Water Water Everywhere… Now What to Do With It: An Evaluation of Water Management Strategies for East Texas

By

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Abstract

The purpose of this project is to do the following: describe the various management strategies for both groundwater and surface water as discussed in the literature; examine the attitudes of stakeholders in Region I about water management strategies; make recommendations to improve current management strategies to ensure long-term water sustainability in East Texas. This project uses a survey, created to illustrate the strengths and weaknesses of certain management strategies, to identify the must useful water management strategy for East Texas. The results of the project indicate a need for new management strategies to ensure long term water sustainability in the region.

About the Author

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Chapter 1 Introduction

Surface and Groundwater Management in the America West

As the American West continues to grow at a rapid pace, state legislators and resources planners have recognized water resource management as an element critical to sustaining growth and economic development. Groundwater law and administration have typically been viewed as having serious and glaring shortcomings that discourage water conservation (Durant & Holmes 1985, 823). For decades, landowners have quarreled over the implications of the rule of capture and other similar groundwater management strategies that prescribe how groundwater is allocated in the West. With regard to ownership, state statutes specify that groundwater is the private property of those holding surface land rights. Owners hold virtually unlimited freedom to “intercept, impede and appropriate” these waters as long as no malice is involved. Owners may use, transfer, or sell groundwater under their land so long as they do “not maliciously take water for the sole purpose of injuring” their neighbor or “want only to waste it” (Durant & Holmes 1985, 823).

These broad guidelines on groundwater management conflict with policy for surface water management. Surface water allocation in the West abides by the " prior appropriation doctrine" under which state administrators or state courts apportion water among the various users according to who was first to put the water to beneficial use (Doerksen 1977, 446). This management tool has also caused conflicts among water users, many of which must be settled in court.

These resource management strategies collectively have a number of important implications. First, they result in piecemeal decision making. Second, they shift much of

the major decision making responsibility onto the courts or state agencies. Third, with each decision, they progressively reduce the options available. Fourth, they deepen the existing divisions between the various components of the decision-making system and make cooperation difficult. Fifth, they provide traditional water users with a disproportionate amount of influence over the decision process. Sixth, they deepen the existing division among the various components of the decision making system and make cooperation difficult (Doerksen 1977, 446).

The literature available on groundwater and surface water management suggests a need for change from current administrative techniques. Most authors agree that current management systems are antiquated and are not prepared to meet the growing demand on water resources. The literature suggests that as urban developments grow in the West, new management tools are necessary to allow transfers of water from agriculture use to domestic purposes. The literature also suggests that two of water's most fundamental functions- its role as a prerequisite for life and its use as a commodity or economic resource- are increasingly in conflict as population and demand increases (Postel 2000, 941).

Research Purpose

The purpose of this applied research project is descriptive and has three goals. First, it describes various management strategies for both groundwater and surface water as discussed in the literature. Second, it examines the attitudes of stakeholders in Region I about current management strategies in East Texas. Third, it makes recommendations to

improve current management strategies to ensure long-term water sustainability in East Texas.

Summary of Chapters

Chapter Two offers a review of the literature available on surface and groundwater management. This chapter is divided into two sections: groundwater and surface water. Each section is then divided into different management strategies, and strengths and weaknesses of each strategy is discussed. The conceptual framework is also introduced in Chapter Two.

Chapter Three is a setting chapter and discusses the history of water planning in Texas. It also introduces Region I and discusses details about this region. Chapter Four describes the methodology used for this project. The chapter introduces the survey which is used and describes the target population.

Chapter Five discusses the results of the survey. The data is collected and then organized into charts and divided by management strategies.

Chapter Six offers a summary of the project and makes some policy change recommendations.

Chapter 2: Literature Review

Chapter Purpose

The purpose of this chapter is to describe current water management strategies for both surface and ground water. The information discussed in this chapter is applied to the descriptive categories framework at the end of this chapter. The categories used in this chapter are strategically created to assess all advantages and shortcomings of current management strategies.

The chapter is divided into two major categories: (1) groundwater and (2) surface water. In the United States, water rights depend on the location of water in the hydrological cycle, or the flow of water from rainfall to collection within the earth. The progression of the hydrological cycle results in the creation of two distinct types of water: groundwater and surface water. Groundwater is defined as water percolating below the surface of the earth. Surface water consists mainly of all water located in lakes, streams, and rivers

Within each major category the discussion is further divided into subcategories that describe different resource management strategies. The groundwater discussion describes strategies such as the *rule of capture, reasonable use, correlative rights, the restatement of torts, prior appropriations, and management by groundwater districts*.

These subcategories discuss both the strengths and weaknesses of each strategy as described in the literature. The descriptive categories framework is ideal for this project because it allows for a detailed discussion of each groundwater management practice.

The surface water discussion is also divided into subcategories such as the *prior appropriations doctrine, instream flows, and water transfers.* These subcategories highlight the advantages and disadvantages associated with each practice.

Groundwater Management

A primary source of water for agricultural and commercial use is groundwater. Abdalla ((1994, 1063) states that "groundwater protection policies can have significant economic consequences for individual, businesses, and communities."

The origins of groundwater law in the United States can be traced back to nineteenth century English courts where most decisions were based on the law of property. "To a much greater extent than other bodies of law such as torts, criminal, contracts, etc., the development of groundwater law has been profoundly affected by scientific advances and our own understanding of hydrology" (Galano 2003, 1). Most of the restrictions on groundwater use enacted by state legislatures since 1930 were physical in nature and were borrowed from the law of oil and gas. "While some legislatures have been active as to groundwater, the majority of American jurisdictions usually leave the initiative to the courts" (Galano 2003, 1).

Western states have adopted a number of groundwater management policies; however, the discrepancies between conflicting state policies have caused problems between neighboring states (Durant and Holmes 1985, 823). The most commonly used management strategies are the *rule of capture, reasonable use, correlative rights, the restatement of torts, prior appropriations, and management by groundwater districts.*

The literature suggests it is important to understand the various methods of groundwater management to formulate a successful water management policy.

The Rule of Capture

Established in the 1900s, the "rule of capture" has long been a measure of consistency and contention among various water users and property owners throughout the West. This doctrine establishes that landowners are the absolute owners of the soil and the percolating waters below it. "In order for groundwater to be governed by the rule of capture, it must be percolating, and not part of an underground stream, which is defined as having all the characteristics of surface water courses such as beds, banks forming a channel, and a current of water" (Drummond et al. 2004, 43). It should be noted, however, that "most groundwater is assumed to be percolating" (Drummond et al. 2004, 43).

There are two exceptions to the rule of capture. Land owners have virtually unlimited freedom to pump water from beneath their land. They may use that water for any purpose they see fit, including selling it to a third party. A land owner, however, may not (1) pump water from the aquifer for the sole purpose of maliciously injuring their neighbor nor (2) may he pump water only to waste it (Durant and Holmes 1985, 823). Historically though, these two exceptions of malicious injury and intentional waste have been difficult to prove in court.

Drummond et al. claim that in many court proceedings the legal finding of malice is a rarity. In order for a court to find that a landowner has maliciously taken water for the sole purpose of causing harm to his neighbor, the plaintiff must prove "that no other

possible explanation for why the defendant was draining the [plaintiff's] property other than malicious spite exists" (Drummond et al. 2004, 46). Additionally, the judiciary has shown little inclination to define what constitutes waste and to find that a landowner has been wasteful with his water.

Opponents to the rule of capture and proponents of groundwater regulation often cite wasteful pumping and increased competition over the resource as an argument for increased regulation. Opponents argue that the doctrine was "originally designed to exploit and allocate a scarce natural resource for the purpose of economic development, without concerns for the many other purposes that water may serve" (Whittlesey and Huffaker 1995, 1202). The argument goes on to state that the rule of capture is outdated because water interacts with our lives and social interests in ways not addressed through the application of private property rights (1995, 1202).

Other opponents claim that the advance of technology and increase on demand has rendered the rule obsolete. These critics claim that with demand increasing and technology making it easier to obtain and transfer groundwater, there is little incentive to conserve the resource. In a non-regulated area, competition for groundwater is high, and it often exceeds the current demand. However, the cost of not pumping the water could outweigh the costs of pumping it prematurely. As with every limited resource, with no regulation, there is little reason for landowners to conserve when they have no guarantee that their neighbor will as well. Opponents note that the current knowledge about aquifers and water movement indicate a need for regulation.

> The amount of movement of groundwater from beneath one landowner's property to another's should be rather modest if they are pumping at about the same rate per acre and the local region of the aquifer is homogenous. But, aquifers are often heterogeneous and water demands among users are quite variable, which creates considerable uncertainty about future availability of the water that is conserved by an individual user (Provencher and Burt 1994, 882).

Additionally, the rule of capture may have negative implications for future water use. According to Provencher and Burt (1994, 882), because of increased demand, water in the future will have to be pumped from a greater depth. Pumping from deeper parts of the aquifer is considerably more costly and physically difficult. As some well owners find available groundwater, it is conceivable that they could over pump the resource. This would have the effect of hindering the efforts of landowners who are located over shallow parts of the aquifer. As demand increases, the deeper parts of the aquifer will be over taxed causing the easily accessible shallow areas to dry up. The rule of capture provides little incentive to prevent this from happening.

Supporters of the rule of capture claim that the rule protects private property rights. The history of the rule can be traced back to English Common law which allowed a landowner to pump as much water as he wanted. Under English law a landowner was not even liable for damage his pumping may cause his neighbor. Supporters claim that this precedent is a compelling reason to leave the rule in tact (Holladay 2006, 2).

In Texas alone the rule has withstood numerous constitutional challenges. Courts have consistently upheld the rule because of the private nature of property rights and the unknown nature of groundwater and its movement. Supporters state that regulation of groundwater will discourage established and future water development projects (Holladay 2006, 2).

While sometimes controversial, the rule of capture is used by a few states. The rule of capture was originally adopted by 28 states, but most states abandoned the doctrine in the mid 1950s when advances in technology led to increased knowledge about groundwater movement (Martin 2000, 10). Today only eight states have either adopted or expressed a preference for the rule of capture. These states include Connecticut, Indiana, Louisiana, Maine, Massachusetts, Rhode Island, Mississippi, and Texas. Drummond et al. states that this commitment to this doctrine is impressive because "throughout the last 1600 years, the rule of capture has been consistently interpreted, applied, and implemented, including a more recent history by countries that have either claimed title to [American] soil or exerted influence over the development of jurisprudence" (2004, 96).

Reasonable Use

The reasonable use management strategy is a modification of the rule of capture. Accepted mainly in Eastern states, this strategy "limits a landowner's use to beneficial uses having a reasonable relationship to the use over his overlying land" (Galano 2003, 1). Reasonable use has been described by some policy makers as "essentially the rule of capture with an exception for wasteful and offsite use" (Drummond et al. 2004, 44).

Drummond et al. (2004, 44) note that although opponents of the rule of capture often cite reasonable use as an alternative, some argue that in practice, the two strategies are the same. Except that under reasonable use, an owner of overlying land may sell water only if the sale does not harm neighboring landowners. In a state where reasonable use is applied, a landowner may pump as much water from the aquifer as he wants as

long as he does not waste it. Additionally the strategy provides a judicial remedy to a landowner whose neighbor is unreasonably using water and preventing the landowner from reasonably using his water. Under the reasonable use rule, "[water] use on land other than land that overlies the aquifer from which a resource originates traditionally is defined as unreasonable" (Holladay 2006, 6).

In a reasonable use state, there is no proportional sharing and no preference for prior users. Critics of this doctrine claim that the doctrine is too vague to guide courts adequately. Durant and Holmes (1985, 828) argue that "expansion of the [reasonable] use doctrine seems opportune as the costs of supplies become dearer to the states in an era of federal retrenchment, spiraling state responsibilities and interstate conflict over groundwater exports." The rule dictates that as states and local municipalities export water to other entities, considerable thought should be given to the beneficial use of the export.

Supporters of this strategy note that limiting water use to the location from where it was pumped discourages excessive pumping and water marketing. By limiting a landowner's use of the water, states can better regulate and manage their aquifers. Supporters state that the increasing demand for water in urban areas increases the need to adopt the rule of reasonable use.

Opponents to the rule, much like supporters of the rule of capture, claim the rule violates private property rights. With no provision or protection for senior users, landowners have no way to maximize the potential of their water. Many large landowners see this rule as infringing on their right to sell groundwater.

Additionally, others complain that the rule is ineffective if neighboring states do not comply with reasonable use as well. These critics point out that even if a state can effectively curb excess groundwater pumping and restrict water exportation, the laws of supply and demand will render the rule useless unless adopted by neighboring states (Durant and Holmes 1985, 829). If neighboring states that share the same aquifer allow unregulated pumping, a state adhering to the reasonable use rule will see their resources diminish. This effect can put a reasonable use state at a disadvantage when planning for growth.

