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Reorganizing Groundwater Regulation in Texas

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A Bush School Capstone Report to
Hon. Glenn Hegar,
Texas State Comptroller of Public Accounts

Executive Summary

The Texas Water Development Board's (TWDB) 2012 State Water Plan paints a pessimistic picture of future availability of groundwater. Is this due to the physical limitations of the resource or a regulation-induced shortage? To answer this question, it was first necessary to determine how much groundwater the state currently has and how long that quantity is expected to last. These primary assessments were reached using data from the TWDB for each of the nine major aquifers including total estimated recoverable storage (TERS), annual recharge, and historical pumping rates. Additionally, interviews were conducted with the staff of each of the state's 97 groundwater conservation districts (GCDs). At current consumption rates, five of the nine major aquifers have unlimited years of supplies of groundwater. Even using historical growth rates in consumption, we obtained much the same result. The two exceptions are the Ogallala and Hueco-Mesilla Aquifers which have less than one hundred years supply. For the others, only if consumption is projected to grow at a rate of 2% annually (a highly unrealistic estimate), do the numbers decline dramatically. Yet even so, five of the nine aquifers would still have over a two-hundred year supply. These calculations reveal a misconception about the state's availability of groundwater. Most citizens believe groundwater is rapidly being depleted and want to protect it for local use. Our findings show there is a relative abundance of groundwater in all but two of the state's major aquifers. Furthermore, a review of the regulatory practices of the local GCDs supported the conclusion that Texas has a regulation-induced shortage of groundwater.

In attempting to examine alternative regulatory options, it is necessary to have basic criteria for evaluation of these options. We adopted the following criteria based on existing legal precedent, economics, basic equity considerations, and hydrology as follows:

- The protection of property rights,
- Using water at its highest and best use,
- Mitigating against landowner losses, and
- Managing aquifers in a prudent manner.

Using these criteria, we have evaluated the following four policy options:

Policy Option One maintains the existing GCD structure while reinstating the landowner's ability to treat groundwater as a property right. This option builds on best practices utilizing many of the features adopted by the Post Oak Savannah GCD. Under the current system, the power of GCDs to treat specific uses of groundwater differently has effectively usurped this property right. Therefore this policy would require GCDs to accept pumping permit applications regardless of use and implement a uniform, nondiscriminatory fee structure. Additionally, this policy would ensure each landowner receives an equal and fair share of groundwater by replacing the existing convoluted regulatory process with a simple formula-based system using a percentage of TERS, annual recharge, and correlative rights.

Policy Option Two proposes the replacement of the existing GCDs based on political boundaries with hydrological boundaries. Like Option One, it would use a simple formula for determining available groundwater and use correlative rights to assign pumping rates. This approach would allow for more effective regulation by treating groundwater consistently within each aquifer and reconciling the differences between adjacent GCDs.

Policy Option Three would create a statewide agency to protect, conserve, and regulate groundwater, using ideas similar to the Texas Railroad Commission's regulation of oil and natural gas. This statewide agency would retain elements of local input by dividing the state into 16 district offices, similar to the existing Groundwater Management Areas (GMAs). However, the state office would assume the responsibility for accepting permits, setting fees, and monitoring wells. This system would allow for economic certainty by creating consistent policy and should more easily facilitate the movement of groundwater from water abundant regions to water scarce regions.

Policy Option Four is based on a novel idea by Nobel Laureate economist, Vernon Smith who advocated the creation of groundwater bank accounts where each property owner owns the water under his/her land and has considerable flexibility to use it as he/she see fit. Groundwater bank accounts would encourage the development of a water market by using clearly defined property rights. The market established by this system promotes conservation by providing an incentive to keep the groundwater in the ground – as scarcity in the market increases, the price of groundwater will rise. Interestingly, this system would utilize the individual GCDs as their "local banks", while aquifer-wide authorities would measure recharge and administer mitigation.

