International Journal of Water Governance
11 (2024) 23–68
DOI: https://doi.org/10.59490/ijwg.11.2024.6847
Publisher: TU Delft OPEN
Publication date: 2024-05-06

Information Sharing and Outreach as Social Capital in Groundwater Governance

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Abstract

Groundwater governance involves a process for developing policies for groundwater use and then implementing those policies for user compliance. A new paradigm of groundwater governance leverages social relationships built with users to engage and include them in the governance process. The focus of this article is to test this paradigm based on the experience and practice of local Texas groundwater district directors and managers who make and implement groundwater policy, respectively. The author conducted 13 interviews with these Texas professionals and made three observations after a qualitative analysis of their responses. First, interview participants see sharing information and expertise as a public service that augments their professional roles, but this sharing is mostly a one-way exchange of information between these professionals and users. Second, the transaction costs of building relationships with the local community and external stakeholders affect the transaction costs of governance and management. Third, factors beyond the control of managers and directors can affect transaction costs of conserving and augmenting groundwater available for future use and preserving its quality. This article contributes to the literature on the importance of social capital to approaches that encourage user-compliant behaviour and result in sustainable groundwater use. The results of the present study reveal the importance of local culture to user behaviour and the transaction costs of public engagement and conflict resolution and bring attention to external factors beyond the control of decision-makers and practitioners that affect their efforts towards achieving effective and efficient groundwater outcomes.

Keywords: Local groundwater governance; groundwater management; rule of capture; Texas; transaction costs; groundwater user behavior; structured interviews.

1. Introduction

Groundwater in Texas is a natural source of freshwater essential to residential users, cities, and for livestock as a source of drinking water and to farmers for irrigation. Groundwater is stored underground and, because it cannot be seen, it is often undervalued. It is also often overused because of the pressures that climate variability, population growth

Please cite as: J. Charles, Information Sharing and Outreach as Social Capital in Groundwater Governance. *International Journal of Water Governance*, 11, 23-68

and migration patterns place on it. Groundwater is a common property resource, meaning that the benefit from its use is available to anyone who accesses and extracts it, yet this very same characteristic can diminish its quantity for future use by other users. Overuse characterizes common property resources, and there are two ways of addressing this problem: assigning property rights to users and the regulation of its use. Property rights address overuse because a landowner has the right to access and extract the groundwater beneath their land. Regulation addresses overuse; it provides institutional oversight over user withdrawals so that sustainable outcomes are achieved. Sustainable outcomes are outcomes that do not result in overuse, deterioration of groundwater quality, and will benefit all life forms and economic growth and development, now and into the future.

Varady et al. (2012) distinguish between groundwater governance (governance) and groundwater management (management) (Suvedi et al., 2000). Definitions are provided in Petersen-Perlman et al. (2018) and de Chaisemartin et al. (2017). Governance is functional in nature because it is about administrative process and institutional structure. A good definition of water governance is found in Edwards and Guilfoos (2021). I define governance as the set of rules or codes of practice (formal or informal) developed and adhered to and which provide direction, guidance and authority to those responsible for making decisions. In this article, rules are specific groundwater standards, made within the context of policies (general guidelines) and followed through with procedures (a series of actions to be taken). Once rules are made, managers determine how to implement those rules practically, effectively, and efficiently.

Managers use instrumental and regulatory tools of scientific/technical expertise and knowledge to oversee the quantity and quality of an aquifer and its groundwater. These activities constitute regulatory oversight of groundwater use; in essence, carrying out the 'cop' functions necessary to preserve the sustainability of groundwater. The traditional paradigm or framework of groundwater management uses this managerial approach. Groundwater professionals use information gained from their fieldwork as inputs into groundwater models, risk analysis, reports and practices to achieve outputs of interest. Although these professionals might engage with users (persons dependent on the extraction and availability of groundwater for various uses) by sharing their scientific knowledge and technical training, local values and beliefs have not traditionally been integrated as inputs in this paradigm (Gorelick & Zheng, 2015).

This paradigm of engagement is no longer considered sufficient. Effective governance of groundwater is complex and requires new frameworks for tackling persistent problems of groundwater protection (Closas & Villholth, 2020). The new paradigm acknowledges that 'local knowledge, beliefs and values' gained from the local community and the 'process' of involvement are needed to build 'capacity' for the solutions needed by managers to protect groundwater and encourage behaviour favourable to the environment (Pretty & Ward, 2001; Simpson & De Loe, 2020; Zwarteveen et al., 2021). Changing individual behaviour towards protecting a resource cannot just be aspirational – it involves the complex task of changing human behaviour (Curtis et al., 2016). Institutions of governance and management depend on the actions and behaviours of users whose compliance and cooperation are necessary if they are to result in sustainable outcomes.

Remote (external) factors, outside of the control of the users or decision-makers – such as changes in weather patterns, the economy, demographic changes, changes in land-use or tourist patterns, and technological changes in groundwater extraction – can also affect outcomes. Thus, the context in which rules are made and the costs of their implementation are important for guidance to those who apply the rules and those to whom the rules apply (Bruns, 2021). This new approach to management is solution-based and context- and behaviour-dependent. I will call this the 'coach' role. The coach role calls for intentional collaboration, inclusion and location- and value-based involvement to result in resource-protection behaviour.

2. Objectives

The core questions of this study are as follows: what user-compliance approaches do groundwater professionals use to implement management plans that result in sustainable use of groundwater? Do these approaches reflect the new paradigm called for in the literature? The objective is to determine whether practice supports behavioural trends in the literature and, thus, whether managers integrate 'cop' functions and 'coach' roles. To achieve this objective, I spoke with groundwater professionals who implement state and local groundwater rules in regions with different hydrological and geological characteristics. Surveys, or qualitative data using comments from survey respondents, can reveal what lies behind attitudes and groundwater availability perceptions (Gholson et al., 2019; Holsman et al., 2000; Lauer & Sanderson, 2020; Somma, 1997; Suvedi et al., 2000). It is equally valuable to hear the attitudes, perceptions, and beliefs held by groundwater experts, practitioners and groundwater decision-makers. These professionals are familiar with the science of groundwater and the sociocultural context behind behaviour and compliance.

Consequently, in this study, I use qualitative methodology to focus on groundwater professionals, thus contributing to other studies that use case studies in governance-related research (Stewart, 2012). I conduct a set of interviews in Texas that comprise a multi-case study to understand the different functions and roles of groundwater professionals as practitioners in different regions of the state. Multiple-case and multi-stakeholder case studies have been used in governance-related research (Flores-Lopez et al., 2022; Stewart, 2012). Two conceptual frameworks underlie the study of these cases – (a) groundwater management as a technical function and (b) groundwater management as two-way engagement. Transaction cost theory is used in this study to support the economics of groundwater management; that is, the management is expected to achieve not just sustainable outcomes but also efficient outcomes by lowering the transaction costs of implementing Groundwater Conservation District (GCD) rules, management plans and state groundwater policies. This study allows interviewees to reveal, in their own words, the approaches they use and also reveal the location-specific aquifer characteristics and remote factors they find important to implementing groundwater rules. The interviews shed light on the importance of the said two frameworks to user compliance with the governance of sustainable groundwater use.

In the next section, I provide a background for groundwater management in Texas. In Section 4, I outline a new paradigm for understanding groundwater management and the support it has from empirical literature. Section 5 describes the context of the case studies, interview methods, and data collection and coding procedures. The results and their implications are presented in Section 6. The article concludes with limitations of this study in Section 7 and, in Section 8, provides a summary of the discussions presented in the article.

3. Background of Groundwater Management in Texas

In Texas, groundwater management is decentralized and implemented locally. Groundwater usage is based on the right of a landowner to extract groundwater beneath their land. Management functions in the state are conducted by Groundwater Conservation Districts (GCDs or District; see Figure 1). GCDs are governmental entities established in Chapter 36 of the Texas Water Code and authorized by the state legislature (Caroom & Maxwell, 2013). Since groundwater is an extractable and transferable resource, GCDs are responsible for groundwater regulation.[1] The Board of Directors (Board) develops a groundwater management plan and submits this plan to a state agency called the Texas Water Development Board (TWDB). Managers help to implement this plan (Puig-Williams, 2020). Managers also advise and educate GCD Directors who are either elected or appointed. Management functions include registering, metering, and permitting wells, and

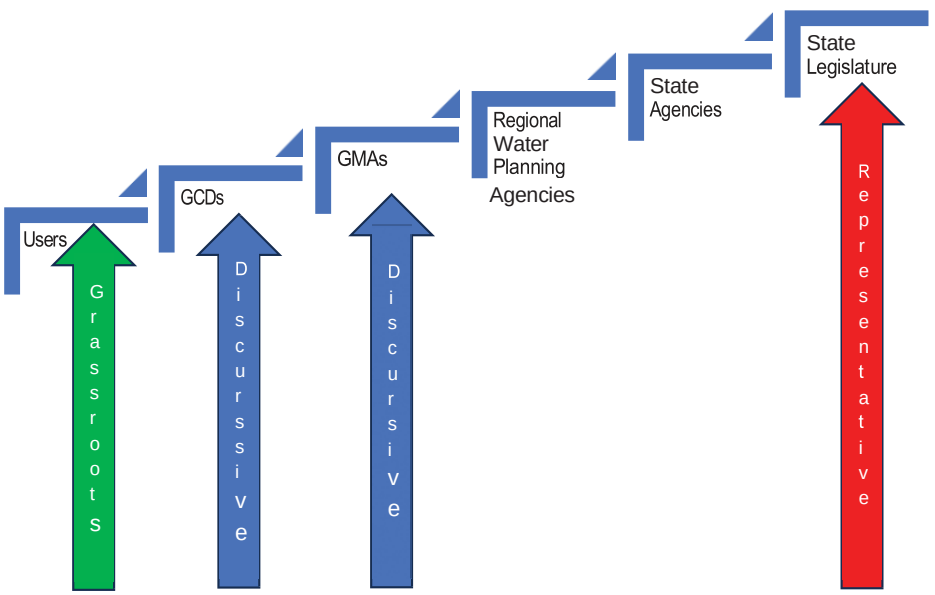

Figure 1. Citizen Involvement and Participation in Multilevel Water Governance

[1] For the history of GCD formation, see Closas and Molle (2018).

monitoring the spacing of neighbouring wells. GCDs enforce spacing between wells to ensure user compliance with sustainable use. In many cases, lot size must be 2 acres. Chapter 36 of the Texas Water Code explains that spacing a well a certain distance from a neighbouring well minimizes the risk that drawdown from one well reduces groundwater available to its neighbour, of subsidence of the ground around a neighbouring well, or puts groundwater near a contaminating source like a septic tank.

