State
1931	The Texas Water Priorities Act “Wagstaff Act” set priorities for Texas water use with municipalities having the highest priority.	State
1933	National Industrial Recovery Act served as the beginning of the New Deal. Title II of the act established the Public Works Administration to help fund construction projects, including dams.	National
1933	Tennessee Valley Authority established.	National
1934	LCRA created by the Texas Legislature as a conservation and reclamation district covering 10 counties along the river.	State
May 1934	Dust storms in the Great Plains of the U.S. lead to worst drought in U.S. history.	National
April 1935	Emergency Relief Appropriations Act provided $525 million in drought relief.	National
April 1935	Soil Conservation Service established in the Department of Agriculture. Began research on wind erosion and later on water erosion.	National
1935	Hoover Dam completed.	National
1935	Rivers and Harbors Act of 1935.	National
1935	The Brazos River C&R District completed its first master plan calling for 13 dams on the Brazos and its tributaries.	State
1936	Flood Control Act of 1936 authorized the first federal flood control reservoirs on tributaries of the Mississippi.	Regional
1937	Rivers and Harbors Act of 1937 authorized building of Central Valley Project	National
1938	Flood Control Act of 1938	Regional
1938	The Brazos River C&R District began work on Possum Kingdom, its first dam and reservoir construction project.	State

Date	Event	Scale
1939	The Rio Grande Compact with New Mexico and Colorado was ratified by the Texas legislature.	Regional
1939	Congress broadened the purpose of the U.S. Army Corps of Engineers to include construction of flood control and water supply projects.	National
1941	Construction on Lake Possum Kingdom on the main stem of the Brazos in Palo Pinto County, TX was completed by the Brazos C&R District.	State
1944	Texas Water Conservation Association established to provide forum for citizens participating in water issues.	State
1944	A treaty between the United States and Mexico allocated water from the Rio Grande below Fort Quitman, Texas one county east of El Paso. Supplemented 1906 treaty.	State
1948	Federal Water Pollution Control Act established to regulate waste disposal. "Spurred by public concern over epidemics of disease caused by waterborne bacteria."	National
1949	Aldo Leopold's *A Sand County Almanac* published.	National
1949	Legislation authorized the creation of underground water conservation districts and recognized groundwater as the private property of landowners.	State
1951	Water system established for the city of College Station and the A&M College.	Local
1951	Soil Conservation Service of USDA began constructing floodwater retarding structures on small watersheds.	National
1951	The Canadian River Compact with Oklahoma and New Mexico was ratified by the Texas legislature.	State
1951	U.S. Army Corps of Engineers and Brazos C&R District established a partnership granting the District water conservation storage in 9 reservoirs to be constructed by the Corps in the next 30 years.	State
1951	U.S. Army Corps of Engineers completed Lake Whitney on the main stem of the Brazos in Johnson, Bosque, and Hill Counties, TX.	State
1952-1957	Record drought in Texas.	State
1952	Texas Railroad Commission investigated complaints from the Briscoe Irrigation Company and the Galveston County Water Company that the oil and gas industry was polluting the Brazos River with salt water.	State
1953	The Texas Water Pollution Advisory Council was established.	State
May 11, 1953	Tornado in Waco killed 114 people, injured 1100.	State
1953	The Sabine River Compact with Louisiana was ratified by the Texas legislature.	State
1954	The U.S. Army Corps of Engineers completed Lake Belton on the Leon River in Bell County, TX.	State
1955	The name of the Brazos C&R District was changed to Brazos River Authority.	State
1956	The construction of Echo Park Dam proposed for Dinosaur National Monument was removed from the Upper Colorado River Storage Project because of opposition from wilderness preservation groups.	National
1956	Water Pollution Control Act (Public Law 84-660) authorized grants for water treatment facilities.	National
1957	Texas Water Planning Act passed in response to drought conditions.	State
1957	Texas Water Development Board was established. A constitutional amendment authorized it to help communities develop water supplies from a newly created Water Development Fund.	State
1959	Open Beaches Act recognized public access on all Texas Gulf Coast beaches.	State
1960	John Graves' *Goodbye to a River* published.	State
1961	A $735,000 chilled water system was installed on the A&M campus to provide air conditioning.	Local
1961	The Board of Water Engineers was reorganized into the Texas Water Commission with water planning responsibilities. The Board issued a surface water development plan to satisfy projected needs until 1980.	State

Date	Event	Scale
1961	Contamination in the upper Brazos River Basin was discovered to be caused by a massive underground salt deposit.	State
1962	Texas Supreme Court decided that Spanish and Mexican land grants in the Rio Grande valley did not include the right to irrigate with water from the Rio Grande.	State
1962	Rachel Carson's *Silent Spring* published.	National
1963	The U.S. Army Corps of Engineers completed Lake Proctor on the Leon River in Comanche County, TX.	State
1964	The Texas Water Commission was directed to develop a comprehensive state water plan.	State
1965	Water Resources Planning Act encouraged coordinated water planning and conservation at all levels of government.	National
1965	1965 Water Quality Act. Established Water Pollution Control Administration within the Department of the Interior.	National
1965	The U.S. Army Corps of Engineers completed Lake Waco on the Bosque River in McLennan County, TX.	State
1965	Land and Water Conservation Fund Act provided for acquisition and development of park land.	National
1965	Sam Rayburn Dam completed on Angelina River near Jasper. Sam Rayburn Reservoir extended 60 miles upstream.	State
1965	Federal Water Project Recreation Act	National
Oct 1965	LBJ signed the Highway Beautification Act at the urging of the First Lady 'Lady Bird' Johnson. It encouraged planting of native wildflowers to beautify highway right-of-ways and conserve water.	National
1966	Clean Water Act, provided grants for wastewater treatment plants.	National
1966	Endangered Species Act.	National
1966	Texas constitutional amendment expanded the Water Development Fund and limited interbasin transfers of water.	State
1966	The Brazos River Authority began construction of the DeCordova Bend Dam and Lake Granbury on the main stem of the Brazos in Hood County, TX.	State
1966-1967	The Brazos River Authority acquired the privately owned American Canal and Briscoe Canal to provide a water supply for rice irrigation, industrial and municipal uses in Galveston, Brazoria, and Fort Bend Counties.	State
1967	The Water Rights Adjudication Act directed the Texas Water Rights Commission to adjudicate and administer surface water rights. "Passed following historic drought."	State
1967	U.S. Army Corps of Engineers completed Lake Somerville on Yegua Creek in the Brazos watershed in Washington and Burleson Counties, TX.	State
1968	U.S. Army Corps of Engineers completed Lake Stillhouse Hollow on the Lampasas River in the Brazos watershed in Bell County, TX.	State
1968	Texas Water Development Board released its Texas Water Plan designed to meet projected needs until 2020. It called for the transportation of water from eastern to western Texas.	State
1968	Wild and Scenic Rivers Act, prohibits dev of hydroelectric plants on designated rivers and limits other types of dev. Rio Grande only Texas river designated Wild & Scenic.	National
1968	Photographs of the earth from the first manned flights orbiting the moon.	Global
1969	Cuyahoga River caught fire.	National
1969	National Environmental Policy Act required Environmental Impact Statement for federally funded projects.	National
Apr 22, 1970	First Earth Day	National
1970	National Environmental Policy Act	National
1970	Environmental Protection Agency established.	National
1971	Texas Water Development Board was authorized to issue $100 million in bonds for water quality enhancement.	State
1971	Brazos River Authority assumed operations of the Waco regional sewer system.	State

Date	Event	Scale
1972	Clean Water Act of 1972. "Enacted as a series of amendments to the Federal Water Pollution Control Act of 1948… The 1972 Act was prompted by the worsening state of U.S. rivers and by several high-profile oil spills, including the Santa Barbara channel spill…" Included establishing management plans for 15 of Texas river basins.	National
1973	Endangered Species Act expanded protection of flora and fauna designated as threatened or endangered by U.S. Fish and Wildlife Service.	National
1973	Elmer Kelton published *The Time It Never Rained*, an award winning novel about a Texas rancher struggling through the drought of the 1950s.	State
1973	The Coastal Public Lands Management Act protected public use of coastal resources and navigation in intracoastal waterways.	State
1974	Safe Drinking Water Act created national drinking water standards for individual contaminants as set by the EPA.	National
1975	Brazos River Authority assumed operations of both the Sugar Land and Temple-Belton regional sewer systems.	State
1975	Old water tower dismantled on TAMU campus.	Local
1977	Clean Water Act amended with regard to point source pollution of hazardous materials into waterways. Protected wetlands by requiring Section 404 permits from Army Corps of Engineers for dredging and filling projects.	National
1977	The Texas Department of Water Resources was established by consolidation of several boards and commissions.	State
1978	The Brazos River Authority completed construction on the Sterling C. Robertson Dam impounding Lake Limestone on the Navasota River in Limestone, Leon, and Robertson Counties, TX.	State
1979	The Red River Compact with Oklahoma, Arkansas, and Louisiana was ratified by the Texas legislature.	Regional
1980	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 created $1.6 billion Superfund to clean up hazardous waste sites.	National
1980	U.S. Army Corps of Engineers completed Lake Granger on the San Gabriel River and Lake Georgetown on the North Fork San Gabriel River, both in the Brazos watershed in Williamson County, TX.	State
1981	Gibbons Creek Reservoir began to fill and was stocked with fish.	Local
1982	Texas Supreme Court upheld the Water Rights Adjudication Act of 1967, including limitations on riparian rights.	State
1983	Commercial production of electricity began from Gibbons Creek Reservoir.	Local
1984	Texas Department of Water Resources adopted a new Water of Texas Plan.	State
1985	$1.2 billion in bonds approved by voters for water quality and supply, flood control, and agriculture conservation. Texas Department of Water Resources was split into the Texas Water Development Board and the Texas Water Commission. A conservation plan was required for the granting of a water use permit.	State
1986	Safe Drinking Water Act amended to expand number of contaminants regulated by EPA and to ban use of lead in pipes of public water systems.	National
1986	Brazos River Authority obtained an option from Houston Lighting & Power Company to acquire the Allens Creek reservoir site.	State
1987	Water Quality Act amended to require states to develop a non-point source management plan. Plans could be voluntary.	National
1988	Brazos River Authority sold the American Canal and Briscoe Canal to the Galveston County Water Authority.	State
1989	Brazos River Authority began to operate the Lake Granbury Surface Water and Treatment System in Hood County.	State
1990	Texas Water Development Board began limited monitoring of aquifers.	State
1990	The Temple-Belton Regional Sewerage System was expanded by the Brazos River Authority	State
1991	The Brazos River Authority began a community volunteer program to monitor water quality issues and raise public awareness.	State

Date	Event	Scale
1992	Brazos River Authority and Soil Conservation Services of the U.S. Department of Agriculture enter a memorandum of understanding for water quality programs in the Brazos River basin.	National
1993	Rio Grande called most endangered river in US by American Rivers, nonprofit org.	National
1994	Brazos River Authority completed Lake Alan Henry in Garza and Kent Counties, TX to provide surface water supply for Lubbock.	State
1995	Brazos-Colorado Water Alliance was formed between the Brazos and Lower Colorado River Authorities to address water needs in Williamson County, TX.	State
1995	Brazos River Authority began operating the Brushy Creek Regional Wastewater System in Williamson County, TX.	State
1996	Additional amendments to Safe Water Drinking Act requiring source water assessment program to identify potential contaminants and required annual report on drinking water sources, quality, and violations beginning in 1999. Allocated $9.6 billion for improving drinking water infrastructure.	National
1997	The Middle Brazos Reconnaissance Study was conducted on the Bosque River as a collaboration between several city, state, and federal agencies seeking data on watershed restorative measures due to land use change.	State
Sept 1,1997	Senate Bill 1. Mandated management by watershed and development of a statewide water plan with stakeholder involvement.	State
1998	Major flooding occurred in the Guadalupe and Colorado River basins in central Texas.	State
1999	Brazos River Authority assumed joint operation with the City of Hutto's wastewater treatment facility.	State
1999	Brazos Authority exercised its 1986 option to purchase the Allens Creek reservoir site from Reliant Energy (formerly Houston Lighting & Power).	State
1999	Texas Supreme Court decision in Sipriano v. Great Spring Waters of America case reaffirmed their 1904 groundwater rule of capture decision but urged the state legislature to change Texas groundwater law.	State
2002	Texas Water Development Board issued the 2002 State Water Plan mandated by Senate Bill 1. It was the most comprehensive water management for the state.	State

APPENDIX B

TOTAL POPULATION OF TEXAS 1850-2000

Texas has experienced steady population growth in each decade since it became the 28th state in the United States in 1846. These data are from decennial censuses of the United States.[464]

Year	Texas Population	Change from previous census	Percentage change
1850	212,592		
1860	604,215	391,623	184.2
1870	818,579	214,364	35.5
1880	1,591,749	773,170	94.5
1890	2,235,527	643,778	40.4
1900	3,048,710	813,183	36.4
1910	3,896,542	847,832	27.8
1920	4,663,228	766,686	19.7
1930	5,824,715	1,161,487	24.9
1940	6,414,824	590,109	10.1
1950	7,711,194	1,296,370	20.2
1960	9,579,677	1,868,483	24.2
1970	11,196,730	1,617,053	16.9
1980	14,229,191	3,032,461	27.1
1990	16,986,510	2,757,319	19.4
2000	20,851,820	3,865,310	22.8

[464] From the Texas State Data Center. http://txsdc.utsa.edu/txdata/apport/hist_b.php (accessed March 11, 2007).

APPENDIX C

POPULATION OF TEXAS CITIES 1850 TO 1930[465]

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Abilene					3,194	3,411	9,204	10,274	23,175
Alamo									1,018
Alamo Heights									3,874
Alice							2,136	1,880	4,239
Alpine								931	3,495
Alvin					261	996	1,453	1,519	1,511
Amarillo					482	1,442	9,957	15,494	43,132
Angleton								1,043	1,229
Anson							1,842	1,425	2,093
Aransas Pass							1,197	1,569	2,482
Arlington					664	1,079	1,794	3,031	3,661
Athens	177		500				2,261	3,176	4,342
Atlanta					1,764	1,301	1,604	1,469	1,685
Austin	629	4,394	4,428	11,013	14,575	22,258	29,860	34,876	53,120
Ballinger					1,390	1,128	3,536	2,767	4,187
Bastrop				1,546	1,634	2,145	1,707	1,828	1,895
Bay City							3,156	3,454	4,070
Baytown									5,208
Beaumont	151				3,296	9,427	20,640	40,422	57,732
Beeville					1,311	2,311	3,269	3,062	4,806
Bellaire									390
Belton	300	305	777	1,797	3,000	3,700	4,164	5,098	3,779
Big Lake									832
Big Spring						1,255	4,102	4,273	13,735
Bishop									953
Bonham	477			1,880	3,361	5,042	4,844	6,008	5,655
Borger									6,532
Bowie					1,486	2,600	2,874	3,179	3,131
Brackettville									1,822
Brady				115	560	690	2,669	2,197	3,983
Breckenridge								1,846	7,569
Brenham			2,221	4,101	5,209	5,968	4,718	5,066	5,974
Bridgeport					498	900	2,000	1,872	2,464
Brownfield									1,907

[465] From the *Texas Almanac, 1964-1965* (Dallas, TX: Belo Publishing, 1963), 122-126.

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Brownsville		2,734	4,905	4,938	6,134	6,305	10,517	11,791	22,021
Brownwood				725	2,176	3,965	6,967	8,223	12,789
Bryan					2,979	3,589	4,132	6,307	7,814
Burkburnett								5,300	3,281
Calvert				2,280	2,632	3,322	2,579	2,099	2,103
Cameron					1,608	3,341	3,263	4,298	4,565
Canadian							1,648	2,187	2,068
Canyon							1,400	1,618	2,821
Carrizo Springs								954	2,171
Carrollton								573	689
Carthage								1,366	1,651
Center							1,684	1,838	2,510
Childress						692	3,818	5,003	7,163
Cisco					1,063	1,514	2,410	7,422	6,027
Clarendon							1,946	2,456	2,756
Clarksville	700	400			1,588	2,069	2,065	3,386	2,952
Cleburne			683	1,855	3,278	7,493	10,364	12,820	11,539
Cleveland									1,422
Coleman				400	906	1,362	3,046	2,868	6,078
Colorado City				1,200			1,840	1,766	4,671
Columbus				1,959					2,054
Comanche				704	1,226	2,070	2,756	3,524	2,435
Commerce					810	1,800	2,818	3,842	4,267
Conroe							1,374	1,858	2,457
Cooper					629	1,518	1,513	2,563	2,023
Copperas Cove								509	406
Corpus Christi		175	2,140	3,257	4,387	4,703	8,222	10,522	27,741
Corsicana			80	3,373	6,285	9,313	9,749	11,356	15,202
Cotulla							1,880	1,058	3,175
Crockett	600	1,500		599	1,445	2,612	3,947	3,061	4,441
Crystal City								800	6,609
Cuero				1,333	2,442	3,422	3,109	3,671	4,672
Dalhart							2,580	2,676	4,691
Dallas	430	2,000	3,000	10,358	38,067	42,638	92,104	158,976	260,475
Dayton									1,207
Decatur				579	1,746	1,562	1,651	2,205	2,037
Del Rio				50	1,980			10,589	11,693
Denison				3,975	10,958	11,807	13,632	17,065	13,850
Denton				1,194	2,558	4,187	4,732	7,626	9,587
Devine									1,363
Dickinson									829
Dimmitt							1,042	995	1,093
Donna								1,579	4,103

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Dublin					2,025	2,370	2,551	3,229	2,271
Eagle Lake					769	1,107	1,717	2,017	2,343
Eagle Pass							3,536	5,765	5,059
Eastland						596	855	9,368	4,648
Edcouch									914
Edinburg								1,406	4,821
Edna									1,752
El Campo							1,778	1,766	2,034
Electra							640	4,744	6,712
Elgin							1,707	1,630	1,823
El Paso				736	10,338	15,096	39,279	77,560	102,421
Ennis				1,351	2,171	4,919	5,669	7,224	7,069
Floydada							664	1,384	2,637
Fort Stockton								1,297	2,695
Fort Worth			500	6,663	23,076	26,688	73,312	106,482	163,447
Fredericksburg									2,416
Freeport								1,798	3,162
Gainesville				2,667	6,594	7,874	7,624	8,643	8,915
Galveston	4,177	7,307	13,818	22,248	29,084	37,788	36,981	44,255	52,938
Garland					478	819	804	1,421	1,584
Gatesville				434	1,375	1,865	1,929	2,499	2,601
Georgetown	200		320	1,354	2,447	2,790	3,096	2,871	3,583
Giddings				624				1,650	1,835
Gilmer							1,484	2,268	1,963
Gonzales	1,072			1,581	1,641	4,297	3,139	3,128	3,859
Graham					667	878	1,569	2,544	4,981
Grand Prairie							994	1,263	1,529
Grapevine							681	821	936
Greenville	246				4,330	6,860	8,850	12,384	12,407
Hallettsville					1,011	1,457	1,379	1,444	1,406
Hamilton							1,548	2,018	2,084
Hamlin							1,978	1,633	2,328
Harlingen								1,784	12,124
Haskell						800	2,346	2,300	2,632
Hearne				1,421		2,129	2,353	2,741	2,956
Henderson								2,273	2,932
Henrietta					2,100	1,614	2,104	2,563	2,020
Hereford							1,750	1,696	2,458
Highland Park								2,321	8,422
Hillsboro			313		2,541	5,346	6,115	6,952	7,823
Houston	2,396	4,845	9,382	16,513	27,557	44,633	78,800	138,276	292,352
Huntsville	892		1,600	2,536	1,509	2,485	2,072	4,689	5,028
Iowa Park							603	2,041	2,009