Finally, to assist policy makers, these policy options were compared with each other as well as with the existing system of groundwater regulation. Grades were assigned to each depending on how effectively each policy (1) protects all property rights (2) allows water to be used towards its highest and best use (3) mitigates against rising costs; and (4) provides prudent aquifer management. Since the purpose of this report is to create a dialogue, we encourage each reader to assign their own grades. While this study does not examine the political feasibility of each option, we encourage policy makers to provide their own assessment.

Introduction

Groundwater—Part of the Problem or Part of the Solution?

The Texas Water Development Board's (TWDB) 2012 State Water Plan paints a dire picture of water availability out to 2060. Even though this plan calls for only modest growth in consumption (from 18 million acre-feet (AF) to 22 million AF by 2060), existing supplies decline significantly. The TWDB concludes the state faces a shortage of 8.3 million AF by 2060.[1] Increased reliance on new lakes and increased diversions from rivers seems problematic for several reasons. First, reliance on surface water makes us increasingly vulnerable to droughts such as in 2012. Second, evaporation of surface water is substantial, making it an inefficient source.

In the TWDB State Water Plan, groundwater is viewed as contributing to the problem rather than offering a solution. The TWDB projects groundwater pumping will actually decline from 8 million AF to 5.7 million AF, citing decreased pumping from the Ogallala and the Gulf Coast Aquifers as the causes for this decline. These forecasts served as the motivation for this capstone project asking the question whether the diminished role for groundwater is justified. Are the causes the hydrological limitations of the state's nine major aquifers or could this be a regulation-induced shortage?

Regulation by GCDs

1. Texas Water Development Board, 2012 Water for Texas (Texas Water Development Board, Austin, January 2012).

The State of Texas has established Groundwater Conservation Districts (GCDs) as the de facto institution for groundwater management under first the Texas Groundwater Act of 1949, and then later expanded GCD power under Senate Bill 1 in 1997. Today 97 GCDs, shown in Figure 1, determine groundwater pumping in their own districts. The Texas Water Development Board provides hydrologic assistance to the GCDs, but pumping rates are set locally. Interestingly, most GCDs project either modest increases or declining pumping rates. Is this due to the physical limitations of the underlying aquifers or is this a local political choice?