Currently 21 states have adopted or indicated a preference for the rule of reasonable use. These states are Alabama, Arizona, Florida, Georgia, Illinois, Kentucky, Maryland, New Hampshire, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia. Arkansas, Delaware, Missouri, Nebraska, and Wyoming have adopted a modified rule of reasonable use.

Correlative Rights

As opposed to reasonable use and the rule of capture, the correlative rights management strategy does not envision an absolute right of access to groundwater or an unlimited right to pump. Rather, this rule maintains that the authority to allocate water is held by the courts. As a result, owners of overlying land and non-owners or transporters have co-equal or correlative rights in the reasonable, beneficial use of water.

The leading correlative rights case involved a dispute between agricultural users and a city water supplier in the California case of Katz v. Walkinshaw. The Katz decision established two guidelines for the correlative rights rule.

> First, a water transporter can protect its right against wasteful or malicious pumping by local users and against interference by other users. Second, disputes between local users in time of insufficient water supply would be settled by a court by allowing each a fair and just proportion of the available water (Galano 2003, 3).

The major feature of this rule is the concept that adjoining lands can be served by a single aquifer. Therefore, judicial power to allocate water permits protects the interests of both the public and private landowners (Drummond et al. 2004, 23).

Proponents of the rule claim it is good public policy because when conflicts or shortages occur, each owner is entitled to a proportionate share of available supplies. Unlike reasonable use, the correlative rights doctrine attempts to accommodate all overlying owners through ratable reductions when all reasonable needs cannot be met (Martin 2000, 10).

Opponents argue that reductions such as these do not take into account that fact that some uses may be more beneficial than others. Under correlative rights, quantities of water are uncertain since shortages result in a reduction for all uses (Bruggink 1992, 17). Critics claim that this system of proportionate yet arbitrary reductions produces instability and is especially damaging to ongoing and prospective water projects.

Six states have either formally adopted or expressed a preference for the doctrine of correlative rights. These states are California, Hawaii, Iowa, Minnesota, New Jersey, and Vermont.

The Restatement of Torts (Beneficial Use)

The restatement of torts doctrine merges the English concept of non-liability with the American standard of reasonable use. The purpose of the restatement was to modernize the old concept into a strategy that meets the growing demands of water resources (Galano 2003, 2). This management strategy is also commonly referred to as the "beneficial use". The rule was adopted by the American Law Institute, which lays out the general common law of the United States in the form of model laws, in the Restatement of Torts section 85 entitled Liability for the Use of Groundwater. This section provides criteria for the comparing reasonableness of competing uses of groundwater.

> According to this rule, a well owner is not liable for withdrawal of groundwater unless the withdrawal (1) causes well interference by lowering the water table or reducing water pressure (2) results in pumping more than the well owner's reasonable share (3) interferes with levels of streams and lakes that depend on groundwater (Martin 2000, 10).

Opponents argue that even though the restatement protects against over pumping, "it does not favor on land use explicitly to encourage recharge of the underlying aquifer" (Martin 2000, 10). Under the beneficial use rule, allocation of groundwater is not determined by the size of a tract of land. This rule allows courts and state agencies to consider the proposed use of water and whether that use is more beneficial than others. Unlike the correlative rights strategy, the restatement of torts allows courts to give preferences to certain users based on their intended beneficial purpose.

Supporters of the restatement of torts strategy consider beneficial use an important consideration when planning for the future. Durant and Holmes (1985, 828)

argue that states should consider anticipatory rights when determining beneficial use. Under this theory an individual would acquire a water right without actually putting it to use. The state could also recognize a holding as a future beneficial use. Anticipatory water rights would allow administrators to plan for depletions and overuse of streams, lakes and aquifers as contemplated in the restatement of torts rule. Helen Ingram (1982, 141) also advocates a change in the definition of beneficial use. She states that "by redefining beneficial use, the states can promote reallocation and gain a good deal of regulatory power over the holders of water rights."

Only three states have either adopted or expressed a preference for the restatement of torts rule. These states are Michigan, Ohio, and Wisconsin.

Prior Appropriations

The prior appropriations management strategy states that the first landowner to beneficially divert or use water from a groundwater source is granted a priority of right. The oldest rights are considered to be senior to newer junior rights and ,therefore, receive a higher priority. During times of drought, the most senior water rights holders receive their full allocation of groundwater, and some junior water right holders may receive nothing (Bruggink 1992, 4). This strategy is popular among Western states for groundwater and surface water management.

This strategy incorporates concepts imbedded in the reasonable use strategy and the restatement of torts. Under this strategy "the quality of water a senior appropriator may withdraw may be limited based on reasonableness and beneficial purposes" (Galano 2003, 3). Permits reflect seniority recognizing a better legal right in the first user.

Landowners whose use predates the permitting system usually receive grandfathered rights. Prior appropriations can apply to all groundwater, although in some states the doctrine applies only to particular sources such as underground streams or areas where conflict is likely to arise.

Supporters of this strategy claim that the system is designed to protect water rights during times of drought and the investment made in those rights. Many landowners make substantial investment in their land and pumping equipment with the expectation of a stable water supply. The prior appropriations strategy guarantees this stability (Martin 2000, 10).

Opponents claim that strict adherence to a rule of prior appropriation is impractical. One argument is that, when dealing with a limited resource such as an aquifer, any pumping done by a junior water right holder will affect a senior holder (Holladay 2006, 7). Unlike surface water, groundwater is much harder to regulate, and it is difficult to determine what results a drought may be having on an aquifer. The prior appropriations rule establishes a sense of stability among landowners, but without increased regulation, it is difficult to enforce.

Another criticism of the prior appropriations rule is the neglect of dormant rights. Bruggink (1992, 6) argues that there is a latent source of uncertainty that lies within holders of unexercised rights (such as dormant senior rights or rights held by Native Americans). Bruggink (1992, 6) states that ff these rights were to be exercised some junior right holders may see their allocation reduced to nothing.

Whittlesey and Huffaker (1995, 1199) claim that the prior appropriations process is one that recognizes a higher value on users of water that came first regardless of how

individuals or society might compare the values of water uses today. Durant and Holmes (1985, 829) argue for changing the system and that using "social or life quality assessment techniques- already a regular component of decision making for federal water projects- may be in order for groundwater management as well."

Twelve states have either formally adopted or expressed preference for the prior appropriations doctrine. These states are Alaska, Colorado, Idaho, Kansas, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, and Washington.

Groundwater Management Districts

Managing groundwater through regulatory districts called groundwater management districts has become increasing popular in Western states. As more knowledge became available about the nature of groundwater, policy makers saw a need to better regulate this resource. When aquifer movement and depletion emerged as an issue, information on the functions and values of groundwater was needed (Abdalla 1994, 1063). Breakthroughs in technology and scientific advances, coupled with drought and competition, provided this information and sparked the need for groundwater regulation. By 1917 most Western states had given their legislatures constitutional authority to regulate groundwater. As early as 1950, landowners recognized the growing demand for water and the possibility that the rule of capture and other similar doctrines would lead to water marketers exporting water to other municipalities and states. A number of states in the West abandoned their allegiance to the rule of capture, while others implemented regulatory measures which worked in conjunction to the rule (Martin 2000, 10).

Groundwater conservation districts fly in the face of the rule of capture. These entities can limit pumping, limit exportation, and limit the number of wells a landowner can have on his property. A conservation district is the only authority that can place limitations on the rule of capture (Holladay 2006, 3).

Conservation districts are usually created through a petition process in which landowners in the proposed district have final approval power. The literature suggests that public participation is critical for the legitimacy of a district. According to Steele et al. (1955, 887), "the people who will be affected by the policy should have ample and continuing opportunity to participate in the formulation of the program and to influence its operation." Each district directs local officials to establish regulations and parameters which govern how the landowners use their groundwater. These guidelines can vary from district to district and are mostly dependent on regional preferences and geological limitations (Holladay 2006, 3).

Traditional groundwater districts have the power to limit groundwater pumping and exportation through tools such as well permitting authority, production limits, well spacing requirements, and the ability to prevent groundwater from being used in an out of district location. District rules are created considering numerous variables such as population growth, per capita consumption, technological changes, export demands and environmental concerns (Berry 1977, 472). These districts are usually governed by elected boards and financed through user fees such a tax on pumping or exportation.

Some have argued that the idea of regulating groundwater came too late. Provencher (1993, 325) claims that one problem with groundwater management is that it is often reactive and not proactive. He states that water in an aquifer will be below its

optimal state by the time policy makers give any thought to regulating it. Numerous state agencies have been directed to study the current condition of aquifers and available groundwater. Some policy makers are fearful that drought and over pumping may have already had a devastating impact on Western aquifers.

Opponents to limiting groundwater production claim that the policy denied landowners their constitutional right to manage their own property. Recognizing their groundwater as a valuable asset, some landowners claim that a better policy for resource regulation that will maximize social benefits is one that relies on economic principles and market forces rather than government regulation (Berry 1977, 474). They claim production limits and limitation of out of district uses is inherently unfair and violates their constitutional right to private property. To these landowners detriment, however, state legislatures have gradually increased the regulatory powers of groundwater conservation districts. Rules for well spacing and stricter restrictions on pumping limits are some of the more recent additions to the powers of districts (Johnson 2001, 17).

Supporters of the management strategy see groundwater districts as vital to long term water stability. They argue that these districts responsibly regulate groundwater pumping and preserve the resource for future use. Small farmers and ranchers are some of the biggest proponents of the regulatory districts. They fear that under the rule of capture, larger landowners will market their water to outside areas leaving the aquifer depleted. Groundwater district offer these stakeholders a form of protection that give them stability in their farming and ranching practices. Environmental groups concerned with the stability of aquifers are also strong supporters of groundwater districts.

Some Western states have added new regulations to their water statutes which address the concerns of landowners, developers, environmentalists, and policy makers. Pierce (1979, 308) argues that when conflicting interests such as these are involved in a group dominated policy development process, two results occur.

> First there appear to be a number of new pro-environment/ preservationist interest groups, along with much increased political activity by those already on the scene. Second, governments at all levels initiate a number of formal mechanisms designed to enhance public involvement; public hearings, survey research, legislatively mandated access to the courts, and citizen advisory committees.

As predicted by Pierce, several Western states have created legislative committees to investigate changes to long term water planning efforts

When the idea of management by ground water districts was fairly new, Edward Ackerman in 1956 claimed that there are three underlying forces that should guide how groundwater management policy is formulated. Ackerman states that law makers should place an emphasis on geographical environment, available technology, and current demographics as guiding principals for developing policy. He argued that past assessment of geographical need has altered between two views.

> One maintains that we proceeded in our development without adequate basic data, and we need a much greater, more aggressive attack on basic data problems. Opposed to this has been the view of those who have been interested primarily in construction now; they maintain that there never is enough basic data, that the nation must go ahead with development and worry about basic data later (Ackerman 1956, 974).

Policy makers now have access to new statistical techniques for measuring available groundwater, new electronic aid for measuring available data, and an

appreciation of recent scientific breakthroughs. With these advances policy makers have been able to obtain a much more effective understanding of the geographical environment of aquifers and the need for responsible regulation.

Addressing available technology, Ackerman (1956, 976) argued that we have a lack of any fundamental analysis of the relation of technologic change to organization of groundwater management policy. Technological advances in applied meteorology and climatology, together with improved ground water exploration, can make water development of the future three dimensional. Since it is likely to be a fast moving period, it is important that groundwater policy not be based on technology of the past, even if it is the immediate past (Ackerman 1956, 977).

Lastly, Ackerman (1956, 977) argues that where and how people of the country live and what their movement amounts to are certainly basic underlying forces for any conservation development plan. A reliance on groundwater conservation districts will be the heaviest in the most populated areas. Condensed population will dictate how policy makers should address groundwater management and whether there is a need for local regulatory authorities to conserve resources.

The argument Ackerman put forth in 1956 has had a substantial impression on how groundwater districts are governed today. When districts are created each element of geographical environment, available technology, and current demographics are used. Newly created districts require extensive geological reports showing the availability of groundwater, assessment of available technology and how it will affect the protection and regulation of an aquifer, and demographic information establishing a need for regulation to protect against growth.

One issue facing policy makers today when discussing groundwater management districts is a district's ability to manage an aquifer when the aquifer lies beneath two or more districts. One of the original goals of the management district strategy was to develop more local control of groundwater use and policy. This goal has proven to be problematic. Reports indicated that competing districts carelessly managed resources with little regard to other communities accessing the same aquifer (Johnson 2001, 17).

> Because no single district has jurisdiction over an entire aquifer, and because aquifers typically extend beyond state lines as well, a classic tragedy of the commons situation results. Districts lack incentives to restrict withdrawals since overall supplies might be preempted by those outside the district's jurisdiction. Ultimately, a race ensues to establish water ownership through pumping before others do (Durant and Holmes 1985, 823).