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Irving								357	731
Jacksboro					751	1,311	1,480	1,373	1,837
Jacksonville					970	1,568	2,875	3,723	6,748
Jasper			360	500	473				3,393
Jefferson		988	4,190	3,260	3,072	2,850	2,515	2,549	2,329
Karnes City								787	1,141
Kaufman					1,282	2,378	1,959	2,501	2,279
Kenedy							1,147	2,015	2,610
Kerrville			226	156	1,044	1,423	1,834	2,353	4,546
Killeen					285	780	1,265	1,298	1,260
Kingsville								4,770	6,815
La Feria								236	1,594
La Grange			1,165	1,325	1,626	2,392	1,850	1,669	2,354
Lamesa								1,188	3,528
Lampasas			420	653	2,408	2,107	2,119	2,107	2,709
Lancaster					741	1,045	1,115	1,190	1,133
La Porte						537	678	889	1,280
Laredo		1,256	2,046	3,521	11,319	13,429	14,855	22,710	32,618
Levelland									1,661
Lewisville									853
Liberty		584	458	497		865	980	1,117	2,187
Littlefield									3,218
Livingston								928	1,165
Llano							1,687	1,645	2,124
Lockhart	423		500	718	1,233	2,306	2,945	3,731	4,367
Longview				1,525	2,034	3,591	5,155	5,713	5,036
Lubbock							1,938	4,051	20,520
Lufkin					529	1,527	2,749	4,878	7,311
Luling					1,792	1,349	1,404	1,502	5,970
McAllen								5,331	9,074
McCamey									3,446
McGregor					774	1,435	1,864	2,081	2,041
McKinney	523			1,479	2,489	4,342	4,714	6,677	7,307
Marfa								3,553	3,909
Marlin					2,058	3,092	3,878	4,310	5,338
Marshall	1,189	4,000	1,920	5,624	7,207	7,855	11,452	14,271	16,203
Mart						300	2,939	3,105	2,853
Memphis							1,936	2,839	4,257
Menard								1,164	1,969
Mercedes							1,209	3,414	6,608
Mesquite					135	406	687	674	729
Mexia				1,298	1,674	2,393	2,694	3,482	6,579
Midland							2,192	1,795	5,484

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Mineola				1,175	1,333	1,725	1,706	2,299	3,304
Mineral Wells					577	2,048	3,950	7,890	5,986
Mission								3,847	5,120
Monahans									816
Mount Pleasant	227						3,137	4,099	3,541
Muleshoe									779
Nacogdoches	468	393			1,138	1,827	3,369	3,546	5,687
Navasota				1,611	2,997	3,857	3,284	5,060	5,128
New Boston								869	949
New Braunfels	1,727	3,500	2,261	1,938	1,608	2,097	3,165	3,590	6,242
Nocona					381	961	1,338	1,422	2,352
Odessa									2,407
Olney							1,095	1,164	4,138
Orange					3,173	3,835	5,527	9,212	7,913
Ozona									
Paducah							1,350	1,357	2,802
Palacios							1,389	1,335	1,318
Palestine	2,000			2,997	5,838	8,297	10,492	11,039	11,445
Pampa								987	10,470
Paris	1,003	1,500		3,980	8,254	9,358	11,269	15,040	15,649
Pasadena									1,647
Pearsall							1,799	2,161	2,536
Pecos					393	639	1,856	1,445	3,304
Pelly									3,452
Perrytown									2,824
Pharr								1,565	3,225
Pittsburg					1,203	1,783	1,916	2,540	2,640
Plainview							2,829	3,989	8,834
Plano					824	1,304	1,258	1,715	1,554
Pleasanton								1,036	1,154
Port Arthur						900	7,663	22,251	50,902
Port Isabel									1,177
Port Lavaca							1,699	1,213	1,367
Port Neches									2,327
Post								1,436	1,668
Poteet									1,231
Quanah					1,477	1,651	3,127	3,691	4,464
Ranger								16,201	6,208
Raymondville									2,050
Refugio							773	933	2,019
Richardson									629
Richmond							1,371	1,273	1,432
Rio Grande City									2,283

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Robstown								948	4,183
Rockdale					1,505	2,515	2,073	2,323	2,204
Rockport					1,069	1,153	1,382	1,545	1,140
Rosenberg							1,198	1,279	1,941
Rotan							1,126	1,000	1,632
Rusk	355	395	1,000		1,383	846	1,558	2,348	3,859
San Angelo							10,321	10,050	25,308
San Antonio	3,488	8,235	12,256	20,550	37,673	53,321	96,614	161,379	231,542
San Augustine			920	503	744	261	1,204	1,268	1,247
San Benito								5,070	10,753
San Juan								1,203	1,615
San Marcos			741	1,232	2,335	2,292	4,071	4,527	5,134
San Saba								2,011	2,240
Seagoville									604
Seagraves									505
Seguin		792	830	1,363	1,716	2,421	3,116	3,631	5,225
Seymour							2,029	2,121	2,626
Shamrock								1,227	3,780
Sherman			1,439	6,093	7,335	10,243	12,412	15,031	15,713
Sinton								1,058	1,852
Slaton								1,525	3,876
Smithville					616	2,577	3,167	3,204	3,296
Snyder							2,514	2,179	3,008
Sonora								1,009	1,942
South Houston									612
Spearman									1,580
Stamford							3,902	3,704	4,095
Stephenville					909	1,902	2,561	3,891	3,994
Sulphur Springs	441	2,500		1,854	3,033	3,635	5,151	5,558	5,417
Sweetwater					614	670	4,176	4,307	10,848
Taft									1,792
Tahoka								786	1,620
Taylor					2,584	4,211	5,314	5,965	7,463
Teague							3,288	3,306	3,509
Temple					4,047	7,065	10,993	11,033	15,345
Terrell				2,003	2,988	6,330	7,050	8,349	8,795
Texarkana				1,833	2,852	5,256	9,790	11,480	16,602
Texas City								2,509	3,534
Tulia							1,216	1,189	2,202
Tyler	1,024			2,423	6,908	8,069	10,400	12,085	17,113
University Park									4,200
Uvalde					1,265	1,889	3,998	3,885	5,286
Vernon					2,857	1,993	3,195	5,142	9,137

City	1850	1860	1870	1880	1890	1900	1910	1920	1930
Victoria	1,440		2,500		3,046	4,010	3,673	5,957	7,421
Waco	749		3,008	7,295	14,445	20,686	26,425	38,500	52,848
Waxahachie				1,354	3,076	4,215	6,205	7,958	8,042
Weatherford	175	1,823		2,046	3,369	4,786	5,074	6,203	4,912
Wellington							576	1,968	3,570
Weslaco									4,879
West University Place									1,322
Wharton							1,505	2,346	2,691
Wichita Falls					1,987	2,480	8,200	40,079	43,690
Wink									3,963
Winnsboro					388	899	1,741	2,184	1,905
Winters							1,347	1,509	2,423
Yoakum					1,745	3,499	4,657	6,184	5,656
Yorktown				430	522	846	1,180	1,723	1,882

APPENDIX D

REFERENCES ABOUT WATER FROM THE JOURNAL OF

PLEASANT B. WATSON[466]

In 1839, at the age of three, Watson moved with his family to Washington-on-the-Brazos, Texas from DeKalb County, Tennessee. He began his journal with an autobiographical essay of his early life and made entries from October 4, 1858 through August 4, 1868. Much of this part of his life was spent at Washington-on-the-Brazos, and in this regard, his attitudes, comments, and usage of water may not be atypical of those of many Texans of his period. During the time of this journal, Watson also fought in Nicaragua with Walker's Rangers and in Virginia during the Civil War, and traveled to Mexico, Tennessee, the Hill Country of central Texas, and bought acreage on Buffalo Bayou in Houston. Pleasant B. Watson's Journal contains 130 pages of narrative entries and 25 pages of original poetry and short stories, some of which were published in the *La Crosse, [Wisconsin] Democrat*. The entries in this table are references made to water or uses made of water by Watson in the narrative entries in his journal. "Type" refers either to type of water use or the condition under which water is mentioned. Often the mention is merely about the weather. He also regularly used rivers and streams as location indicators and campsites during his travels. River and ocean transportation are also noted. Watson noted water's use for medicinal purposes, both as something ingested and in the context of the healing powers of mineral waters at Sour Lake, Texas, and on one occasion he recorded that he had bathed. He was at the very least indignant, and possibly angered, at having to purchase water on several occasions while in Mexico. Never in the course of his description of his life in Washington-on-the-Brazos or later in Houston did he mention his domestic water supply or the use of water in his daily life. Watson's Journal is from of the collection of the Star-of-the-Republic Museum at Washington-on-the-Brazos, Texas.

Type	Page	Date	Entry
Water not mentioned, but apparently not perceived as problem.	2	Oct 4, 1858	My parents moved to Texas in the Fall of 1839. They were in moderate circumstances, and settled in Washington County 3 miles from the town of Washington on the Brazos. I was raised up by indulgent parents and never knew what it was to want for anything. My Father never made me work any—which I then thought very indulgent and right but which I new regret; as work would have given me a better constitution than I now have.
Transport	3	Nov 16, 1856	Steamship from New Orleans to Nicaragua.

[466] Pleasant B. Watson, *Journal*, unpublished manuscript dated October 4, 1858 through August 4, 1868, from the collection of the Star-of-the-Republic Museum at Washington-on-the-Brazos, Texas.

Type	Page	Date	Entry
Transport	4		Steamer to Grenada
Transport	5		Steamer out on lake
Transport	12	Feb 16, 1858	Schooner from New Orleans to Yucatan on business for Wm. Allen in 1858
Transport	13		Little canoe boat 50 ft long from schooner to shore near Campeche
Transport	14		Steamship from Campeche to Veracruz and then another steamship to New Orleans
Weather	19	Oct 10	Thunderstorm during church
Location	23	Nov 3	Stopped on Navidad [beginning on his journey to Mexico] about 12 o'clock and camped till next morning.
Location	23	Nov 4	Camped in an old house 10 mi west of the Lavaca.
Location	23	Nov 5	Camped near Clinton on the Guadaloupe. Had some bread baked at a bakery.
Location	23	Nov 7	Camped on the Blanco. Killed a prairie chicken.
Location	24	Nov 8	Camped on the Aransas—a small river.
Location	24	Nov 9	Camped on small creek called the Poppylotae.
Location	24	Nov 10	Camped on Agua Dulce, a small stream and were under apprehension that our horses would be stolen by Mexicans. False fears however.
Availability	24	Nov 11	Sam rode down a small stream to look for water and I went up it…. We went back and got some water and camped short distance off in the prairie.
Availability	25	Nov 13	Camped at a tank called Los Animas. Water plenty here, but we had suffered considerably for it.
Location, recreation	25	Nov 14	Camped two mi from Sal Colorado. Camp 9 mi fro Rio Grande. Camped on the banks of the Rio Grande 15 mi above Brownsville. Go swimming in Rio Grande.
Location	26	Nov 22-30	Into Mexico. Camped 12 mi from Rio Grande. Went as far as 150 mi from Rio Grande.
Availability	26	Nov 22-30	6 months without rain in northern Mexico. "The greatest inconvenience in raising stock is the scarcity of water. The water is obtained by digging wells and have troughs for stock to drink from. The Mexicans are mean enough to sell water. We had to buy water for our horses and ourselves, and however justifiable the selling of it may appear in a Mexican's opinion, Texans certainly consider it penurious and low in the extreme."
Location	27	Dec 2	Crossed Rio Grande [back into Texas].
Transport	27	Dec 2	Charged penny a head to ferry sheep across Rio Grande at Matamoras.
Weather	27	Dec 5	Rained all day. Henry and I made a tent large enough for us all to sleep under. Very good sewers in a rough way.
Weather	27	Dec 7	Cold wind and rain, very disagreeable weather. Spend a miserable night.
Weather	28	Dec 8	Very cold and rainy day
Availability	28	Dec 8	Strike the road at a watering hole called Whan Pelone where we camp.
Availability	28	Dec 12	Crossed the Sal. Colorado at the ford called Paso los Starvarnes. Camp 5 miles from it without water.
Availability	28	Dec 13	Buy water at Lamalta from a Mexican.
Availability	28	Dec 17	Pass Carsonsias, which is a little well about 6 feet deep procure water

Type	Page	Date	Entry
			for horses & sheep. Camp near Mohairas, another well.
Weather	29	Dec 18	Rainy weather.
Availability	29	Dec 23	Camped near the San Fernando.[467] Find a company boring artesian wells just commenced.
Location	29	Dec 24	Camped on the Las Pintas.
Weather	29	Dec 24	Bad weather.
Location	29	Dec 25	Camped on Aqua Dulce [Nueces County].
Weather	29	Dec 25	Bad weather.
Location	30	Dec 27	Camped at San Patricio. Crossed the Nueces [Present day Corpus Christi].
Location	30	Dec 29	Camped at the Poppylotae, a small stream.
Location	30	Dec 30	Camped at the Aransas River near Dan Pages.
Location	30	Jan 4, 1859	Camped 3 miles east of Goliad on the Pica.
Location	31	Jan 8	Passed through Clinton—Crossed Guadaloupe… Camp at the edge of Bottom ½ mile from the river.
Weather	31	Jan 10	Camp in pararie by myself--Rain all night.
Location	31	Jan 11	Arrive at Albert Searcy's on Navidad.
Weather	31	Jan 11	Bad weather rainy.
Weather	32	Jan 12	Bad weather.
Weather	32	Jan 13	Good weather.
Location	32	Jan 14	Camp at Capt Shad Owen's , on the Navidad.
Location	32	Jan 15	Camp on the east Navidad 9 mile from Lagrange.
Location	32	Jan 16	Crossed the Colorado – camp on Caedar Creek.
Weather	32	Jan 17	Good weather.
Location	32	Jan 19	Camp on Mills Creek. Loose 6 sheep.
Weather	32	Jan 20	Camped 2 miles east of Brenham. Rains all night.
Location	35	Mar 25-30	Hunting with little success. Went up the Navasota.
Recreation	36	Apr 2-6	Hunting and fishing at the [Hidalgo] Falls with Derrick Smith and John [his brother] – stay all night go to Hick Hall's in the morning to dig bait. Hick went down with us and we had a lively time. Hick fell in the river, got wet and we laughed at him so much that he pushed Derrick and I into the waters – we gathered him and dragged him through a mud hole several times till completely saturated with mud and water.
Location	36	Apr 7-11	Have bad weather. Rains on us – get wet
Transport	41	May 8	The steamboat Bell Sulphur, which has been lying up here for six months, starts up the river tomorrow. … Wash Crawford and I caught a skiff that came down the river. We chased it, before catching it, about a mile. It turned out to be valueless and we left it afloat and had some tough and muddy work to get back.
Recreation	42	May 9	I have had considerable fun today. The boat went up to Aldridges Ferry today after Cotton and 8 or 10 young men and Misses Puss Norwood and Eugenie Cartmell and several married ladies went up on it as a kind of a pleasure trip. Capt Cartmell got us all to work rolling

[467] Handbook of Texas Online, entry for "San Fernando Creek," runs from Alice to Kingsville.

Type	Page	Date	Entry
			cotton and I never done as hard work in my life. I took a sketch of the river as we went up. I carried my rifle along and we had some fin sport shooting various kinds of waterfowls. I also shot two alligators. The young ladies took their guitars along and we had some fine music. Went up home with …
Transport	42	May 10	Steamboat Belle Sulphur left to day for the lower Country.
Medicinal	43	May 22-Sep 1	Passed at home, with the exception of a three weeks trip up to Austin and from there to Lampasas Springs. Enjoyed the trip very well. Saw a great deal of fine country. Was accompanied by James Hutchinson, a young friend of mine. We camped out all the trip and my health was improved in consequence. There was a great many persons at the springs, about 600. We came back via of Belton, Cameron, & Caldwell. I killed a good many deer on the trip.
Weather	46	Jan 6, 1860	Start home [from Anderson to Washington]. Caught in the rain and ride in the rain home.
Weather	47	Jan 11	Rained, snowed, and sleeted to day.
Bathe	83	Jul 10	Go over to the Mill Pond [near Richmond, VA] and bathe.
Mill	101	Feb 4, 1867	Our “honey-moon” was spent at home in Washington very pleasantly. I stayed at home most all the time until the following September when I took a trip up to the northern portion of Texas after flour. I carried a large ox-wagon and buggy. My wife accompanied me. We “camped out” most of the time in pretty weather and had a very pleasant time. I killed a great deal of game on the trip, was gone about two months, and returned in fine health both of us. We called on Louis Autry 12 miles above Corsicana in Navarro Co and had flour ground at a mill 12 miles below Corsicana belonging to Mr. Byrd a very clever man. He had a fine lady for his wife with whom my wife became very friendly. The mill is situated on Richland creek and is one of the finest places for hunting that I ever saw. I stayed there 10 or 12 days and killed 8 or 10 deer, ducks and turkeys innumerable.
Spring	106		During this time I took the wagons & teams and went up some 12 miles above San Marcos with my family and camped at a Spring at the foot of the Guadaloupe mountains. The neighborhood was called Purgatory.
Medicinal	107		Then we commenced to gather them [cattle], John and Jimmie Cartmell were both sick and could not go with us. So Stevenson and myself started accompanied by a Negro man depending on hiring hands to drive. We went up in the lower end of Llano County before we commenced, and the very day we commenced herding I was taken sick with bilious fever. Up in the Mountains, 50 miles to a physician, and no medicine. You can imagine my situation. I had a hot burning fever for a week. I at least broke the fever by drinking an abundance of cold water but I was so weak that I could not walk. I hired a man to take me down to Blanco City about 25 miles in the hopes of finding some medicines there but was disappointed and had to go back to my cold water.
Medicinal	114	Jul 2, 1867	I went up to Washington got my wife & child, returned through Houston on my way to Sour Lake in the Eastern part of this State, for my health. I bought two tents, a cooking stove, supplies &c and took the R.R. for Sour Lake Station after being detained in Houston five days exposed to the Fever.
Transport	114-115	Jul 2	We started from Houston in the morning and got to the station 9 miles from the Lake late in the evening, where we found a Hack in waiting. There was two other passengers besides my family and we had to cross a Bayou that was Swimming, from the Recent heavy Rains. We had a small flat boat to cross in and just as the boat was leaving the

Type	Page	Date	Entry
			bank and had got out into the water some 10 feet the end next to the bank sunk. I jumped towards the bank with my little girl in my arms and landed about waist deep in the water my wife quickly following we scrambled out in safety, and I built a fire were soon all dry again. The boat containing the Hack two horses sunk a little way and rested on some cypress knees. The rivers with the assistance of one of the passengers who had remained aboard the boat got the horses unhitched jumped them off the boar and got them out, after nearly losing one of them that was badly wounded by jumping upon one of the sharp cypress knees so plentiful in the Bayou. They prized up the boat, bailed it out good, got it back to bank, put the Horses in went over safely come back after us, and we got to the Lake about 10 o'clock at night, got some supper and went to Bed. My wife had a severe spell of fever a few days after our arrival and I was fearful for a time that it was the Location fever but it proved not to be.
Weather	115	Jul 2	For 15 days after our arrival at the Lake it rained nearly all the time; the creeks were up and I could not get my Baggage from the Station and we were compelled to stay at the Hotel.
Medicinal, recreation	115	Jul 2	My health commenced improving as soon as I got there. When I got my tents had Provisions from the R.R. Station I stretched my tents facing each other, placed the stove in one, and our Bed in the other and covered the intervening space with a board shelter for a dining room, and built a rail fence around them all to keep out Hogs, and we found it very comfortable and agreeable. The camping done us as much good as the waters, though I think the waters are the best medical waters in the world, for a great many diseases. There was not a great many visitors at the Lake, but enough to make it agreeable and pleasant….. Sour Lake, if it was properly improved would be one of the greatest watering places in the South, especially, if the facilities for traveling to and from it were good. After dry weather set in I commenced hunting and fishing. When the usual routine of watering place pleasures became irksome I would take my Rifle and go out hunting. I borrowed a gently hunting pony from a man living near the Lake and had fine sport hunting and fishing. I kept my Table supplied with the finest of game and fish and had plenty to give away. Jas Terry hunted with me a great deal. The first deer I killed was a fine Buck; made a splendid shot at him. The next was also a Buck. Terry and I went fire hunting with a pine torch and I killed a fine deer in half a mile from the Lake. I killed 10 or 12 deer while at the Lake. Turkeys were scarce owing to several wet seasons previous killing off the young ones. I went out one day by myself and had hitched my horse and was slipping along through a thicket looking for a bear, when I heard a flock of turkeys not far from me making a noise as though something was after them. They all flew up into the trees and I started towards them and saw a large wild-cat coming directly towards me, not seeing me. I hid myself behind a clump of bushes and he walked up to within a dozen paces of me. I shot him dead, loaded up and killed six turkeys in quick succession. I believe I could have killed the whole flock if I had desired it. I skinned the wild-cat, carried my turkeys out to my horse and went to camp well satisfied with the days hunt. There was a small bayou in about two miles of the Lake, and it was the best fishing stream that I ever fished in. We had several fish-frys there. All the Ladies at the Lake would go and we would cook dinner in the woods. On such occasions the crowd would catch 300 and 400 fine perch and trout. I have frequently while fishing by myself caught