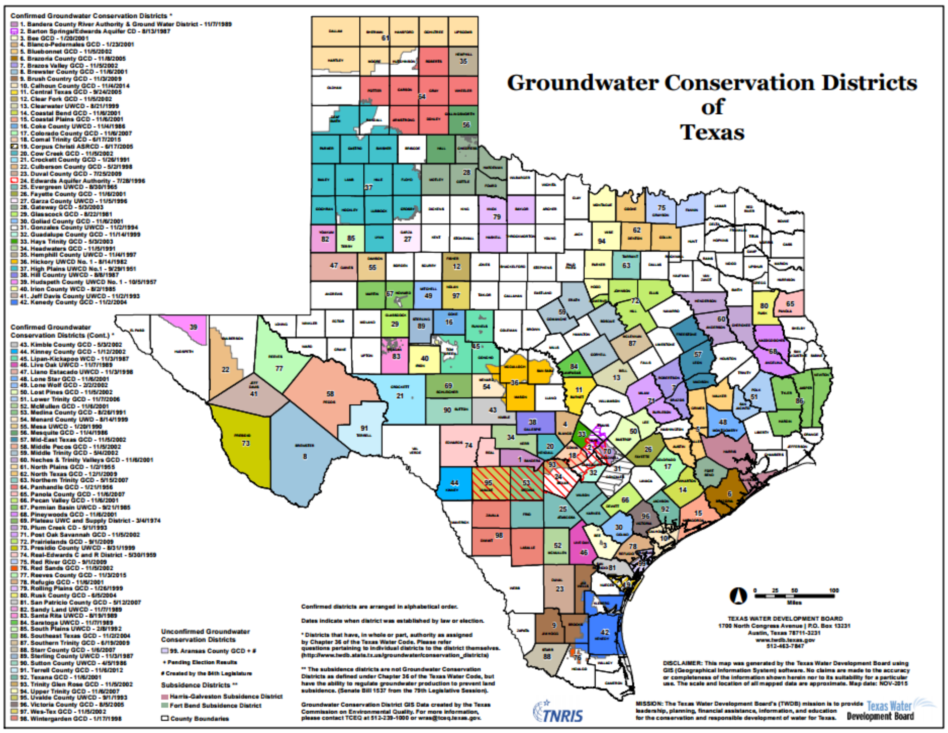

Figure 1-Groundwater Conservation Districts in Texas[2]

Assessing the Year's Supply of the 9 Major Aquifers

As shown in Figure 2, Texas has 9 major aquifers. In measuring the size of the underlying resource base of these aquifers, the TWDB uses a concept called TERS —total estimated recoverable storage. In effect TERS represents the technical maximum amount of groundwater that is retrievable from the aquifer. Because what is economically recoverable is generally less

2. "Groundwater Conservation Districts of Texas." Digital Image. Texas Water Development Board. Accessed March 31, 2016. https://www.twdb.texas.gov/mapping/doc/maps/GCDs_8x11.pdf.

than what is technically recoverable, the TWDB calculates 25% of TERS and 75% of TERS to provide a bracket of what might be practically recoverable for each aquifer. For simplicity, we have adopted the midpoint of this bracket —50% TERS as an approximate measure of the economically recoverable portion of the groundwater in an aquifer.[3]