Some GCDs cover single counties, and others more than one county, although there are some areas of Texas that are not represented by a GCD. County areas can be large or small, with the GCDs lying fully or partially within a county.[2] GCDs can generate funding from fees, taxes, export permits, grants and the issuance of debt (Brock & Sanger, 2003). They are tasked with conserving and preserving aquifer groundwater, collecting data, preventing waste of the groundwater, and preventing damage to the aquifer. Regardless of the institutional characteristics of the GCD, their local jurisdiction reflects the preference of the state that groundwater regulation remains local and limited. At the state level, major and minor aquifers are grouped into areas called Groundwater Management Areas (GMAs) that facilitate coordination and cooperation between GCD professionals.

Managers, with the assistance of their staff, monitor and manage groundwater use and users, enforce regulatory rules, and assess the level of groundwater and the health of the aquifer using several different tools. Management tools have been helpfully categorized as technical instruments (scientific models, surveys, sustainable aquifer yield estimates and other diagnostic analyses), managerial and planning instruments (land use and spatial planning), regulatory instruments (inspections, permitting, well licensing and registration, groundwater caps), economic instruments (fees, taxes), and behaviour-changing instruments (awareness-raising and training; de Chaisemartin et al., 2017). These tools exist to ensure that managers can control use as hydrogeological, climatic, economic and socio-demographic changes occur and to prevent over-extraction that affects groundwater sustainability.

4. Using New Frameworks to Understand the Practice of Groundwater Management

The traditional paradigm of groundwater management is about the resource itself – the responsibility to implement sustainable groundwater policies to direct its use, and the technical, scientific, economic and regulatory tools to assess and report its status. Changing individual behaviour towards protecting a resource cannot just be aspirational because it requires the complex task of changing human behaviour (Curtis et al., 2016). Theory and conceptual frameworks of governance, whether at the policy level or at the implementation level, need to account for how managers' actions impact user behaviour *and engage users* beyond just providing them with information and knowledge about the resource.

[2] https://www.twdb.texas.gov/groundwater/conservation_districts/facts.asp.

The idea is that successful management activities and 'effective governance' surrounding a resource require 'social consensus', a two-way collaborative, more inclusive approach to management. This is the paradigm shift in understanding what it means to manage a complex resource like groundwater (Garduño et al., 2010). Groundwater professionals engage with users affected by their decisions so that both can share and learn together (Newig & Kvarda, 2012).

I call engagement with users an 'outreach' effort in the context of groundwater management. Outreach is typically a one-way transfer of technical or scientific knowledge that includes information about user conservation practices and best management practices for preserving water quality, to educate and inform both the general public and the schools. Sometimes outreach is informal, indirect, and informational such as through social media, publications or reports, and posted announcements (Gornish & Roche, 2017). Other times, managers engage in direct communication, facilitate training or hold conservation workshops for users. Extension agencies affiliated with universities can hold workshops and programmes designed to engage and educate farmers and ranchers in responsible groundwater use. The funding for such outreach, indirect or direct, is sometimes limited (Re & Misstear, 2017).

When outreach is two-way, collaborative and inclusive, managers can leverage relationships formed with users to facilitate the desired outcome. The desired outcome of a rule, defining its effectiveness, is sustainable groundwater use. The horizontal relationships managers build with community members and the vertical relationships they establish with policymakers (legislators) underlie rule implementation (Simpson & De Loe, 2020). Policymakers are in the hierarchy of influencers of implementation at the local level (Fallon et al., 2021). When information is provided to users at a local level, even using a local representative, communities of users need to trust the information provided (McClurg & Sudman, 2003) and then, ideally, users will share information based on their experience with managers. Successful sustainable environmental outcomes occur when users act collaboratively at the local level to mitigate harmful actions imposed on their neighbours or to the environment. The horizontal and vertical relationships built between managers, community members, and policymakers are what I call social capital. The degree of success is related to how managers leverage social capital and become more accepting of contributions to knowledge and technology shared by governmental and nongovernmental agencies. Environmental governance theory, empirical research and conceptual models suggest that two-way sharing of expertise and knowledge between managers and their community of users is the new direction for environmental governance (Pahl-Wostl et al., 2011).

Leveraging social capital contributes to the efficiency of sustainable groundwater use. As mentioned above, funding for outreach can be limited. Efficient management economizes on the allocation of local resources needed to collect revenue, to conduct inspection and/or monitoring of wells. Efficiency in management lowers the costs of allocating time and human resources to ensure cooperation and compliance with managerial functions. Transaction costs are the costs of making decisions and implementing

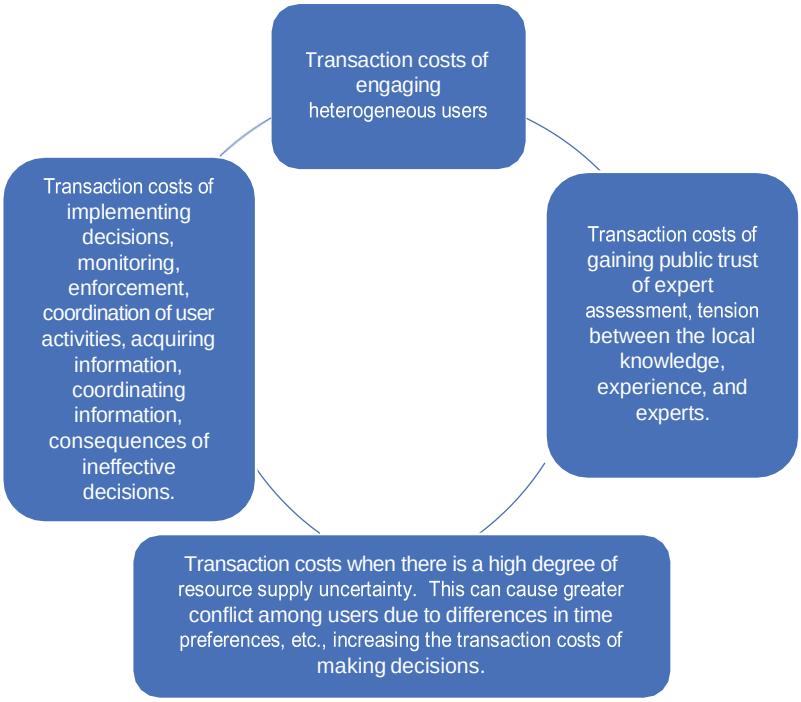

Figure 2. Contextual Factors, Transaction Costs and Trade-offs in Governance

those decisions. They may be direct and indirect, explicit and those that cannot be determined explicitly or 'directly', ex ante or ex post of project (or rule) implementation (Coggan et al., 2010; Garrick et al., 2013; Lu et al., 2015; McCann, 2013). Transaction costs include collecting data from GMAs or districts in accordance with desired measurable outcomes, coordinating user activities, and communicating with stakeholders about scheduled meetings, workshops, or trainings (see Figure 2) (Stupak et al., 2021). An actual detailed calculation of these costs is beyond the scope of this study since the interviews conducted with managers and directors were meant to reveal important themes from which inference could be made about the transactions costs of implementing rules across GCDs. However, measures such as meeting frequency and duration can be used, where the opportunity costs of this time can be calculated using daily wage rates (Sravanthi et al., 2015). Transaction costs are the interpretive lens through which actions of groundwater oversight will be understood.

Lubell et al. find variables such as conflict, the frequency and breadth of participatory engagement, scientific and political knowledge in water governance, and the experience of participants with institutions to be significant in the transaction costs incurred by participants in three different regions when they are assembled by institutions to address complex water problems (Lubell et al., 2017). The costs of coordinating user activity are the costs of well-spacing, monitoring pumpage rates, permitting, making and enforcing

rules. These costs are determined by whether the GCD is tax-based or fee-based, the type of aquifer geology (described below) and the area of Texas in which the aquifer is located. Social capital affects the transaction costs of groundwater management and implementing rules and can serve to help managers monitor the trade-offs necessary to achieve sustainable outcomes. Figure 1 shows the various levels of involvement at which citizens can participate and engage within a governance hierarchy. Figure 2 and its visual depiction show the relationship between contextual factors, transaction costs, and the resulting trade-offs in governance and management.

Analytical evidence that new approaches need to reflect intentional collaboration, inclusion and place- and value-based involvement are found in experimental and empirical studies. In an experimental study, Asprilla-Echeverria finds that individual as well as social drivers increase the complexity of protecting resources that have common-pool characteristics of groundwater (Asprilla-Echeverria, 2021). One empirical study shows that lay and expert knowledge can be integrated (Simpson et al., 2015). The Simpson et al. case study provides an empirical example of a collaborative problem-solving approach that used both types of knowledge. Qualitative analysis of survey responses and comments from the study showed that participants valued the idea and principle of including expert and lay knowledge into decision-making more than they valued the actual experience they had of this type of integration. This was because technical/scientific expertise was either difficult to reconcile with lay values and beliefs or difficult to integrate with lay experiential and often multigenerational knowledge (Simpson et al., 2015).