Drummond et al. (2004, 85) states that since localized decision making is usually myopic, aquifer management schemes are based on different scientific assumptions. Sometimes different management districts even use differing data for aquifer measurement, and there is little communication or coordinated management efforts among neighboring groundwater districts.

Legislative committees have recommended that districts adopt management plans that address specific, stated management goals. Districts should set performance standards and management goals and state the actions, procedures, and performance measures necessary to implement the plan. Each of these adopted plans should then be sent to the state's administrative agencies and used to create a state water plan (Ingram 1982, 143).

Critics of the single county conservation district concept state the inconsistencies in aquifer management and decry the "arbitrariness of political boundaries in relation to the more logical and efficient use of aquifer boundaries" (Martin 2000, 12). Additionally, the proponents of multi-county districts claim the tax revenue generated by a larger aquifer size district can provide the funds needed to obtain engineering and technical expertise. Many single county districts do not generate enough revenue to adequately manage an aquifer efficiently (Martin 2000, 12). The "overlay" of local groundwater conservation districts, combined with the vested private property rights conferred by the rule of capture, strikes a delicate balance in a state's groundwater resources (Drummond et al. 2004, 97).

Despite the inconsistencies in conservation plans and aquifer management, groundwater management districts have remained a popular management strategy in Western states. "Invested with the appropriate powers, local districts are effective agencies for the development of resources. They may undertake limited development on their own initiative or they may take an essential part in cooperative activities with state and federal governments" (Steele and Regan 1955, 890).

The next section will discuss surface water, its role in agricultural and urban development, and current management strategies.

Surface Water Management

Surface water provides as an essential element to ranchers and farmers in the West. According to Ingram (1982, 134), since World War II the amount of irrigated land has more than doubled. Most irrigated land relies entirely upon surface water. Agriculture accounts for 85-95% of surface water use in many Western states (Colby 1990, 1184). Surface water is also a growing necessity for urban areas as groundwater become less reliable and harder to obtain. Surface water is defined as the water of the ordinary flow, underflow and tides of every flowing river, natural stream, and lake, as well as the storm water, flood water, and rainwater of every river, natural stream, canyon, ravine, depression, and water shed in the state.

The history of the development of surface water law involves Spanish civil law, English common law and appropriation pursuant to state statutes beginning with the 1889 Irrigation Act (Johnson 2001, 2). In the early 1900s most Western states adopted the doctrine of prior appropriation, or a hybrid version of it. The doctrine stated that rights to use state owned water are acquired by statutory provisions which rely upon the principle of "first in time, first in right," generally meaning senior water rights holders have priority over junior water rights holders (Armstrong 2004, 20). Most Eastern states abide by the riparian law doctrine. Under these laws the "owner of the land that is contiguous to a watercourse or other natural body of water has certain rights to the use of the water, principally for domestic, livestock and irrigation purposes" (Armstrong 2004, 19).

The Doctrine of Prior Appropriations

The law of prior appropriation is fundamental to the promotion of agriculture development in the West. Western states developed the doctrine of "first in time, first in right." This law of prior appropriation allows the first user on a stream to obtain a priority over all other subsequent users. Under the system all surface water is placed in a public trust maintained by the state. Each potential user must apply for a right from a state administrative agency or court. An applicant must exhibit a history of beneficial use in order to receive a water right from the state. "The only restriction the state puts on the use of water was that it be beneficial. The appropriative right is based on historical use, not ownership of land, and could be reduced or forfeited for nonuse" (Ingram 1982, 135).

Applicants who prove the longest history of beneficial use receive rights that are senior in priority to newer users. In a time of drought, junior water rights are the first to be cut off by the state ensuring senior water rights are fulfilled. "Since agriculture holds senior water rights in many of the Western states, many farmers are shielded from water scarcities that face more junior appropriators" (Ingram 1982, 140).

With water demand approaching the limits of water supply all over the West, and with few good prospects for increasing supply, there seems to be little alternative to a reallocation of existing supplies among new users and established users (Ingram 1982, 137). Other observers claim that the system is becoming more difficult to administer because in many parts of the West water supplies are already fully appropriated (Whittlesey and Huffaker 1995, 1199).

One problem identified with the doctrine of prior appropriation is the struggle between senior rights holders and growing urban communities. Strong pressure is put on

legislators to redefine the definition of beneficial use so that more municipal and fewer agricultural uses can be included. The doctrine calls for a right to be based on the amount of water applied to beneficial use, but state agencies and courts who administer water rights disagree over what constitutes a beneficial use. Opponents argue that the doctrine and its supportive definitions of beneficial use protect the private economic interest but do little, if anything, for the broader public interest in water (Whittlesey and Huffaker 1995, 1200).

Despite political attempts to alter the prior appropriations system to favor urban developments, observers agree that the unified efforts of the agricultural interests outweigh any such efforts. In water policy, there is a bias for the status quo expressed by the rules governing water rights. “Indeed, to alter the status quo, forces for change need to be reasonably unified and stable and need to have the support of public opinion and important interest groups. Agriculture continues to be well regarded in the West and has a number of important allies, while competitors for water are divided and sometimes weak” (Ingram 1982, 140).

However, agriculture interests and other senior water right holders fear that technological advances will diminish the value of their senior water rights. Whittlesey and Huffaker (1995, 1200) argue that changes are taking place as new technology gradually replaces older ones. These changes affect recharge, return flows, and stream flows and other right holders without any changes in the overriding institutional structure and administration of water allocation policy. The result is that junior rights are firmed up with more security in periods of drought, and senior rights seek institutional means to

continue claims to old diversion quantities while diverting less to currently irrigated lands.

In her essay on market based water policy, Katherine Armstrong (2004, 24) states that the system of senior water rights will only work if there is plenty of water for everyone's needs. She claims that historically there has been sufficient water in the West to meet those needs, but as demand for water increases, the system breaks down. She also advocates for a new definition of beneficial use, claiming that junior rights holders often exhibit a greater need for water than senior right holders.

> Today we see senior water rights owners allocated water priorities before junior water rights owners, even if the value of the water usage of the junior rights holder is far in excess of the senior rights owner. Consequently, the system is now driving premature and costly transfers of groundwater from rural areas to municipalities in order to augment water that could otherwise be supplied by surface water (Armstrong 2004, 24).

Assuming that the prior appropriations doctrine will remain in force, James Wescoat (1885, 23) suggested two types of institutional adjustments that should be made to achieve maximum utilization. First, he argues that the concept of waste and beneficial use have lagged in their development and should be redefined. He claims that the concept of water injury (malicious and economic harm to other water users) has evolved considerably, yet beneficial use has not. Secondly, he states that the tradition of administrative restraint in allowing water transfers must be reformed to achieve effective water management. He claimed that even though administrative appropriations have evolved with water scarcity, administrative tools for promoting water efficiency are ineffective. To date many states have yet to redefine beneficial use, and have not exhibited a tendency towards fining waste.

Solutions such as inter-basin water transfers and other diversionary techniques have been suggested, but most policy makers continue to show a preference toward the prior appropriations system. There is, however, increasing pressure to abolish or reform the doctrine, and this pressure continues to grow as the West continues to grow in population and urban development.

> The existing legal structure is more than one hundred years old, is inflexible, and was not designed to recognize value of uses other than those yielding a quantifiable economic return. The certainty and reliability that this system did indeed provide to a developing West is disappearing as the system becomes progressively more difficult to administer (Whittlesey and Huffaker 1995, 1200).

Water rights developed and administered under this system have been and will continue to be affected by new innovations in technology and growing demands for urban uses.

In-stream Flows

Few Western states have recognized the need to protect in-stream flows when awarding water rights under the prior appropriation system. The term in-stream flow is used to identify a specific stream flow (typically measured in cubic feet per second, or *cfs*) at a specific location for a defined time and typically following seasonal variations. In-stream flows are usually defined as the stream flows needed to protect and preserve in-stream resources such as fish, wildlife, and recreation (Washington Department of Ecology). An argument against the doctrine of prior appropriation is that little thought is given to preserving in-stream flows. Most states limit access to water rights for in-stream uses. Only two of the thirteen Western states allow private parties to acquire water rights

for maintaining stream flows. In most other Western states, water rights cannot be acquired for protecting water quality or in-stream flows, and the impairment of water quality is not a valid basis for protesting a water transfer (Colby 1990, 1186).

Several states have assembled legislative committees to study the need for in-stream flow protection. When put against competing agricultural and urban interests, however, there seems to be little support for expanding water rights for in-stream purposes. Parties concerned with protecting these flows do not represent the multiple interests that benefit from water resources and that experience losses as a result of water transfers (Colby 1990, 1186).

In addition to over appropriated surface water in streams and rivers, Postel et al. (2000, 941) estimate that policy makers have already appropriated nearly half of all accessible runoff which deposits into surface water supplies. They have done so either directly in the form of withdrawals for agriculture, cities, and industries or indirectly in the form of pollution dilution and other in-stream uses. However, little water has been left to accommodate sufficient in-stream flows. Annual water demands by households and industries in developing countries will increase by 590 million between 1995 and 2020, and the share of water going to these activities will more than double, from 13% of total water use to 27%. Postel et al. (2000, 945) claim that these demographic trends have already led to a serious state of decline of many freshwater ecosystems.

Critics of the prior appropriation doctrine also charge that it discourages water conservation by not awarding water rights holders for their conservation efforts (Wescoat 1985, 5). Most Western states create no incentive to conserve water for the preservation of in-stream flows. Kathleen Hartnett White (2004, 29) maintains that uncertainty,

instability and indefinite delay in Western states' decision making procedures complicate local government's ability to conserve water for ecological uses. "Uncertainty frustrates plans for water conservation and protection of environmental flows" (Hartnett White 2004, 29)..

Additionally most Western states traditionally have policies allowing for water to be transferred from one basin to another. These transfers diminish in-stream flows even further. Colby argues that preserving in-stream flows lack the market incentive to demand attention other water uses receive. "Benefits generated by water in-streams are often classic public goods not conducive to well defined property rights and characterized by non-rivalry, non-rechargability, and misallocation in private market exchanges" (Colby 1990, 1185). Consequently these needs tend to come last in Western water management.

Colby also believes that momentum is building for the protection of environmental flows in an effort to sustain a higher quality of life.

> While city growth is still the driving force behind water markets…new forces for reallocation [have] emerged. Water transfers to support wildlife, fisheries, and recreation have become more common as the role of water in supporting environmental amenities and tourism is increasingly recognized (Colby 1990, 1185).

The literature suggests that there more work is needed to completely protect the viability of fish, wildlife, and recreation from competing interests and the doctrine of prior appropriations. According to Colby (1990, 1191), one policy goal that should be considered is the broadening of the types of externalities that are considered in water

transfers. He suggests that water rights should be appropriated for in-stream uses just as they are for off-stream uses.

Water Transfers

Under the prior appropriation doctrine, surface water can also be administered by the state for different purposes and transferred between river basins. In most Western states, a water right holder can petition a state agency or court for an amendment to the right that will allow water use to be transferred. Examples of this are transferring a right used for irrigation to a right used for domestic purposes or diverting water from one basin to another. As the population continues to grow, more water use transfers will be needed to meet domestic demands. By 2025, nearly five billion people are expected to live in cities, about twice as many as 1995. If those projections hold, the urban population will represent 61% of the global population, up from 46% in 1996 (United Nations 1997).

Water transfers have long been a point of contention between environmentalists, ranchers, and urban planners. Urban planners claim,

> The American West's economic transition from ranching, irrigated farming, and mining to urban growth, services, tourism and industry brings strong incentives to transfer some water out of agriculture. The cost of reducing irrigated acreage so that water can be available for other uses is generally far less than the cost of developing new water supplies (Colby 1990, 1184).

Colby (1990, 1184) also claims that transferring only a small portion of water used for agricultural purposes would be sufficient to meet the need of nonagricultural demands. He claims that such a transfer would not harm agricultural production.

Opponents to surface water transfers argue that there could be negative consequences related to each transfer. One claim is that a transfer reduces available water for all junior water rights holders. In times of drought junior right holders would be left with a reduced water supply. Others cite diminished economic activity in communities from which the water is taken. Studies have shown that this trend is especially prevalent in small communities who depend on tourism as a primary source of income (Colby 1990, 1184).

Other opponents, such as environmental groups, state that water transfers will lead to a degradation of water quality and a diminished environment for fish and wildlife. They claim that once water is transferred from a basin of origin, there is no guarantee for a reinstatement of the water if these habitats began to erode. Most transfers can only be voided in time of drought and not for environmental reasons (Colby 1990, 1185).