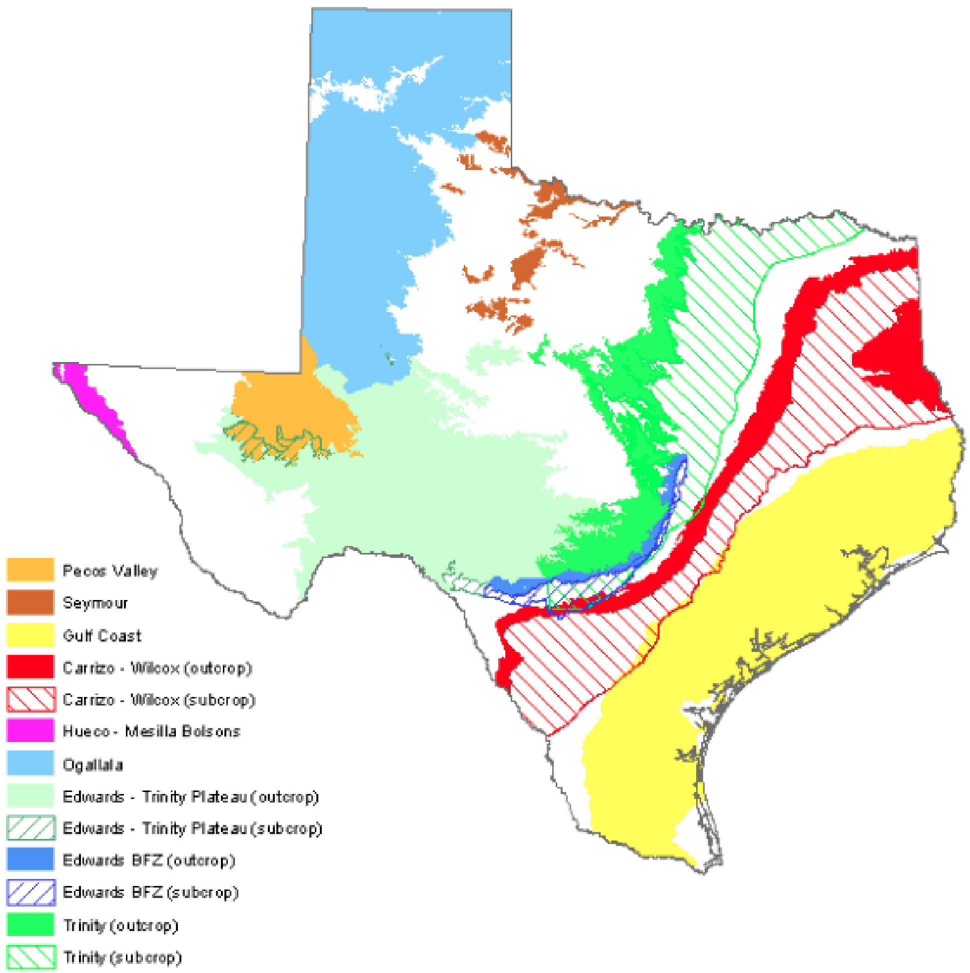

Figure 2: "Major Aquifers Map." Texas Water Development Board[4]

Table 1 shows current consumption, estimated annual recharge, and 50% of TERS based on data gathered by the TWDB for each of the nine major aquifers. The aquifers are ranked in terms of

3. We use 50%TERS as a mid-point in the TWDBs classification, acknowledging that for specific aquifers the economically recoverable portion can vary above or below 50% depending on the type of aquifer, the depth, water quality, etc.

4. "Major Aquifers Map." Digital image. Texas Water Development Board. Accessed November 19, 2015. http://www.twdb.texas.gov/groundwater/aquifer/.

their storage capacity. Interestingly, as shown in Figure 2, the three largest—the Gulf Coast, the Trinity, and the Carrizo-Wilcox are located in the most populous parts of the state. The key objective of Table 1 is to calculate how many years each of these nine major aquifers could produce at various consumption rates before reaching 50% of TERS.

Aquifer	Consumption (KAF)	Recharge (KAF)	50% TERS (KAF)	Years Supply at Constant Consumption	Years Supply at Historical Consumption Growth Rate	Years Supply at 2% Consumption Rate
Gulf Coast	**851**	**1,300**	**2,587,224**	**Unlimited**	**Unlimited**	**200**
Trinity	**178**	**95**	**702,618**	**8,459**	**2,071**	**218**
Carrizo-Wilcox	**415**	**1,002**	**261,354**	**Unlimited**	**Unlimited**	**243**
Ogallala	**5,568**	**440**	**203,472**	**35**	**36**	**17**
Pecos Valley	**78**	**71**	**151,171**	**219**	**Unlimited**	**195**
Edwards Trinity	**250**	**780**	**36,420**	**Unlimited**	**Unlimited**	**120**
Edwards BFZ	**392**	**440**	**11,706**	**Unlimited**	**Unlimited**	**49**
Hueco-Mesilla	**132**	**5.6**	**6,927**	**51**	**49**	**26**
Seymour	**129**	**215**	**2,545**	**Unlimited**	**Unlimited**	**59**

Table 1 –Years Supply of the Nine Major Aquifers

As shown in column five of Table 1, at the *current rate* of consumption, the Gulf Coast, Carrizo-Wilcox, Edwards Trinity, Edwards BFZ, and the Seymour Aquifers have an unlimited years of supply because recharge exceeds consumption. The vitally important Trinity Aquifer in central Texas has 8,479 year's supply before reaching 50% of TERS. In contrast, the Ogallala Aquifer, located in the Texas Panhandle, and the Hueco-Mesilla, in the El Paso area, are heavily pumped unconfined aquifers, which at current consumption rates face depletion.

Criticism of assuming constant consumption is that it does not allow for economic and population growth. Column six of Table 1 projects future consumption based on the historical growth rate in consumption for each major aquifer. Even based on the *historical growth rate of consumption*, six of the nine major aquifers still have an unlimited supply of water, and the Trinity Aquifer has 2,071 years of supply. Finally, since the historical growth rates in consumption tended to be less than 1% annually, we thought it wise to present a worst case scenario in column seven—based on a *2% annual consumption growth rate*. In this worst case scenario, the seven most abundant aquifers drop sharply ranging between 49 and 243 years. Given historical growth trends going back to the 1970's, these outcomes appear unlikely.