An empirical study of farmers showed that social capital is especially important when groundwater-dependent users resist top-down or centralized control over groundwater. Farmers in California participated in water governance because they did not want to lose control to higher administrative authority (Méndez-Barrientos et al., 2020). Another empirical study of farmers showed that individual participation in collective efforts to manage groundwater improved when considerations of social, cultural, legal, economic and political contexts were considered (Vafaei et al., 2021). In the Mancha region of Spain, two types of social capital, bonding and bridging social capital, were examined to assess their effectiveness in groundwater governance, through regulation, specifically to reduce the amount of groundwater extraction (López-Gunn, 2012). The authors found that both types of social capital were needed for institutional processes that oversee groundwater management. Bonding capital uses relationships built between individuals or groups of individuals who share a social identity, social norms, or come from the same community background. Bridging capital is derived from relationships which allow individuals or groups of individuals who have differences in social identity or social norms to work together, taking advantage of the differences they bring into their interactions to accomplish a common goal. Berardo finds that the latter can lower the transaction cost of solving problems by facilitating information exchange across social networks (Berardo, 2014). These case study examples of non-traditional management frameworks are consistent with effective and efficient groundwater management.

Contextual Factors	Effect on Transaction Costs	Trade-offs Implicit in Governance
Public participation	Inclusiveness and greater participation can reduce conflict and reduce the costs of making unpopular decisions.	Relying more on scientific and technical expertise and hard data can also lower the cost of governance.
Values, beliefs, and local culture	Homogeneous communities, strong local culture, organizational ties, shared values/norms, beliefs and similar time preferences can reduce distributional conflicts, the costs of making decisions, and implementing those decisions at the local level.	Highly homogeneous communities may be more resistant to change in light of changing contextual factors and make it more difficult to exercise state authority when coordinated efforts are required at the state level.
Physical attributes of the groundwater and aquifer	Threats to an aquifer can strengthen alliances among heterogeneous users and reduce transaction costs of making and implementing decisions in the social interest.	A high degree of resource supply uncertainty can cause greater conflict among users due to differences in time preferences, greater tension between the public and experts, and a greater chance that the public will defer to the competence of experts.

5. Materials, Methods, Analysis, and Ethical Consideration

5.1 Case Study Regions, Study Design, and Participant Selection

There are 101 GCDs and special districts. Aquifers vary greatly across the state as can the type of groundwater user. Aquifers vary in their permeability and ability to be recharged from surface water or precipitation.[3] The geological characteristics of aquifers include karst (fractured rock/caves), sand, gravel and silt. The water in an aquifer is determined by recharge rate, recharge area, the rate of water movement, the rate of drawdown, and can be fresh, saline, or brackish. The main users of groundwater in Texas are households, municipalities, industry, farms and ranches.[4]

For this study, I categorized the GCDs into nine different regions of Texas: East Texas, West Texas, Central Texas, Far North Texas, North Texas, Panhandle Regions 1 and 2, South Central, and the Gulf. South Texas was not represented in the interviews either because district representatives did not respond to a request to be interviewed or declined the request, and I considered saturation to be reached with the data collected from the regions represented. GCDs were selected to have as much regional representation as possible. Specific GCDs are not mentioned; neither are particulars about gender or representation of non-traditional groups reported or collected to protect, as much as possible, the identity of the interviewees. Visual inspection of age would place the age of those interviewed as 30 years of age and older.

[3] https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R345/R345Complete.pdf.
[4] https://www.twdb.texas.gov/groundwater/aquifer/index.asp.

Table 1
Interview questions and prompts

Interview Questions	Introductory
	Please tell me your title.
	Can you describe for me, the role you play in the district?
	Is there a motivation that keeps you engaged with the district in this capacity?
	Explanatory
	Tell me about your users. Engagement question: Probe: Do members of the community or public interact with directors or staff? **Probe:** In what ways? **OR** Why not? **Probe:** Does this **(lack of)** involvement affect your decision-making?
	How would you say the users in your district differ from users in other parts of (this region) (the state)?
	Descriptive
	Are there any local characteristics of how groundwater is discharged or recharged in this area that affect how groundwater is managed by this district?
	Have you or other directors ever had to make a decision about a groundwater user or groundwater use which was viewed as controversial by the local community? Engagement question: Probe: If yes – I won't ask what the controversy was about or about what decision had to be made, but I would like to ask if the community became involved? **Probe:** If no – If you or other directors had to make such a decision, how do you think the affected community members would communicate with the Board **and** become involved?
	Do you see any factors which would make you more or less certain about groundwater availability in your district in the immediate future or distant future?
	Have the directors or staff ever considered or discussed these ways of addressing diminished supplies of groundwater? Demand? Engagement question: Probe: If yes, what sentiments are being expressed? Do you incorporate public opinion about (supply) (demand) uncertainty into district decisions along with those of water professionals? **Probe:** If no, and **if this were to ever become a subject of discussion, would there be a role for the expertise of water professionals and public opinion?**
	Do the Board and/or staff engage with legislative representatives or other environmental stakeholders on matters surrounding groundwater? Probe: If yes, in what ways does this occur? **Probe:** If no, are there issues on which you can see such engagement taking place?

I used a script with interview questions and prompts. These questions and their prompts are displayed in Table 1. There were three introductory questions that allowed the interviewee to introduce themselves, their role and their personal interest in becoming involved with the GCD. Two explanatory questions followed, allowing the interviewee to describe their users, any unique characteristics of their users, and any specific characteristics of their GCD or region. A final set of five descriptive questions followed that provided more detailed information. I asked about groundwater discharge or recharge in their district or region that affected management, any controversy that affected any decisions, groundwater availability immediate or future, discussions over adaptive management

to diminished future demand/supply of groundwater, and the interviewees' engagement with legislative representatives or other environmental stakeholders (e.g. non-profit environmental organizations, environmental advocates, etc.) on matters surrounding groundwater. All interviewees were asked the same set of questions. Throughout the interview, interviewees were provided additional information and contributed freely as they wished, which provided me with additional information I could use in later analysis. I developed the questions based on the conceptual frameworks found in the research literature mentioned in the previous section. This study submitted as IRB Application Number 2017789 was approved as exempt from IRB review.

There were 13 semi-structured interviews that lasted for 45 to 60 minutes, with 15 interviewees representing single and multiple counties. Some of the interviewees were GCD Directors, and others were managers. When the interviews were set up either by telephone or email, generally, it was the managers who were willing to be interviewed. However, in some cases, managers invited their district directors, or directors themselves agreed to be interviewed. The interviews were recorded using a digital recorder and later recorded again and transcribed with OtterAI. Transcripts were first entered into an Excel spreadsheet, and then into NVivo software which allowed the responses to be coded and sub-coded thematically.

5.2 Coding and Data Analysis

After reading the transcripts, responses from the managers and directors in each representative GCD were organized into categories of themes based on guidance from the conceptual frameworks and transaction cost theory presented above. The categories of broad themes that emerged from responses are presented in Table 2.

6. Results and Discussion

This section is a discussion summary based on the results of the responses and according to user-compliance approaches that practitioners use to implement management

Table 2
Themes from interview responses

Categories	Themes
Conflict	Distributional, compromise, education, public involvement and engagement, litigation, adaptive methods, land use
Personal interactions and encounters/culture	Personal interactions and encounters, preserving a way of live/living, social media, identification with GCD representation, affinity/heterogeneity of users, and land use
Institutional alliances	State, regional, professional associations
Physical attributes of the groundwater and aquifer; availability; considered technology and adaptive measures	Growth, weather, land-use changes, regulatory environment, aquifer characteristics

plans. Detailed responses for each of the nine regional cases can be found in the Appendix of this article.

6.1 Cop Regulatory Functions

Collecting field data is a critical function of regulatory oversight and especially when recharge of the aquifer is low or demand for groundwater puts stress on the aquifer. Setting spacing rules is also an important regulatory function. Monitoring well-spacing is a basis for engagement with the public if there is any uncertainty or questions about spacing requirements. Well-spacing is a way of reducing conflict resulting from dense housing development and critical in areas where users primarily depend on their own well water and connections as their source of water. Well-spacing also becomes an agent of control for the GCD to sustain groundwater availability when remote factors such as aquifer characteristics and variable weather patterns affect the availability of groundwater.

Permitting is used to control and monitor new wells and where they are located. The number of permits issued determines the number of wells that are allowed. Permits are issued to large users such as water suppliers or small users that want to drill for groundwater. It is one of the regulatory functions of a GCD and is explicitly mentioned in interview responses. While issuing permits is a significant source of revenue for districts that are fee-based, public opposition to a permit can draw larger-than-usual attendance at an open meeting of a district to challenge, oppose, or 'contest' another source of withdrawal from the aquifer. So, contested permit hearings are a way for district residents and district personnel to hear from each other. When an applicant for a permit becomes controversial, or the permitting process is being circumvented by a new or existing applicant, the district may incur direct costs to hire legal counsel to defend itself. Indirect costs of extra staff time are incurred to inform the public of the hearing. If long-held family-owned wells are part of the local culture of a district, then permits are not issued often.