Considering these arguments, some Western states have adopted policies which allow water transfers while protecting the basin of origin. Some state policies have made inter-basin transfers of surface water much tougher than they were previously. Most water transfers now require notice being given to every county judge in the entire basin, mayors and a wide host of other stakeholders (Combs 2004, 12). Most importantly, in Western states, transfers are junior to every water right already granted in the basin of origin and the first to be cut off in times of drought. This protection of seniority is significant because cities and environmental groups are now actively seeking water supplies that will be reliable even during dry years. Urban planners have begun to petition senior right holders for the use of their water. A premium has been placed on rights with the highest priorities (Colby 1990, 1185).

Some economists have argued against overregulation of such transfers. In some states, policy induced transaction costs, such as large export fees and higher sales tax rates for the purchase of water, have been placed on proposed transfers. Colby (1990, 1186) states that water market transactions are undertaken for economic gain, based on the perception that water supplies will generate higher returns in their new use than in their former use. The power to erode expected gains through imposing transaction costs, however, should be resisted. Instead, he argues that a level of maximum social marginal costs should be achieved if a state is to encourage reasonable inter-basin transfers.

> Social welfare is maximized when water transfers occur to the point where the marginal social benefits of transferring one more acrefoot [of water] equals the marginal social costs. Given the public good nature of many water uses and pervasive externalities associated with water transfer, private marginal costs of water transfers are likely to diverge from social marginal costs (Colby 1990, 1186).

An additional policy induced transaction cost used by some states is a measure that allows all affected parties in the basin of origin to legally protest the transfer. The most common legal basis for protesting a transfer is the impairment of existing water rights (Colby 1990, 1186). A study by Colby in 1990 showed that protests have a significant and positive impact on application costs per foot. The study also demonstrated that time delay, a measure of applicants' opportunity costs, is also significantly and positively related to whether or not protests are filed. The results of the study suggested that policy induced transactions costs were higher in areas where the economic values that may be affected by the proposed transfer were higher. Additionally the costs were higher in areas where water is scarce and water rights sell for a higher price (Colby 1990, 1188).

In response to Colby's study, Richard Gardner (1990, 1207) made some similar observations. He stated that the conclusions in the study were appealing because he believes water markets fail not only because of pecuniary externalities of secondary economic impacts and to public good aspects of in-stream uses but also because water markets fail to meet the competitive market requirements of complete information and profit-maximizing participants. However, Gardner did not agree with Colby's views on transaction costs. He claimed that Colby's conclusion that transitions costs are good should be dispelled. He concluded that delays in water transfers are tedious and costly. Gardner advocates improving administrative efficiency by streamlining the transfer process (1990, 1207)..

Gardner also disagreed with Colby's assumption that a competitive water market is always present. He argued that it is very rare for buyers and seller to act in the market at the same time. Marketing activity usually increases for a short time to accommodate a particular water purchase (1990, 1207). Finally, Gardner suggests the notion that maximizing economic efficiency is not society's only goal. His research showed that other cultural and social values should be considered. He argues that water administrators should consider the importance of maintaining a rural lifestyle and preserving environmental quality before approving a water transfer.

In addition to water transfers, surface water rights can be sold with minimal state review.

> A water right is a defensible property interest because the state can revoke or cancel the right if it is not used in accordance with the stipulated beneficial use, not used at all, wasted, or abandoned. However, among the most salient of the rights in the private property rights bundle, typical surface rights are in perpetuity and, most critically, water rights are clearly fungible (Hartnett White 2004, 31).

In some Western states, review of a water right sale is limited to a change of ownership form and legal documents demonstrating change of title. The sale of water rights has also come under scrutiny in the public eye because the all important priority date remains attached to any water right sold. “The priority date of the water right is the most valuable property interest in that it guarantees exercise of the right, in other words, actual diversion and use, to the exclusion of all other water rights with more junior priority dates” (Hartnett White 2004, 31). As such, the exercise of the senior water right is protected against infringement and enforcement actions through state administrators and state courts.

Conceptual Framework

The conceptual framework used for this project is descriptive categories. This framework is useful for placing different water management strategies into particular categories. This conceptual framework is the easiest and most basic to use, yet it is ideal for describing various management strategies (Shields 1998, 213). This framework is also flexible and will allow for modifications if a category becomes incomplete or incompatible (Shields 1998, 213). These descriptive categories follow the design of the literature review in this chapter. The framework is operationalized in Chapter Four.

This project discusses management strategies for both surface water and groundwater. Each category is divided into subject areas discussed in the literature. The issues described in this chapter serve as a basis for the survey used in this project. The

conceptual framework table illustrates the fundamental categories used in the discussion of water management strategies.

Tables 2.1 and **2.2** present a summary of each category and links the category to the literature used.

Table 2.1 Conceptual Framework Table for Groundwater Management

Descriptive Categories	**Sources**
• Rule of Capture • Explanation of strategy and its application • Supporting argument • Opposing argument • Current and future use of the rule for long term water planning.	Drummond et al., 2004 Durant and Holmes, 1985 Holladay, 2006 Martin, 2000 Provencher and Burt, 1994 Whittlesey and Huffaker, 1995
• Reasonable Use Doctrine • Explanation of the strategy and its application • Supporting argument • Opposing argument • Current and future use of the strategy for long term water planning	Durant and Holmes, 1985 Galano, 2003 Holladay, 2003 Martin, 2000
• Correlative Rights Doctrine • Explanation of the strategy and its application • Supporting arguments • Opposing arguments • Current and future use of the strategy for long term water planning	Bruggink, 1992 Galano, 2003 Martin, 2000
• The Restatement of Torts • Explanation of the strategy and its application • Supporting arguments • Opposing arguments • Current and future use of the strategy for long term water planning	Durant and Holmes, 1985 Galano, 2003 Ingram, 1982 Martin, 2000
• Prior Appropriations Doctrine • Explanation of the strategy and its application • Supporting arguments • Opposing arguments • Current and future use of the strategy for long term water planning	Bruggink, 1992 Durant and Holmes 1985 Galano, 2003 Holladay, 2006 Martin, 2000 Whittlesey and Huffaker, 1995

• Groundwater Management Districts • Explanation of the strategy and its applicability • Supporting arguments • Opposing arguments • Political boundaries • Geological boundaries • Regional boundaries • Current and future use of the strategy for long term water planning	Abdalla, 1994 Ackerman, 1956 Berry, 1977 Drummond et al., 2004 Durant and Holmes, 1985 Holladay, 2006 Ingram, 1982 Johnson, 2001 Martin, 2000 Pierce, 1979 Provencher, 1993

Table 2.2 Conceptual Framework Table for Surface Water Management

Descriptive categories	**Sources**
• Doctrine of Prior Appropriations • Explanation of strategy and its application • Supporting argument • Opponents argument • Rural versus urban water use • Impacts of technological advances	Armstrong, 2004 Ingram, 1982 Wescoat, 1985 Whittlesey and Huffaker, 1995
• Instream flows • Explanation of instream flows and their uses • Arguments for protecting instream flows • Argument against protecting instream flows • Water transfers to support maintaining instream flows	Colby, 1990 Hartnett White, 2004 Postel et al., 2000 Wescoat, 1985
• Water Transfers • Surface water as personal property • Beneficial use of surface water • Market forces and water transfers • Arguments for interbasin transfers • Arguments against interbasin transfers • Obstacles in obtaining water transfers	Combs, 2004 Colby, 1990 Gardner, 1990 Hartnett White, 2004

Chapter Summary

This chapter reviewed the literature available for each water management strategy. The literature discussed the applicability, strengths and weaknesses of each strategy. This chapter also introduced the conceptual framework for this project. The framework is descriptive categories. Each management strategy represents a category in

the conceptual framework. The next chapter offers a summary of water planning in Texas and connects the concepts discussed in this chapter to their applicability in Texas.

Chapter 3: Setting

Chapter Purpose

In 1997 the Texas Legislature passed Senate Bill 1. This bill divided the state into numerous regions (A-P) and required all local management entities to compile regional water plans that would project water needs for the next fifty years. The regional plans are then used to establish a state water plan. The planning process is done every five years and requires input from all stakeholders including water marketers, city planners, farmers, ranchers, developers, and numerous other entities.

The purpose of this chapter is to provide information on the water planning process in Texas. Specifically it will focus on Region I (East Texas) as described by the Texas Water Development Board.

History of Water Planning in Texas

In Texas, water rights depend on the location of water in the hydrological cycle, or the flow of water from rainfall to collection within the earth. The progression of the hydrological cycle results in the creation of two distinct types of water: groundwater and surface water. Groundwater is defined by the Texas Water Code as water percolating below the surface of the earth. Groundwater is contained in aquifers formed when water collects in permeable strata such as rock and sand. Aquifers underlie about four-fifths of Texas's surface area of 266,807 square miles. Nine major and twenty minor aquifers have been identified within the state (Martin 2000, 2). Thirty six percent of all water used for municipal purposes comes from aquifers, and 80% of water used for agriculture is groundwater (Holladay 2006, 1).

Surface water consists mainly of all water located in Texas's lakes, streams, and rivers. Surface water in Texas is owned publicly, and the use of this water is subject to the permission of state administrators. State agencies such as the Texas Commission on Environmental Quality (formerly the TNRCC and the Texas Water Board) grants users surface water permits. These permits are issued using the "prior appropriation doctrine" which gives priority to permit holders on the basis of seniority.

In contrast, groundwater is owned privately by the owner of the land above the groundwater. Texas adheres to the rule of capture. In 1904 the Texas Supreme Court adopted the rule of capture which allows a landowner to pump as much groundwater as the landowner chooses without liability to neighbors who might claim that pumping has depleted their wells. Under this doctrine, groundwater may be used without waste on overlying land as well as off site land.

The rule of capture has been upheld by the Supreme Court in 1955, 1978, and again in 1999. However, over the past century Texas policy makers have expressed concerns about the limited supply of available groundwater and have enacted certain conservation and management measures intended to curb the misuse and overuse of groundwater. After the droughts of 1910 and 1917, Texas voters approved the Conservation Amendment that helped lawmakers fight water depletion and made it clear that the responsibility for a sustainable water supply lay with the legislature (Martin 2000, 8).

After more years of drought and scientific advances in the field of groundwater detection, the Legislature used its constitutional authority to create the state's first groundwater management tools. In 1949 the legislature created a petition process in

which local entities could create taxing districts that would manage the area's available groundwater resources. These districts consisted of municipal utility districts, special utility districts, and groundwater conservation districts. The purpose of these special districts is to manage and conserve groundwater resources. The 1949 legislation also divided the state into groundwater reservoirs (now called Groundwater Management Areas or GMAs) for the purposes of groundwater management. These districts are all locally created and approved, and by 2005, Texas voters had created 84 districts which covered all or part of 138 counties (Holladay 2006, 3).

As mentioned earlier, surface water is the Texas's other primary source of usable water. Surface water is defined as any natural water found in the ordinary flow, underflow and tides of every flowing natural watercourse in the state. Natural watercourses consist of rivers, streams, lakes, and springs that form headwaters for streams (Kaiser 1998, 2). Originally, Texas adhered to the "riparian water law doctrine" which is the English system for determining a person's right to use the surface waters in a natural stream. "Under riparian law, water rights on natural streams are determined according to land ownership with rights accruing only to the owner of land adjacent to the stream. The water right is inherent in the property and continues in full force even if the water is not used" (Kaiser 1998, 2). This doctrine operates on the basis of beneficial use by a landowner. By the middle of the 20th century, however, landowners were disputing over surface water use and what constituted beneficial use.

As a result, in 1967 the Texas Legislature passed the Water Rights Adjudication Act. This legislation merged the riparian water law regime into a prior appropriation system. Under this new doctrine all surface water was put into a public trust and managed

by the state. Parties who desired a water right could petition the state by showing a history of prior beneficial use. “Petitioners were required to prove that they had used a certain amount of water from a specific stretch of a river, stream, or reservoir. State district courts then reviewed all claims and the state's recommendations for their disposition. Certificates were issued for approved claims. Each certificate was assigned a priority date, indicating the time when the water use first occurred” (TCEQ).

Despite their best efforts to manage available water resources, local water districts and the state failed to maintain resource stability and proper management during one of Texas’s worse droughts in 1996. The 1996 drought cost Texas nearly $2.4 billion in agricultural value and other economic losses (Comptroller of Texas). These losses were blamed in part on the failure of local water districts to work together on management plans. Each district was so interested in preserving its own region that there was little thought to the negative effect on neighboring districts.