Fortunately, the largest three aquifers, the Gulf Coast, Carrizo-Wilcox, and the Trinity, lay adjacent to large population centers such as Harris County, Bexar County, and Dallas County, respectively; yet they have almost unlimited supplies of groundwater under both the constant and historical consumption growth rate scenarios.[5]

A Regulation-Induced Shortage?

Juxtaposed against the above findings is the troubling statistic that most GCDs' management plans call for either constant or declining pumping out to 2060. Only 3 project increased pumping.[6] On an individual GCD basis, there appears to be a strong disconnect between projected pumping rates and the results based on TERS in Table 1. Could it be that political balkanization of local GCDs is preventing expanded use of the state's groundwater resources? Three pieces of evidence point in this direction. First, is the fact that only a few GCDs project future increases in pumping.[7] Second, as shown below, detailed evidence for three very important GCDs show a big disparity between potential consumption and actual consumption. Third, there is considerable evidence that GCDs oppose groundwater leaving the confines of their district.

Evidence from Three GCDs

Table 2 contrasts potential consumption versus actual consumption for three geographically distinct GCDs --the Evergreen, the Bluebonnet, and the Neches-Trinity Valley. The Evergreen GCD contains the Carrizo-Wilcox Aquifer and lies just south of San Antonio. The Bluebonnet GCD is primarily served by the Gulf Coast Aquifer and lies just to the north of Houston. The Neches-Trinity Valley GCD also contains the Carrizo-Wilcox Aquifer and lies approximately

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5. Additionally, the Edwards Balcones Fault Zone (BFZ) adjacent to San Antonio has large supplies; however, pumping is restricted by the Edwards Aquifer Authority (EAA) in response to Federal Court Rulings.

6. See Beckermann, Wayne, Ross Brady, Amber Capps, Braden Kennedy, Peyton McGee, Kayla Northcut, Mason Parish, Abdullilah Qadeer, Shuting Shan, "An Assessment of Groundwater Regulation in Texas" Unpublished Paper, January 2016, Appendix B.

7. Ibid. , Appendix B.

100 miles southeast of Dallas. In order to compute potential consumption, two components must be added. First, it was assumed that prudent aquifer management would allow the TERS in each GCD to be drawn down by 5% over a 50 year period—or .1% of TERS annually. [8] In addition, precipitation recharge should be added to compute potential consumption.

As shown in column five of Table 2, the Bluebonnet GCD has a potential modelled available groundwater (MAG) of 284,201 AF from the Gulf Coast Aquifer. In contrast, the current MAG was determined to be 95, 803 AF with actual consumption was only 15,070 AF. The potential MAG is 18.8 times current production. For the Neches-Trinity Valley GCD, one sees much the same picture with the potential MAG far exceeding actual consumption by 21 times. For the Evergreen GCD, the potential MAG is about 3 times actual consumption. This statistic is particularly troublesome as the City of San Antonio is embarking on a very expensive pipeline project, Vista Ridge, to move groundwater 140 miles from Burleson County. Yet abundant supplies in the Evergreen GCD appear at its doorstep.

A criticism of the existing regulatory approach is that the MAG is determined by a reverse-engineered approach that places an arbitrary, excessively restrictive ceiling on future pumping. In turn, the GCDs permitting process is designed to keep pumping under the MAG. Table 2 also reveals just how overly restrictive the MAGs are compared to a potential MAG, which involves using a small fraction of TERS plus annual recharge. For the Bluebonnet GCD, the potential MAG is almost three times the current MAG. For the Evergreen GCD it is one and a half times, and for the Neches-Trinity GCD it is 15 times. These ratios support the preposition that the existing process of determining the MAGs results in overly restrictive permitting.