Another regulatory function – capping groundwater withdrawal beyond amounts permitted – occurs because of aquifer characteristics. The capping is an answer to conflicts arising from withdrawals by large industrial users. According to one interview response, capping is done with a change of rules. This is an administrative action with low transaction cost. Economic instruments as a cop function are limited to fees and taxes by the Water Code as ways of generating revenue for districts. Districts with populous counties can raise higher tax revenues. Economic instruments are a financial constraint on GCDs because they determine and limit the technology and adaptive measures available and are considered for sustained quantity and quality of groundwater for use.

6.2 Coach Context-Based Roles

The coach role recognizes horizontal and vertical relationships in governance and management, land uses, and remote factors.

The most-often-mentioned statement about local culture is the desire to keep water in a district. Directors' and managers' responses indicate that local management is to be protected, and control over groundwater not ceded to Austin, the state capitol. Respondents mention that residents want to have autonomy in a decision about whether to join a GCD, which is another level of government. Their users feel that the best knowledge about managing groundwater in the area is found within the district. Another sentiment that shows the value that local culture has over the governance of groundwater is the desire of users to have the composition of the elected Board reflect the interests of voters in that district. If there is a lack of representation of certain interests on the Board, it is to reflect the choice of voters.

Two-way communication in GCDs between users and Board decision-makers does not mean an inclusive, participatory process as suggested by the new paradigm in groundwater governance. Participation in governance means to vote for Board members who represent the current district composition of groundwater users. There is a 'lack of time' for more involved participation; that is, there is a transaction cost of attending a meeting. The frequency and duration of meetings increase this type of transaction cost. In cases where the interviewee expressed a homogeneity of feelings about local culture, the transaction cost of governance and management is lowered because a Board knows what their users expect. In one case, district residents have a view of the Texas way of life as farming, different from the urban interests of some legislators in the state capitol – an urban-rural divide of users and land uses.

With this kind of division between the way of life as perceived by some districts and the growth of urban interests represented in Austin, many districts see the importance of visiting Austin during legislative sessions despite it being a costly and lengthy trip. They are willing to incur the cost of hiring lobbyists and attorneys to represent them and maintain communication and contact with legislative staff. Communication in this sense is again one-way. Very few cases mention district visits by their own legislators or legislators from other parts of Texas to a district office or public meeting.

There is conflict between large and small users, historic and more recent users, urban and rural interests, those who prefer regional planning and those who prefer state groundwater planning, older generations and younger generations, and different types of land use. This is the time when the coach's role is most important and most needed. These differences and divides are what comprise heterogeneity in users and increase the transaction cost of governance. Even motives of a GCD can fall under suspicion. It is also when the transaction cost of governance becomes most apparent. In one case, an interviewee mentioned that while they might see themselves as an impartial professional protecting the interests of the aquifer, users might see a GCD and its Board as a biased regulatory cop responsible for punishing offenders and protecting their interests at the expense of actions that benefit a region. There is a desire – even an expectation – that the GCD will intervene in conflicts.

There are very explicit references to the cost of resolving and intervening in conflicts when professionals interact with the public and legislators. There are governance costs of

balancing the interests of users from different areas and with different interests. These are the costs of acquiring information, coordinating information and the consequences of ineffective decisions. If the Board is conscientious about making good decisions, acquiring good information, spending time holding many lengthy meetings, and realizing effective outcomes, then transaction costs increase. There is also a personal cost when decision outcomes are contrary to what a personal friend of a Board member might expect, especially because that member is a member of the community. Users can be apathetic, so it is important to get out in front of an issue, and be proactive, so that an issue doesn't become a larger, more contentious issue when the public does become involved. This highlights the transaction cost of not managing a conflict well and putting in place processes for a good decision outcome. When technical components of a conflict are an issue, there are transaction costs of gaining the public's trust of expert assessment, experience and experts to gather facts.

Remote factors are beyond the control of GCD decision-makers and those that implement rules consistent with the district's management plans. Changing weather patterns, demographic changes and economic development impact the direct costs of making decisions about whether to move groundwater (export) to people or accommodate developer plans to move people to groundwater.

GCDs communicate with users primarily through providing information, training, workshops and outreach through media, personal conversations, school visits and public meetings. To a more limited extent, GCDs communicate with legislators when new laws are being considered. However, this communication, too, is more often one-way, by the district making a call or visit to the Office of the Legislator, and not the other way around. Groundwater users become more actively involved by voicing their opinions and sharing their expertise when an issue threatens their supply of groundwater. Even then, GCDs incorporate these opinions and expertise when they are supported by scientific data. GCD managers want to make sure that their actions are driven by data and not based on personal opinion or emotion. Managers are very sensitive to the local community and culture as context for the governance of groundwater. In Texas, the new paradigm of more inclusive and participatory involvement in groundwater governance is tempered by the transaction cost to directors, managers and users.

7. Limitations

There are limitations to the research conducted for the present study. First, although the interviews were a rich source of data, the interviews covered most, but not all, regions of the state. Two managers of those contacted chose not to participate in the study. However, this author feels that enough number of interviews were conducted so that the GCDs represented captured different regional aquifer characteristics, styles of governance, and approaches to management. All themes were exhausted in the qualitative analysis of the data collected.

Interview subjects included General Directors and General Managers. Comparisons between responses, especially those that referred to aquifer geology, were omitted to maintain the confidentiality of respondents. Selected manager functions were omitted for the same reason. Therefore, some differences in users and uses could not be fully explored. Also, because certain information shared was easily identified with a GCD, aquifer, interviewee, and/or contained sensitive information about an ongoing groundwater conflict, care was taken not to include this information.

8. Conclusion and Recommendations for Further Study

This study shows that groundwater professionals find their cop functions compatible with the social capital of horizontal and vertical relationships needed to implement sustainable-use management plans. However, groundwater governance in Texas falls short of the new paradigm of participatory inclusion and collaborative engagement with users envisioned by Garduño et al. (2010), Pahl-Wostl et al. (2011), Simpson and De Loe (2020). Groundwater users, especially those directly dependent on wells for groundwater and irrigation, do not seek to be more active in decision- or rules-making or provide their input unless an event occurs that threatens their supply of groundwater. Neither the directors nor the managers seek user input or use a user's lay knowledge and expertise unless it supplements data needed by groundwater professionals.

Results reported in this study support the importance of explicitly considering transaction cost theory in groundwater governance. Ex ante and ex post transaction costs of a rule, and the direct and indirect transaction costs of implementing that rule, are considered by directors, especially in conflict management, and contemplating options for adaptive technologies and augmented groundwater supply. Communication between GCD personnel and legislators is another type of social capital that can be leveraged, but this type of interaction occurs, at best, on a limited basis. The discussion of the results shows that it is equally important to cultivate the social capital of vertical relationships with external stakeholders.

Governance and management entails people, processes and rules. Although this multi-case study is based on Texas, there are many opportunities to extend the direction taken and broaden the general applicability of this study of water governance beyond Texas. Methodologically, studies of groundwater users often report socio-demographic data, user perceptions of groundwater availability, and/or attitudes towards groundwater management. These data can be compared and contrasted with the kind of qualitative research detailed in this study to examine trust and conflict issues, along with data on perceptions of groundwater and its availability. More in-depth exploration of the effect of remote factors on transaction costs is another direction for future research. Many groundwater users reside in suburbs or in large metropolitan areas with socio-demographic diversity and political clout. Traditional policies on groundwater may not reflect this type of user diversity, so there will be continued tension between the interests of rural landowners

whose present generational wealth depends on retaining the groundwater they own and the needs of other groundwater users who do not own land but have equally legitimate claims to groundwater and political power. Additional research is needed into low-income users in rural and urban areas who depend on groundwater for everyday needs but do not typically have a seat at the table or a voice when state policies are written or GCD plans are implemented. Questions of environmental justice and equity for users whose voices may not be heard are additional fruitful opportunities for future research.

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Appendix

A.1 Data of Contextual Factors and Outcomes in East Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 1 – An East Texas District	Professional Roles	Personal Interactions, Encounters, and Engagement	Local Culture	Physical Attributes
	Make decisions. Protect the 'good' of the aquifer. Provide water for user purposes. Consider the property rights ownership of all landowners. Protect interests/ equitable treatment of homeowners, farmers, ranchers, industry vs. municipalities with more financial resources and voice.	Social media, YouTube videos, TV water-saving clips. Public meetings. Written materials for user decision-making. Text and emails subject to open meetings requirements. Not much involvement unless a user is upset about personal water usage or rates. Proxy letter-writing. Education programmes about water conservation for middle- and elementary-school students. Farmer irrigation seminars for efficiency and better water management. Direct face-to-face-meetings with users. Input from community if it is scientifically based.	Dominant agriculture lifestyle with historic-use landowners. Rural interests that see Texas as a farming state vs. legislators who represent widespread urban interests.	Karstic, sand, and gravel. Artesian head pressure. Different aquifers of different formations and quality of groundwater. Very little recharge.
	Users	Alliances	Conflict	Availability
	Homeowners, farmers, ranchers, industrial users and power plants. Historic-use landowners who did not require acreage to build wells vs. wells built after GCD formed to reduce permits.	Cities, water providers and groundwater rights groups. No interaction with environmental groups since the groundwater supports no habitat, although a drop in the water table can stop stream flow, affecting habitat. Responsive to legislators who reach out on behalf of their constituents. Participation in regional water associations. Use of attorneys and lobbyists to represent the Board's position on issues.	Deep rural/urban divide seen. Distrust over motives of cities with larger populations with urban amenities vs. rural farming interests protecting their current need for water litigation. Residents who see GCDs as vehicles for punishment vs. GCDs with non-pecuniary interests responsible for protecting the aquifer. Region-wide coordinators vs. districts that only	Reduced used in the long-term probable to preserve availability. Drought affecting recharge. Drought affecting demand. Over-pumping by one district affects another.