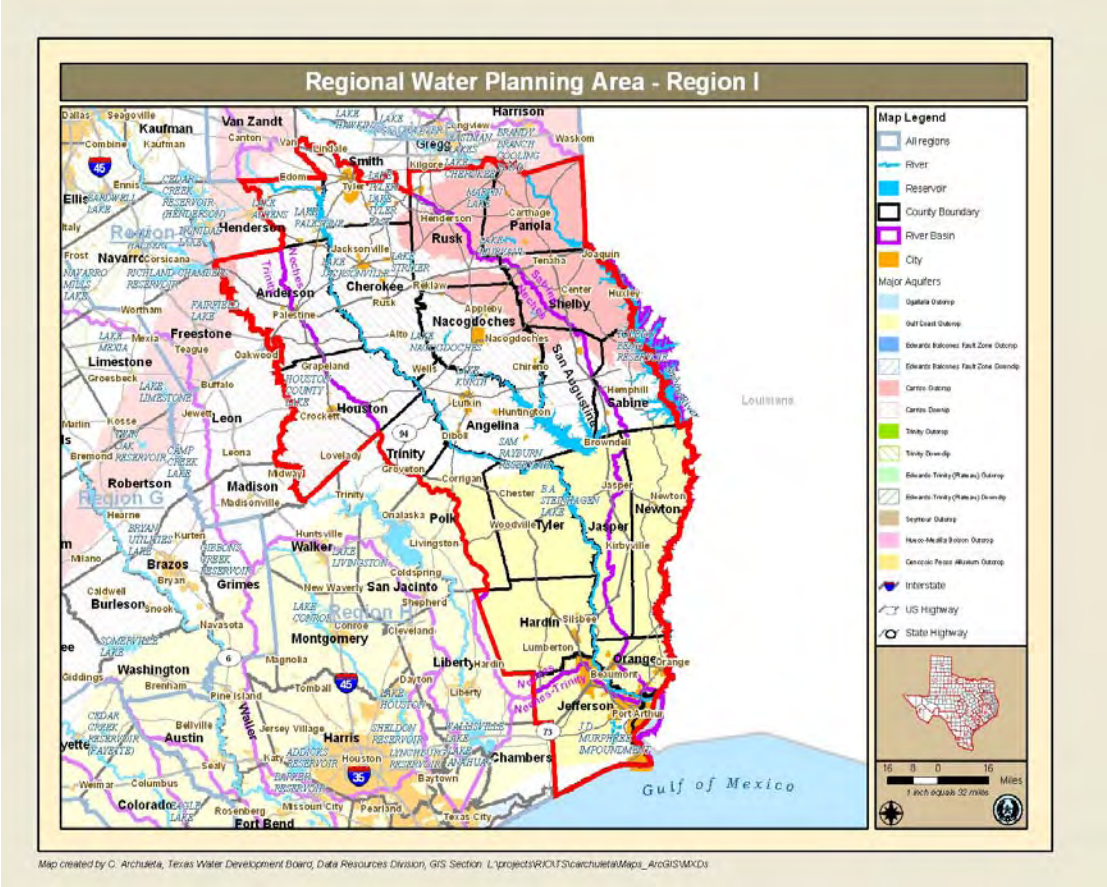
In 1985 Durant and Holmes observed that, “Texas neither integrates surface and groundwater rights nor provides a permit system for controlling excessive groundwater extraction. Moreover, state courts have consistently ruled that the doctrine of private ownership supersedes any claim that groundwater depletions have compromised surface water quantity and quality” (Durant & Holmes 1985). This perception, in conjunction with the economic losses in 1996, caused the legislature to again address water management. In 1997 the legislature passed Senate Bill 1 which created a state water plan and dictates the way water is managed in Texas.

Senate Bill 1 allowed policy makers to mobilize more efficiently during droughts. It required the Texas Water Development Board to create regional water planning groups. Each group was ordered to develop a drought contingency plan good for 50 years (Barron 2006, 29). Among other things, the plan was required to establish mandatory rationing procedures and identify backup sources of water (Martin 2000, 4). These individual plans are then approved by the Texas Water Development Board and used to create a state water plan every five years.

Region I

Region I encompasses all of East Texas which is known for its abundance of surface water. This region is composed of all or parts of twenty counties, stretching from the Golden Triangle of Beaumont, Port Arthur, and Orange in the south to Tyler in the north and from the Texas-Louisiana border in the east to the Trinity River Basin boundary in the west. These counties include Anderson, Angelina, Cherokee, Hardiu, Henderson, Houston, Jasper, Jefferson, Nacogdoches, Newton, Orange, Panola, Polk, Rusk, Sabine, San Augustine, Shelly, Smith, Trinity, and Tyler. **Image 3.1** illustrates the location, river basins, and aquifers of Region I.

Image 3.1 Region I



According to the Texas Water Development Board, approximately four percent of the state's population is projected to live in the East Texas Region in 2010. By 2060, the region's population is projected to grow thirty six percent, and water demands in the region are projected to increase forty one percent. The region includes three cities with populations of 50,000 or more and five cities with populations of 10,000 or more. **Table 3.2** shows the Texas water Development Board's population growth predictions for the largest cities in Region I.

Table 3.1 Region I Growth Predictions

City	2000	2004[1]	2010[2]	2060[2]
Beaumont	113,866	113,866	113,866	113,866
Tyler *(Within East Texas Region)*[3]	83,650 *82,927*	86,018 *85,089*	89,571 *88,332*	119,994 *116,102*
Port Arthur	57,755	57,755	57,755	57,755
Nacogdoches	29,914	31,166	33,044	54,345
Lufkin	32,709	34,513	37,219	70,997
Region Total[2]	***317,171***	***322,389***	***330,216***	***413,065***

[1] Interpolated between 2000 census figures and 2010 projections..
[2] 2010 and 2060 projections as approved by the TWDB including several revisions approved November 3, 2003 at the request of East Texas Region.
[3]East Texas Region component disaggregrated from total Tyler population by East Texas Region subconsultants.

* Chart created by East Texas Regional Water Planning Group

According to the latest information available using Water Availability Models, surface water supplies comprise the region's largest source of water. In this region, surface water accounts for 80% of the existing water supply. The region has fifteen reservoirs which provide 1,945,245 acre/feet of water per year. All river water in the region comes from the Naches, Sabine, and the Trinity River Basins. Available river water amounts to 1,658,986 acre/feet per year.

Most of the region falls within the Neches River basin. This basin accounts for the majority of surface water available in East Texas. The Sabine River serves as a border between Texas and Louisiana. This river begins in the Dallas area and flows through East Texas. Nearly one fourth of the river's drainage basin is in Louisiana. The Trinity River

flows through two counties in Region I and accounts for a small portion of the available surface water.

Region I draws groundwater from two major aquifers, the Carrizo-Wilcox and the Gulf Coast, and three minor aquifers, the Queen City, Sparta, and Yegua-Jackson. These aquifers provide 442,270 acre/feet per year.

The Gulf Coast aquifer follows the borders of Florida to Mexico through the Gulf of Mexico. In Texas, the aquifer provides water to 54 counties and extends from the Rio Grande northeastward to the borders with Louisiana and Arkansas. The Gulf Coast aquifer provides the sole source of groundwater in the seven southern counties in Region I (ETRWPG 2006, 1-15).

The Carrizo-Wilcox aquifer extends from the Rio Grande in south Texas northeastward into Arkansas and Louisiana. The aquifer provides water to 60 counties in Texas, including Smith, Nacogdoches, and Angelina counties (ETRWPG 2006, 1-16).

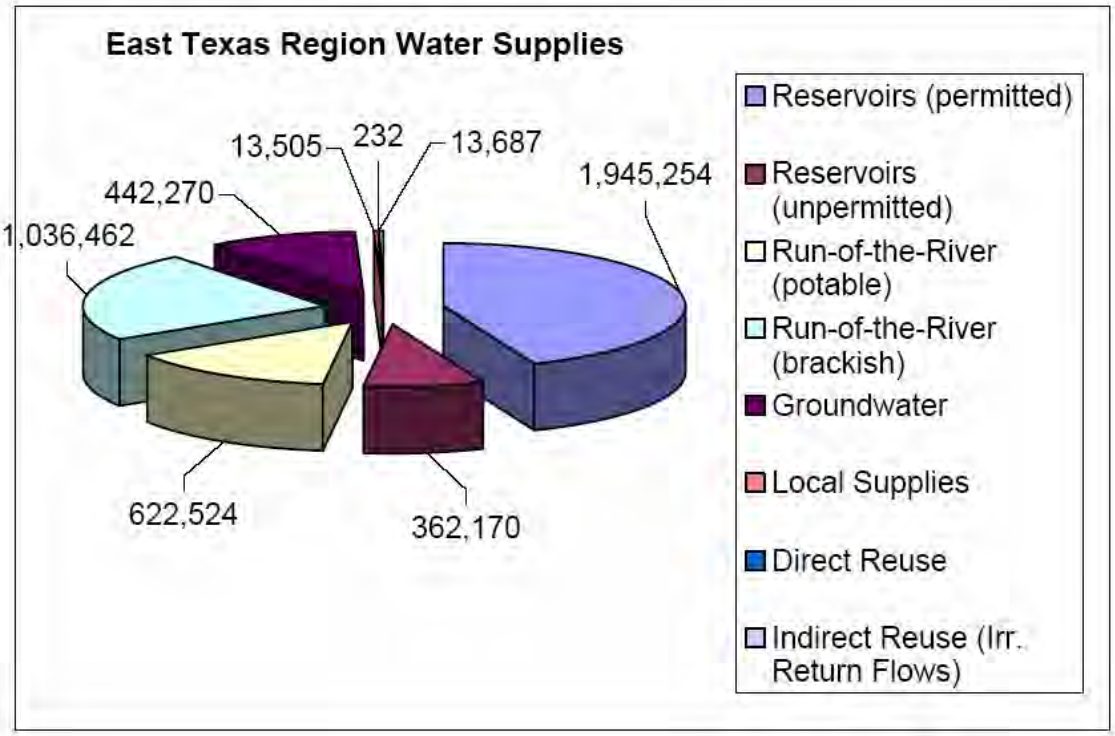
The Sparta aquifer extends in a narrow band across Texas from the Frio River in South Texas northeastward to the Louisiana border in Sabine County. Large amounts of usable quality groundwater are contained within the Sparta aquifer (ETRWPG 2006, 1-17). This aquifer has been a stable source of groundwater in East Texas for a long time.

The Yegua-Jackson aquifer extends in a narrow band from the Rio Grande to Louisiana. In the East Texas Region the aquifer is located in the southern half of Sabine and San Augustine counties, the lower tip of Nacogdoches county, most of Angelina county and in those portions of Polk and Trinity counties located in the East

Texas Region (ETRWPG 2006, 1-17). This aquifer also provides a significant amount of ground water to the region.

Table 3.3 illustrates the sources of water available in Region I.

Table 3.3



* Chart created by East Texas Regional Water Planning Group

The primary forms of industry in the region are agriculture, mineral production, and the manufacturing components of the petrochemical and timber industry. These activities require substantial amounts of water to be viable. **Table 3.4** lists the industries and major irrigated crops in Region I.

Table 3.4 Major water users in Region I

Industries	Crops
Petroleum Refining	Rice
Chemical and Allied Products	Soybeans
Lumber and Wood	Hay
Food and Kindred	Vegetables
Power Generation	Cotton

* Chart created by East Texas Regional Water Planning Group

This region is also in competition with the cities of Houston and Dallas for its surface water supplies. Both municipalities are growing at a rapid pace and have an increased water demand. Available surface water in East Texas could meet this demand, but most water right holders in Region I are senior to both cities.

Chapter Summary

This chapter discussed the history of water planning in Texas. It also offers some specific information on Region I. The purpose of this chapter was to connect the issues discussed in the literature review to their applicability in Texas. The next chapter describes the methodology used in this project. Surveys were used to operationalize the conceptual framework.

Chapter 4: Methodology

Chapter Purpose

This chapter connects the literature on water management and the conducted survey. The research examines the attitudes of stakeholders in Region I on current water management strategies. The research design and methodology are also described in this chapter.

Operationalization of the Conceptual Framework

The methodology used in the project is survey research. This type of research is easily linked to the descriptive categories framework (Shields 1998, 214).The questions used in the survey reflect the descriptive categories and the literature available on the categories. The questions are designed to opetrationalize issues, strengths, and weaknesses associated with each management strategy as addressed in the literature.

For this survey, each groundwater management strategy is separated into its own category in the survey. The different management strategies used in this survey are rule of capture, reasonable use, correlative rights, restatement of torts, prior appropriations, and groundwater districts. On the subject of surface water the categories are the doctrine of prior appropriations, instream flows, and water transfers. The categories are then divided into sections that reflect the issues outlined in the conceptual framework table (**Table 2.1**). Next each category is operationalized by making statements about each management strategy's issues. Each question is designed to examine how stakeholders rate the usefulness or necessity of a particular management strategy. **Tables 4.1** and **4.2**

list each descriptive category and show how the conceptual framework is operationalized in the survey.