Type	Page	Date	Entry
			an hundred in an hour or so. Some of the trout a foot long. My wife enjoyed the fishing very much. The Lake is within a few miles of the Edge of "Big Thicket." I got one shot at a Bear, wounding him badly, but having no dog he got away from me. It was the only Bear that I saw while there, but could see their tracks often. If I had have had some Bear dogs I could have had fine sport with them. About the last of October the Ducks commenced coming in and I killed a great many of the fattest that I ever saw. They were so thick in the ponds about the edge of the timber that I could frequently with a shot gun loaded with small squirrel shot (I had no buck shot) kill 10 or 12 at a shot. I killed one morning 20 at three shots in about an hour of the large canvass back duck. I will always remember my visit to Sour Lake with pleasure. Besides the sport I had hunting and fishing, the health of my wife and myself was very much benefited. When I went there I weighed 119 lbs and when I came away I weighed 140 lbs. I had been in bad health for several years previous, but have had good health ever since. My wife and little girl both improved in health and appearance. We intended staying until Christmas, but a sad and fatal tragedy in which two of our family, Felix Farquhar (my brother-in-law) and poor little Tommie Autry (my half brother) were shot and killed.
Potential due to location on water	120	March 1868	In the latter part of March I traded my wagon and four mules to a Mr. Harrell for 15 ½ acres of land situated on Buffalo Bayou 2 ½ miles below Houston – valued at $600.00. I have been at work on it ever since trying to improve it for a home. It is a very pretty place and its situation will make it valuable some day. I have put up a log-house that I design for a kitchen and have the lumber on the ground to build my dwelling house. My wife was so impatient to et home that we moved down and are now living in the kitchen. It is the first home of our own that we have had since we were married and if we can only be healthy here I am sure that we can get along happily. But "Poverty is a hard task-master. We are very poor, but hope by hard work and economy to "get along" contentedly. I have named my place "Eagle Nest." I have built immediately on the Bank of the Bayou, and the Boats that run between Houston & Galveston pass by our doors. When the contemplated "Ship Channel" is cut my place will be much more valuable. This "Houston Ship Channel Company" organized a few days since, and are now engaged in securing subscriptions to their stock pending the securing of their charter. I think it will be built. It is m intention to plant all of my land in fruit trees and grape-vines, but it will require 3 or 4 years for them to commence bearing. In the meantime I must do something to make a living for my family.
Weather	128	Jul 21	Rained last night. Work a little to day chopping. Clearing up land. Rained this morning, and is now very cloudy and drizzling. Thunder and much lightning. Planted some plum & peach seed.
Weather	129	Jul 23	Heavy rain to day. Brought up logs to make a chicken house. Work balance of the evening clearing up land.
Weather	129	Jul 28	Work at ditching and chopping. Rain again to day. I have never seen so much rain in this country at this time of year.
Weather	130	Jul 31	We had one of the most severe thunder and lightning storms last night that I ever remember to have seen. The lightning struck in 4 or 5 places in Houston stunning several but killing no one I believe. A very heavy rain fell with it.

APPENDIX E

WATER BOND DATA FROM 1870 TO 1931

One of the duties of the Office of the Comptroller is to register, seal, and sign all bonds issued by the State of Texas or by any of its political subdivisions including cities, counties, school districts, and water districts. The majority since 1870 have been for specific purposes.[468] It is those bonds clearly identified as being issued for water-related purposes that are compiled in this table. "Bond Number" is a unique and consecutive number issued to identify each bond upon filing with the Comptroller's Office. This numbering procedure was begun in 1915. Earlier bonds have no such number. "Bond Issuer" is the name of the city, county, or district that issued the bond. "Entity" is the controlling level of government with jurisdiction to call the bond election, either city or county. "Vol." and "Pg." are the volume and page number where the approved bond has been recorded. "Type of Bond" is identified as W=Water, S=Sanitary Sewer, F=Fire protection, L=Levee, D=Drainage or storm sewer, N=Navigation, R=Reservoir, I=Irrigation, and A=Additional. Improvement bonds are not listed. Compiled from General Bond Index volume 304-2227, from records of the Bond Department, 1852-1861, 1870-1994, bulk 1870-1994, 56.31 cubic ft. (133 volumes) of the Texas Comptroller's Office, from the collection of the Texas State Library and Archives Commission.

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
11529	Abbott	City	32	472	W									
	Abilene	City	14	418							R			
3152	Abilene	City	20	126							R			City purchased reservoir
3221	Abilene	City	20	195							R			
4914	Abilene	City	22	614		S								
5188	Abilene	City	23	248							R		A	Pipeline
8921	Abilene	City	28	604	W									
8965	Abilene	City	28	648	W									
8969	Abilene	City	28	652		S								
8970	Abilene	City	28	653			F							
9791	Abilene	City	30	95			F							
9792	Abilene	City	30	96		S								
9796	Abilene	City	30	100	W									
10420	Abilene	City	31	49	W									

[468] From the records of the Texas Archival Resources Online, a catalog of the records of the Bond Department of the Texas Comptroller's Office, www.lib.utexas.edu/taro/tslac/30097/tsl-30097.html (accessed March 11, 2007.

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
11699	Abilene	City	32	644	W									
9255	Alamo	City	29	244	W									
10232	Alamo Heights	City	30	536			F							
10233	Alamo Heights	City	30	537		S								
536	Albany	City	15	542	W									
5737	Albany	City	24	137	W									
	Alice	City	14	437	W									
9172	Alice	City	29	161		S								
10369	Alice	City	30	673	W									
11388	Alice	City	32	333			F							
11389	Alice	City	32	334	W									
4728	Alpine	City	22	428	W									
4729	Alpine	City	22	429		S								
5022	Alto	City	23	82	W									
5419	Alto	City	23	479	W									
9532	Alto	City	29	523		S								
6653	Alvarado	City	25	419	W									
7470	Alvarado	City	26	537		S								
10682	Alvin	City	31	311		S								
	Amarillo	City	14	483		S								
1708	Amarillo	City	17	528		S								
1709	Amarillo	City	17	529		S								
5833	Amarillo	City	24	233			F							Fire alarm system
5834	Amarillo	City	24	234		S								
5835	Amarillo	City	24	235		S								
9153	Amarillo	City	29	142	W									Questionable page no.
10050	Amarillo	City	30	354	W									
10051	Amarillo	City	30	355		S								
8777	Amherst	City	28	458	W									
3801	Anderson	Co	21	136				L						
9950	Angleton	City	30	254	W									
12554	Angleton	City	34	11		S								
6361	Anson	City	25	127	W									
8948	Anson	City	28	631		S								
8949	Anson	City	28	632	W									
636	Aransas Pass	City	16	44	W									
1067	Aransas Pass	City	16	484	W									
11219	Aransas Pass	City	32	164		S								
12574	Aransas Pass	City	34	31	W									
	Archer City	City	14	397	W									
11233	Archer City	City	32	178	W									
11234	Archer City	City	32	179		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
1953	Arlington	City	18	186		S								
4652	Arlington	City	22	352	W									
4709	Arlington	City	22	409	W	S								
5348	Arlington	City	23	408	W	S								
9935	Arlington	City	30	239		S								
11364	Asherton	City	32	309		S								
1101	Aspermont	City	16	520	W									
	Atlanta	City	14	339	W									
1128	Atlanta	City	16	547	W									
	Austin	City	14	563		S								
1532	Austin	City	17	351		S								
1534	Austin	City	17	353		S							A	
3411	Austin	City	20	385		S								
7532	Austin	City	26	599	W									Water filtration
11591	Austin	City	32	536		S								
11593	Austin	City	32	528			F							
11742	Austin	City	32	687			F							
11743	Austin	City	32	688		S								
12445	Austin	City	33	578		S								
10413	Austwell	City	31	42	W									
	Baird	City	7	129	W									
	Baird	City	8	343	W									
	Baird	City	14	403	W									
	Baird	City	14	404			F							
5019	Baird	City	23	78	W									
6025	Baird	City	24	425	W									
	Ballinger	City	10	139	W									
5277	Ballinger	City	23	331	W									
6130	Ballinger	City	24	532	W									
12525	Ballinger	City	33	658			F						A	City Hall
12526	Ballinger	City	33	659	W									
	Ballinger	City	3A	69	W									
10713	Bangs	City	31	342	W									
	Bartlett	City	8	637	W									
	Bartlett	City	8	755	W									
2722	Bartlett	City	19	338			F						A	City Hall
	Bay City	City	11	395	W									
159	Bay City	City	15	161	W									
10870	Bay City	City	31	500			F						A	City Hall
	Beaumont	City	3	175	W									
	Beaumont	City	3	643		S								
	Beaumont	City	6	616	W								A	

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Beaumont	City	8	46	W									
	Beaumont	City	8	267		S								
	Beaumont	City	8	702		S								
	Beaumont	City	9	397		S								
	Beaumont	City	10	543		S								
	Beaumont	City	11	511			F							
	Beaumont	City	14	457		S								
	Beaumont	City	14	487		S								
685	Beaumont	City	16	93	W									
1460	Beaumont	City	17	279		S								
2303	Beaumont	City	18	537	W									
6535	Beaumont	City	25	301			F							
6534	Beaumont	City	25	300		S								
6536	Beaumont	City	25	302	W									
7537	Beaumont	City	26	604	W									
7549	Beaumont	City	26	616	W									
7957	Beaumont	City	27	328	W									
9100	Beaumont	City	29	88		S								
9150	Beaumont	City	29	139	W									
9688	Beaumont	City	29	679			F							
9691	Beaumont	City	29	682		S								
10764	Beaumont	City	31	394		S								
12176	Beaumont	City	33	321			F							
12180	Beaumont	City	33	325		S								
12185	Beaumont	City	33	330	W									
	Beaumont	City	10A	7						N				
1558	Beeville	City	17	377		S								
10562	Bellville	City	31	191	W									
12272	Bellville	City	33	405		S								
	Belton	City	1	381	W									
388	Belton	City	15	390	W									
1704	Belton	City	17	524	W									
4599	Belton	City	22	299			F							
4600	Belton	City	22	300	W									
4749	Belton	City	22	449		S								
5296	Belton	City	23	356	W									
5297	Belton	City	23	357			F							
11391	Benjamin	City	32	336	W									
10688	Beverly	City	31	317		S								
8798	Bexar	Co	28	479										Medina & Atascosa Cos.
8991	Big Lake	City	28	674	W									
97	Big Spring	City	15	99	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
5298	Big Spring	City	23	358	W									
7394	Big Spring	City	26	461		S								
7939	Big Spring	City	27	310		S								
8804	Big Spring	City	28	485	W									
12675	Big Spring	City	34	105	W									
12677	Big Spring	City	34	107		S								
456	Bishop	City	15	458		S								
8140	Blooming Grove	City	27	513		S								
8141	Blooming Grove	City	27	514	W									
10584	Boerne	City	31	213	W									Service 1927 waterworks
	Bonham	City	3	170	W									
	Bonham	City	3	202	W									
	Bonham	City	7	164	W									
	Bonham	City	2A	25	W									
	Bonham	City	2A	679	W									
10788	Booker	City	31	418	W									
	Bower	City	12	5	W									
6755	Bowie	City	25	521	W									
	Bowie	City	2A	438	W									
	Bowie	City	2A	564	W									
4475	Bowie	Co	22	175				L						
8943	Bowie	Co	28	626				L						
	Brady	City	14	382	W									
3254	Brady	City	20	228	W									
3343	Brady	City	20	317	W									
8342	Brady	City	28	20	W									
8960	Brady	City	28	643		S								
10585	Brady	City	31	214			F						A	City Hall
10587	Brady	City	31	216	W								A	City Hall
11024	Brady	City	31	655	W									
11048	Brady	City	31	679	W									
	Brazoria	City	8A	415					D					
	Brazoria	City	8A	471					D					
	Brazoria	City	8A	515					D					
1652	Brazoria	Co	17	472					D					Angleton
7428	Brazoria	Co	26	495					D					San Bernard Dist #10
	Brazoria	Co	10A	18					D					
	Brazoria	Co	10A	27					D					
	Brazoria	Co	10A	98					D					
18	Brazoria	Co	11A	19					D					
19	Brazoria	Co	11A	20					D					

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
24	Brazoria	Co	11A	25					D					
34	Brazoria	Co	11A	35					D					
50	Brazos	Co	11A	51				L						Dist #1
9903	Brazos River	City	30	207										Harbor Navigation Dist
5903	Breckenridge	City	24	303		S								
1221	Brenham	City	17	39		S								
1222	Brenham	City	17	40	W									
7529	Brenham	City	26	596	W									Water purification
	Brenham	City	2A	426	W									
1280	Bridgeport	City	17	98			F						A	City Hall
5649	Bronte	City	24	49	W									
12146	Brown	Co	33	291										Water Imp Dist #1
8174	Brownfield	City	27	547	W									
9106	Brownfield	City	29	94		S								
	Brownsville	City	11	347	W									
	Brownsville	City	12	97	W									
	Brownsville	City	14	368	W									
3734	Brownsville	City	21	68				L						
5856	Brownsville	City	24	256		S								
9847	Brownsville	City	30	151		S								
9848	Brownsville	City	30	152	W								A	Light & power
	Brownwood	City	3	62	W									
	Brownwood	City	11	283	W									
	Brownwood	City	14	484	W									
1396	Brownwood	City	17	214		S								
2493	Brownwood	City	19	109			F						A	City Hall
5430	Brownwood	City	23	490		S								
5842	Brownwood	City	24	242		S								
	Brownwood	City	3A	5	W									
	Brownwood	City	3A	43	W									
	Bryan	City	3	382	W									Waterworks, 10/20/1889
	Bryan	City	8	613	W									WW refinancing
	Bryan	City	12	500	W	S							A	Lights
	Bryan	City	14	422	W									
	Bryan	City	14	423		S								
184	Bryan	City	15	186	W									
2412	Bryan	City	19	28		S								
9229	Bryan	City	29	218	W									Water tower
1026	Burkburnett	City	16	443	W									
4842	Burkburnett	City	22	542	W									
7463	Burkburnett	City	26	530		S								
	Caldwell	City	12	137	W								A	refrig