(continued)

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
			show information that protects their interests. Older generation of users vs. younger generation with water-efficient landscaped homes, city and developer incentives. Those who favour moving water to the people (export) vs. people who move to the water (affecting growth and revenues of different areas). Those who favour regional groundwater planning vs. those who favour responsible state groundwater planning. Resentment about overrepresentation of municipalities on Board.	
	Land Use Residential. Farming for irrigation. Ranching for livestock.			Considered Technology and Adaptive Measures Aquifer storage and recovery (ASR) affected by climate change-induced flooding. Potable reuse of water to meet demand for drinking water. Treated effluent irrigation. Reservoir construction. Dependence on trends seen from Modelled Available Groundwater (MAG) and knowledge of Desired Future Conditions (DFCs) by geologists and scientists. Desalination. Building a pipeline to import water.

A.2 Data of Contextual Factors and Outcomes in North Texas – Panhandle 1

Region, Funding, and Geography	Professional Roles	Personal Interactions, Encounters, and Engagement	Conflict	Physical Attributes
Case 2 – A North Texas Panhandle 1 District	Protect remaining water in aquifer and extending its life. Protect water primarily for irrigation; less concern for drinking water. To represent different areas and different interests. Users are primarily agricultural. Level the playing field for all producers. Juggle rules for farmers and ranchers. Setting rules to equalize everyone's usage. Responsible for tax-based revenue.	Lack of time for farmers to go to regional groundwater meetings. Users mostly interact with the Board when they have a complaint or when there is a 'rules' change or a perceived threat that their water supply is affected/'cut off'. Local control represented by GCDs means that there is interaction with the public. Educational meetings occur on a regular basis. GCD personnel hold adult education classes and classes for school children. The public feels comfortable approaching GCD personnel at chance meetings in the community. Continuing education is mandated by the state. GCD hires technical and scientific expertise and uses modelling to make information available to users. User-provided information to the Board is welcomed as long as it's scientifically based.	Conflict among different historic users of water and industrial users. Conflicts over production wells being drilled and then exporting water outside of the district which can be a lucrative source of revenue.	Negligibly chargeable aquifer. Slow transmissibility. Activity in the district is withdrawing more water from the aquifer than is being recharged. Not much surface irrigation of crops and for ranchers. Unlike urban areas. Most comes from groundwater.
	Users Farmers. Petrochemicals. Beef and dairy cattle production. Nuclear power. Manufacturing. Land Use Agriculture. Oil and Gas. Ranching.		Funding Tax-based. Tax revenues are highly dependent on the population of counties within the GCD. Tax revenues allow funding of better technology.	Availability Drought has made users more conscious of the water they are using. Considered Technology and Adaptive Measures Computer entry of field data. Satellite GPS in the field. Weather modification.

A.3 Data of Contextual Factors and Outcomes in Central Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
	Professional Roles	Personal Interactions, Encounters, and Engagement	Funding	Physical attributes of the groundwater and aquifer
Case 3 – A Central Texas District	The director is also a representative, with governing authority, of special, environmental or recreational interests of constituents. The director has the authority to make decisions on behalf of the district. Manager addresses overall operations and day-to-day operations as a financial manager; he is also a liaison between the Board and staff, takes direction from policy decisions given by the Board, brings the major policy and permit decisions, overall operations of the district to the Board, implements and carries out decisions, plays a supporting role, provides a balance providing information without biasing their decisions and being supportive of what they need to know for an informed decision, supports the Board's strong emphasis on data-driven science, is a source of in-house technical expertise and technical background rather than outsourcing to contractors, and manages quantity and quality of aquifer. Balances the different needs for water, including water used for recreational use, drinking water, and other uses.	Big users interact with the Board and are very well represented with their own groundwater professionals. Not a lot of individual users try to represent themselves. There is a need to balance expertise. Well-publicized and well-attended meetings are held using a well-designed website. Transparent process. Electronic newsletter with a broad distribution list. There is an education outreach coordinator and public information coordinator. Very few people attend meetings.	Fee-based.	Karst aquifer, a very porous aquifer in an environment where there is a desire for a lot of development and different aquifer characteristics in different places. It has no known discrete recharge points where a lot of water goes in, and has only general and widespread diffuse recharge points. Depends on scientific data to indicate availability of water, to set a cap on pumping. Well water may be the sole source of drinking water for many, but the tap may not be in their backyard as it may be for users in other districts. The water supplier supplies the well water. There can be some disconnect with the impact of a neighbour's action of your source of drinking water. The recharge zone is within the district, so no worry about adjacent pumping across county lines or contributing watersheds that cross recharge zones. Some coordination occurs with other districts and other GMAs.

Users	Alliances	Conflict	Availability
Urban recreational users. Water supply companies that have wells. Dominant user is public water supply systems because of an urban environment and a growing population centre. Users have very different demands.	The district has lobbyists to represent their interests to legislators at the state capitol. Directors interact with legislators, testify at the capitol.	Large companies that are awarded a permit and want to pump water. Companies that are denied a permit and want to circumvent the district's processes. The public then voices its intentions and preferences to the Board. Landowners who wanted to pump more water than the district has to permit, without disclosing the use for the water leading to contested permits. Controversies involve the use of a lot of staff time to send emails or demand attorney general's opinions. There is a trade-off between defending an already made decision that can be energy-, time- and resource-intensive and getting in front of an issue, that is, to be proactive. The latter approach has been successful in the past. Important to make sure everyone is informed, has an opportunity to provide their input to comment and inform the Board of their opinions. Important to make Board recommendation based on the technical components to make decisions less emotional and political although those factors always exist. Trade-off between the defending an already made decision that can be energy-, time- and resource-intensive and getting in front of an issue. Opportunities for public comment and hearings. Town halls take a lot of energy; it takes a lot of staff time and talent and takes a lot of resources.	Increased demand for water. An aquifer with a finite capacity and ability to produce a reliable volume on a sustainable basis in the long term. Utilities have had to be more creative with their water supply, exploring new water supplies and innovative ways to store more water. ASR has been explored. Treated effluent has been explored, even for a potable water supply. 'No such thing as bad water anymore.' Looking as not just demand management, but new water supplies to reduce the pressure on freshwater – at the supply side of the equation. Putting in more drilling monitor wells, doing sampling and analysis.

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
	Land Use			Considered Technology and Adaptive Measures
	Use is for urban agricultural users. Commercial users. Industrial users. Health, safety, Human welfare uses.	Cultivation of external relationships, just from the environmental advocacy angle on things.		Recharge enhancement. Desalination to increase supply. ASR (not preferred). Exporting water, moving it around at high capacity gets many people's attention. Assessing the feasibility of desalination. These efforts are consistent with the mission of the district. Technologies can benefit the reduction on the more vulnerable areas of the aquifer in the district but providing regional water supply for the whole geographical area.
		Interaction with environmental stakeholders and those involved with habitat conservation.		
		Involved with a citizens' advisory group that includes a lot of biologists.		
		Interaction with water suppliers who can take district feasibility research and data and make good investment decisions without a level of risk they might have occurred if the district had not collaborated with them. The district can use its objectivity (vs. a hydrogeologist or a developer) and credibility as a technical arbiter.		

A.4 Data of Contextual Factors and Outcomes in the Gulf of Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 4 – A Gulf District in Texas	Professional Roles Water is my profession. Hydrology and geology do motivate us towards one management style or another.	Personal Interactions, Encounters, and Engagement Rural interactions are based on community and residency, what neighbours are doing, and how it affects the protection of their water and whether the neighbours have permits for their use. Residents have direct contact with staff to ask questions about everyday well registrations and permit applications. Posted monthly, open public meetings where interaction and participation take place since it is a rural county. Rare attendance at meetings. Size of the district limits attendance, even if there is a controversial application for a permit. District staff are their neighbours, and direct contact occurs through coming into the district office or calling in to the district. Community may approach directors in church and so on. Use of the district website. Social media/ Facebook. Urban-residing landowners who visit their land on the weekends and need to come into the district office to ask questions.	Local Culture Citizens who don't want another level of government within their confines. This affects whether a county wants a GCD in their area. Most residents grew up in the district.	Physical Attributes of the Groundwater and Aquifer Little recharge. Recharge is more inflow from other districts; therefore, no enhanced recharge. Aquifers not very productive. It is good that the number of users is small.

(continued)

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
	Users	Alliances	Funding	Availability
	Main users are small single-dwelling domestic users, Local public water suppliers and farmers due to the agrarian, rural community. Each user is treated the same when applying for a permit – fracking, irrigation, water suppliers, and industrial supply. Most residents grew up in the district.	Engagement with state representatives and state entities. Interviewee sits on state councils, Boards and committees regarding water planning for water and drought. State representatives do not visit very often or come to meetings. Some interaction with non-profit environmental groups. Some interaction with vocal citizenry groups to answer questions and provide information. When there are questions over surface water, the district has no jurisdiction over that.	Tax-based. This revenue source makes equipment purchases and projects based on taxes being increased, for example, 'a hundredth of a penny'. Purchases made have to consider the source of the revenue, since the district is working with public funds. A lot of 'bargain planning' takes place. Low budget, since by legislation, the district can only tax so much to gather money for operation and maintenance.	Sandy aquifers that retain water, but it is highly mineralized so water quality can vary depending on where in the district you are and how close you are to the neighbouring county.
	Land Use		Conflict	Considered Technology and Adaptive Measures
	Usage is broad across the district. Few people, large area. 'Agricultural' use.		No contested permits.	User reduction. Enhanced recharge. No need to consider additional groundwater supplies due to low usage, rural community and not facing immediate problems.