Table 4.1 Survey on Groundwater Management Strategies

Rule of Capture	
• Explanation of strategy and its application	The rule of capture is a responsible practice for resource management.
• Supporting argument	Strict adherence to the rule of capture is a property right and should be allowed in any regional water plan..
• Opposing argument	The rule of capture is an antiquated management strategy that should be replaced with a more responsible strategy.
• Current and future use of the rule for long term water planning	The rule of capture is a useful part of long term resource planning
Reasonable Use	
• Explanation of the strategy and its application	The reasonable use doctrine is a responsible management strategy that should be used in East Texas.
• Supporting argument	Adherence to the reasonable use doctrine will provide a responsible way to limit waste and resource misuse.
• Opposing argument	The reasonable use strategy should be implemented in East Texas even if neighboring states do not adhere to reasonable use.
• Current and future use of the strategy for long term water planning	The reasonable use doctrine is a useful part of long term resource planning.
Correlative Rights	
• Explanation of the strategy and its application	Adherence to the correlative rights doctrine is a way to properly manage conflicting interests within one aquifer.
• Supporting argument	Allowing state courts to appropriate water is an equitable way to distribute resources.
• Opposing argument	Allowing state courts to arbitrarily reduce water allocations does not recognize that some water uses are more beneficial than others.
• Current and future use of the strategy for long term water planning	The correlative rights doctrine is a useful part of long term resource planning.
Restatement of Torts	
• Explanation of the strategy and its application	Water rights should be appropriated based on a users beneficial use of the resource.

Restatement of Torts (cont.)	
• Supporting argument	Anticipatory water rights should be considered by administrative agencies as a form of beneficial use.
• Opposing argument	One type of water use should not gain priority over another based on beneficial use.
• Current and future use of the strategy for long term water planning	The restatement of torts is a useful part of long term resource planning
Prior Appropriations	
• Explanation of the strategy and its application	Users who can exhibit a record of historical use should also provide a record of beneficial use.
• Supporting argument	Users who can exhibit a record of historical use should have priority over newer users.
• Opposing argument	During a time of drought, junior and senior water right holders should have equal access to the resource.
• Current and future use of the strategy for long term water planning	The prior appropriations doctrine is a useful part to long term resource planning
Groundwater Districts	
• Explanation of the strategy and its application	Groundwater districts are a responsible management tool for a region as large as East Texas.
• Supporting argument	Groundwater districts should allow historical users larger pumping allotments.
• Opposing argument	Resource management through groundwater districts erodes private property rights.
• Political boundaries	Groundwater district boundaries should be consistent with political boundaries.
• Geological boundaries	Groundwater district boundaries should be consistent with geological boundaries.
• Regional boundaries	Groundwater district boundaries should be expanded to incorporate larger areas such as “regions” (as designated by the Texas Water Development Board).
• Current and future use of the strategy for long term water planning	Groundwater districts are a useful part to long term resource planning.

Table 4.2 Survey on Surface Water Management Strategies

Doctrine of Prior Appropriations	
• Explanation of the strategy and its application	The doctrine of prior appropriations protects the private economic interests of individuals in East Texas but does little for the broader public interest.
• Supporting argument	Surface water rights should be appropriated based on necessity and beneficial use and not seniority.
• Opposing argument	The theory of "first in time first in right" is an outdated practice and does not account for urban growth.
• Rural versus urban water use	Pressure from growing urban communities is eroding the rights of senior water rights holders.
• Impacts of technological advances	Technological advances will eventually diminish the value of senior water right holders in East Texas.
Instream Flows	
• Explanation of insream flows and their uses	The State of Texas should appropriate water rights for the purpose of maintaining sufficient instream flows.
• Arguments for protecting instream flows	Water that maintains instream flows are a vital part of the environment and should be held in the same regard as commercial water use.
• Argument against protecting instream flows	Instream flows should not be given the same priority as agricultural and urban interests.
• Water transfers to support maintaining instream flows	Water transfers to support wildlife, fisheries, and recreation should become more commonly recognized.
Water Transfers	
• Surface water as personal property	Surface water rights should be treated as personal property, and owners should be able to use the water to its maximum benefit.
• Beneficial use of surface water	The surplus of surface water in East Texas could be better used by transferring its use to more populated areas of the state.
• Market forces and water transfers	Market forces should be able to play a role in determining if water use transfer should be allowed.
• Argument for interbasin transfers	Interbasin transfers are a necessary tool for long term resource management.
• Argument against interbasin transfers	Interbasin transfers should not be subject to junior water right provisions.
• Obstacles in obtaining water transfers	Obtaining a water use transfer from a regulatory authority is too difficult and requirements should be relaxed

Respondents are asked to rate each statement with the response of strongly agree, agree, neutral, disagree, or strongly disagree

The surveys were sent to respondents electronically using www.surveymonkey.com. Each participant was sent a survey along with a brief description of each management strategy. The respondent was then asked to answer the survey questions and results were then available. The respondents were also reminded via email about the survey one week before the data was processed.

Advantages of Survey Research

Survey research is a popular method for data collection among scholars and professionals. One advantage to using survey research is the ability to reach a large number of stakeholders efficiently and at a reasonable cost (Sinclair 2005, 52). By accessing available lists of elected officials, city managers, groundwater district managers, environmental interest groups, and agricultural interests, this project is able to efficiently reach the target group of East Texas water stakeholders.

Survey research also offers the possibility of making refined descriptive assertions of the selected group (Babbie 2000, 274). The results of the survey illustrate the overall opinions of East Texas water management stakeholders.

Another advantage of survey research is the respondent's guarantee of anonymity. Anonymity in this survey allows the stakeholder to express opinions that may not have been represented during the regional planning process. The East Texas Regional Water Planning Group conducts its meeting in accordance with the Texas Open Meeting Act. Under these provisions all activity and opinions expressed throughout the planning process must be made public. Using the anonymity of survey research to ask similar

questions that may have been discussed during the planning process allows for a freer expression of opinions

Disadvantages of Survey Research

There are some disadvantages associated with survey research. One such weakness is possibility of a low response rate. There is little incentive for participants to answer the survey. As a result, there is a distinct possibility of bias when few surveys are returned.

Additionally, Babbie (2000) states that creating standard questions for respondents is not always the most effective way to obtain information. "By designating questions that will be at least minimally appropriate to all respondents, you may miss what is most appropriate to many respondents" (2000, 247). Survey research rarely deals with the context of social life and, therefore, is sometimes inflexible. This methodology can provide information about the topic being studied. However, it cannot obtain subjective information that a respondent might want to add.

Sample

For this project, a target group of stakeholders was identified which included elected officials, city administrators, water managers, environment interests groups, and agricultural interests. Each stakeholder group previously participated in the East Texas regional water planning process. The Texas Water Development Board identifies these groups as crucial to the water planning process (ETRWP 2006, 4). One additional stakeholder group identified by the Texas Water Development Board is electric

generating utilities. Stakeholders from this group did not receive surveys due to the difficulty in obtaining contact information for every utility.

Surveys were sent to all twenty county judges in Region I, city administrators in all twenty county seats, the general managers of all six groundwater conservation districts in Region I, the general managers of all four river authorities in Region I, twenty members of the region's division of the Sierra Club (one person from each county), and twenty members of the region's division of the Texas Farm Bureau (one from each county). Individuals' contact information was easily attainable through government websites and through association directories.

The number of people who have an intimate knowledge of water resource management in East Texas is relatively small; therefore, the sampling method used in this project was purposive. Purposive sampling should be used when the individuals being studied have a particular interest or expertise in the field (Helmle 2005, 54). The individuals used in this study have a specific background in water management and therefore fit well with this sampling method,

Anonymity of Respondents

The surveys were administered under the strictest form of anonymity. The only person who saw the responses was the individual administering the survey. The website used to administer the surveys ensures anonymity of all parties including the survey administrator. The website used sends an email to each participant asking them to participate in a survey. The stakeholders could then open the link and answer the attached

survey. Upon completion all responses were calculated, but no information about the respondent was released.

This project also received an exemption from the IRB review board. This project in no way harmed, caused potential harm, or compromised any participants.

Statistics

For this survey, descriptive statistics are used. Respondents are asked to rate each statement with the response of strongly agree, agree, neutral, disagree, or strongly disagree. Responses of strongly agree and agree are combined and computed for percentage of total responses. Neutral responses are computed for percentage of total responses. Disagree and strongly disagree are combined and computed for percentage of total responses. The mode for each survey question is also recorded.

Chapter Summary

This chapter described the survey which was administered and how it is connected to the conceptual framework. Questions were asked of each respondent to assess his conception of the usefulness of each water management strategy. The responses were then collected and organized into charts that indicate which strategies are most useful. The results of the surveys are discussed in the next chapter.

Chapter 5: Results

Chapter Purpose

This chapter examines the results for the conducted survey. The purpose of this survey is to assess the opinions of water management strategies by stakeholders in East Texas. The survey asks questions about surface and groundwater strategies. The data has been collected and organized in tables by management strategy. The results are then discussed.

Description of Survey Results

A total of ninety surveys were sent out via email. The surveys were sent out to individuals who have a vested interest in water management in East Texas. A total of thirty four responses (or 38%) were returned. According to Babbie (2004), due to the low response rate, there is a significant chance for bias. **Table 5.1** shows the response rate for each stakeholder group.

Table 5.1 Stakeholder Response Rate

Stakeholder Group	Number of Responses Received
County Judges	7
City Administrators	12
Farmers	6
Sierra Club Members	5
Groundwater District Managers	2
River Authority Managers	2

The responses of strongly agree and agree were combined together and calculated for percentage of total responses. The Neutral responses were calculated for percentage

of total responses. The responses of disagree and strongly disagree were combined and calculated for percentage of total responses. **Tables 5.2** through **5.10** provide modes and percentages from respondents' answers to survey questions.

Rule of Capture

Respondents were asked to rate their opinion about statements on the rule of capture. The statements reflected some of the general perceptions of the rule and of some arguments for and against the rule. The statements were designed to operationalize issues discussed in the literature. **Table 5.2** shows the results from the survey on the rule of capture.

Table 5.2 Management by the Rule of Capture

Rule of Capture	N	Strongly Agree-Agree	Neutral	Disagree-Strongly disagree	Mode
The rule of capture is a responsible practice for resource management.	34	59%	6%	35%	Agree
Strict adherence to the rule of capture should be a component to any regional water plan.	34	53%	9%	38%	Agree
The rule of capture is an antiquated management strategy that should be replaced with a more responsible strategy.	34	38%	6%	56%	Disagree
The rule of capture is a useful part of long term resource planning.	34	38%	27%	35%	Agree

That data indicates a preference for management by the rule of capture. Fifty nine percent of respondents agreed that the rule was a responsible method for managing available groundwater, while only 38% thought the rule was outdated and in need of change. To a lesser extent, stakeholders in East Texas think the rule of capture should be

strictly adhered to. It is interesting to note that while over half of respondents agree that the rule is a responsible practice, only 38% think that it should be used for long term planning. This variance could be attributed to the area's relatively small amount of groundwater. Region I draws only 20% of its water from the ground. Perhaps the respondents have little interest or knowledge of the rule of capture and how it can affect aquifer stability.

Reasonable Use

Respondents were asked to rate their opinion on statements about groundwater management through reasonable use. The survey was designed to illustrate strengths and weaknesses of this strategy as illustrated in the literature. Management through reasonable use limits a landowner's use of groundwater for reasonable purposes on his own land. **Table 5.3** shows results from the survey on the reasonable use management strategy.

Table 5.3 Management by Reasonable Use

Reasonable Use	N	Agree-Strongly Agree	Neutral	Disagree-Strongly Disagree	Mode
Reasonable use is a responsible management strategy that should be used in East Texas.	34	53%	12%	35%	Agree
Adherence to reasonable use will provide a responsible way to limit waste and resource misuse.	34	15%	9%	76%	Disagree
The reasonable use strategy should be implemented in East Texas even if neighboring states do not adhere to reasonable use.	34	29%	6%	65%	Disagree
The reasonable use strategy is a useful part of long term resource planning.	34	38%	21%	41%	Disagree

These results indicate slightly less support for reasonable use than the rule of capture. There seems to be a strong disagreement that the strategy would be beneficial if neighboring states did not use this strategy (65%). The literature points out that when two neighboring states do not adhere to the strategy, one state will see their resources diminish. Region I adjoins the Louisiana border; this might explain the disagreement with the use of this strategy. It should be noted that only 41% of respondents thought the reasonable use strategy was not useful for long term planning, but 38% did. There was also a high amount of neutral responses. This might be attributed to the foreign nature of this idea. This strategy is not currently employed anywhere in Texas.

Correlative Rights

Respondents were asked to rate their opinion on statements about groundwater management through correlative rights. Under this management strategy the authority to allocate water is held by the courts. As a result, owners of overlying land and non-owners or transporters have co-equal or correlative rights in the reasonable, beneficial use of water. **Table 5.4** shows the results for the survey on the correlative rights strategy.