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Caldwell	City	14	348	W									
8057	Caldwell	City	27	428		S								
	Caldwell	City	3A	24	W									
1614	Calhoun	Co	17	434					D					
9452	Calhoun	Co	29	443					D					
	Calvert	City	6	333			F						A	
114	Calvert	City	15	116		S								
933	Calvert	City	16	349			F						A	City Hall
	Cameron	City	3	602	W								A	
	Cameron	City	14	343		S								
6710	Cameron	City	25	476		S								
7903	Cameron	City	27	274		S								
	Cameron	City	2A	488	W									
1087	Cameron	Co	16	504								I		
1087	Cameron	Co	16	506								I		
2481	Cameron	Co	19	97								I		
2496	Cameron	Co	19	112				L						
4579	Cameron	Co	22	279										Water imp Dist #1
4621	Cameron	Co	22	321										Water Imp Dist #5
4579	Cameron	Co	22	279	W									Water Imp Dist 1
5259	Cameron	Co	23	319										Water Imp Dist #5
5302	Cameron	Co	23	362										Water Imp Dist #3
7539	Cameron	Co	26	606					D					
10371	Cameron	Co	30	675										Water Con. & Imp. D. #5
10398	Cameron	Co	31	27										Water Con. & Imp D. #6
10476	Cameron	Co	31	105										Water Con & Imp Dist #7
10499	Cameron	Co	31	128										Arroyo Colorado Nav Dist 128
11790	Cameron	Co	33	45										Water Imp. D. #12
11828	Cameron	Co	33	54										Water Imp. D. #11
12015	Cameron	Co	33	169										Water Imp D #8
	Cameron	Co	10A	36					D					
	Cameron	Co	10A	71					D					
	Cameron	Co	10A	97					D					
14	Cameron	Co	11A	14					D					
14	Cameron	Co	11A	15					D					
15	Cameron	Co	11A	16					D					
14	Cameron	Co	11A	14					D					
48	Cameron	Co	11A	49								I		Cameron & Hidalgo Cos.
48	Cameron	Cos	11A	49								I		and Hidalgo counties
7827	Campbell City	City	27	197		S							A	Lights
156	Canadian	City	15	158		S								
157	Canadian	City	15	159	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
1181	Canadian	City	16	600	W									
5870	Canadian	City	24	270	W									
5871	Canadian	City	24	271		S								
6697	Canton	City	25	463	W									
	Canyon	City	14	27	W									
11056	Carriazo Springs	City	32	1		S								
10646	Carrizo Springs	City	31	275	W									
9386	Carrollton	City	29	377	W									
7402	Carthage	City	26	469	W									
9618	Carthage	City	29	609	W									
8197	Celina	City	27	570	W									
	Celine	City	14	431		S								
	Center	City	9	337	W									
	Center	City	14	103	W									
5558	Center	City	23	618		S								
5559	Center	City	23	619	W									
950	Chambers	Co	16	366					D					
	Chambers	Co	10A	94					D					
	Chambers	Co	10A	97					D					
16	Chambers	Co	11A	17							R			Water
16	Chambers	Co	11A	17	W									Trinity Riv., "fresh water"
	Childress	City	12	25	W									
	Childress	City	13	105	W									
	Childress	City	14	204	W									
	Childress	City	14	204	W									
6073	Childress	City	24	474	W									Service 1922 waterworks
9415	Childress	City	29	406		S								
9417	Childress	City	29	408	W									
10722	Childress	City	31	351	W									
	Chillicothe	City	14	356	W									
5895	Chillicothe	City	24	295	W									
5896	Chillicothe	City	24	296		S								
	Cisco	City	8	470	W									
	Cisco	City	11	583	W									
4081	Cisco	City	21	416	W	S								
4911	Cisco	City	22	611	W									
4912	Cisco	City	22	612	W									
5325	Cisco	City	23	385	W									
5808	Cisco	City	24	208	W									
6602	Cisco	City	25	368	W									
6603	Cisco	City	25	369	W									
6833	Cisco	City	25	599		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
7122	Cisco	City	26	189	W									
7123	Cisco	City	26	190	W									
9495	Cisco	City	29	485		S								
9496	Cisco	City	29	487	W									
9498	Cisco	City	29	489			F							
9875	Cisco	City	30	179	W									
	Clarendon	City	13	217		S								
486	Clarendon	City	15	491	W									
751	Clarendon	City	16	159	W									
6305	Clarendon	City	25	71	W									
9762	Clarendon	City	30	66	W									
11729	Clarendon	City	32	674	W									
	Clarksville	City	8	198	W									
	Clarksville	City	9	237	W									
	Clarksville	City	14	374	W									
	Clarksville	City	14	409	W									
33	Clarksville	City	15	35		S								
2131	Clarksville	City	18	365		S								1st issue
2132	Clarksville	City	18	366		S								2nd issue
6222	Clarksville	City	24	624	W									
7222	Clarksville	City	26	289		S								
8205	Claude	City	27	578	W									
	Cleburne	City	1	397	W									
	Cleburne	City	9	299			F							
	Cleburne	City	14	477	W									
	Cleburne	City	14	477	W									
1291	Cleburne	City	17	109		S								
6314	Clifton	City	25	80	W									
10478	Clifton	City	31	107		S								
9643	Clyde	City	29	634	W									
9644	Clyde	City	29	635		S								
11988	Coahoma	City	33	142	W									
	Coldwell	City	10	519	W									
	Coleman	City	7	631	W									
	Coleman	City	9	463	W								A	
	Coleman	City	14	10	W									
5885	Coleman	City	24	285	W									
8233	Coleman	City	27	606	W									
8234	Coleman	City	27	607	W									
10640	Coleman	City	31	269			F						A	City Hall
12193	Coleman	City	33	318	W									
	Coleman	City	2A	389	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
2497	Collin	Co	19	113				L						
10973	Collinsville	City	31	604	W									
	Colorado	City	1	281		S								
	Colorado	City	1	513	W									
5724	Colorado	City	24	124	W									
5725	Colorado	City	24	125		S								
1638	Colorado	Co	17	458					D					
1727	Colorado	Co	17	547					D					
2384	Colorado	Co	18	618					D					
4097	Colorado	Co	21	432					D					
	Columbus	City	1	198	W									
9973	Columbus	City	30	277	W									
	Comanche	City	8	449	W									
	Comanche	City	8	640	W									
	Comanche	City	9	184	W									
	Comanche	City	9	415	W									
	Comanche	City	11	383		S								
	Comanche	City	11	387	W									
	Comanche	City	14	59		S								
5329	Comanche	City	23	389		S								
6030	Comanche	City	24	430	W									
8325	Comanche	City	28	3	W									
9167	Comanche	City	29	156	W									
	Commerce	City	11	451	W									
215	Commerce	City	15	217	W									
445	Commerce	City	15	447	W									
619	Commerce	City	16	27	W									
620	Commerce	City	16	28	W									
9186	Como	City	29	175	W									
	Conroe	City	12	451	W									
4550	Conroe	City	22	250	W									
9773	Conroe	City	30	77		S								
2045	Coolidge	City	18	279	W									
12562	Coolidge	City	34	19		S								
8881	Copperas Cove	City	28	564	W									
	Corpus Christi	City	3	688	W									
	Corpus Christi	City	6	665	W									
	Corpus Christi	City	14	64	W									
	Corpus Christi	City	14	281		S								
	Corpus Christi	City	14	398		S								
	Corpus Christi	City	14	451			F						A	City Hall
36	Corpus Christi	City	15	38		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
1197	Corpus Christi	City	17	15	W									
8912	Corpus Christi	City	28	595		S								
9537	Corpus Christi	City	29	528		S								
9538	Corpus Christi	City	29	529	W									
9620	Corpus Christi	City	29	611	W									
9824	Corpus Christi	City	30	126		S								
10981	Corpus Christi	City	31	612			F							
10982	Corpus Christi	City	31	613		S								
10983	Corpus Christi	City	31	614	W									
10984	Corpus Christi	City	31	615					D					Storm sewer
	Corsicana	City	3	317		S								
	Corsicana	City	14	86		S								
1703	Corsicana	City	17	523		S								
3274	Corsicana	City	20	248	W									
6401	Corsicana	City	25	167	W									
7374	Corsicana	City	26	441		S								
7375	Corsicana	City	26	442	W									
9159	Corsicana	City	29	148		S								
1176	Cotulla	City	16	595	W									
8027	Crawford	City	27	398	W									
	Crockett	City	12	533	W									
528	Crockett	City	15	534	W									
695	Crockett	City	16	103	W									
7520	Crosbyton	City	26	587	W									
10066	Crosbyton	City	30	370	W									
12226	Crosbyton	City	33	359	W									
8734	Cross Plains	City	28	415	W									
5714	Crowell	City	24	114	W									
8760	Crowell	City	28	441		S								
591	Crystal	City	15	598	W									
802	Crystal City	City	16	214	W									
10850	Crystal City	City	31	480	W								A	
	Cuero	City	3	377	W									
	Cuero	City	9	319	W									
	Cuero	City	14	55	W									
	Cuero	City	14	71	W								A	refrdg
	Cuero	City	14	545		S								
10459	Cuero	City	31	88	W									
	Cuero	City	3A	12	W									
8092	Cumby	City	27	465	W									
	Dalhart	City	10	591			F						A	City Hall
	Dalhart	City	12	16		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
5634	Dalhart	City	24	34		S								
12932	Dalhart	City	34	362		S								
	Dallas	City	1	104	W									
	Dallas	City	1	453	W									
	Dallas	City	1	289					D					
	Dallas	City	3	581		S								
	Dallas	City	3	584	W									
	Dallas	City	3	127	W									
	Dallas	City	3	454		S								
	Dallas	City	3	455	W									
	Dallas	City	3	456		S								
	Dallas	City	3	457	W									
	Dallas	City	3	458	W									
	Dallas	City	3	522	W									
	Dallas	City	7	775	W									
	Dallas	City	8	383	W									
	Dallas	City	8	437	W									
	Dallas	City	8	649			F						A	
	Dallas	City	8	667	W									
	Dallas	City	11	567	W									
	Dallas	City	13	201	W								A	
	Dallas	City	14	208	W									
	Dallas	City	14	208		S								
	Dallas	City	14	557			F							
	Dallas	City	14	558		S								
	Dallas	City	14	558	W									
617	Dallas	City	16	25		S								
1188	Dallas	City	17	6		S								
1700	Dallas	City	17	520		S								
3022	Dallas	City	19	638					D					
4702	Dallas	City	22	402		S								
4705	Dallas	City	22	405	W									
5434	Dallas	City	23	494	W									water filteration plant
6271	Dallas	City	25	37		S								
7143	Dallas	City	26	210		S								
7144	Dallas	City	26	211		S								
7504	Dallas	City	26	571	W									
8601	Dallas	City	28	281		S								
8604	Dallas	City	28	284					D					
10957	Dallas	City	31	588			F							
10958	Dallas	City	31	589		S								
10963	Dallas	City	31	594	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
10967	Dallas	City	31	598					D					
12309	Dallas	City	33	442					D					
12314	Dallas	City	33	447		S								
12315	Dallas	City	33	448	W									
	Dallas	City		551	W									
2413	Dallas	co	19	29				L						levee imp #1
3076	Dallas	co	20	50				L						D#2
3911	Dallas	co	21	246				L						imp dist #5
4367	Dallas	co	22	67				L						Dist 6
4413	Dallas	co	22	113				L						Kaufmann co bois D Levee imp
4533	Dallas	co	22	233				L						dist 8
4578	Dallas	co	22	278				L						imp dist 3
6207	Dallas	co	24	609	W									arcadia fresh water supply d 1
8047	Dallas	co	27	418	W									dallas co fresh water supply d 4
8871	Dallas	co	28	554				L						bois darc island levee imp dist
8936	Dallas	co	28	619	W									dallas co fresh water supply d7
8953	Dallas	co	28	636				L						levee impd6
9641	Dallas	co	29	632	W									fresh water supply d9
10931	Dallas	co	31	562				L						city & co levee imp dist
6683	Dawson	City	25	449	W									
11630	Dayton	City	31	575	W									
12538	Dayton	City	33	671	W									
	De Leon	City	11	155	W									
4552	De Leon	City	22	252	W	S								
4715	De Leon	City	22	415	W	S								
4804	De Leon	City	22	504	W									
	Decatur	City	2	276	W									
	Decatur	City	12	129	W									
	Decatur	City	14	462	W									
	Decatur	City	14	463	W									
1493	Decatur	City	17	312	W									elect light & water plant
5642	Decatur	City	24	42	W									
5643	Decatur	City	24	43		S								
9758	Dekalb	City	30	62	W									
4004	Del Rio	City	21	339	W									
8322	Del Rio	City	27	696		S								
3685	Delta	co	21	19				L						imp dist #1
4401	Delta	co	22	101				L						imp dist 2
5488	Delta	co	23	548				L						imp dist 8
	Denison	City	3	459		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Denison	City	3	461		S								
	Denison	City	11	595	W									
	Denison	City	13	173	W									
	Denison	City	14	224	W									
967	Denison	City	16	383	W									
7459	Denison	City	26	526	W									
7461	Denison	City	26	528		S								
	Denton	City	7	570	W								A	
	Denton	City	12	387		S								
3799	Denton	City	21	134		S								
12370	Denton	City	33	503			F							
	Denton	City	9A	431	W									
6299	Desdemona	City	25	65	W									
9753	Devine	City	30	57	W									
1415	Dewitt	Co	17	233					D					Dist 1
8385	Dilley	City	28	64	W									
11339	Dilley	City	31	284		S								
1768	Donna	City	17	591								I		
8403	Donna	City	28	83	W									
8404	Donna	City	28	84		S								
	Dublin	City	8	664			F						A	City Hall
	Dublin	City	14	284		S								
	Dublin	City	14	321	W									
	Eastland	City	14	313	W									
3810	Eastland	City	21	145		S								
3847	Eastland	City	21	182	W									
4719	Eastland	City	22	419					D					
4720	Eastland	City	22	420					D					
4721	Eastland	City	22	421	W									
2228	Eastland	co	18	462				L						
11374	Eden	City	32	319	W									
7130	Edgewood	City	26	197	W									
5534	Edinburg	City	23	594	W									
12357	Edna	City	33	490		S								
12358	Edna	City	33	491	W									
9257	El Campo	City	29	246		S								
9353	El Campo	City	29	344			F						A	City Hall
	El Paso	City	3	471	W									
	El Paso	City	3	472	W									
	El Paso	City	3	473	W									
	El Paso	City	6	541		S								
	El Paso	City	7	1	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
	El Paso	City	7	455		S								
	El Paso	City	12	173		S								
	El Paso	City	14	211	W									
	El Paso	City	15	104		S								
	El Paso	City	15	105	W									
784	El Paso	City	16	196	W									
785	El Paso	City	16	197		S								
2421	El Paso	City	19	37		S								
3082	El Paso	City	20	56	W									
4379	El Paso	City	22	79	W									
4382	El Paso	City	22	82		S								
5752	El Paso	City	24	152		S								
5753	El Paso	City	24	153		S								
5757	El Paso	City	24	157					D					
5759	El Paso	City	24	159	W									
5776	El Paso	City	24	176					D					
5778	El Paso	City	24	178	W									
7909	El Paso	City	27	280					D				A	
7910	El Paso	City	27	281		S								
7915	El Paso	City	27	286			F							
12020	El Paso	City	33	174					D					
12019	El Paso	City	33	173		S								
12025	El Paso	City	33	179			F							
12026	El Paso	City	33	180	W									
12124	El Paso	City	33	269			F							
12125	El Paso	City	33	270	W									
12586	El Paso	City	34	43		S								
12587	El Paso	City	34	44	W									
12592	El Paso	City	34	49			F							
12594	El Paso	City	34	51					D					
12979	El Paso	City	34	409	W									
12998	El Paso	City	34	428	W									
13190	El Paso	City	34	604			F							
13191	El Paso	City	34	605	W									
	El Paso	City	11A	58					D					
	El Paso	City	2A	138	W									
	El Paso	City	2A	306	W									
	El Paso	City	9A	14		S								
2034	El Paso	co	18	268				L						
826	Electra	City	16	242	W									
3049	Electra	City	20	23	W									
3156	Electra	City	20	130		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
3286	Electra	City	20	260		S								
3374	Electra	City	20	348	W									
3398	Electra	City	20	372	W									
3691	Electra	City	21	25	W	S								
4510	Electra	City	22	210	W	S								
4522	Electra	City	22	222	W									
4860	Electra	City	22	560	W									
6012	Electra	City	24	412	W									
6058	Electra	City	24	459		S								
6059	Electra	City	24	460	W									
6806	Electra	City	25	572	W									
7194	Electra	City	26	261	W									
7369	Electra	City	26	436	W	S								
7905	Electra	City	27	276	W									
8634	Electra	City	28	314	W									
9040	Electra	City	29	28	W									
9468	Electra	City	29	459	W									
10976	Electra	City	31	607	W									
	Elgin	City	12	515	W									
1685	Elgin	City	17	505	W									
	Elgin	City	3A	4	W									
1275	Ellis	co	17	93					D					
1392	Ellis	co	17	210					D					
2004	Ellis	co	18	237				L						
2335	Ellis	co	18	569				L						
2502	Ellis	co	19	118				L						
2583	Ellis	co	19	199				L						
2584	Ellis	co	19	200				L						
2756	Ellis	co	19	372				L						
3761	Ellis	co	21	95				L						
3778	Ellis	co	21	113				L						
4021	Ellis	co	21	356				L						
4264	Ellis	co	21	599				L						
4447	Ellis	co	22	147				L						
4666	Ellis	co	22	366				L						
4840	Ellis	co	22	540				L						
	Ellis	co	10A	34					D					
	Ellis	co	10A	91					D					
	Ellis	co	8A	539					D					
	Ennis	City	13	81	W									
	Ennis	City	14	112	W									
1214	Ennis	City	17	32		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
1216	Ennis	City	17	34	W									
6671	Ennis	City	25	437	W	S								
7314	Ennis	City	26	381		S								
8763	Ennis	City	28	444	W									
9587	Ennis	City	29	578		S								
2098	Erath	co	18	332				L						
2099	Erath	co	18	333				L						
12871	Fabens	City	34	301	W									
10997	Fannin	Co	31	628				L						Fannin Lamar Delta Co Dist 3
11984	Fannin	Co	33	138				L						Fannin Co Levee Imp Dist 4
	Farmersville	City	8	393	W									
5529	Farmersville	City	23	589	W									
5530	Farmersville	City	23	590		S								
9801	Fayetteville	City	30	105	W									
1278	Ferris	City	17	96		S								
5633	Ferris	City	24	33	W									
8610	Flatonia	City	28	290	W									
8611	Flatonia	City	28	291		S								
11081	Florence	City	32	26	W									
	Floresville	City	10	175	W									
	Floresville	City	10	535	W									
6090	Floresville	City	24	491	W									
9123	Floresville	City	29	111	W									
	Floresville	City	9A	167	W									
1260	Floydada	City	17	78	W									
5766	Floydada	City	24	166	W									
7952	Floydada	City	27	323		S								
7953	Floydada	City	27	324	W									
	Forney	City	14	453		S								
1265	Fort Bend	Co	17	83					D					
3497	Fort Bend	Co	20	471					D					
3565	Fort Bend	Co	20	539					D					
5820	Fort Stockton	City	24	220	W									
	Fort Worth	City	1	132		S							A	
	Fort Worth	City	1	407		S							A	
	Fort Worth	City	3	417		S								
	Fort Worth	City	3	422	W									
	Fort Worth	City	3	689	W									
	Fort Worth	City	3	693	W									
	Fort Worth	City	14	15		S								
	Fort Worth	City	14	69	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
	Fort Worth	City	14	70			F							
	Fort Worth	City	14	298					D					
	Fort Worth	City	14	286	W									
	Fort Worth	City	14	287			F							
	Fort Worth	City	14	300			F							
	Fort Worth	City	14	305			F							
	Fort Worth	City	14	288					D					
	Fort Worth	City	14	298					D					
	Fort Worth	City	14	307					D					
	Fort Worth	City	14	288	W									
	Fort Worth	City	14	300	W									
	Fort Worth	City	14	305	W									
361	Fort Worth	City	15	363							R			
3912	Fort Worth	City	21	247		S								
3913	Fort Worth	City	21	248	W									
3914	Fort Worth	City	21	249		S								
3915	Fort Worth	City	21	250					D					
4852	Fort Worth	City	22	552		S								
4853	Fort Worth	City	22	553	W									
4854	Fort Worth	City	22	554		S								
4855	Fort Worth	City	22	555					D					
6723	Fort Worth	City	25	489			F							
6725	Fort Worth	City	25	491	W	S								
9122	Fort Worth	City	29	110	W	S								
9379	Fort Worth	City	29	370	W	S								
9819	Fort Worth	City	30	123	W	S								
10004	Fort Worth	City	30	308	W	S								
10335	Fort Worth	City	30	639	W	S								
10809	Fort Worth	City	31	439		S								
18810	Fort Worth	City	31	440	W									
11634	Fort Worth	City	32	579		S								
11635	Fort Worth	City	32	580	W									
12379	Fort Worth	City	33	512			F							
12734	Fort Worth	City	34	164			F							
13184	Fort Worth	City	34	598	W									
	Fort Worth	City	9A	403	W									
1047	Franklin	City	16	464	W									
2992	Franklin	City	19	608		S								
2733	Franklin	Co	19	349				L						Dist #1
5024	Franklin	Co	23	84				L						Imp Dist #1
5004	Freeport	City	23	64				L						Series A levee
10860	Freeport	City	31	490		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
9217	Frio	Co	29	206	W									Frio Co Water Control Dist #1
7522	Frisco	City	26	589	W									
2271	Frost	City	18	505		S								
9065	Frost	City	29	53	W									
	Gainesville	City	3	178		S								
	Gainesville	City	8	122		S							A	
	Gainesville	City	14	309	W									
	Galveston	City	6	81	W									
	Galveston	City	6	536	W									
	Galveston	City	7	227		S								
	Galveston	City	12	243					D					
	Galveston	City	12	491					D					
	Galveston	City	13	464					D					
	Galveston	City	14	356	W									
	Galveston	City	14	544	W									
761	Galveston	City	16	169	W	S								
818	Galveston	City	16	233			F							
1879	Galveston	City	18	112	W									
7240	Galveston	City	26	307	W									
7401	Galveston	City	26	468					D					
9552	Galveston	City	29	543		S								
9731	Galveston	City	30	35					D					
9732	Galveston	City	30	36	W	S								
10742	Galveston	City	31	371			F							Fireboat #2!
13152	Galveston	City	34	566					D					
13153	Galveston	City	34	567		S								
13156	Galveston	City	34	570			F							
	Galveston	City	10A	73					D					
	Galveston	City	8A	571					D					
7982	Galveston	Co	27	353	W						R			1924 Reservoir
	Galveston	Co	10A	26					D					
	Galveston	Co	10A	67					D					
	Galveston	Co	11A	55					D					
5933	Garland	City	24	333	W									
5934	Garland	City	24	334		S								
1742	Gatesville	City	17	565		S								
6605	Gatesville	City	25	371	W									
	Georgetown	City	1	421	W									
	Georgetown	City	14	233	W									
688	Georgetown	City	16	96	W									
	Georgetown	City	2A	90	W									
8425	Giddings	City	28	105	W									