A.5 Data of Contextual Factors and Outcomes in West Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 5 – A West Texas District	Professional Roles	Personal Interactions, Encounters, and Engagement	Local Culture	Physical Attributes of the Groundwater and Aquifer
	Field technical lab analyst work. Office duties. Posting notices if someone wants to drill a well. Posting an agenda for the meeting. Getting ready for Board meetings. Setting spacing rules from the property line to the well. Revealing any permits for the districts. Mainly, the integrity of groundwater. Submitting well reports to the state. Determining if a well is exempt or non-exempt (from needing a permit). Monitoring the website for well reports from well drillers. Answering face-to-face questions.	Residents will proactively visit the office since they know their wells can be contaminated by saltwater spills. The district will also talk to the landowners. Communicating with oil field workers and drillers in the industry to know when there will be an increase in fracking activity, and they will be using wells in a certain area due to oil price spikes. Users know that the district does a lot of testing so they come in and ask questions about the results of water monitoring, rainfall, and to make use of maps and charts in the district office. Local long-term landowners know about the bad water quality in some areas, so they interact with the district to help them monitor the quality of their well water. Users contact the district office to learn where to place their pump and similar services. City residents who, if not local, are unsure about the permitting process for spacing, and needing to be educated about rules and legislative requirements, will visit the office. Largely being local people, the district staff and administrators will get stopped in church. Users will call to find good groundwater, although some will end up cleaning up old wells instead of drilling new ones. Users will call the district with technical questions about, for example, the depth of their well.	The area started off as an area of historic permits. Residents try to make sure everything is kept under local management rather than the state. Residents know if you are not from the area. It's a small town. Board members see themselves as very different because their composition reflects the people who voted for them to do things 'a certain way'.	Some saltwater spills/ disposals from oil field activities which can contaminate people's wells, although it doesn't affect the discharge or recharge of water and where people can put wells. This is part of the local monitoring.

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
	Users Some gas. Water is needed for drilling and some of their operations. With not a lot of drilling going on, there's not a lot of need for water. Some is needed, but not at any great volumes. Users have a lot of local knowledge. Many wells have been owned by families for a long time. Domestic users are household, oil, windmill for livestock, and electric pumps for livestock. Domestic users are retirees moving to the area because it's cheap. Neighbourly users.		Conflict The most likely conflict is if the legislature goes to area- or statewide management of the aquifer since the surrounding counties are very different from each other in terms of geology and lifestyle, how the water is used, and how the permitting occurs (little permitted irrigation because of low use). Conflict is handled by compromise. Because many of the big permanent irrigation wells are on large family ranches held for a long time. Newer wells are very visible. The older community with long-held permits knows that people have a right to their water, and newer wells can't be denied permits, but the district can promise to monitor. Newer wells are closer to town, more visible, and may draw attention. There have been no lawsuits, and no permits contested by newspapers or press. These types of issues, while 'they don't directly affect groundwater, they may end up affecting people's accessibility to groundwater' on the terms they see appropriate for them. That's why the concern.	Availability No surface water and not a lot of water loss to surface or bore evaporation. Rainfall is low for recharge. Recharge requires good rain, which doesn't always happen, so recharge events are not frequent. Activity in neighbouring counties affect their aquifer since they all draw from the same aquifer.

Land Use

Issuance of permits, but not a lot – 99% are domestic and livestock. Lots of ranching, not much irrigated farming. Some fluoridation wells, permanent irrigation wells. Most are lifelong wells, windmills and stock tanks. Because many are lifelong wells, there is not much issuing of permits. Very rarely does property go up for sale because it stays within families.

Funding

Tax-based – therefore, the district tries to provide some services to the users for free, like checking their water well monthly or quarterly or annually.

Considered Technology and Adaptive Measures

Transport of water even if hypothetical? The salt spills can affect where permits are issued for wells away from the salt spill areas. The presence of oil wells and field wells and the lack of surface water engender a lot of interest in the district office. Oil spikes mean more fracking activity in the area. There are differences in the hydrogeology of the aquifers – groundwater in some areas, some or no surface water in other areas, and some mostly reliant on surface water. Forcing everyone to follow the same rule will be difficult. Even export of water based on a universal rule would not work for the county, since some users don't use their capacity and regulating and writing rules based on when someone else is going to need it outside the county

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
				may affect the access of users within the county. Not suited for ASR. The county is landlocked, surrounded by privately owned land and the technology can't be applied to the windmills and the domestic and livestock wells.
			Alliances	
			Occasionally legislators came through and attended a town meeting. Board members have gone to Austin to meet with legislators and staffers. If there is an action. Counties within a district will band together to show unified presence to senators. A piece of legislation will have several signatories on it so that the senator knows that it represents a good portion of their voting base. Good relationship with regional organizations. There are a bunch of small counties with two employees or three full-time staff.	Oil price spikes cause more trailer parks and increase in water use, but it is a temporary strain on water, so long-term supply planning is not really big in the district.

There are different local issues but one aquifer. Not much interaction with environmental groups since there isn't any surface water or endangered species, and 'no one fights for a rancher's stock tanks.' Lots of environmental knowledge but no environmental activism. No contested hearings or contested permits. Meetings are very similar and are held once a month. If something's not going right, people will mention it. Hypothetically, they would call your phone, and you are almost sure they would attend the meetings. Engaged with professional organizations, regional organizations and state agencies.

A.6 Data of Contextual Factors and Outcomes in Far North Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 6 – A Far North Texas District	Professional Roles	Personal Interactions, Encounters, and Engagement	Funding	Physical Attributes of the Groundwater and Aquifer
	CEO of District, CFO of District, and Manager of Staff. Inform and bring information to the Board so they can make an educated decision. Preserve the local nature of the rural area that they were brought up in. The position allows for addressing the decline of potentially large areas of land which could be rendered useless because of declining water levels in their home area, an issue personally worrisome to them. Different districts have core missions, but the above issues were personal to them. The position allows for consideration of people way out in the county who have large or small acreage but there is no public water and the only way they can exist is to have water that is sustainable into the future.	Public water systems appreciate being able to easily call the district to get information that technology can provide a knowledgeable staff. District has to interact with city users who don't understand conservation but have been sold the rural life. Large turnout at meetings, especially when the community thinks rules are being circumvented by a permit applicant. Attendance at many committee hearings, whenever there is something pertaining to groundwater on the agenda. Social media energizes opposition with large turnout and participation at meetings. Community is energized, engaged and protective of water being taken out of the district or large developments with hundreds of built homes. The public can have great ideas. Public perception can be about big things. Balancing the ideas and realism. Some perceptions are based on incorrect ideas about an aquifer. There is a fine line when addressing concerns. The district spends time educating youth about being smart about using water.	Fee-based.	The aquifer is close to an outcrop. The aquifer is close to where it should be easily recharged but because of development, formerly prairie grass areas have been covered over with impermeable surfaces. Normally, the grasses would slow the water and allow for recharge through percolation. Lot size and lot size spacing are very important; otherwise, there would not be water in five years without a 2-acre requirement. This is because of the growth in the area, unless they're in town where they're on public water. The aquifer is less productive, so it has to be managed, due to its geology. Being on the outcrop where the aquifer is very shallow, where water levels are 60 feet below the surface and extremely sensitive to drought. The district wishes they could do more to stop growth, but that's not their purpose. Different areas over the aquifer are so different. Even the outcrop in the same aquifer can be different. One area may be more uniform and more productive and thicker vs. in another area where there may be a thinner outcrop. Only one county away, there may not be many subdivisions going in with a well on every lot.

Users	Alliances	Conflict	Availability
The majority of the users are exempt – anything that produces less than 25 gallons a minute, exempt for agricultural users. The dominant user is exempt from metering, which is a concern for a fee-based district. The dominant user is the private user who relies solely on their well for water. Some livestock but exempt. Non-exempt users are the public water systems that are in the cities, but these are small users. They use surface water but have a few wells to add to their surface water. Users who are on surface water but want a well to water their lawn have to be educated about conservation. Users who have grown up all their life depending on wells as their sole source of water understand what a low-productive aquifer means to them. They are extremely sensitive to drought. Water suppliers have a small number of well connections all over the area. For example, there might be 4 wells for 100 connections. Growth has meant that city people move out to the area and want rural life on their 2 acres. Never had to rely on a well and a septic system which can contaminate the well and need	Given testimony numerous times at the capitol that the aquifer doesn't see the county lines, but there are very real differences from county to county as they make their decisions. Very involved in that legislative process. Tries to meet with all of the local legislators as often as possible during session in Austin. Attorney who works on behalf of the district in Austin, who spends a good amount of time at the capitol, working on. Works with local Chambers of Commerce organization. Works with commissioner's court and with the county. Has met with the legislative representative, but only in their office. Organized groups, not as common in North Texas as it is in Central Texas. We interact when we take our trailer to local festivals. Any kind of public event, we try to be there with our trailer, so we can help. People understand the aquifer and where the water comes from. I think I'm pretty good at listening to the citizens and at least addressing their ideas and concerns, and doing what we can to address that.	Spacing in one area of the district may mean a reduction of conflict, but spacing is not done because of growth or lack of water, but done to prevent clusters from becoming too tight. Conflict can be where water use for oil and gas production is high and people want to stop that. They want the district to intervene. But that is not what the district is there for. Private property rights allow them to do that although rules can be changed to cap the amount they are producing and let the district know how much water they're using. Conflict occurs when large communities want to put in a larger well. Developers who put in a large number of homes and, in the first phase, want large lawns on 1-acre lots. The district advises 2-acre lots. Each hires their own hydrologist. This results in falling water levels for people who live across from these large developments.	Public is aware that in their area where the saturated sands are only 30 feet vs. karst aquifers. District has to address the local city user who wants a well to water their lawn. During the oil shale boom, once the drilling stopped the aquifer recovered. With 30-year mortgages, people will still be paying and the water will be declining, even if the aquifer being near the outcrop means recharge is possible. Trucking water may be in the future. Cones of depression may grow in the summer months. People always need and use water unlike the oil shale days.