Table 5.4 Management by Correlative Rights

Correlative Rights	N	Strongly Agree-Agree	Neutral	Disagree-Strongly Disagree	Mode
Adherence to the correlative rights strategy is a way to properly manage conflicting interests within one aquifer.	34	24%	11%	65%	Disagree
Allowing state courts to appropriate water is an equitable way to distribute resources.	33	45%	19%	36%	Agree
Allowing state courts to arbitrarily reduce water allocations does not recognize that some water uses are more beneficial than others	34	68%	11%	21%	Agree
Water distribution by correlative rights is a useful part of long term resource planning.	34	24%	20%	56%	Disagree

Less that a half of the respondents agreed that the courts should appropriate water. A much larger percentage doesn't think that courts are the appropriate entity to manage conflicts in groundwater. An even larger percentage thinks that courts should not be able to cut pumping allotments during times of drought. The literature states that one argument against this strategy is allowing the courts to arbitrarily decide what water uses are more important than others during a drought. The survey indicates that stakeholders in Region I agree that a court room is not the proper place to administer and decrease water rights. This survey also indicates that over half of the respondents do not think the correlative rights management strategy is a useful part of long term planning.

Restatement of Torts (Beneficial Use)

Respondents were asked to rate their opinion on statements about the restatement of torts groundwater management strategy. Under this strategy, allocation of groundwater is not determined by the size of a tract of land. This rule allows courts and state agencies to consider the proposed use of water and whether that use is more beneficial than others. **Table 5.5** shows the results for the survey on management by the restatement of torts.

Table 5.5 Management by the Restatement of Torts Strategy

Restatement of Torts	N	Strongly Agree-Agree	Neutral	Disagree-Strongly Disagree	Mode
Water rights should be appropriated based on a user's beneficial use of the resource.	34	24%	20%	56%	Disagree
Anticipatory water rights should be considered by administrative agencies as a form of beneficial use.	34	24%	23%	53%	Disagree
One type of water use should not gain priority over another based on beneficial use.	34	71%	12%	17%	Agree
The restatement of torts is a useful part of long term resource planning.	34	18%	26%	56%	Disagree

This survey indicates that the majority of respondents do not agree with the principles of the restatement of torts management strategy. Seventy-one percent of respondents do not think that a preference should be given to one use of water over another. Over half of the respondents do think that anticipatory water rights should be recognized or honored by state courts or administrative agencies. Fifty-six percent of respondents do not think the restatement of torts management strategy is a useful part of long term planning. These numbers show a strong disapproval of the restatement strategy. Opponents to this strategy argue that the restatement of torts dissolves private property rights and replaces it with an administrative decision and definition of beneficial use. The results of this survey indicate that respondents may agree with this argument.

Prior Appropriations

Respondents were asked to rate their opinion about statements on groundwater management by the prior appropriations strategy. This management strategy states that the first landowner to beneficially divert or use water from a groundwater source is granted a priority of right. The oldest rights are considered to be senior to newer junior rights, and, therefore, receive a higher priority. **Table 5.6** shows the results for the survey on groundwater management by the prior appropriations strategy.

Table 5.6 Management by the Prior Appropriations Strategy

Prior Appropriations	N	Strongly Agree-Agree	Neutral	Disagree-Strongly Disagree	Mode
Users who can exhibit a record of historical use should also provide a record of beneficial use.	34	29%	6%	65%	Disagree
Users who can exhibit a record of historical use should have priority over newer users.	34	76%	6%	18%	Agree
During a time of drought, junior and senior water right holders should have equal access to the resource.	34	26%	6%	68%	Disagree
The prior appropriations doctrine is a useful part to long term resource planning.	33	55%	21%	24%	Agree

This survey shows that over half of the respondents support the prior appropriations strategy. Stakeholders in Regions I place a strong importance on the historical use of water. Three of every four respondents agree that landowners who can exhibit a record of historical use should have priority over newer users. Over half of the respondents, however, did not think the historical use must be considered beneficial to gain priority. This might be attributed to the fact that there is no clear understanding of what constitutes a beneficial use. Some argue municipal uses are more beneficial that agricultural. Others argue the opposite. It is clear, though, that stakeholders in Region I place an importance on historical use instead of beneficial use. Sixty-eight percent of respondents also think historical users should have a priority of right in times of drought. It is interesting to note that for this survey, there are a low number of neutral opinions. This seems to indicate that this issue is important to Region I.

Groundwater Districts

Respondents of this survey were asked to rate their opinions on statements about groundwater management districts. These districts are created by local voters and can

limit pumping, limit exportation, and limit the number of wells a landowner can have on his property. The statements used in this survey were created in response to some of the issued raised in the literature including increased government regulation, historical use, and the debate over political versus geographical boundaries. **Table 5.7** shows the results from the survey on groundwater district management.

Table 5.7 Management by Groundwater Management Districts

Groundwater Districts	N	Strongly Agree-Disagree	Neutral	Disagree-Strongly Disagree	Mode
Groundwater districts are a responsible management tool for a region as large as East Texas.	34	35%	24%	41%	Disagree
Groundwater districts should allow historical users larger pumping allotments.	34	53%	18%	29%	Agree
Resource management through groundwater districts erodes private property rights.	34	44%	15%	41%	Agree
Groundwater district boundaries should be consistent with political boundaries.	34	59%	9%	32%	Agree
Groundwater district boundaries should be consistent with geological boundaries.	34	38%	18%	44%	Disagree
Groundwater district boundaries should be expanded to incorporate larger areas such as “regions” (as designated be the Texas Water Development Board).	34	24%	14%	62%	Disagree
Groundwater districts are a useful part to long term resource planning.	34	62%	17%	21%	Agree

The results from this survey show that a there is not a large difference between landowners who think groundwater districts erode private property rights (44%) and those who do not (41%). This result is intriguing because in a previous portion of the survey over half of the respondents thought that the rule of capture was a responsible way of managing groundwater. One argument against groundwater management districts is that the districts contradict the rule of capture. Management districts limit a landowner’s

ability to determine the use of his underlying groundwater. This survey indicates that a majority of stakeholders favor the rule of capture but do not necessarily agree that groundwater districts erode their private property rights. These two opinions seem to contradict themselves.

The survey also illustrates that stakeholders think historical users should receive priority under district rules. This finding is consistent with the question found in the prior appropriations strategy.

This survey also shows a preference for political boundaries for management districts (59%). When asked about geological boundaries, however, only nearly half of the respondents said they disagreed. The concept of boundaries should be further explored in future research.

The survey also showed strong agreement (62%) that groundwater districts were a useful tool for long-term resource planning. It should be noted, however, that Region I has only six groundwater districts for twenty counties. The majority of groundwater in Region I is not protected by a groundwater district.

Doctrine of Prior Appropriations for Surface Water Management

Respondents of this survey were asked to rate their opinion on statements about the doctrine of prior appropriations for surface water. The doctrine of prior appropriations allows the first user on a stream to obtain a priority over all other subsequent users. Under the system all surface water is placed in a public trust maintained by the state. Each potential user must apply for a right from a state administrative agency or court. An applicant must exhibit a history of beneficial use in order to receive a water right from the

state. Applicants who prove the longest history of beneficial use receive rights that are senior in priority to newer users. In a time of drought, junior water rights are the first to be cut off by the state ensuring senior water rights are fulfilled.

The statements for this survey were developed from the literature. The survey covers important issues such as junior versus senior water rights, urban growth and its impact on surface water demand, and technological advances in surface water management. **Table 5.8** shows the results from the survey on the doctrine of prior appropriations.

Table 5.8 Doctrine of Prior Appropriations

Doctrine of Prior Appropriations	N	Strongly Agree-Agree	Neutral	Disagree-Strongly Disagree	Mode
The doctrine of prior appropriations protects the private economic interests of individuals in East Texas but does little for the broader public interest.	33	24%	24%	52%	Disagree
Surface water rights should be appropriated based on necessity and beneficial use and not seniority	34	15%	9%	76%	Disagree
The theory of "first in time first in right" is an outdated practice and does not account for urban growth.	34	26%	9%	65%	Disagree
Pressure from growing urban communities is eroding the rights of senior water rights holders.	34	79%	12%	9%	Agree
Technological advances will eventually diminish the value of senior water right holders in East Texas.	34	53%	18%	29%	Agree

The results from this survey indicate a strong preference for the senior/junior water rights system (65%). One in every four respondents expressed a preference for senior water rights over beneficial rights. Eighty percent of the water in Region I is surface water. Stakeholders place a high priority on senior water rights because they are competing with the cities of Dallas and Houston for East Texas's surface water. Both

municipalities have an increasing demand for surface water, and Region I has an abundance of water. Some argue that the water would serve a more beneficial use in the city, but stakeholders in Region I would argue their needs should receive first priority.

Not surprisingly, seventy-nine percent of respondents agree that urban growth and increased demand for water is eroding Region I's priority rights. This survey also shows that respondents feel technological advances in water management may diminish the value of their water rights.

Instream Flows

Respondents of this survey were asked to rate their opinion on statements about instream flows. Instream flows are defined as the stream flows needed to protect and preserve instream resources such as fish, wildlife, and recreation (Washington Department of Ecology). This survey is designed to address some of the environmental concerns raised in the debate over protection of instrem flows. **Table 5.9** shows the results from the survey on instream flows.

Table 5.9 Instream flows

Instream Flows	N	Strongly Agree-Agree	Neutral	Disagree-Strongly Disagree	Mode
The State of Texas should appropriate water rights for the purpose of maintaining sufficient instream flows.	34	47%	21%	32%	Agree
Water that maintains instream flows are a vital part of the environment and should be held in the same regard as commercial waster use.	34	41%	24%	35%	Agree
Instream flows should not be given the same priority as agricultural and urban interests.	34	71%	11%	18%	Agree
Water transfers to support wildlife, fisheries, and recreation should become more commonly recognized.	34	35%	21%	44%	Disagree

About half of the respondents agree that Texas should place a higher priority on protecting instream flows by appropriating water for that purpose. It should be noted that in 2005 the Texas Legislature published a report advocating the protection of instream flows. The survey also shows strong preference for placing urban and agricultural uses above protecting instream flows (71%), but less than half of respondents think commercial uses should receive priority. Lastly, the survey results state that environmental concerns should not become more commonly recognized, but twenty-one percent of respondents were neutral on the issue.

Water Transfers

Respondents were asked to rate their opinion on statements about water transfers. Under the prior appropriation doctrine, surface water can also be administered by the state for different purposes and transferred between river basins. In most western states, a water right holder can petition a state agency or court for an amendment to the right that will allow water use to be transferred. Examples of this are transferring a right used for irrigation to a right used for domestic purposes or diverting water from one basin to another. **Table 5.10** shows the results from the survey on water transfers.

Table 5.10 Water Transfers

Water Transfers	N	Strongly Agree-Agree	Neutral	Disagree-Strongly Disagree	Mode
Surface water rights should be treated as personal property, and owners should be able to use the water to its maximum benefit.	34	74%	11%	15%	Agree
The surplus of surface water in East Texas could be better used by transferring its use to more populated areas of the state.	34	12%	9%	79%	Disagree
Market forces should be able to play a role in determining if water use transfer should be allowed.	34	21%	17%	62%	Disagree
Interbasin transfers are a necessary tool for long term resource management.	34	26%	26%	48%	Disagree
Interbasin transfers should not be subject to junior water right provisions.	34	12%	6%	82%	Disagree
Obtaining a water use transfer from a regulatory authority is too difficult and requirements should be relaxed	34	26%	21%	53%	Disagree

This survey illustrates the emphasis Region I puts on keeping its water in East Texas. A large amount of respondents (79%) favor preventing water transfers to other parts of the state, and eight out of every ten respondents think that water transfers should be subject to senior water right provisions. There is also a large number of respondents (74%) who think surface water should be treated as personal property and water right holders should be able to determine the water's beneficial use.

This survey, like the one on prior appropriations, illustrates a strong desire to keep the region's surface water within East Texas. This survey generated the strongest responses in favor of one policy over another. The survey results deliver a clear message about the stakeholders' priorities. Region I does not favor unfettered interbasin transfers, and stakeholders feel they should be able to determine the most beneficial use of surface water.

Chapter Summary

This chapter summarized the results of the surveys distributed. The responses were calculated for percentage of total responses. The mode of each survey question was also noted. A total of thirty-four surveys were returned and calculated for this chapter. The next chapter summarizes the research and makes recommendations for water planning in East Texas.

Chapter 6: Conclusion

Chapter Purpose

The purpose of this chapter is to summarize the findings from the research project. This chapter makes conclusions about East Texas stakeholders and their opinions on different water management strategies. This chapter also makes recommendations for water planning in Region I and discusses steps for future research.

Summary of Research

The purpose of this project was to do the following: describe the various management strategies for both groundwater and surface water as discussed in the literature; examine the attitudes of stakeholders in Region I about water management strategies; make recommendations to improve current management strategies to ensure long-term water sustainability in East Texas.