8. Later, we propose that this measure of potential consumption should be used to replace the MAGs currently calculated. See section under Option One.

GCD	Aquifer	0.1% TERS (in AF)	Recharge (in AF)	Potential MAG	Current MAG	MAG Difference	2010 Consumption	Potential Growth
Bluebonnet	Gulf Coast	210,000	54,201	284,201	95,803	3X	15,070	18.8X
Evergreen	Carrizo-Wilcox	540,000	20,850	560,850	375,654	1.5X	186,119	3X
Neches-Trinity Valley	Carrizo-Wilcox	436,000	18,758	454,758	30,141	15X	21,644	21X

Table 2 – Comparison of Potential MAGs, current MAGs, and Consumption

Discouraging Water Exportation

Additional evidence on the lack of water exportation leaving a GCD suggests that GCDs tend to be insular, protecting local historical agricultural irrigators and local municipalities.[9] While state law requires every GCD to allow groundwater exportation, only six have a significant percentage of groundwater being exported exceeding about 1% of supply.[10]

Even though by law, a GCD cannot prohibit the export of water outside a GCD, a GCD has considerable power to thwart the process. Examples include (1) reducing the permitted amount thereby vitiating the economies of scale of the project,[11] (2) taxing exports at a higher rate, and/or (3) increasing legal costs through the costly appeals process. All of these actions can raise the cost of water exports. An example of higher taxes being charged to exporters occurred in the Bluebonnet GCD where exporters were charged a fee of $55.38/AF as contrasted with $14.60/AF for local municipalities and zero for local agricultural pumpers.[12] A lengthy, litigious permitting process makes it very expensive to the party trying to get a project approved. Consequently, any

[9] Mason Parish points out that lower rates for agricultural users may be justified. However, there is no justification for treating export fees different from local municipal and industrial users.

10. Beckermann et al, op. cit., Appendix B

11. Edmond R. McCarthy. 2013. Motion for Rehearing. http://indytexans.org/wp-content/uploads /Forestar_s-Motion-for-Rehearing-8-6-13-1.pdf.

12. See Beckermann et al, op. cit., Appendix B

entity attempting to complete an export project must have a great deal of funding.[13] Lawyers and expert witnesses on both sides are incentivized to prolong litigation and subsequently bill more hours.[14] Water marketers are at a distinct disadvantage because they must pay the GCDs legal bill if they do not win appeals, and even if they do win, they may or may not be able to recover their own legal costs.[15]

Limits to GCD Authority

While some might characterize the 97 GCDs as Balkanized fiefdoms whose "jurisdictional entitlements" create an imbalance between our state's "municipal, agricultural, [and] industrial...water demands," their power is not absolute.[16] Recent legal proceedings indicate court intervention limits such powers. Ownership of groundwater throughout Texas must now be understood by the Texas Supreme Court's ruling in *Edwards Aquifer Authority v. Day* that, "…each owner of land owns separately, distinctly and exclusively all the oil and gas under his land and… we now hold that this correctly states the common law regarding the ownership of groundwater in place…."[17] As a private property right, groundwater is subject to equal protection and takings statutes, which place significant burdens on GCDs seeking to restrict pumping. The court also ruled landowners are, "…accorded the usual remedies against trespassers who appropriate the minerals or destroy their market value…for groundwater just like oil and gas…."[18]

It is important to define takings at this juncture. Under the United States Constitution, the Fifth Amendment states, "…nor shall private property be taken for public use without just

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13. Stuart R. White, "Guitar Holding: A Judicial Re-write of chapter 36 of the Texas Water Code?," The Baylor Law Review 62 (2010):324.

14 For a discussion of Clayton Williams' legal disputes with the Middle Pecos GCD, see Beckermann et al, op. cit., pp. 51-52.