Bond					Type of Bond									
Number	Bond Issuer	Entity	Vol.	Pg.	W	S	F	L	D	N	R	I	A	Note
8426	Giddings	City	28	106		S								
	Gilmer	City	10	347	W									
754	Gilmer	City	16	162		S								
7901	Gilmer	City	27	272		S								
7902	Gilmer	City	27	273	W									
1672	Goldthwaite	City	17	492	W									
	Gonzales	City	6	599		S								
	Gonzales	City	9A	11			F							
10434	Goose Creek	City	31	63		S								
10435	Goose Creek	City	31	64	W									
9917	Gordon	City	30	221	W									
8565	Goree	City	28	245	W									
4654	Gorman	City	22	354	W									
4655	Gorman	City	22	355		S								
4675	Gorman	City	22	375		S								
4676	Gorman	City	22	376	W									
4744	Gorman	City	22	444	W									
	Graham	City	11	263	W									
	Graham	City	12	117	W									
2669	Graham	City	19	285		S								
5586	Graham	City	23	646		S								
5587	Graham	City	23	647	W									
11651	Graham	City	32	596	W									
	Grand Falls	City	11A	4					D					
7164	Grand Prairie	City	26	231		S								
8944	Grand Prairie	City	28	627	W									
	Grand Saline	City	10	55	W									
1210	Grand Saline	City	17	28	W									
7873	Grand Saline	City	27	243	W									
6822	Grandbury	City	25	588	W									
	Grandview	City	8	679	W									
11923	Grandview	City	33	77		S								
11924	Grandview	City	33	78	W									1929
	Grandville	City	13	61	W									
828	Granger	City	16	244		S								
11519	Granger	City	32	464	W									
12797	Grapeland	City	34	227	W									
8184	Grapevine	City	27	557	W									
	Greenville	City	1	211			F							
	Greenville	City	3	241	W									
	Greenville	City	10	199	W									
	Greenville	City	11	139		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Greenville	City	12	153	W									
	Greenville	City	12	247	W									
	Greenville	City	14	6	W									
	Greenville	City	14	108			F							
	Greenville	City	14	108	W									
	Greenville	City	14	274	W									
	Greenville	City	14	425	W									
1929	Greenville	City	18	162		S								
6871	Greenville	City	25	637			F							
6872	Greenville	City	25	638		S								
7342	Greenville	City	26	409	W									
6873	Greenville	City	27	639	W									
8343	Greenville	City	28	21	W									
	Groesbeck	City	14	334	W									
	Groesbeck	City	2A	433	W									
	Groesbeck	City	3A	41	W									
11123	Grooms	City	32	68	W									
12010	Groveton	City	33	164	W									
9656	Hale Center	City	29	647	W									
	Hallettsville	City	3	518	W									
	Hallettsville	City	3	519	W									
	Hallettsville	City	3	520	W									
	Hallettsville	City	3	522	W									
	Hallettsville	City	3	531	W									
11475	Hallettsville	City	32	420		S								
	Hallettsville	City	3A	9	W									
	Hamilton	City	14	117	W									
84	Hamilton	City	15	86	W									
350	Hamilton	City	15	352		S								
6786	Hamilton	City	25	552	W									
8818	Hamilton	City	28	500		S								
	Hamlin	City	12	511	W									
5260	Hamlin	City	23	320	W									
5261	Hamlin	City	23	321		S								
5670	Hamlin	City	24	70	W									
5671	Hamlin	City	24	71		S								
10488	Happy	City	31	117	W									
	Harlingen	City	14	445	W								A	
5244	Harlingen	City	23	304		S								
5388	Harlingen	City	23	448		S								
8618	Harlingen	City	28	298		S								
8619	Harlingen	City	28	299	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
9592	Harlingen	City	29	583	W									
9593	Harlingen	City	29	584		S								
9596	Harlingen	City	29	587			F						A	
9920	Harlingen	City	30	224	W								A	Lights
9922	Harlingen	City	30	226		S								
9923	Harlingen	City	30	227			F						A	
12452	Harlingen	City	33	585					D					
12453	Harlingen	City	33	586		S								
12455	Harlingen	City	33	588		S								
12457	Harlingen	City	33	590			F							
	Harris	Co	9	13					D					
684	Harris	Co	16	92						N				Houston Ship Channel
753	Harris	Co	16	161					D					
1457	Harris	Co	17	276					D					
4076	Harris	Co	21	411						N				Houston Ship Channel Ser. 1919
5765	Harris	Co	24	165					D					
6730	Harris	Co	25	496					D					
6959	Harris	Co	26	26										Houston Channel Nav Dist
8182	Harris	Co	27	555						N				
10147	Harris	Co	31	46						N				Houston Ship Channel
12605	Harris	Co	34	62						N				Ship Channel
13073	Harris	Co	34	487						N				
	Harris	Co	10A	73						N				
8	Harris	Co	11A	8					D					
	Harris	Co	8A	555					D					
6731	Harris	Co	25	497					D					
10508	Harris	Co	31	137						N				Ship Channel
4474	Harrisburg	City	22	174	W									
5411	Harrisburg	City	23	471		S								
8044	Harrisburg	City	27	415		S								
8367	Harrisburg	City	28	45	W									
8368	Harrisburg	City	28	46		S								
9931	Harrisburg	City	30	235		S								
9934	Harrisburg	City	30	238	W									
	Haskell	City	12	535		S								
	Haskell	City	12	543	W									
240	Haskell	City	15	242	W									
5445	Haskell	City	23	505	W									
	Hearne	City	14	336	W									
7099	Hearne	City	26	166		S								
9084	Hedley	City	29	72	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
468	Henderson	City	15	470	W									
4007	Henderson	City	21	342			F							
4069	Henderson	City	21	404	W									
2522	Henderson	Co	19	138				L						Levee Imp #1
4928	Henderson	Co	22	628				L						Henderson Co Levee Dist #2
	Henrietta	City	14	562	W									
	Henrietta	City	3A	80	W									
	Hereford	City	12	121	W	S								
	Hereford	City	13	297		S								
9201	Hereford	City	29	190	W									
10479	Hereford	City	31	108			F						A	
	Hico	City	6	259	W									
	Hico	City	8	520	W									
	Hico	City	11	43	W									
11196	Hico	City	32	141		S								
11402	Hico	City	32	347	W									
3812	Hidalgo	Co	21	147								I		
4939	Hidalgo	Co	22	639										Water Improvement Dist #2
5591	Hidalgo	Co	23	651										Water Dist 3 Improvement
8909	Hidalgo	Co	28	592										Hidaldo Co. Water Imp. Dist #5
10520	Hidalgo	Co	31	149										Water Cons & Imp Dist 6
11796	Hidalgo	Co	33	51										Water Cons & Dist 7
12270	Hidalgo	Co	33	403										Hidalgo Co Water Imp Dist #6
12304	Hidalgo	Co	33	437										Hidalgo & Cameron Co Dist #9
12348	Hidalgo	Co	33	481										Hidalgo Co Water Imp Dist #6
12580	Hidalgo	Co	34	37										Water Imp Dist #12
12835	Hidalgo	Co	34	265										WC & 2D #7
13030	Hidalgo	Co	34	460										HC Water Con Dist 11
	Hidalgo	Co	10A	2					D					
48	Hidalgo	Co	11A	49								I		Hidalgo & Cameron District
2411	Higgins	City	19	27	W									
6716	Highland Park	City	25	482	W									
	Hillsboro	City	3	636	W									Well and water supply
	Hillsboro	City	6	252	W	S								
	Hillsboro	City	13	21	W	S								
	Hillsboro	City	14	499	W									
	Hillsboro	City	14	500		S								
594	Hillsboro	City	16	1	W	S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
3337	Hillsboro	City	20	311		S								
3719	Hillsboro	City	21	53	W									
8420	Hillsboro	City	28	100	W	S								
	Hillsboro	City	2A	494	W									
	Hillsboro	City	2A	582	W	S								
11415	Holland	City	32	360	W									
	Honey Grove	City	8	152	W		F							
9906	Honey Grove	City	30	210	W									
3692	Hopkins	Co	21	26				L						Hopkins Co Levee Dist 1
9694	Hopkins	Co	29	685				L						Hopkins Co Levee Dist 3
	Houston	City	6	279		S							A	
	Houston	City	6	607		S							A	
	Houston	City	7	114		S							A	
	Houston	City	7	370		S							A	
	Houston	City	8	319		S								
	Houston	City	11	303	W									
	Houston	City	12	343	W									
	Houston	City	12	351		S								
	Houston	City	12	355					D					
1	Houston	City	15	1					D					
2	Houston	City	15	3		S								
725	Houston	City	16	142					D					
1264	Houston	City	17	82	W									
1339	Houston	City	17	157					D					
1340	Houston	City	17	158		S								
1735	Houston	City	17	555					D					
1744	Houston	City	17	567	W									
2136	Houston	City	18	370		S								
2387	Houston	City	19	3		S			D					
2441	Houston	City	19	57	W									
3792	Houston	City	21	127	W									
4070	Houston	City	21	405	W									
4071	Houston	City	21	406		S								
4649	Houston	City	22	349	W									
6173	Houston	City	24	575					D					
6178	Houston	City	24	580		S								
6285	Houston	City	25	51			F						A	Police
6295	Houston	City	25	61				L						Levee Dist #1
7383	Houston	City	26	450					D					
8162	Houston	City	27	535					D					
8163	Houston	City	27	536		S								
8191	Houston	City	27	564					D					

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
8244	Houston	City	27	617		S								
8519	Houston	City	28	199			F						A	Police
8520	Houston	City	28	200	W									
8522	Houston	City	28	202					D					
8523	Houston	City	28	203		S								
8797	Houston	City	28	478	W									
9067	Houston	City	29	55		S								
9071	Houston	City	29	59					D					
9309	Houston	City	29	300	W									
9430	Houston	City	29	421					D					
9432	Houston	City	29	423		S								
9663	Houston	City	29	654		S								
10089	Houston	City	30	393			F						A	
10090	Houston	City	30	394		S								
10097	Houston	City	30	401					D					
10098	Houston	City	30	402		S								
10596	Houston	City	31	225			F						A	Fire alarm, 1st traffic light
10597	Houston	City	31	226			F						A	
10598	Houston	City	31	227		S								
10601	Houston	City	31	230					D					
10602	Houston	City	31	231										Bayou
10729	Houston	City	31	358		S								
11090	Houston	City	32	35		S								
11100	Houston	City	32	45					D					
11965	Houston	City	33	119		S								
12557	Houston	City	34	14	W									
12774	Houston	City	34	204					D					
12775	Houston	City	34	205		S								
12776	Houston	City	34	206	W									
13134	Houston	City	34	548					D					
13139	Houston	City	34	553	W									
13141	Houston	City	34	555			F							
13144	Houston	City	34	558		S								
	Houston	City	9A	351			F						A	
7668	Houston	Co	27	38				I						Houston Co Levee Dist 2
8462	Houston	Co	28	142				L						Houston Co Levee Dist 2
9014	Houston	Co	29	2				L						Houston Co Levee Dist 3
12805	Houston	Co	34	235				L						Levee Dist 1
749	Houston Heights	City	16	157		S								
7521	Howe	City	26	588	W									
	Hubbard	City	7	221	W									
	Hubbard	City	12	447		S							A	

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
8899	Hubbard	City	28	582	W									
8472	Hudspeth	Co	28	152					D					Hudspeth Co Cons & Recl Dist 1
	Huntsville	City	6	321	W									
649	Huntsville	City	16	57	W									
2023	Huntsville	City	18	257		S								
4980	Huntsville	City	23	40		S								
4980	Huntsville	City	23	40		S								
8636	Idalou	City	28	316	W									
4757	Independence Heights	City	22	457	W									
4791	Iowa Park	City	22	491	W									
5341	Iowa Park	City	23	401	W									
6512	Iowa Park	City	25	278		S								
13097	Irving	City	34	511		S								
1220	Italy	City	17	38		S								
8684	Italy	City	28	365			F						A	
	Itasca	City	3	607	W									
	Itasca	City	7	215	W									
	Itasca	City	7	432	W									
	Itasca	City	14	277			F						A	
1924	Itasca	City	18	157		S								
	Jacksboro	City	14	101	W									
6231	Jacksboro	City	24	633		S								1922
349	Jackson	Co	15	351					D					
1272	Jackson	Co	17	90					D					
1548	Jackson	Co	17	367					D					
1592	Jackson	Co	17	412					D					
28	Jackson	Co	11A	29					D					
58	Jackson	Co	11A	59					D					
	Jacksonville	City	10	67	W									
	Jacksonville	City	14	102	W									
242	Jacksonville	City	15	244		S								
243	Jacksonville	City	15	245	W									
5617	Jacksonville	City	24	17	W									
	Jefferson	City	12	587	W									
	Jefferson	City	9A	211	W									
866	Jefferson	Co	16	282					D					
944	Jefferson	Co	16	360					D					
4673	Jefferson	Co	22	373					D					
	Jefferson	Co	10A	7						N				
30	Jefferson	Co	11A	31					D					
	Kaufman	City	8	395	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Kaufman	City	13	129	W									
29	Kaufman	City	15	31	W									
1399	Kaufman	City	17	217		S								
	Kaufman	City	9A	61	W									
1044	Kaufman	Co	16	461				L	D					Dist 1
2465	Kaufman	Co	19	81				L						Dist 1
2484	Kaufman	Co	19	100				L						
2253	Kenedy City	City	18	487	W									
2254	Kenedy City	City	18	488		S								
1148	Kerens	City	16	567	W									
4985	Kerrville	City	23	45	W									
957	Killeen	City	16	373	W									
539	Kingsville	City	15	545		S								
2056	Kingsville	City	18	290	W									
3638	Kingsville	City	20	612	W									
	La Grange	City	3	553	W									
	La Grange	City	14	511		S								
1761	La Grange	City	17	584			F						A	
	Ladonia	City	14	357	W									
	Lampasas	City	1	498	W									
	Lancaster	City	8	595	W									
	Lancaster	City	14	58	W									
1673	Lancaster	City	17	493	W	S								
1106	Laredo	City	16	525					D					
	Laredo	City	3A	74		S								
825	Leonard	City	16	241	W									
2370	Liberty	City	18	604					D					
547	Liberty	Co	15	553				L						
2595	Liberty	Co	19	212					D					
	Liberty	Co	10A	4					D					
1021	Livingston	City	16	437	W									
1205	Livingston	City	17	23	W									
2402	Lockhart	City	19	18		S								
3052	Lockney	City	20	26	W									
	Longview	City	10	525	W									
	Longview	City	11	415	W									
	Longview	City	12	299	W									
	Longview	City	12	527	W									
	Longview	City	13	515	W									
	Longview	City	14	77	W									
	Longview	City	14	249	W									
	Longview	City	14	329		S								

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Longview	City	14	429		S								
	Longview	City	14	469	W									
	Longview	City	14	485	W									
	Longview	City	14	580		S								
	Longview	City	14	580	W									
100	Longview	City	15	102	W									
638	Longview	City	16	46	W									
640	Longview	City	16	48		S								
1233	Longview	City	17	51		S								
1234	Longview	City	17	52	W									
1802	Longview	City	18	35	W									
1803	Longview	City	18	36		S								
	Longview	City	9A	509	W									
2103	Lorraine	City	18	337	W									
	Lott	City	14	405	W									
1225	Lott	City	17	43	W									
	Lubbock	City	14	321	W									
	Lubbock	City	14	322		S								
	Lufkin	City	6	579	W									
	Lufkin	City	8	22	W									
	Lufkin	City	12	487	W									
	Lufkin	City	14	49	W									
	Lufkin	City	14	303	W									
	Lufkin	City	14	455	W									
1203	Lufkin	City	17	21	W									
	Lufkin	City	9A	393	W									
155	Madisonville	City	15	157	W									
278	Madisonville	City	15	280	W									
1196	Magnolia Park	City	17	14	W									
1317	Magnolia Park	City	17	135	W									
1817	Mansfield	City	18	50	W									
	Marlin	City	3	659	W									
	Marlin	City	8	373	W									
	Marlin	City	10	575	W									
136	Marlin	City	15	138		S								
1945	Marlin	City	18	178		S								
1946	Marlin	City	18	179	W									
	Marshall	City	3	261	W									
	Marshall	City	8	616	W									
	Marshall	City	10	107		S								
	Marshall	City	11	59		S								
	Marshall	City	14	77	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
	Marshall	City	9A	193		S								
	Marshall	City	9A	325		S								
	Marshall	City	9A	457	W									
	Mart	City	12	559	W									
	Mart	City	14	15	W									
1615	Mart	City	17	435	W									
	Matagorda	Co	14	63					D					
439	Matagorda	Co	15	441								I		
470	Matagorda	Co	15	472					D					
920	Matagorda	Co	16	336					D					
1161	Matagorda	Co	16	580								I		
1556	Matagorda	Co	17	375					D					
	Matagorda	Co	10A	92					D					
	Matagorda	Co	10A	92					D					
	Matagorda	Co	11A	1					D					
	McKinney	City	6	529	W									
	McKinney	City	8	529	W									
	McKinney	City	12	69	W									
	Memphis	City	14	133		S								
	Memphis	City	14	133		S								
	Memphis	City	14	133		S								
	Mercedes	City	14	61	W									
	Merkel	City	13	353	W									
	Mexia	City	3	90	W									
	Midland	City	14	76	W									
	Miles	City	14	222	W									
1139	Milford	City	16	558	W									
1190	Mineola	City	17	8	W									
	Mineral Wells	City	8	66	W									
	Mineral Wells	City	8	464			F							
	Mineral Wells	City	8	467	W									
	Mineral Wells	City	10	423	W									
	Mineral Wells	City	10	427		S								
	Mineral Wells	City	10	483		S								
	Mineral Wells	City	11	419		S								
	Mineral Wells	City	11	463	W									
	Mineral Wells	City	12	45		S								
	Mineral Wells	City	12	363		S								
	Mineral Wells	City	14	232		S								
2044	Mineral Wells	City	18	278		S								
3296	Mineral Wells	City	20	270	W									
	Mineral Wells	City	2A	454	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Mineral Wells	City	9A	451		S								
	Mineral Wells	City	9A	453	W									
	Mount Pleasant	City	8	495	W									
	Mount Pleasant	City	14	58	W									
	Mount Pleasant	City	14	419		S								
	Mount Vernon	City	14	523	W									
2925	Mount Vernon	City	19	541	W									
	Nacogdoches	City	10	571	W									
	Nacogdoches	City	14	541		S								
	Navasota	City	3	11	W									
	Navasota	City	3	199	W									
453	Navasota	City	15	544	W									
597	New Boston	City	16	4	W									
	New Braunfels	City	1	553	W									
	New Braunfels	City	14	522	W									
	New Braunfels	City	3A	15	W									
	Nocona	City	14	359	W									
1419	Nocona	City	17	238	W									
1528	Nueces	Co	17	347					D					
	Oak Cliff	City	2A	244	W									
	Olney	City	14	471	W									
1897	Olney	City	18	130	W									
	Orange	City	6	326	W									
	Orange	City	12	29					D				A	
1823	Orange	City	18	56	W								A	
	Orange	Co	10A	6						N				
	Orange	Co	10A	62						N				
45	Orange	Co	11A	46					D					
	Paducah	City	14	471	W									
	Palacios	City	14	573	W									
	Palestine	City	14	109			F							
	Palestine	City	14	219			F							
	Paris	City	3	114	W									
	Paris	City	3	138	W									
	Paris	City	6	465	W									
	Paris	City	9	83	W									
	Paris	City	10	95		S								
	Paris	City	11	431		S								
	Paris	City	12	591	W									
	Paris	City	14	129	W									
	Paris	City	14	442	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
	Paris	City	14	494	W									
	Paris	City	14	594		S								
435	Paris	City	15	437	W									
2151	Paris	City	18	385		S								
216	Pecos City	City	15	218		S								
622	Pecos City	City	16	30		S								
725	Pecos City	City	16	133	W									
439	Peyton (Creek)	City	15	441								I		
1161	Peyton (Creek)	City	16	580								I		
1189	Pilot Point	City	17	7	W									
	Pittsburg	City	9A	435	W									
	Plainview	City	12	435	W									
	Plainview	City	12	439		S								
	Plainview	City	14	36		S								
192	Plainview	City	15	194	W	S								
	Plano	City	6	275	W									
	Plano	City	8	433	W									
	Plano	City	10	563	W									
	Plano	City	14	401	W									
2670	Pleasanton	City	19	286	W									
	Polytechnic	City	14	393	W									
137	Polytechnic	City	15	139		S								
	Port Arthur	City	8	225					D					
	Port Arthur	City	14	568			F							
	Port Arthur	City	14	568	W									
	Port Arthur	City	14	569	W									
	Port Arthur	City	14	569		S								
	Port Arthur	City	14	570	W									
	Port Arthur	City	14	570		S								
1262	Port Arthur	City	17	80			F							
1782	Port Arthur	City	18	14					D					
2042	Port Arthur	City	18	276			F							
2404	Port Arthur	City	19	20		S								
2405	Port Arthur	City	19	21	W									
	Quanah	City	3	83	W									
	Quanah	City	8	533	W									
	Quanah	City	14	35	W									
609	Quanah	City	16	16	W									
2282	Quanah	City	18	516		S								
2491	Red River	Co	19	107				L						
2763	Red River	Co	19	379				L						
1570	Reeves	Co	17	389								I		