Information on water management was collected from a selection of scholary publications. Six groundwater and three surface water management strategies were identified from the literature. Each management strategy was further researched and organized into categories. A conceptual framework was then designed using the categories of management strategies discussed in the literature.

A setting chapter described the history of water planning in Texas and offered specific information about Region I. This chapter was designed to link the literature review with its relevance to Texas. The discussion revealed that Texas relies on the rule of capture and groundwater district for groundwater management and the doctrine of

prior appropriations for surface water management. Region I is also discussed and why it was the subject of this project.

Next a survey was designed to operationalize the conceptual framework. The survey asked stakeholders to express their opinions on statements regarding management strategies. Each statement was designed from issues discussed in the literature. The statements were created to operationalize issues and perceptions about each strategy.

The survey was sent to elected officials, groundwater district and river authority managers, city administrators, environmentalists, and agricultural interests. A total of ninety surveys were sent out and thirty-four were returned. The data was then collected and summarized. **Tables 6.1** and **6.2** offer a summary of the survey results

Table 6.1 Summary of Groundwater Management Responses

Survey Statement	Mode
Rule of Capture	
The rule of capture is a responsible practice for resource management.	Agree
Strict adherence to the rule of capture should be a component to any regional water plan.	Agree
The rule of capture is an antiquated management strategy that should be replaced with a more responsible strategy.	Disagree
The rule of capture is a useful part of long term resource planning.	Agree
Reasonable Use	
Reasonable use is a responsible management strategy that should be used in East Texas.	Agree
Adherence to reasonable use will provide a responsible way to limit waste and resource misuse.	Disagree
The reasonable use strategy should be implemented in East Texas even if neighboring states do not adhere to reasonable use.	Disagree
The reasonable use strategy is a useful part of long term resource planning.	Disagree
Correlative Rights	
Adherence to the correlative rights strategy is a way to properly manage conflicting interests within one aquifer.	Disagree
Allowing state courts to appropriate water is an equitable way to distribute resources.	Agree
Allowing state courts to arbitrarily reduce water allocations does not recognize that some water uses are more beneficial than others	Agree
Water distribution by correlative rights is a useful part of long term resource planning.	Disagree
Restatement of Torts	
Water rights should be appropriated based on a user's beneficial use of the resource.	Disagree
Anticipatory water rights should be considered by administrative agencies as a form of beneficial use.	Disagree
One type of water use should not gain priority over another based on beneficial use.	Agree
The restatement of torts is a useful part of long term resource planning.	Disagree
Prior Appropriations	
Users who can exhibit a record of historical use should also provide a record of beneficial use.	Disagree
Users who can exhibit a record of historical use should have priority over newer users.	Agree
During a time of drought, junior and senior water right holders should have equal access to the resource.	Disagree
The prior appropriations doctrine is a useful part to long term resource planning.	Agree
Groundwater Districts	
Groundwater districts are a responsible management tool for a region as large as East Texas.	Disagree
Groundwater districts should allow historical users larger pumping allotments.	Agree
Resource management through groundwater districts erodes private property rights	Agree
Groundwater district boundaries should be consistent with political boundaries.	Agree
Groundwater district boundaries should be consistent with geological boundaries.	Disagree
Groundwater district boundaries should be expanded to incorporate larger areas such as "regions" (as designated be the Texas Water Development Board).	Disagree
Groundwater districts are a useful part to long term resource planning.	Agree

Table 6.2 Summary of Surface Water Management Responses

Survey Statement	Mode
Doctrine of Prior Appropriations	
The doctrine of prior appropriations protects the private economic interests of individuals in East Texas but does little for the broader public interest.	Disagree
Surface water rights should be appropriated based on necessity and beneficial use and not seniority	Disagree
The theory of "first in time first in right" is an outdated practice and does not account for urban growth.	Disagree
Pressure from growing urban communities is eroding the rights of senior water rights holders.	Agree
Technological advances will eventually diminish the value of senior water right holders in East Texas.	Agree
Instream Flows	
The State of Texas should appropriate water rights for the purpose of maintaining sufficient instream flows.	Agree
Water that maintains instream flows are a vital part of the environment and should be held in the same regard as commercial waster use.	Agree
Instream flows should not be given the same priority as agricultural and urban interests.	Agree
Water transfers to support wildlife, fisheries, and recreation should become more commonly recognized.	Disagree
Water Transfers	
Surface water rights should be treated as personal property, and owners should be able to use the water to its maximum benefit.	Agree
The surplus of surface water in East Texas could be better used by transferring its use to more populated areas of the state.	Disagree
Market forces should be able to play a role in determining if water use transfer should be allowed.	Disagree
Interbasin transfers are a necessary tool for long term resource management.	Disagree
Interbasin transfers should not be subject to junior water right provisions.	Disagree
Obtaining a water use transfer from a regulatory authority is too difficult and requirements should be relaxed	Disagree

The data indicated that stakeholders were apprehensive about new groundwater management strategies. Results showed approval for the rule of capture and groundwater districts. These are the only methods currently employed in East Texas. The results also revealed a hesitation about new strategies. Some responses indicated willingness to try new management strategies. The survey also indicated that stakeholders favor political boundaries for groundwater districts instead of geological ones.

The survey revealed a strong desire to keep East Texas surface water within Region I. Most respondents favored the doctrine of prior appropriations which gives

water right holders in East Texas a priority of right above others. Respondents favored giving water right owners more discretion when deciding the most beneficial use of water. The majority of respondents wanted to stop or slow down water transfers to other parts of the state, and there was an overwhelming majority who favored senior water rights being honored during time of drought.

The results from the survey illustrate the importance stakeholders place on controlling their water. They support local control for their groundwater districts, increased government regulation for interbasin transfers, and more protection for senior water right holders. There is also a fear that increasing demand for water may eventually erode their priority rights.

Policy Recommendations

Water sustainability is an important issue for all of Texas. This issue is especially important to Region I. In the near future the demand for available surface water will be too high to prevent water exportation. Policy makers should take this opportunity to plan for the future and ensure that East Texas water right holders are treated fairly.

Even though an overwhelming majority of stakeholders prefer the prior appropriations doctrine for surface water management, this practice is outdated and in need of change. As pressure increases to diminish the importance placed on senior water rights, policy makers should install safeguards to protect East Texas interests. Some possible safeguards are increased regulations for water transfers and higher transaction costs for these transfers. Some economic models have suggested that a policy induced

transaction cost, such as a high tax on a transfer or an export fee, might deter interbasin transfers.

Policy makers should also examine the restatement of torts strategy. This strategy calls for policy makers to assign beneficial uses to all water rights. As the population of Texas continues to increase, policy makers should consider the possibility that not all water uses are equal. Water is a necessity for development and an element of life. Considerations such as beneficial use of water should be employed in the future.

Policy makers should also consider making regional regulatory districts to control pumping over an entire aquifer, instead of local management districts. This concept was not popular among the stakeholders in Region I, but it is a responsible strategy for maintaining the integrity of an aquifer. Local districts do not have the scientific and geological expertise to properly manage an aquifer, and most districts do not have the funds to hire this kind of help. As management districts are created, voters must approve a funding mechanism (such as taxing authority or fee assessment). Most voters are reluctant to approve a district that will charge high taxes or fees. As a result, many districts are not properly funded and equipped to manage an aquifer. Ideally, regional districts would be financially equipped to manage an entire aquifer.

Future Research

Geological versus political boundaries for management districts will be an important management debate in the future. Multiple management plans for a single aquifer is not beneficial. Technological advances in the past fifty years have taught scientists much about groundwater, but most geologists believe there is more to be

learned. Future research should concentrate on the effects multiple management strategies can have on an aquifer and its available groundwater. A study of this subject may lead to the long term water sustainability that policy makers in Texas desire.

Conclusion

The law applicable to groundwater has never been more uncertain. The literature and survey results seem to suggest that with depleting aquifers and increased population growth, regulation of groundwater and its uses will represent the preferred method of exercising regulatory control over unlimited groundwater withdrawals. With groundwater management districts receiving increased regulatory powers, conflicts between districts and the adherence to the rule of capture seems inevitable (Johnson 2001, 20). There is also competition between districts over the same aquifer. The literature and survey results also suggest that there is a need for defining what is a beneficial use of water. Such a subjective definition is sure to spark controversy in the years ahead.

Likewise, surface water administration faces an uncertain future. Conflicting interpretations of beneficial use and the ongoing struggle between junior and senior water rights holders will prove to be a hotly debated issue. The battle for sustainable surface water between irrigators, urban developers, and environmental interests has caused parties to explore new possible sources of water. Some options include building reservoirs, harvesting rain clouds, and desalination plants. These options are extremely expensive, somewhat experimental, and all will be subject to some form of legislative regulation.

The water market for Western groundwater and surface water is severely constrained by institutional limitations and regulatory requirements which must be overcome before water can be transferred from one user to another (Johnson 2001, 20). Creativity will help address surface water supply and management issues, and groundwater transactions can be anticipated to increase in frequency and scope. Both forms of water supply will generate additional debate concerning the need for governmental regulation. As the West plans for the future and strives to attain long-term water resource stability, state policy makers and administrators face a challenging task. Proper resource management is vital to agriculture, business and urban development, and quality of life. It is imperative that prudent decisions are made to ensure water management for the future.

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Appendix A IRB Exemption

Exemption Request

The exemption application you sent on 10/04/ 2006 has been accepted.
Your project is exempt from full or expedited review by the Texas State
Institutional Review Board.

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Appendix B Survey on Water Management

Please express your opinion of each statement with a response of strongly agree, agree, neutral, disagree or strongly disagree.

Rule of Capture
1. The rule of capture is a responsible practice for resource management

2. Strict adherence to the rule of capture is a property right and should be allowed in any regional water plan.

3. The rule of capture is an antiquated management strategy that should be replaced with a more responsible strategy.

4. The rule of capture is a useful part of long term resource planning

Reasonable Use
5. The reasonable use doctrine is a responsible management strategy that should be used in East Texas.

6. Adherence to the reasonable use doctrine will provide a responsible way to limit waste and resource misuse.

7. The reasonable use strategy should be implemented in East Texas even if neighboring states do not adhere to reasonable use.

8. The reasonable use doctrine is a useful part of long term resource planning

Correlative Rights
9. Adherence to the correlative rights doctrine is a way to properly manage conflicting interests within one aquifer.

10. Allowing state courts to appropriate water is an equitable way to distribute resources.

11. Allowing state courts to arbitrarily reduce water allocations does not recognize that some water uses are more beneficial than others.

12. The correlative rights doctrine is a useful part of long term resource planning

Restatement of Torts
13. Water rights should be appropriated based on a user's beneficial use of the resource.

14. Anticipatory water rights should be considered by administrative agencies as a form of beneficial use.

15. One type of water use should not gain priority over another based on beneficial use.

16. The restatement of torts is a useful part of long term resource planning.

Prio Appropriations
17. Users who can exhibit a record of historical use should also provide a record of beneficial use.

18. Users who can exhibit a record of historical use should have priority over newer users.

19. During a time of drought, junior and senior water right holders should have equal access to the resource.

20. The prior appropriations doctrine is a useful part to long term resource planning

Groundwater Districts
21. Groundwater districts are a responsible management tool for a region as large as East Texas.

22. Groundwater districts should allow historical users larger pumping allotments.

23. Resource management through groundwater districts erodes private property rights.

24. Groundwater district boundaries should be consistent with political boundaries.

25. Groundwater district boundaries should be consistent with geological boundaries.

26. Groundwater district boundaries should be expanded to incorporate larger areas such as “regions” (as designated by the Texas Water Development Board).

27. Groundwater districts are a useful part to long term resource planning.

Doctrine of Prior Appropriations
28. The doctrine of prior appropriations protects the private economic interests of individuals in East Texas but does little for the broader public interest.

29. Surface water rights should be appropriated based on necessity and beneficial use and not seniority.

30. The theory of “first in time first in right” is an outdated practice and does not account for urban growth.

31. Pressure from growing urban communities is eroding the rights of senior water rights holders.

32. Technological advances will eventually diminish the value of senior water right holders in East Texas.

Instream Flows

33. The State of Texas should appropriate water rights for the purpose of maintaining sufficient instream flows.

34. Water that maintains instream flows are a vital part of the environment and should be held in the same regard as commercial water use.

35. Instream flows should not be given the same priority as agricultural and urban interests.

36. Water transfers to support wildlife, fisheries, and recreation should become more commonly recognized.

Water Transfers

37. Surface water rights should be treated as personal property, and owners should be able to use the water to its maximum benefit.

38. The surplus of surface water in East Texas could be better used by transferring its use to more populated areas of the state.

39. Market forces should be able to play a role in determining if water use transfer should be allowed.

40. Interbasin transfers are a necessary tool for long term resource management.

41. Interbasin transfers should not be subject to junior water right provisions.

42. Obtaining a water use transfer from a regulatory authority is too difficult and requirements should be relaxed

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