15. Edmond McCarthy, Interview, November 24, 2015.

16. Larson, Lyle. "Balkanization of Texas Water Must End." San Antonio Express-News. March 28, 2014. Accessed April 07, 2016. http://www.mys anantonio.com/opinion/commentary/article/ Balkanization-of-Texas- water -must-end-5354966.php.

17. The Supreme Court of Texas. February 24, 2012. The Edwards Aquifer Authority and the State of Texas, Petitioners, v. Day and McDaniel, Respondents. No. 08–0964. http://caselaw.findlaw.com/tx-supreme-court/1595644.html#footnote_ref_141.

18. Ibid.

compensation…" and this just compensation requirement extends to easements, personal property, contract rights, and trade secrets. Takings, however, must not only be understood in terms of seizures, but also recognized as regulations that prevent an owner of private property from fully accessing and capitalizing upon their property. The government is absolutely financially liable if it physically invades or seizes private property, and remains potentially financially liable if regulatory effects burden property owners.

With respect to the groundwater governance situation in Texas, GCDs do not physically seize private groundwater; rather, they regulate its withdrawal. When GCDs across Texas approve or deny pumping permits they are effectively regulating groundwater from one perspective, and engaging in compensable regulatory takings from another. Texas Property Code Sections 21.012 and 21.0121 reveal the State of Texas created a relatively high standard for GCDs to meet before they may restrict the use of, or take, groundwater. Therefore GCDs who are actively engaged in regulation without meeting these thresholds expose themselves to financial liability.

Another landmark case, the case of *Edwards Aquifer Authority (EAA) v Bragg* involved owners of two pecan orchards seeking damages from the EAA because the authority denied their permit for the Home Place Orchard and only granted half of the requested amount for the D'Hanis Orchard.[19] Ultimately, the Courts ruled that a takings had occurred and awarded damages to the Braggs. Furthermore, the Edwards Aquifer Authority and not the state of Texas was ruled liable. Thus GCDs are financially responsible when the courts rule that their actions have resulted in a takings.

Common Elements of Regulatory Reform

If the existing regulation-induced shortage of groundwater is addressed by regulatory reform to allow greater pumping, there are two features that must accompany that any reform. First, increased pumping will raise lifting costs which can have both positive and negative effects as

19. Justice Sandee Bryan Marion. The Fourth Court of Appeals. The Edwards Aquifer Authority V. Bragg No. 04-11-00018-CV. August 28, 2013. http://www.search.txcourts.gov/SearchMedia.aspx? MediaVersionID= 88cef3c2-8ca6-41f2-9637-eb471dc21b13&coa=coa04&DT=Opinion&MediaID=d5ce49aa-44b2-4042-98fb-faac1ea3cd53.

discussed below. Second, currently groundwater is not metered in Texas; compulsory metering must be a part of responsible regulation.

Rising Pumping Costs – Both Positive and Negative Effects

In the event that regulatory restraints on pumping are relaxed to allow groundwater to help alleviate the impending future water shortage, the costs of extracting groundwater will rise. As pumps are lowered in wells to allow for greater use of groundwater, water will be pumped from greater depths and lifting costs will no doubt rise. Rising pumping costs can have both positive as well as negative effects, and the winners and the losers are likely to be different.

Negative Effects of Increased Pumping and need for Mitigation

Whereas rising costs slow growth in consumption and promote conservation, there are losers as well. As time progresses and more pumpers enter the market, and TERS is drawn further down, pumpers will find it necessary to lower their pumps. This will increase their pumping costs. Rising costs in most cases will be reasonable and manageable.[20] However, in other cases it may not be simply a case of pumpers needing to lower the pumps in their well.[21] Figure 3 describes a steeply down-dipping aquifer experiencing a 5% reduction in TERS over a 50 year period. This causes the water level to drop from the blue line to the red line. Farmer Smith must simply lower the pump in his well and pay the higher electricity cost of pumping from the red line.