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
2674	Reeves	Co	19	290								I		
	Rockdale	City	3	610	W									
	Rockdale	City	8	535	W									
368	Rockdale	City	15	370	W									
771	Rockdale	City	16	179	W									
	Rogds	City	14	342	W									
	Roscoe	City	14	387	W									
	Rosebud	City	12	407	W									
2874	Rosebud	City	19	490	W									
721	Rosenberg	City	16	129	W									
	Royse City	City	11	563	W									
670	Runge	City	16	78	W								A	
643	Rusk	City	16	51	W									
1511	Rusk	City	17	330	W									
	San Angelo	City	14	54			F							
477	San Antonio	City	15	482		S								
479	San Antonio	City	15	484					D					
481	San Antonio	City	15	486			F						A	Police
	San Antonio	City	2A	221		S								
	San Augustine	City	14	295	W									
	San Benito	City	14	501		S								
1522	San Benito	City	17	349		S								
1552	San Marcos	City	17	371		S							A	
	Santa Anna	City	13	429	W									
1421	Santa Anna	City	17	240		S								
	Schulenburg	City	8	537	W									
	Seguin	City	6	476	W									
1242	Seguin	City	17	60	W								A	Lights
2234	Seguin	City	18	468		S								
	Seymour	City	13	153		S								
	Seymour	City	13	157	W									
518	Shamrock	City	15	524	W									
	Sherman	City	3	74	W									
	Sherman	City	8	261		S								
	Sherman	City	8	737	W									
	Sherman	City	8	741		S								
	Sherman	City	10	23	W									
	Sherman	City	10	163	W									
	Sherman	City	12	327	W									
	Sherman	City	14	258	W									
	Sherman	City	14	382	W									
	Sherman	City	14	571	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Sherman	City	14	571		S								
10	Sherman	City	15	11			F							
9	Sherman	City	15	10	W									
887	Sherman	City	16	303	W									
889	Sherman	City	16	305		S								
2300	Sherman	City	18	534			F							
2298	Sherman	City	18	532	W									
2297	Sherman	City	18	531		S								
2296	Sherman	City	18	530		S								
	Sherman	City	2A	644	W									
	Shine	City	14	276	W									
	Snyder	City	14	223		S								
	Snyder	City	14	224	W									
524	Somerville	City	15	530	W									
442	Spur	City	15	444	W									
618	Spur	City	16	26	W									
2805	Stamford	City	19	421			F							
2806	Stamford	City	19	422			F							
	Stephenville	City	13	37		S								
	Stephenville	City	14	473	W									
	Stratford	City	12	65	W									
	Sulphur Springs	City	7	270	W								A	
	Sulphur Springs	City	7	300	W									
	Sulphur Springs	City	8	752	W									
	Sulphur Springs	City	12	109	W	S								
	Sulphur Springs	City	14	17	W									
116	Sulphur Springs	City	15	118	W									
	Sulphur Springs	City	9A	251	W									
	Sweetwater	City	6	645	W									
	Sweetwater	City	13	305			F						A	
	Sweetwater	City	14	581		S								
804	Sweetwater	City	16	216	W									
2160	Sweetwater	City	18	394		S								
	Teague	City	12	287	W									
	Teague	City	13	381	W									
585	Teague	City	15	592	W									
	Temple	City	11	531	W									
	Temple	City	12	49	W									
	Temple	City	14	10	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond W	S	F	L	D	N	R	I	A	Note
	Temple	City	14	81	W									
563	Temple	City	15	569		S								
1497	Temple	City	17	316			F							
1498	Temple	City	17	317			F							
	Temple	City	2A	550			F							
	Terrell	City	6	471	W									
	Terrell	City	8	270	W									
	Terrell	City	8	547	W									
	Terrell	City	10	219	W									
	Terrell	City	14	71	W								A	
	Terrell	City	14	207	W								A	Lights
	Terrell	City	14	244	W								A	Lights
	Terrell	City	14	373	W									
	Terrell	City	14	529	W									
779	Terrell	City	16	187			F						A	
	Texarkana	City	3	17	W									
	Texarkana	City	3	39	W									
	Texarkana	City	6	226		S								
	Texarkana	City	11	607		S								
	Texarkana	City	12	483			F							
	Texarkana	City	13	117			F							
	Texarkana	City	14	166		S								
	Texarkana	City	14	166			F							
1362	Texarkana	City	17	180		S								
2992	Texarkana	City	19	608		S								
1393	Timpson	City	17	211	W									
2214	Trinity	City	18	448	W									
2216	Trinity	City	18	450	W									
1935	Troupe	City	18	168	W									
	Tulia	City	14	505	W								A	
	Tyler	City	14	195	W									
2094	Tyler	City	18	328	W									
	Uvalde	City	3	543	W									
1058	Uvalde	City	16	475		S								
	Van Alstyne	City	6	623	W									
	Van Alstyne	City	8	579	W									
28	Van Alstyne	City	15	30	W									
1186	Van Alstyne	City	17	3	W									
1829	Van Alstyne	City	18	62	W									
	Van Alstyne	City	9A	131	W									
1750	Venus	City	17	573		S								
	Vernon	City	12	455	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Vernon	City	12	463		S								
	Vernon	City	14	247		S								
	Vernon	City	14	247	W									
2144	Vernon	City	18	378	W									
2148	Vernon	City	18	382		S								
	Victoria	City	1	345	W									
	Victoria	City	1	373	W									
	Victoria	City	8	589	W									
	Victoria	City	11	447	W									
1444	Victoria	City	17	263			F							
2010	Victoria	City	18	244		S								
584	Victoria	Co	15	591					D					
1554	Victoria	Co	17	373					D					
1724	Victoria	Co	17	544					D					
	Waco	City	3	563		S								
	Waco	City	3	97		S								
	Waco	City	11	227		S								
	Waco	City	12	315	W									
	Waco	City	14	25	W									
	Waco	City	14	393		S								
	Waco	City	14	394					D					
	Waco	City	14	526		S								
	Waco	City	14	527	W									
115	Waco	City	15	117	W									
188	Waco	City	15	190		S								
713	Waco	City	16	121					D					
714	Waco	City	16	122		S								
2545	Waco	City	19	161		S								
2547	Waco	City	19	163			F							
	Waco	City	2A	371	W									
	Waco	City	3A	91		S								
	Waco	City	9A	111	W									
	Waco	City	9A	361	W									
	Ward	Co	9	84					D					
1022	Ward	Co	16	438								I		
4	Ward	Co	11A	4					D					
	Ward	Co	8A	427					D					
	Ward	Co	8A	423					D					
	Waxahachie	City	3	703	W									
	Waxahachie	City	6	130		S								
	Waxahachie	City	10	191	W									
	Waxahachie	City	11	83	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
	Waxahachie	City	11	591	W									
	Waxahachie	City	14	57	W									
463	Waxahachie	City	15	465	W									
2415	Waxahachie	City	19	31		S								
	Waxahachie	City	2A	168	W									
	Waxahachie	City	9A	173	W									
	Waxahachie	City	9A	175	W									
	Weatherford	City	8	295	W									
	Weatherford	City	10	115		S								
	Weatherford	City	12	197		S								
	Weatherford	City	14	384	W									
462	Weatherford	City	15	464		S								
	Weatherford	City	9A	367		S								
1486	West	City	17	305		S								
	Wharton	City	14	30		S							A	
	Wharton	City	14	255	W									
	Wharton	City	14	522	W									
484	Wharton	City	15	489	W									
625	Wharton	City	16	33		S								
626	Wharton	City	16	34	W									
	Wharton	City	9A	157		S								
	Wharton	City	9A	160	W									
36	Wharton	Co	11A	37					D					
	Whitesboro	City	10	195	W									
	Whitesboro	City	11	535	W									
	Whitewright	City	7	768	W									
	Whitewright	City	8	341	W									
876	Whitewright	City	16	292	W									
	Whitewright	City	9A	31	W									
2675	Whitney	City	19	291	W									
	Wichita Falls	City	11	579		S								
	Wichita Falls	City	12	291		S								
162	Wichita Falls	City	15	164		S								
1169	Wichita Falls	City	16	588			F							
	Wichita Falls	City	3A	89		S								
2321	Willington	City	18	555	W									
522	Willis	City	15	528	W									
752	Wills Point	City	16	160	W									
1244	Wills Point	City	17	62	W									
	Winnsboro	City	14	125	W									
85	Winnsboro	City	15	87	W									
	Winters	City	14	389	W									

Bond Number	Bond Issuer	Entity	Vol.	Pg.	Type of Bond									Note
					W	S	F	L	D	N	R	I	A	
1722	Winters	City	17	542	W									
	Wolf City	City	10	407	W									
	Wolf City	City	12	519	W									
	Wortham	City	14	486	W									
7	Yoakum	City	15	8		S								
	Yoakum	City	3A	3	W									
	York	City	9A	68	W									
	Yorktown	City	14	481	W									

APPENDIX F

BOND VOLUME DATES AND NUMBER OF EACH TYPE

Volume Number	Date Range	1st WW Bond for Town	Total WW Bonds	1st Sewer Bond for Town	Total Sewer Bonds	Fire Bonds	Levee Bonds	Drainage Bonds
1	1875-1885	9	11	2	3	1	0	1
2	1895-1897	1	1	0	0	0	0	0
3	1886-1892	25	38	7	11	0	0	0
4	1899-1900	0	0	0	0	0	0	0
5	1900-1903	0	0	0	0	0	0	0
6	1896-1899	11	16	5	7	1	0	0
7	1899-1900	5	12	1	4	0	0	0
8	1899-1904	12	35	1	6	4	0	1
9	1909	1	7	0	1	1	0	1
10	1905-1907	6	19	1	6	1	0	0
11	1907-1908	9	20	2	8	1	0	0
12	1908-1909	13	33	8	15	1	0	5
13	1909	5	12	23	5	2	0	1
14	1909-1911	40	115	17	43	14	0	6
15	1912-1914	11	36	13	20	2	1	5
16	1914-1915	17	40	5	13	4	1	9
17	1915-1916	6	28	14	26	6	0	18
18	1916-1917	18	19	9	20	2	6	3
19	1917	3	7	2	10	5	13	3
20	1917-1919	2	10	1	4	0	1	2
21	1919	1	9	2	7	1	9	2
22	1919-1920	6	26	5	13	1	10	4
23	1920-1921	3	17	5	12	1	3	0
24	1921-1922	5	26	6	17	1	0	4
25	1922-1923	9	19	1	8	4	1	2
26	1923-1924	6	18	5	12	0	0	4
27	1924-1925	7	17	5	12	1	1	3
28	1925	11	27	5	14	3	4	4
29	1925-1926	9	26	5	19	4	2	3
30	1926-1927	5	20	2	15	4	0	2
31	1927-1928	10	21	6	12	9	2	3
32	1928-1929	7	14	6	10	3	0	1
33	1929-1930	3	12	3	10	7	1	3
34	1930-1931	1	12	3	9	5	1	4
1A	1870-1881	0	0	0	0	0	0	0
1B	1893-1895	0	0	0	0	0	0	0
2A	1894-1896	6	18	1	2	1	0	0
3A	1892-1893	7	11	1	3	0	0	0
3B	1897-1899	0	0	0	0	0	0	0
6A	1900-1902	0	0	0	0	0	0	0
7A	1902-1917	0	0	0	0	0	0	0
8A	1905-1909	0	0	0	0	0	0	8
9A	1903-1905	6	19	4	6	2	0	0
10A	1909-1912	0	0	0	0	0	0	17
11A	1912-1914	1	0	0	0	0	1	19
Column Totals		**298**	**771**	**176**	**383**	**92**	**56**	**138**

APPENDIX G

1910 BURLESON COUNTY LEVEE COORDINATES

Compiled from electronic versions of Tunis, Chances Store, Wellborn, and Clay USGS 7.5 minute topographic sheets on CD-ROM from 3-D TopoQuads by DeLorme. Elevations are in feet.

Note 1: Gap in levee on topo sheet due to washout. Note 2: Levee coordinates estimated due to washout.
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	Latitude	Longitude	Elev (ft)	Note
1.	30.62390	-96.54253	256	
2.	30.62443	-96.53902	246	
3.	30.62066	-96.53346	238	
4.	30.61825	-96.53273	222	
5.	30.61525	-96.53288	228	
6.	30.61012	-96.52702	246	
7.	30.60926	-96.52408	246	Note 1
8.	30.61149	-96.52155	242	Note 2
9.	30.61750	-96.51469	246	Note 2
10.	30.62227	-96.51300	246	Note 2
11.	30.61778	-96.50654	213	Note 2
12.	30.61853	-96.49766	223	Note 2
13.	30.61743	-96.49413	212	Note 1
14.	30.61684	-96.49253	233	
15.	30.61491	-96.49063	233	
16.	30.61319	-96.49011	228	
17.	30.60896	-96.49150	230	
18.	30.60583	-96.49107	230	
19.	30.60199	-96.48499	230	
20.	30.60272	-96.47930	230	
21.	30.60424	-96.47524	233	
22.	30.60355	-96.47367	230	
23.	30.60111	-96.47110	230	
24.	30.59845	-96.46497	233	
25.	30.59699	-96.46068	230	
26.	30.59495	-96.45973	230	
27.	30.59388	-96.45776	230	
28.	30.58746	-96.44911	230	
29.	30.58517	-96.44819	233	
30.	30.58283	-96.44684	233	
31.	30.58210	-96.44549	233	Note 1
32.	30.58156	-96.44439	229	Note 2
33.	30.58173	-96.43814	213	Note 2
34.	30.58587	-96.43233	208	Note 2
35.	30.58456	-96.42916	192	Note 1
36.	30.58285	-96.42575	225	
37.	30.57929	-96.42635	198	
38.	30.57639	-96.42537	229	
39.	30.57229	-96.42491	211	
40.	30.56714	-96.42623	217	Note 1
41.	30.56469	-96.42668	229	Note 2
42.	30.55962	-96.42629	230	Note 2
43.	30.55778	-96.42570	222	Note 1
44.	30.54641	-96.42234	223	
45.	30.54400	-96.41985	211	Note 1
46.	30.54286	-96.41861	210	Note 2
47.	30.54055	-96.41203	195	Note 2
48.	30.53977	-96.41018	206	Note 1
49.	30.53779	-96.40796	209	
50.	30.53323	-96.39838	207	
51.	30.53113	-96.39227	210	
52.	30.53149	-96.38761	218	
53.	30.53649	-96.38187	207	
54.	30.53596	-96.37873	203	Note 1
55.	30.53560	-96.37654	207	Note 2
56.	30.53734	-96.37461	207	Note 1
57.	30.53765	-96.37382	213	
58.	30.53639	-96.37038	222	
59.	30.52819	-96.36519	223	
60.	30.52317	-96.36404	223	
61.	30.51996	-96.36513	187	Note 1
62.	30.51667	-96.36625	222	Note 2
63.	30.51544	-96.36586	221	Note 2
64.	30.51254	-96.36412	190	Note 2
65.	30.51160	-96.36163	215	Note 1
66.	30.51136	-96.36126	220	
67.	30.50120	-96.35533	213	
68.	30.49910	-96.35000	222	
69.	30.49726	-96.34726	217	
70.	30.49123	-96.34185	217	
71.	30.48843	-96.34027	217	
72.	30.48348	-96.33627	216	
73.	30.47761	-96.34123	212	
74.	30.47037	-96.34154	216	
75.	30.46815	-96.33916	217	
76.	30.46656	-96.33614	202	Note 1
77.	30.45362	-96.32834	217	Note 2
78.	30.45108	-96.32114	179	Note 1
79.	30.45024	-96.31851	196	
80.	30.44664	-96.31714	210	
81.	30.44276	-96.31098	213	
82.	30.43385	-96.30237	210	
83.	30.43001	-96.29568	210	
84.	30.42364	-96.29186	203	

	Latitude	Longitude	Elev (ft)	Note

APPENDIX H

CHRONOLOGY OF TEXAS RESERVOIRS WITH CAPACITY GREATER THAN 5,000 AC-FT

Owner column includes original owner and present owner. Scale column represents the scale of original ownership. Since most reservoirs of this size are government owned, the scale is determined to be either local (city or county), regional/state (more than one county, a river authority, or state agency), or federal (usually the US Army Corps of Engineers, but also other federal agencies plus the international Boundary & Water Commission for two dams on the Rio Grande). A scale category of "Non-gov" is assigned to non-government entities, usually utilities, but also other industry, private irrigation companies, and private individuals. Year column is the year construction was completed for the reservoir's dam. Capacity column represents initial estimated conservation storage capacity in ac-ft. Reservoirs with less than 100,000 ac-ft capacity are shown in "regular" font style. Those with a capacity of between 100,000 and 1,000,000 ac-ft are highlighted in "**bold**" style, and those few with a capacity of greater than 1,000,000 ac-ft are indicated in "***bold italic***" style. This corresponds to the 3 capacity sizes indicated in the timeslice maps in Figures 6.7 through 6.10. The "Water Use" columns are indicated with small bullets under column headings EN for environment, FC for flood control, HY for hydroelectric power, IN for industry, IR for irrigation, RE for recreation, and WS for water supply. Data is from the Texas Water Development Board.[469]

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Lake Austin (Lake McDonald)	City of Austin. Dam collapsed in 1900.	Local	1893	49,300		●	●				●	Colorado
Eagle Lake	(Wilham Dunovant) / Lower Colorado River Authority	Non-gov	1900	9,600					●			Colorado
Lake Wichita	(Lake Wichita Co., Jos. Kemp) Wichita CWID #2, City of Wichita Falls	Non-gov	1901	14,000				●			●	Red
Lake Pauline	(Col. Cecil A. Lyon[470]) / West Texas Utilities	Non-gov	1906	7,000				●	●	●		Red
Randell Lake	City of Denison	Local	1909	5,400							●	Red
San Esteban Lake	(St. Stephens Land & Irrigation Co.) Alpha Twenty-One Corporation	Non-gov	1911	18,770								Rio Grande
White Rock Lake	(City of Dallas) / Dallas Parks & Recreation	Local	1911	10,740						●	●	Trinity