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
	to have care. They like not having a water bill but don't realize that they have to pay for the well driller and pump installer and the pump and all of this with no grants (your wealth), and they can't use all the water they want. Developers promote no water bill, and you can use as much water as you want.			
	Land Use Developers like to drill a domestic well cheaply here, which also makes it cheap for them to build subdivisions. Large number of applications each year. Because of this large number of applications, well-spacing is a concern, and not because there is one large well, or a marketer, or an investor pumping to move water outside of the district. Previous history was during shale booms, and there was concern about wells pumping into ponds and then using water for oil and gas production. The concern was over-pumping for oil that had to be managed. Proliferation of small domestic wells clustered together in tight areas causing huge cones of depression.			Considered Technology and Adaptive Measures The public water systems appreciate the technology that allows the district to say where they can find water and at what depth. ASR: Has to be somewhere where some of the excess surface water supplies that they can treat and pump in normal ways, and they're highly treating effluent, which is possible. It has to be treated to almost drinking water standards and put back in the ground. It has to be one of those situations, and there's only a few of those within the district that exist, and most of those, where they exist, aren't in the area that I feel conducive to ASR, but I think it's our job as a district to find out for sure. It all goes back to the geology.

A.7 Data of Contextual Factors and Outcomes in South Central Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 7 – A South Central Texas District	Professional Roles	Personal Interactions, Encounters, and Engagement	Conflict	Physical Attributes of the Groundwater and Aquifer
	Representative in the district from which they were elected, and sometimes to represent the entire district. Do what the legislature charges each GCD to do – preserve, conserve, protect and manage groundwater. Implementing policies. Permitting. How to contest a permit. Basics of managing groundwater. Make sure everybody has water. A manager may communicate with a director several times a day. If the director meets with a legislator, the manager is asking questions because they are the ones who ultimately have to enforce whatever the directors decide. The manager is the one who has to implement, and it has to be doable, so their input is really important.	The public primarily interacts with a staff member or manager. If there is a complaint, the interaction may be with a director. Directors mainly interact with their constituents. Good interaction whether it's a homeowner or business. There is an open line of communication at meetings. The public is able to speak at meetings. All directors get informal interaction. Organizations are very good at being involved and coming forward with their recommendations and their own proposals and public relations (PR). Very open formal or informal communication with all of our constituents, our users, because groundwater is all there is, with one exception. Not much on social media. A couple of directors are not on Facebook at all. There is a website and people are really good at calling our office, or calling people directly. We have a very open direct line of communication – the newspaper, emails and phone calls. There are videos of meetings, and there is a charge for a CD or a video of meetings. The public can record on the phone. No newsletters.	Economic cost = the cost of fact gathering, listening to everything, Manager is good at fact gathering and bringing that to the Board. A lot of what comes up in certain cities may be perceived as negative. Difficult decisions. Have to consider the impact on the community as a whole. Have to consider everyone that the person asked for the water, whatever their needs. Have to consider the wealth around that person who's asking for a permit or an increase in their permit. Transaction cost of conflict is time. I think time is just the biggest cost because we want to really know. The more information you have, the better decision you can come to. And so, making sure we covered all the bases. And again, a lot of that is listening. Considering everything. And some decisions have been difficult. If you're an expert, you're not ever going to please everybody all the time. That's just the bottom line on that. But I think this district does a good job at preserving and conserving and managing; they offer that as our ultimate goal and as long as we keep that goal in mind. It's hard to not get wrapped up in the emotions but to separate those out and look at the business of it. We consider what are	5% recharge – very slow. Growth and development is a major concern. We are a karst aquifer, which means we are solidified sponge. Rock with holes in it.

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
			the charges from the legislature and stay true to that. I think this enables us to do the right thing, whether I like it or personally. Or, my best friend likes it or doesn't like it, you know; I've certainly had to make decisions that people have not liked.	
	Users Homeowners are primary users. The largest permittees are water supply corporations. Local developers have permits. No huge business permittees.	Alliances Involvement with our legislators. By interacting with our legislators, going to the legislature speaking for or against groundwater bills. It's imperative that you have that interaction because you have legislators who are getting the developers the water. Providers are coming in with bills for them to sponsor, and it sounds good, but they don't understand the aquifer or how it's going to affect groundwater districts. It's important to educate the legislators and that there is a direct line. Interact with our county commissioners. Work with educational institutions. Work with and have joint programmes and projects with them. We work with the other groundwater districts around. Work with other cities and other organizations that are responsible for development, and they come to us frequently with proposals or resolutions. Other environmental groups, but I don't think we have a real direct interaction with them, but I certainly hear from them at various meetings. They, and we, seem to typically be on the same page. Our senator has never visited our office, and we have difficulty getting in to see them. Another representative has come to a meeting here, but this doesn't happen very often. Normally we have to go to there.		Availability Developers only care about building homes and not really thinking about whether these homes will have water 10 years from now. The impervious cover that comes with growth decreases our recharge areas. We don't have enough water for everybody who is here already. So, for those coming in, not only are they going to possibly create hardships for those who are here; they're also not going to have the water they need and want in the future, so conservation is becoming a huge issue. And we're getting close to the point where we're going to have to start saying to developers that the water is not there based on the MAG models and it's going to get worse.

Land Use

It is a very diverse district. There are some areas where there's plenty of water and other areas where there isn't. A rain recharge area, with more impervious cover as more of the area comes into development. Local wells that provide water to homes.

Considered Technology and Adaptive Measures

Water purveyors and county looking at piping water in from other areas. Well, in this area, this is rock. A pipeline is going to be exceedingly expensive. And we're getting close to the point where we're going to have to start saying to developers that the water is not there based on the MAG models and it's going to get worse. Plus, we're hills and valleys, and a lot of those areas do not want to sell them. They don't want to sell, and they want to protect it for themselves. ASR is really not possible within our aquifer. We are not, as a district, responsible for providing water to people. As far as making sure it gets pumped in from somewhere else, or anything like that. We are responsible for taking care of the office. If a new development needs water. They have to provide the water, but the bottom line is if you don't have it, you can't do it.

A.8 Data of Contextual Factors and Outcomes in North Texas – Panhandle 2

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 8 – A North Texas Panhandle 2 District	Professional Roles Running the day-to-day operations of the district representatives. To tell the story of the district, and to do everything we can do to get the word out about conservation, each person's personal role in conservation, and ultimately get everybody involved in leaving more water in the ground – anyone who uses water. The directors represent an electorate in each of the counties. They represent their precincts. The representation is based on the elected populace here, so, if your particular industry doesn't have any directors, we're all elected. Most of the time that people who run for elected Boards in this area do it because they have skin in the game when it comes to the aquifer. As far as oil and gas representation, if there's someone who lives in the county, they can vote for whoever they want to be on our Board – it's an elected Board.	Personal Interactions, Encounters, and Engagement We do education. We have the groundwater conservation demonstration for the state of Texas. We cooperate with producers and irrigators in our area on best management practices, and the best methods for them, and how to pump only the water they actually need. So primarily the measure of engagement is attendance at the Board meeting where they're presented with noncompliance, or there is the phone call.	Local Culture Philosophically, I believe that people should be elected, you know, on a local management scale. We spend a lot of money making sure that our local control management is protected, and we work with them to ensure that we know best about managing groundwater here in this area. We have a certain number of people in our entire district. We are a large district. That means we're pretty sparsely populated. We have a mission statement. That goes to protecting our way of life here in conservation. We're concerned about not just the farmers who use water; we have a lot of people in dry-land farming scenarios, but we're also concerned about the automobile dealership up the street. We need to work on coming up with other economic venues used for this area. We're in advocacy for bringing in industries that don't use that much water.	Physical Attributes of the Groundwater and Aquifer Recharging this area is like a quarter of an inch a year, so we don't get a lot. So, we're mindful of that when we're putting together our management plans. We know that we have a declining aquifer for questions that help us address what sustainability vs. discharge is. The recharge is so minimal that that has to be obviously considered, and, when considering all of the management strategies, we know that we cannot rely on significant recharge to offset pumping. This is an ongoing consideration with everything that the Board does in terms of regulation. We don't get that much rain in this area. I don't know if we're a sub-arid area or not, and because of that and because of our sandy soils, most of the rain that falls goes directly into the ground that isn't evaporated away, so that physical characteristic is a big reason that we don't have a lot of recharges, and we just don't get that much rain and a lot of it evaporates away before it ever is sent to the ground.

About 95% of the water that's pumped in this district is used in agriculture, is used on irrigating some kind of crop. That means 5% is for industry and for residential and municipal. This is a different percentage than you see in most of the rest of the state. That's because farming agricultural production is the number one or number two economic driver for our area, depending on how oil and gas is doing at a particular time. This obviously shapes policy and regulation for the district.

Funding

Tax-based. We're a taxing entity where taxes are really our primary operating funds. There's a small part of our district that's not taxed. We get a fee from their production in that area. Other funding revenues are from our permitting programme. We charge a fee for the big wells that are drilled and their permitting fees. Those are the three primary sources of revenue.