[469] Supplemented by the Texas State Historical Association, Handbook of Texas Online at http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007); and C. L. Dowell, *Dams and Reservoirs in Texas: Historical and Descriptive Information*, Bulletin 6408, Austin: Texas Water Commission, 1964.
[470] Texas State Historical Association, Handbook of Texas Online, "Damsite, TX" entry. http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Lake Austin (Matagorda Co.)	(John W. Garner) LCRA. Destroyed by rain in 1930 and hurricane in 1932.	Non-gov	1912							●	●	Brazos-Colorado
Medina Lake	**(Medina Valley Irrigation Co.) Bexar-Medina-Atascosa Cos WCID #1**	**Non-gov**	**1913**	**254,000**					●			**San Antonio**
Lake Worth	City of Fort Worth	Local	1914	38,130						●	●	Trinity
Imperial Reservoir	Pecos Co WID 2	Local	1915	6,000					●			Rio Grande
Lake Balmorhea	Reeves County WID No 1	Local	1917	7,707					●			Rio Grande
Lake Mineral Wells	City of Mineral Wells	Local	1920	6,760							●	Brazos
Lake Abilene	City of Abilene	Local	1921	7,900						●	●	Brazos
Lake Halbert	City of Corsicana	Local	1921	7,420							●	Trinity
Lake Cisco	City of Cisco/Water Department	Local	1923	26,000						●	●	Brazos
Lake Crook	City of Paris	Local	1923	11,500						●	●	Red
Lake Kemp	**City of Wichita,Water Imp Dist #2**	**Local**	**1923**	**319,600**					●		●	**Red**
Lake Diversion	Wichita CWID #2, City of Wichita Falls	Local	1924	40,000					●			Red
Trinidad Lake	TXU Generation Company LP	Non-gov	1925	7,450				●				Trinity
Olmos Reservoir	City of San Antonio	Local	1926	15,500		●						San Antonio
Bivins Lake	City of Amarillo	Local	1927	5,122	●							Red
Lake Dallas	**City of Dallas**	**Local**	**1927**	**214,000**			●				●	**Trinity**
Lake Dunlap	Guadalupe-Blanco River Authority	Non-gov	1928	5,900			●					Guadalupe
Lake Kirby	City of Abilene	Local	1928	7,620					●		●	Brazos
Lake McQueeney	Guadalupe-Blanco River Authority	Non-gov	1928	5,000			●					Guadalupe
Devils Lake	Central Power & Light	Non-gov	1928	92,00			●					Rio Grande
Santa Rosa Lake	(Waggoner Refining Co.) W. T. Waggoner Estate	Non-gov	1929	11,570				●	●			Red
Lake Lovenskiold (old Lake Corpus Christi)	City of Corpus Christi	Local	1929	54,430			●		●		●	Nueces
Lake Eddleman	City of Graham	Local	1929	6,500							●	Brazos
Lake Walk	Central Power & Light	Non-gov	1929	5,400			●					Rio Grande
(old) Lake Waco	City of Waco	Local	1929	39,378							●	Brazos
Lake Nasworthy	City of San Angelo	Local	1930	12,390						●	●	Colorado
Lake Sweetwater	City of Sweetwater	Local	1930	11,900						●	●	Brazos
Lake Bridgeport	**(Tarrent Co. Water Control & Imp. Dist.) Tarrant Regional Water District**	**Regional**	**1931**	**386,420**		●					●	**Trinity**
Lake Gonzales (H-4)	Guadalupe-Blanco River Authority	Non-gov	1931	6,500			●			●		Guadalupe
Eagle Mountain Lake	**(Tarrent Co. Water Control & Imp. Dist.) Tarrant Regional Water District**	**Regional**	**1932**	**190,460**							●	**Trinity**

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Lake Brownwood	**Brown County WID No. 1**	**Local**	**1933**	**143,400**		●					●	**Colorado**
Lake Olney / Lake Cooper	City of Olney	Local	1935	6,650						●	●	Red
Mountain Creek Lake	(E.S. Heyser) Exelon Generation	Non-gov	1936	22,840				●				Trinity
Red Bluff Reservoir	**Red Bluff Water Power District**	**Local**	**1936**	**310,000**			●		●			**Rio Grande**
Buffalo Lake	(Federal Farm Securities Administration) U.S. Fish and Wildlife Service	Federal	1938	18,150						●		Red
Coffee Mill Lake	United States Forest Service	Federal	1938	8,000						●		Red
Inks Lake	Lower Colorado River Authority	State	1938	17,545			●					Colorado
Lake Buchanan	**Lower Colorado River Authority**	**State**	**1938**	**992,000**			●				●	**Colorado**
Lake Fort Phantom Hill	City of Abilene	Local	1938	74,310				●			●	Brazos
Monte Alto Reservoir	(Union Irrigation Dist) (Hidalgo-Willacy Cos. Water Control & Imp Dist No. 1 of Edcouch	Regional	1939	25,000					●			Rio Grande
Delta Lake	Delta Lake Irrigation District	Regional	1939	25,000					●			Nueces-Rio Grande
Lake Austin	City of Austin	Local	1939	21,000			●				●	Colorado
Lake Rita Blanca	(U.S. Soil Conservation Service) leased by City of Dalhart	Local	1939	12,100	●							Canadian
Possum Kingdom Lake	**Brazos River Authority**	**State**	**1941**	**724,700**			●	●	●		●	**Brazos**
Lake Travis	***Lower Colorado River Authority (Bureau of Reclamation)***	***State***	***1942***	***1,172,600***		●	●				●	***Colorado***
Highlands Reservoir	(U.S. Federal Works Adm) San Jacinto River Authority	Federal	1943	5,580				●				Trinity-San Jacinto
Ellison Creek Reservoir	Lone Star Steel Company	Non-gov	1943	24,700				●				Cypress
Sheldon Reservoir	(U.S. Federal Works Adm) Texas Parks and Wildlife Department	Federal	1943	5,420				●	●	●		San Jacinto
Lake Texoma	***Corps of Engineers-SWT***	***Federal***	***1944***	***2,733,000***		●	●			●	●	***Red***
Barker Reservoir	**Corps of Engineers-SWG**	**Federal**	**1945**	**207,000**		●						**San Jacinto**
Lake Kickapoo	**City of Wichita Falls**	**Local**	**1945**	**106,000**							●	**Red**
Valley Acres Reservoir	Valley Acres Water District	Regional	1947	7,840					●			Nueces-Rio Grande
William Harris Reservoir	Dow Chemical	Non-gov	1947	10,200				●				Brazos
Addicks Reservoir	**Corps of Engineers-SWG**	**Federal**	**1948**	**204,500**		●						**San Jacinto**
Gulf Coast Water Authority Reservoir	Gulf Coast Water Authority	Local	1948	7,308				●			●	San Jacinto-Brazos
Hords Creek Lake	Corps of Engineers-SWF	Federal	1948	8,640		●					●	Colorado
Lake Cherokee	Cherokee Water Company	Local	1948	46,700				●		●	●	Sabine

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Lake Daniel	City of Breckenridge	Local	1948	9,515							●	Brazos
Upper Nueces Lake	Zavala-Dimmit Counties WID No. 1	Regional	1948	7,590					●			Nueces
Camp Creek Lake	Camp Creek Water Company	Local	1949	8,550						●	●	Brazos
Eagle Nest Lake / Manor Lake	T. L. Smith, et al.	Non-gov	1949	18,000								Brazos
Lake Colorado City	TXU Generation Company LP	Non-gov	1949	31,805				●		●	●	Colorado
Baylor Lake	City of Childress	Local	1950	9,220						●	●	Red
Benbrook Lake	Corps of Engineers-SWF	Federal	1950	88,250		●					●	Trinity
Lake Electra	City of Electra	Local	1950	8,730							●	Red
B A Steinhagen Lake	Corps of Engineers-SWF	Federal	1951	94,200			●				●	Neches
Casa Blanca Lake	Webb County	Local	1951	20,000					●	●		Rio Grande
Lake Lyndon B Johnson	**Lower Colorado River Authority**	**State**	**1951**	**138,500**			●	●			●	**Colorado**
Lake Marble Falls	Lower Colorado River Authority	State	1951	8,760			●					Colorado
Lake Whitney	**Corps of Engineers-SWF**	**Federal**	**1951**	**627,100**		●	●				●	**Brazos**
O C Fisher Lake	**Corps of Engineers-SWF**	**Federal**	**1951**	**119,200**		●					●	**Colorado**
Alcoa Lake	Alcoa, Inc.	Non-gov	1952	14,750				●				Brazos
Grapevine Lake	**Corps of Engineers-SWF**	**Federal**	**1952**	**188,550**		●					●	**Trinity**
Lake Creek Lake	TXU Generation Company LP	Non-gov	1952	8,400				●				Brazos
Lake Gladewater	City of Gladewater	Local	1952	6,950							●	Sabine
Lake J B Thomas	**Colorado River Municipal Water Dist**	**Regional**	**1952**	**203,600**						●	●	**Colorado**
Oak Creek Reservoir	City of Sweetwater	Local	1952	39,360							●	Colorado
Lake Stamford	City of Stamford	Local	1953	53,930						●	●	Brazos
Lavon Lake	**Corps of Engineers-SWF**	**Federal**	**1953**	**456,500**		●					●	**Trinity**
River Crest Lake	TXU Generation Company LP	Non-gov	1953	7,000				●				Sulphur
Belton Lake	**Corps of Engineers-SWF**	**Federal**	**1954**	**457,600**		●					●	**Brazos**
Brazoria Reservoir	Dow Chemical	Non-gov	1954	21,970				●				Brazos
International Falcon Reservoir	***International Boundary & Water Comm.***	***Federal***	***1954***	***2,767,400***		●	●		●		●	***Rio Grande***
Lake Anahuac	Chambers-Liberty Cos Navigation Dist	Regional	1954	35,300				●	●		●	Trinity
Lake Houston	**City of Houston**	**Local**	**1954**	**146,700**				●	●	●	●	**San Jacinto**
Lake Leon	Eastland County Water Supply Dist	Local	1954	27,290				●		●	●	Brazos
Wright Patman Lake	**Corps of Engineers-SWF**	**Federal**	**1954**	**145,300**		●					●	**Sulphur**
Lewisville Lake	**Corps of Engineers-SWF**	**Federal**	**1955**	**640,986**		●					●	**Trinity**

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
New Terrell City Lake	City of Terrell	Local	1955	8,712		●				●	●	Trinity
Cox Lake / Raw Water Lake / Recycle Lake	Alcoa World Aluminum Atlantic	Non-gov	1956	5,034				●				Colorado-Lavaca
Lake Amon G Carter	City of Bowie	Local	1956	20,050					●	●	●	Trinity
Lake Waxahachie	Ellis Co Water Control & Imp Dist #1	Local	1956	13,500							●	Trinity
Lake Arlington	City of Arlington	Local	1957	45,710						●	●	Trinity
Lake Jacksonville	City of Jacksonville	Local	1957	30,500						●	●	Neches
Lake Striker	Angelina-Nacogdoches Co WCID	Local	1957	26,960				●		●		Neches
Lake Weatherford	City of Weatherford	Local	1957	21,233					●	●	●	Trinity
North Lake	TXU Generation Company LP	Non-gov	1957	17,000				●				Trinity
Smithers Lake	Reliant Energy	Non-gov	1957	18,700		●		●				Brazos
Lake Corpus Christi	**City of Corpus Christi**	**Local**	**1958**	**308,700**						●	●	**Nueces**
Lake Graham	City of Graham	Local	1958	53,680							●	Brazos
Lake Murvaul	Canadian River Municipal Water Auth	State	1958	44,650						●	●	Sabine
Lake O the Pines	**Corps of Engineers-SWF**	**Federal**	**1958**	**254,937**		●				●	●	**Cypress**
Champion Creek Reservoir	TXU Generation Company LP	Non-gov	1959	42,500				●		●	●	Colorado
Lake Davis	Troy Powell	Non-gov	1959	5,454					●			Brazos
Anzalduas Channel Dam	International Boundary & Water Comm	Federal	1960	13,910					●			Rio Grande
Farmers Creek Reservoir	North Montague Co WSD	Local	1960	25,400				●			●	Red
Lake Tawakoni	**Sabine River Authority of Texas**	**State**	**1960**	**936,200**							●	**Sabine**
Town Lake	City of Austin	Local	1960	6,248						●		Colorado
Johnson Creek Reservoir	AEP-Southwestern Electric Power Co	Non-gov	1961	10,100				●				Cypress
Lake Kurth	Abitibi Consolidated Industries	Non-gov	1961	16,200				●				Neches
Lake Mexia	Bistone MWS District	Local	1961	10,000						●	●	Brazos
Valley Lake	TXU Generation Company LP	Non-gov	1961	16,400				●				Red
Hubbard Creek Reservoir	**West Central Texas Muni Water Dist**	**Regional**	**1962**	**317,750**							●	**Brazos**
Lake Hawkins	Wood County	Local	1962	11,890		●				●		Sabine
Lake Holbrook	Wood County	Local	1962	7,990		●				●		Sabine
Lake Palestine	**Upper Neches River Muni Water Auth**	**State**	**1962**	**411,840**						●	●	**Neches**
Lake Quitman	Wood County	Local	1962	7,440		●				●		Sabine
Lake Winnsboro	Wood County	Local	1962	8,100		●				●		Sabine
Victor Braunig Lake	City Public Service	Local	1962	26,500				●		●		San Antonio
Brady Creek Reservoir	City of Brady	Local	1963	30,000							●	Colorado
Lake Athens	Athens Municipal Water Authority	Local	1963	32,790						●	●	Neches

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Loma Alta Lake	Brownsville Navigation District	Local	1963	26,500								Nueces-Rio Grande
Navarro Mills Lake	Corps of Engineers-SWF	Federal	1963	63,300		●					●	Trinity
Proctor Lake	Corps of Engineers-SWF	Federal	1963	59,400		●					●	Brazos
Twin Buttes Reservoir	**Bureau of Reclamation - USDOI**	**Federal**	**1963**	**186,200**		●			●	●	●	**Colorado**
White River Lake	White River Municipal Water District	Local	1963	38,600							●	Brazos
Canyon Lake	**Corps of Engineers-SWF**	**Federal**	**1964**	**386,200**		●					●	**Guadalupe**
J D Murphree Wildlife Impoundment	Texas Parks and Wildlife Department	State	1964	13,500	●							Neches-Trinity
Lake Bastrop	Lower Colorado River Authority	State	1964	16,590				●		●		Colorado
Lake Palo Pinto	Palo Pinto County MWD No. 1	Local	1964	27,650							●	Brazos
Lake Pat Cleburne	City of Cleburne	Local	1964	25,560							●	Brazos
North Fork Buffalo Creek Reservoir	City of Iowa Park	Local	1964	15,400							●	Red
Bardwell Lake	Corps of Engineers-SWF	Federal	1965	54,900		●				●	●	Trinity
Lake Meredith	**Canadian River Municipal Water Auth**	**Regional**	**1965**	**864,400**				●			●	**Canadian**
Lake Waco	**Corps of Engineers-SWF**	**Federal**	**1965**	**152,500**		●					●	**Brazos**
Sam Rayburn Reservoir	***Corps of Engineers-SWF***	***Federal***	***1965***	***2,898,500***		●	●				●	***Neches***
Cedar Creek Reservoir Trinity	**Tarrant Regional Water District**	**Regional**	**1966**	**679,453**						●	●	**Trinity**
Houston County Lake	Houston Co WCID No 1	Local	1966	19,500						●	●	Trinity
Hubert H Moss Lake	City of Gainesville	Local	1966	23,210				●			●	Red
Lake Arrowhead	**City of Wichita Falls**	**Local**	**1966**	**262,100**							●	**Red**
Lake Coleman	City of Coleman	Local	1966	40,000						●	●	Colorado
Lake Tyler	City of Tyler	Local	1967	80,900							●	Neches
Lake Walter E Long	City of Austin	Local	1967	33,940				●				Colorado
Pat Mayse Lake	**Corps of Engineers-SWT**	**Federal**	**1967**	**124,500**				●			●	**Red**
Somerville Lake	**Corps of Engineers-SWF**	**Federal**	**1967**	**160,100**		●					●	**Brazos**
Caddo Lake	**Northeast Texas Municipal Water Dist**	**Regional**	**1968**	**129,000**						●	●	**Cypress**
Greenbelt Lake	Greenbelt MIWA	Local	1968	60,400				●			●	Red
Stillhouse Hollow Lake	**Corps of Engineers-SWF**	**Federal**	**1968**	**235,700**		●					●	**Brazos**
Tradinghouse Creek Reservoir	TXU Generation Company LP	Non-gov	1968	37,814				●				Brazos
Calaveras Lake	City Public Service	Local	1969	63,200				●				San Antonio
E V Spence Reservoir	**Colorado River Municipal Water Dist**	**Regional**	**1969**	**488,760**						●	●	**Colorado**

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Fairfield Lake	TXU Big Brown Company LP	Non-gov	1969	50,600				●				Trinity
Intl Amistad Reservoir	***International Boundary & Water Comm.***	***Federal***	***1969***	***3,505,400***		●	●		●	●		***Rio Grande***
Lake Bonham	City of Bonham	Local	1969	12,000				●			●	Red
Lake Granbury	**Brazos River Authority**	**State**	**1969**	**153,500**				●	●		●	**Brazos**
Lake Livingston	***Trinity River Authority***	***State***	***1969***	***1,750,000***							●	***Trinity***
Lake Ray Hubbard	**City of Dallas/DWU**	**Local**	**1969**	**490,000**							●	**Trinity**
Lewis Creek Reservoir	Entergy	Non-gov	1969	16,400				●		●		San Jacinto
Mustang Lake East/ West	Chocolate Bayou Water Company	Local	1969	6,451								San Jacinto-Brazos
Toledo Bend Reservoir	***Sabine River Authorities of TX and LA***	***State***	***1969***	***4,477,000***			●			●	●	***Sabine***
Lake Clyde	City of Clyde	Local	1970	5,748							●	Colorado
Lake Kiowa	Lake Kiowa Property Owners Assn.	Non-gov	1970	7,000						●		Trinity
Lake Cypress Springs	Franklin Co Water District	Local	1971	72,800				●			●	Cypress
Cedar Bayou Generating Pond	Reliant Energy	Non-gov	1972	13,750				●				Trinity-San Jacinto
Lake Conroe	**San Jacinto River Authority**	**State**	**1973**	**430,260**					●		●	**San Jacinto**
Lake Sulphur Springs	City of Sulphur Springs	Local	1973	14,160						●	●	Sulphur
Monticello Reservoir	TXU Generation Company LP	Non-gov	1973	40,100				●				Cypress
Bryan Utilities Lake	City of Bryan	Local	1974	15,227				●				Brazos
Mackenzie Reservoir	Mackenzie Municipal Water Authority	Local	1974	46,450				●			●	Red
Martin Lake	TXU Generation Company LP	Non-gov	1974	77,619				●				Sabine
Millers Creek Reservoir	North Cent Tex MWA et al.	Regional	1974	34,000							●	Brazos
Mud Lake NO 4	Alcoa World Aluminum Atlantic	Non-gov	1974	11,048				●				Colorado-Lavaca
Welsh Reservoir	AEP-Southwestern Electric Power Co	Non-gov	1975	23,587				●				Cypress
Prudential Reservoir	Formosa Development Corporation	Non-gov	1976	9,792					●			Lavaca
Cedar Creek Reservoir Colorado	Lower Colorado River Authority	State	1977	74,080				●				Colorado
Lake Nacogdoches	City of Nacogdoches	Local	1977	41,140						●	●	Neches
Lower Running Water Draw WS SCS Site 2 Dam	Hale County SWCD	Local	1977	5,429		●						Brazos
Pinkston Reservoir	City of Center	Local	1977	7,380							●	Neches
Squaw Creek Reservoir	**TXU Generation Company LP**	**Non-gov**	**1977**	**151,047**				●		●		**Brazos**
Lake Bob Sandlin	**Titus Co Fresh Water Supply Dist #1**	**Local**	**1978**	**213,350**							●	**Cypress**