Availability

We do have some areas over the eastern part of the district that we do get substantial discharge from the Ogallala, and Board members in that area are more concerned about that discharge. Our rules are designed around keeping those things in mind. Our public water suppliers are required to either metre their well or report that they're using alternative measuring methods. We've been collecting metre data – flow metre data – and from alternative measuring methods since 2007. It has shaped our policy on those production reports, on our long-term outlook for the district, and gives us an ability to do more science. Caliche and clay are an issue as well. Rain has a hard time getting through all that to get to the aquifer. We have a pretty good handle on how much water

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
				we good handle on how much water we have in the ground. We measure the water coming out of the ground, so we can better predict what we think our future is going to look like. I think we've developed certainty over what our future means is that we're going to have to figure out how to live with less water, physically.
			Conflict A governing Board tells their constituents that they've got wells and they've got abide by a production limit. We don't care what your use is. Our directors have had to make decisions on compliance matters with our rules. If someone isn't following our rules, then they end up in front of our Board and those individual directors have to make decisions that could affect the livelihood of those producers. Whether it's a public water supplier, industrial user, or irrigated agriculture. There have been times that their friends or the people who they've known have been in front of them. In a decision process to get them to follow the rules.	Considered Technology and Adaptive Measures The Board has been engaged in water conservation because users know that this is a limited resource. It's a declining resource, and the way they use water today is not sustainable. It means that we have to find new methods and ways to stretch that water around. We do 'field projects' that our Board supports because conservation and bringing new technologies and methods 'helps us be' as efficient as we can. A water bill that will show average use and it'll show who is on the low end. This can create some water conservation because it brings awareness to people. This is true in the irrigated community too. Producers have moved from conventional tools of irrigation, too. We offer incentives for farmers or agricultural users to initiate these

In the face of conflict, we do public forums, and a lot of hearings. We go above and beyond what's required by law that we do as a governmental entity. In some of those cases, we were spending a lot of time with the public, saying this is where we're headed. We held meetings across the district. Sometimes they were not happy campers in lots of the areas where we were headed. There were some supporters, and some didn't support the Board. Then they finally adopted the set of rules.

kinds of technologies (tillage and irrigation), new kinds of technology. It's a cost, but there are results from that. Metres to monitor groundwater use are installed. Federal grants have funded field projects along with partnering with educational institutions. We've been able to show the farmers that it's not costing them to do conservation because 'they've' heard conservation costs (them). If this is the case, nobody is going to do any business, if it's going to cost them financially over the long term to do conservation. Board members have travelled to other districts to see and be able to prove that different technologies work in anticipation of any conflict. Economic incentives put tools in an irrigator's hand to pay half the cost, so they have skin in the game, and they get some help to try different technology. They're told to try this equipment and get some training, some understanding about the equipment that they're using so they get the most benefit from it. The Board has discussed the likelihood, at some point in the future, bringing water from a surface water source in order to replenish. The problem right now is the cost of agriculture is so low, it's economically extremely difficult to have agriculture pay for moving water.

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
	Users Most of our uses are from groundwater irrigation. The group that is in this area is probably among some of the most advanced irrigators in the state of Texas.	Alliances Yes, we keep our legislators apprised of all groundwater issues, and we watch issues in the legislature. They have worked well with us, and we have engaged them. Our representative has helped us with his written letters of support, and our federal grant applications. We keep him and his staff as informed as we can. It's important to us, not just on the local scale. In our management of groundwater. We have to make sure that the rest of the state and other legislators know that we're doing a good job; we're doing about as good as we can get. We spend time with our legislators and those who are not directly representing us. Most of the organizations that we deal with are agricultural in nature, involved in groundwater management, and water conservation, not just environmental advocacy. Some out-of-state organizations are focused on educating the general populace about how to take care of water resources. We have a lobbyist in Austin. When you're so far away, you have to speak louder because the legislature is there. So, we do that.		

A.9 Data of Contextual Factors and Outcomes in North Texas

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
Case 9 – A North Texas District	Professional Roles The buck stops here. Managing staff work under the direction of the Board of Directors who set policy, and ultimately grows the district – all those things are promulgated via the Board. Provide the details and a lot of the expertise that the Board uses without being micro-managed. Support of the Board is important. Recognize that your opinion is just one and there might be a dominant director to kind of guide the way the district goes. Always ready to answer the hard questions from the Board and the public. Protect the groundwater and get the job done. Earn the public's trust that you're there to help protect their water, not take their groundwater.	Personal Interactions, Encounters, and Engagement We do a lot of them. We have a curriculum we put in 24 school districts within, within our counties. We have a teacher lesson plan that covers things such as testing, storage, and all that. It's updated every three years, to make sure you're in line with those state testing requirements. We give that out. Anytime we get a chance to talk to the public, you know, civic clubs service clubs, anything, we do that. Educational outreach is part of the state management plan. Every district has to have a management plan; it has to be approved by the Texas Water Development Board. The district has its own education coordinator. The district has made an extra step to have an educational outreach person, just dedicated to this type of work. People don't come to meetings. Not involved unless something is being done to stir them up – fencing, metres, spacing (2 acres) to protect someone else's investment, especially in small subdivisions, but, other than that, no interest in being engaged. Once the user has their well, that's it. We help the people who need the water, get the water they need,	Local Culture Because to get back to the local, some people want to call it local control, but it is about viability; but the people in our district want to make sure and keep the water here. They don't want a mandate from the county courts in those counties to establish a groundwater district or want to be required to join one. You don't trust somebody in Austin to do it for you, so you do it yourself, but you pick where you want to join up with and that's how that happened.	Physical Attributes of the Groundwater and Aquifer We understand the aquifer, and it'll only give up water so fast, so there are production limits. The hard part is the hydrological knowledge to know where the water is given the complexity of the aquifer structure. The aquifer is not a karst which will fill up really quickly when it rains, and it also can be pumped out. In the district, precipitation is very important because the aquifer needs to recharge. The district has different recharge capabilities. One part can benefit from precipitation almost immediately. Another part doesn't really get precipitation, so all those different characteristics of the aquifer have to be considered. The district has to consider neighbouring population in their habits.

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Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
		and still assure them that they're not taking more than they should. We look at how much they can pump. There are notice requirements in the statute. The state legislature is relying now more on the internet and websites than they did in the past when notices were placed at the courthouse. At one point, they became really creative about what drove communication with people, trying to get feedback, by going to all the banks, and putting notices in their bank statements, and having a weekly spot on the radio. They've had many town-hall meetings, public hearings, especially when it came time to do rules, so there is no lack of opportunity. People will be involved, but don't seem to be involved and a little apathetic about things until it's in their own backyard or in their own pocketbook.		
	Users	Alliances	Funding	Availability
	The people have their own groundwater wells. Not provided from a water system. Users who get their water from their own well have a lot more appreciation for their water and a much better understanding. Users who get their water from a system consider their water the same water as the people getting it out of the ground with their own well, but they don't have any understanding of any terminal tap.	The Board has a legislative committee, and certain members of the group may want to volunteer for that and testify in Austin. It's very important to be a part of the process. It makes a difference. Sometimes it's frustrating. Legislators want to do the right thing. When there are ASR studies, legislators will have rules-making hearings, because there'll be some rules that they'll have to make to help implement a new statute. We get involved with those also.	Tax-based. This requires prudent decision-making; you don't want frivolous lawsuits because you're using taxpayer money. This includes hiring attorneys and spending a lot of money to defend the district.	The quantity of the water varies. In the summertime and especially in the highly agricultural areas, the water level drops. In the winter it recharges, and there is no overdraft. There has been some concern around high-growth suburbs. There has been an effort to set up groundwater management areas to work together in an adaptive process over five years to develop desired future conditions. This was an effort to have districts start working together, focusing on the same thing, such as rules.

Many of us take part in the regional planning process. The Board is involved in regional planning. The district is on the mailing list of grassroots and environmental organizations that they network with, and county extension agents.

Land Use

The predominant use of groundwater in the area is agricultural. There are some communities that use almost 100% groundwater.

Conflict

Although people don't get involved until there is an issue that directly affects them, there just aren't many types of these kinds of issues. If you don't have knowledge of how the public perceives, and you decide, and the public finds out about it, then you could have backlash, repercussions, and problems. Then you must come back and redo.

Considered Technology and Adaptive Measures

Because of the desire for local control and the users in the district want to make sure and keep the water there, there was an effort to discourage water marketing. Somebody will want to come in and mine the water, but, given the agricultural economy, of which there is a lot, local users are very protective. The cost of drilling a well depends on the geology of the aquifer. Affects the efficiency of the decisions. The well could cost $100K. The ones that are really expensive are the public water supply wells. They have to be constructed differently than the well used by an individual homeowner. They have more concrete to protect them from the influence of other wells around them. With respect to desalination around water, the district has been told that they're sitting on oceans of salty water. It can be used, but it's only cost-effective to desalinate water that has a certain percentage of salt when it gets too salty. It's just not cost-efficient to do so. If you have proximity to where you're doing it, it makes a big difference.

(continued)

Region, Funding, and Geography	Professional Roles, Users, and Land Use	Personal Interactions, Encounters, and Engagement, and Alliances	Local Culture, Funding, Conflict	Physical Attributes of the Groundwater and Aquifer, Availability, Considered Technology and Adaptive Measures
				If the water use is proximal to the desalination facility, it's a whole lot better than if you're far away. This and ASR need a whole lot more study. Both have been done in different-sized cities. We have not seen the increase in demand side, but growth keeps moving this way. We'll see increasing demand; we'll see increasing population. You don't need water just for the increasing population. One of the most water-intensive products we have is electricity. So, you need a lot of water to generate electricity. We've looked at more efficient irrigation techniques. We've looked at plugging abandoned private and commercial wells. It protects the water you already have, so it's there to be used when you need it. There is a state-prescribed process. If somebody finds one, it's illegal to have one like that and you are liable to your neighbour and anyone else if pollution occurs from it. The district will plug it at no expense to you. We will fill it, disinfect it, and plug it with concrete.