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Lake Limestone	**Brazos River Authority**	**State**	**1978**	**225,400**					●	●	●	**Brazos**
Granger Lake	Corps of Engineers-SWF	Federal	1979	65,500		●					●	Brazos
Coleto Creek Reservoir	American Electric Power	Non-gov	1980	31,040				●				Guadalupe
Forest Grove Reservoir	TXU Generation Company LP	Non-gov	1980	20,038				●				Trinity
Lake Fork Reservoir	**Sabine River Authority of Texas**	**State**	**1980**	**675,819**				●	●		●	**Sabine**
Gibbons Creek Reservoir	Texas Municipal Power Agency	Non-gov	1981	26,824				●				Brazos
Lake Texana	**Lavaca-Navidad River Authority**	**State**	**1981**	**170,310**				●		●	●	**Lavaca**
South Texas Project Reservoir	**Reliant Energy HL&P, Central Power & Light Co., - City of Austin, City Public Service Board**	**Non-gov**	**1981**	**202,600**				●				**Colorado**
Choke Canyon Reservoir	**Bureau Of Reclamation - USDOI**	**Federal**	**1982**	**691,130**						●	●	**Nueces**
Lake Georgetown	Corps of Engineers-SWF	Federal	1982	37,100		●					●	Brazos
Lower Running Water Draw WS SCS Site 3 Dam	Hale County SWCD	Local	1982	8,213		●						Brazos
Twin Oak Reservoir	TXU Generation Company LP	Non-gov	1982	30,319				●				Brazos
Aquilla Lake	Corps of Engineers-SWF	Federal	1983	52,400		●					●	Brazos
Brandy Branch Cooling Pond	AEP-Southwestern Electric Power Co	Non-gov	1983	29,513				●				Sabine
Lake Winters / New Lake Winters	City of Winters	Local	1983	8,374						●	●	Colorado
Peacock Site 1A Tailings Reservoir	Lone Star Steel Company	Non-gov	1983	11,248				●				Cypress
Truscott Brine Lake	**Corps of Engineers-SWT**	**Federal**	**1983**	**111,147**	●							**Red**
Lake Ballinger / Lake Moonen	City of Ballinger	Local	1984	6,850						●	●	Colorado
Red Draw Reservoir	Colorado River Municipal Water Dist	Regional	1985	8,538	●			●				Colorado
Lake Ray Roberts	**Corps of Engineers-SWF**	**Federal**	**1987**	**799,600**		●					●	**Trinity**
Richland-Chambers Reservoir	***Tarrant Regional Water District***	***Regional***	***1987***	***1,181,866***						●	●	***Trinity***
Natural Dam Lake	Colorado River Municipal Water Dist	Regional	1989	54,560	●							Colorado
O H Ivie Reservoir	**Colorado River Municipal Water Dist**	**Regional**	**1989**	**554,340**						●	●	**Colorado**
Jim Chapman Lake	**Corps of Engineers-SWF**	**Federal**	**1991**	**310,312**		●					●	**Sulphur**
Joe Pool Lake	**Corps of Engineers-SWF**	**Federal**	**1991**	**181,200**		●					●	**Trinity**
Lost Creek Reservoir	City of Jacksboro	Local	1991	11,961							●	Trinity
Mitchell County Reservoir	Colorado River Municipal Water Dist	Regional	1991	27,266	●			●				Colorado

Reservoir Name	Owner (Original) / Present	Scale	Year	Capacity (Ac-ft)	Water Use							River Basin
					EN	FC	HY	IN	IR	RE	WS	
Palo Duro Reservoir	Palo Duro River Authority	State	1991	60,897						●	●	Canadian
Sulphur Springs Draw Storage Reservoir	Colorado River Municipal Water Dist	Regional	1993	7,997	●	●		●				Colorado
Alan Henry Reservoir	**Brazos River Authority**	**Local**	**1994**	**115,937**					●	●	●	**Brazos**
Lake Gilmer	City of Gilmer	Local	1999	12,720							●	Cypress
Wallisville Lake	Corps of Engineers-SWG	Federal	1999	58,000	●					●	●	Trinity
Alders Reservoir	US Fish and Wildlife Service	Federal		7,064						●		Trinity

APPENDIX I

NOTES FOR RESEARCHERS ON METHODOLOGY

This section is written for the person who may not be all that interested in the topic of water use or who really is not particularly interested in that place called Texas. This section is designed to appeal to the historical geographer. It is written knowing that what I say may sound obvious, even trivial to those of you who may have already wandered down this path. But to a historical geographer, one with a passion for and appreciation of information buried in dusty archives, it is my hope that if you plow through this section, you will find at least one hint that inspires a new way of exploring your own research. As Alan Baker has reminded us, the archives are a lonely place, but we can overcome our isolation through the shared joy that comes from making that making that long-sought discovery in a long-forgotten document. Maybe something in these notes will help.

Figure 5.1. Central business district fires

There are several points historical geographers might find useful that I discovered while making the Central Business District Fires map in Figure 5.1. Historical census data is widely available from a number of sources, but it is usually in the form of either state or county population totals. Finding a tabulation of city populations was more difficult. The *Texas Almanac* was the source I used. It has been published since 1857, usually biannually, by the *Dallas Morning News* or its publishing company, and includes population data of incorporated towns. It is a treasure trove of tabulated information about the state.

The *New York Times* has also been published since 1857 and is available online through ProQuest Historical Newspapers. This subscription database service is available through my university library. Not only is it online, but it is searchable! You can search for specific words (a city name, for instance) between specifiable date ranges. By selecting the "More Search Options" link on the Basic Search page, you can specify the type of document to be searched within the newspaper including an article, birth notice, classified ad, comic, display ad, editorial article, editorial cartoon, fire loss, front page, legal notice, letter, lottery numbers, marriage, obituary, photo standalone, real estate transaction, review, stock quote, table of contents, or the weather.

The idea for making a Central Business District Fire map began when I was searching the vertical files of the Carnegie Library in Bryan, Texas for history on their waterworks. I expected to find articles from the local newspaper chronicling local fires, which I did. I did not expect to find articles about these local fires in the *New York Times*, and yet there were several. Bryan was unincorporated in the 1880 census, and had a population of less than 3,000 in 1890. It was not a major city, and yet three of its fires were included in *The Times* "Losses by Fire" column.[471]

I searched for "Texas" before the date of "01/01/1900" in the Historical *New York Times* database and specified the document type as "Fire loss." This turned up 129 hits. From this list I selected each Texas fire that destroyed what I considered to be a

[471] *New York Times*, 8 March 1874, p. 1, a large fire destroyed four businesses. *New York Times*, 29 September 1881, p. 5, fire destroyed the city block that included the post office. *New York Times*, 30 September 1881, p. 5, additional note about yesterday's previously reported fire killing "an old and estimable citizen." *New York Times*, 11 July 1887, p. 5, fire in drug store and dry goods store that was insured by 15 companies.

significant amount of a town's central business district (CBD) for inclusion on my Central Business District Fire map. From this list I found forty-nine fires that fit my criterion. Most Texas towns circa 1880 were small with a central business district of only several blocks in extent. If a fire destroyed several businesses or half a downtown block, I considered it to be a major fire for that town. If it were a courthouse fire in a county seat, I considered that to be a major fire. I generally did not include fires that affected only one business, and I never selected purely residential fires or fires that occurred between towns—along a rail line, for instance. This was an admittedly subjective exercise, but, none the less, I think it is useful in demonstrating the widespread problem of fires in late nineteenth century Texas towns.

Then I tabulated the CBD fire list into an Excel spreadsheet that included columns for the name of the town where the fire occurred and the year of the fire. This was saved in DBF IV format and brought into ESRI's ArcView as a table. In order to turn this table into a map, I needed locations for each town. The USGS GNIS data set described in Chapter IV includes latitude and longitudes in decimal degrees for proper place names in Texas, so I joined it to the newly created database of NYT Texas fires using the name of the town as the join criterion. By using the "Add Event Theme" command, designating the x-coordinate as longitude and the y-coordinate as latitude, followed by the "Convert to Shapefile" command, a map view of my NYT fire data was made. Then I created a layout of this view for the final map and exported it as a graphics file that I inserted into a Microsoft Word document. This allowed me to add a description of the figure at the bottom of the page.

Beginning in 1894, the format of the "Fire Loss" column of the *New York Times* changed from reporting short articles about fires around the nation to being a log of the time, address, and damages of fires that had occurred in New York City the previous day. Thus, the method described here works only when searching for fire data between 1857 and 1894. The Historical *Chicago Tribune*, *Christian Science Monitor*, *Los Angeles Times*, *Wall Street Journal,* and *Washington Post* are also included in the ProQuest database.

Tables 5.1 and 5.2. Compilation and chronology of early Texas waterworks

The basis for Table 5.1, Texas waterworks established before 1890, is *The Manual of American Water-Works, 1889-1890*, edited by M.N. Baker of the [472]*Engineering News.* It contains technical specifications for fifty-five Texas waterworks. Table 5.2 is a chronology of the establishment of one hundred twenty-one public water supplies in Texas, beginning with seventeenth century Spanish acequias and including two waterworks established as late as the 1940s. It is similar to, and yet different from, Table 5.1. Because I am writing this from the perspective of an American historical geographer, I am particularly interested in identifying new and useful archival sources and in sharing this information with others with similar interests. Historical data is imperfect, but is still useful in reconstructing an interpretation of the past. I think it instructive to organize around my archival source. This table is a summary of information on waterworks that was collected by historians and civil

[472] I owe a debt of gratitude to Texas historian T. Lindsay Baker for recommending that I make use of this resource.

engineers at Texas Tech University as part of a larger history of southwestern United States civil engineering projects. This archive has been made available within the last two years to researchers at the Southwest Collection at Texas Tech. This is a new archive facility that deserves to be used more. It provides the researcher with good lighting, plenty of room to spread out, and a helpful staff. The Center for Historic Preservation and Technology archives I accessed had just been compiled and made available to the public. It contains a wealth of resources on a wide variety of engineering projects. For a sampling of the topics covered, see T. Lindsay Baker's *Building the Lone Star*.[473]

Although the above mentioned archive is the source for the data in Table 5.2, I have in a few cases supplemented the information using other sources. For example, if the description of a waterworks indicated that a nearby river served as its water source or that a nearby lake served as a storage reservoir for a waterworks, then I tried to find out the name of the river or lake, when the reservoir was constructed, and by whom. This was accomplished by iterating between the Handbook of Texas Online[474] and the computer software program Google Earth.[475] I would "travel" to a town about which I needed more information by using Google Earth. Once there I searched the area for the river or lake matching the description in the archive. Google Earth usually labeled the lakes but did not usually label the rivers. I then used either a Texas Highway

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[473] T. Lindsay Baker, *Building the Lone Star* (College Station, TX: Texas A&M University Press, 1986). For additional information on this archive, see http://swco.ttu.edu/Manuscripts/CenterHPT_press.htm.
[474] Made available by the Texas State Historical Association, Handbook of Texas Online. http://www.tsha.utexas.edu/handbook/online/ (accessed March 11, 2007).
[475] Google Earth, version 3.0.06, September 2005.

Department map or county map to identify the river or creek. Then I would look up the town in the Handbook of Texas Online. By using the "Find in this page" command under the edit menu in my web browser, I could quickly find all references to water in the Handbook article about that town. I could also use the Handbook's search feature to come up with a possible list of names for local creeks, if I could not find them elsewhere. By moving back and forth between the Handbook of Texas Online and Google Earth, I was able to "see" what the geography looked like in the vicinity of the particular waterworks I was interested in.

Figures 5.3 through 5.7. Water bond timeslices

These maps were constructed from data collected from the archives of the Bond Department of the Office of the Comptroller of the State of Texas. The archive is located immediately to the east of the state capitol building in Austin. I made several unsuccessful trips to the state archives in Austin to find the collection that might contain bond information about waterworks before discovering an extremely helpful online index, Texas Archival Resources Online (TARO).[476] Through this index I identified an archive that sounded promising.[477] It turned out to be just what I was looking for. I knew that waterworks were established in Texas beginning in the 1870s and that the city of Bryan purchased its waterworks in 1911. This made Volume 304-2227, a general bond index covering dates from 1870 to 1931, a logical volume to examine. The data set

[476]Texas Archival Resources Online, Finding Aids, http://www.lib.utexas.edu/taro/index.html (accessed March 12, 2007).
[477] Texas State Library and Archives Commission, "Texas Comptroller's Office: An Inventory of Comptroller's Office General Revenue Volumes at the Texas State Archives, 1836-1994," http://www.lib.utexas.edu/taro/tslac/30097/tsl-30097.html (accessed March 12, 2007).

in Appendix A was compiled from this volume into an Excel spreadsheet. I used the volume number in which the bond was recorded to get an approximate date for each bond using the chart in Appendix C. Then I extracted water bond by decades data for my timeslice maps. The process of constructing the maps in ESRI's ArcView is similar to that described in making the map in Figure 5.1.

Figures 5.9 through 5.12. Water supply network for Bryan, Texas, 1885,1891, 1912, and 1925

My university library had an atlas of Sanborn maps for Bryan, but they were not useable for my purposes. Updates had repeatedly been added to the same base map, rendering the maps practically useless for historical analysis because it was not possible to tell when an improvement had been added to the map. My university library also subscribes to Texas Sanborn maps online, and this was extremely helpful. I was able to view page-sized scans of each map on the computer screen. Colors were not included, but each page could be enlarged on screen, making reading map details easier. I printed each map section, spliced them together, and had a full-sized copy made of each map. Then I highlighted each part of the water system on each map. This made the water main network stand out and I was able to find well, cistern, and hydrant locations. I wanted to translate this into a series of uncluttered maps showing Bryan's water system at four different times.

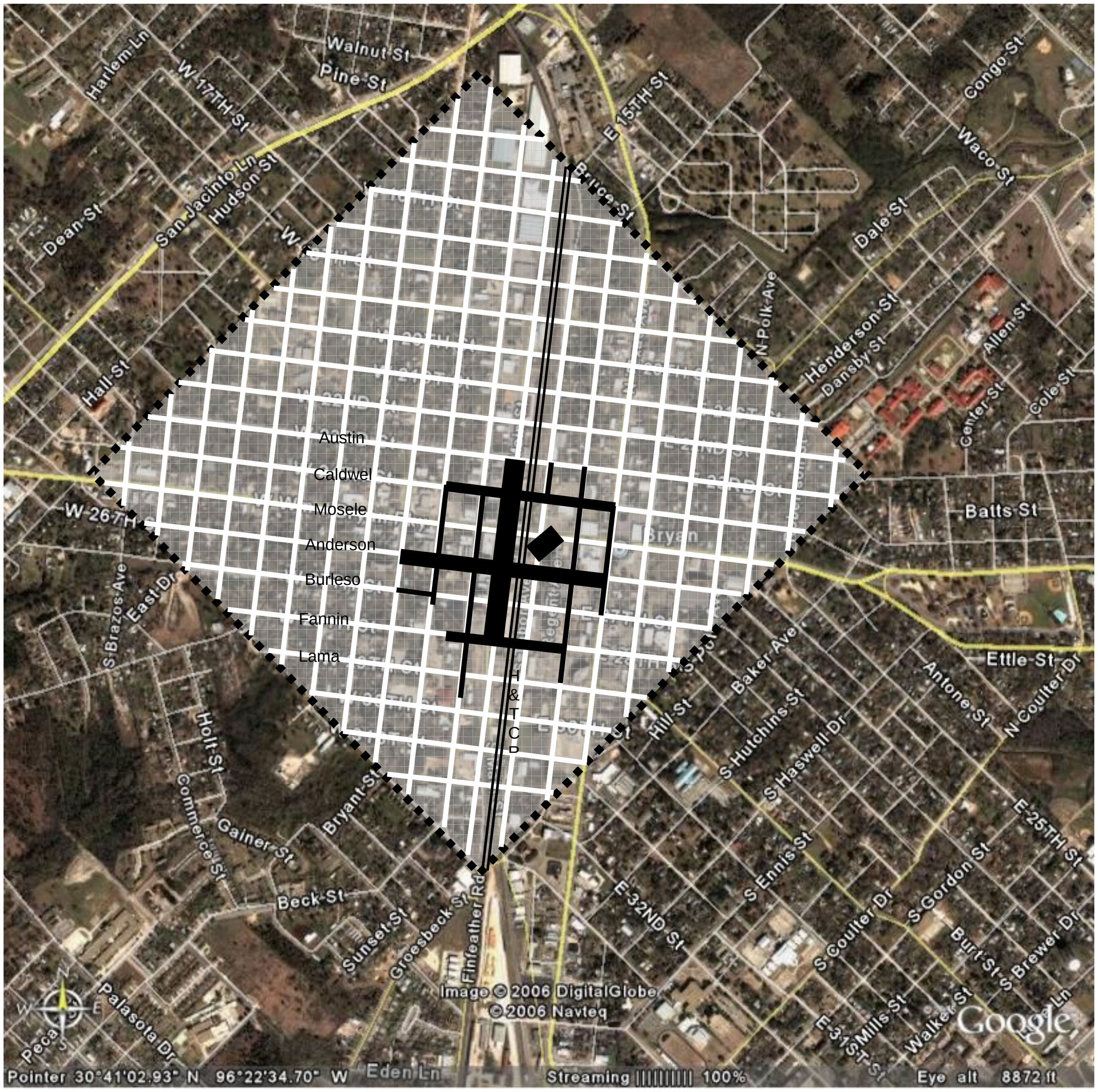

Figure I.1. Construction of Bryan, Texas Base Map. I captured a view of the city in the computer program Google Earth and opened the resulting image of Bryan in PowerPoint. I used the drawing tools in PowerPoint to draw an overlay of the streets and rail line in the original townsite. On this overlay became the base map upon which I drew the maps showing the expansion of Bryan’s water supply network. This also demonstrates one of Dodgshon’s geographic inertias—that of the built environment. Clearly the original layout of Bryan remains intact, and the city has expanded from its original central business district.

For this I needed a basemap of Bryan. Once again Google Earth helped. I used Google Earth to bring up an image of Bryan on my computer screen. Then I used a screen capture program called MWSnap to capture an image of Bryan from an elevation of 8872 feet. I saved the image in jpeg format and imported it into Microsoft PowerPoint. I used the drawing tools in PowerPoint to draw the diamond that outlined Bryan's original townsite and the line tool to draw Bryan's streets and main rail line. This is an example of Dodgshon's inertia of the built environment. Neither the train tracks nor the roads have moved since they were laid out in the late nineteenth century. Only the names of the roads have changed. Figure I.1 illustrates how I made the basemap of Bryan.

Once I had a basemap, I drew the water system in PowerPoint using the highlighted Sanborn maps as my guide. PowerPoint is probably not the best graphics program to use, but it is what I have. It worked because the map I needed to draw consisted mostly of straight lines, something well within PowerPoint's somewhat limited drawing capabilities. Then I exported my maps into Microsoft Word, resized them, and added a description of each map. These notes may seem a bit long on small details, but each archival detail represents a something that I found exciting, and each technical detail represents a victory for this somewhat computer-challenged historical geographer.

The notes to researchers in this appendix are a detailed description of how I used computer databases to search for and compile data, and how I used commonly available software to generate the figures and tables in Chapter V. Similar techniques, databases, and software packages were used in Chapters IV, VI, and VII.

APPENDIX J

PLATES

Plate 1. Map of Improvement District No. 1. Burleson County, Texas. By J.C. Nagle, Improvement Engineer. February, 1911.

Plate 2. Profile of a Protection Levee Along the Brazos River in Improvement District No. 1, Burleson County, Texas. Miles 0 through 3. By J.C. Nagle, Improvement Engineer. January, 1914.

Plate 3. Profile of a Protection Levee Along the Brazos River in Improvement District No. 1, Burleson County, Texas. Miles 2 through 8. By J.C. Nagle, Improvement Engineer. May, 1914.

Plate 4. Profile of a Protection Levee Along the Brazos River in Improvement District No. 1, Burleson County, Texas. Miles 9 through 14. By J.C. Nagle, Improvement Engineer. May, 1914.

Plate 5. Profile of a Protection Levee Along the Brazos River in Improvement District No. 1, Burleson County, Texas. Miles 15 through 20. By J.C. Nagle, Improvement Engineer. May, 1914.

Plate 6. Profile of a Protection Levee Along the Brazos River in Improvement District No. 1, Burleson County, Texas. Miles 21 through 26. By J.C. Nagle, Improvement Engineer. May, 1914.

The above six large format documents are included as Plates. The existence of the map in Plate 1 was indicated in the Minutes of the Burleson County Commissioners' Court, however, the County Clerk no longer had a copy of this map. I discovered an old blueprint version of this map in the Texas State Library in Austin. The Levee Profiles in Plates 2 through 6 were found in the same archive. All were on brittle paper that had been folded many times. Restoration was done under the supervision of John Anderson, Preservation Officer for the Archives and Information Services division of the Texas State Library and Archives Commission. These are archived under the Department of Water Resources, Reclamation Engineer Division, "Historical Files," and were dated circa 1908 to circa 1960. The Volume number is OAH VII 200.

In the print version of this dissertation, these Plates are bound separately between the last numbered page and the inside back cover. In the electronic version of this dissertation, I have included each plate as a separate computer graphics file in jpg format. I have also arranged the six profiles on two 36 inch by 56 inch slides in PowerPoint format for easier printing on a wide format printer. The map in Plate 1 has been reduced to 1:2500. The original map is at a scale of 1:2000.

VITA

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