But Farmer Jones' well is in the confined portion of the aquifer and his well becomes dry as the water level drops to the red line. Lowering the pump is not an option. Rather he could face significant mitigation costs by drilling a new well to a deeper aquifer, connecting to rural water supply, or finding some other water source.

20. At $.10/kwh electricity cost, every 100 feet of increased lift due to aquifer drawdown is estimated to cost $17.05/AF or $.06 per thousand gallons. Michael Thornhill, Feb. 16, 2016 email.

21. Some pumpers wells may go dry and lowering the pump is not an option, Figure 3 shows that shallow wells located in the up-dip confined portions of a strongly down-dipping aquifer may find their wells going dry entirely.

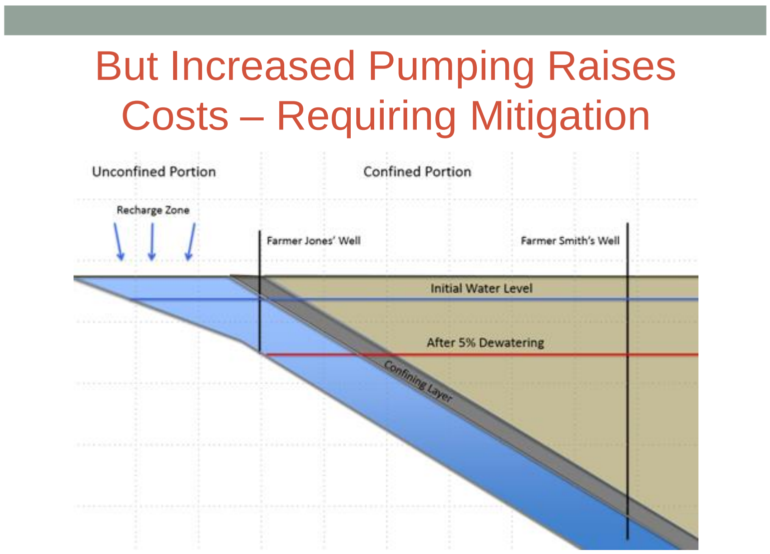

Figure 3 – Steeply Down Dip Aquifer

With this in mind, each of the proposed solutions incorporates a form of mitigation to alleviate injury to those like Farmer Jones who are severely impacted. Mitigation would involve some form of cost sharing for landowners severely impacted. These mitigation policies will be discussed in more depth in the policy proposals.

Positive Effects resulting in Increased Conservation

Now let us consider the positive effects of rising costs on the incentive to conserve. The price elasticity of demand for water can be used to estimate how much water could be conserved as a result of increasing water prices. The connection between the price of water and conservation can be illustrated by constructing a simple example. For this scenario, let us assume that initial consumption in year 0 is 100 AF and the price elasticity of demand for water is -0.5[22] Let us also assume that the initial water price is $100/AF. After adjusting for inflation, assume that its price increases by 3.5% per year over 20 years rising to $200/AF after 20 years. To put $100/AF into perspective for an average residential or agricultural user, this translates to 3/10 of a penny per gallon.

22. For an analysis of various elasticities that would justify the choice of - .5 price elasticity estimate, see Griffin, Ronald C. "Water Resource Economics." *The Analysis of Scarcity, Policies, and Projects* (2006).

Figure 4 shows the effect of the rising prices on consumption. Gradually rising prices in excess of inflation causes consumption to gradually decrease reaching 50 AF in year 20. The shaded area in Figure 4 shows the amount of water that would be saved due to the increasing price of water from $100/AF to $200/AF over the 20-year period. The shaded area in Figure 4 shows water savings of 500 AF of water. If instead the water price had not increased, consumption would have been 2,000 AF instead of 1500 AF. This calculation shows that price-induced conservation accounted for a 25% reduction in consumption. Keep in mind; this level of savings came from raising the price of water from 3/10 of a penny per gallon to just 6/10 of a penny per gallon over a 20-year period. This simple calculation shows that properly functioning water markets can be the friend of conservationists and help to provide a sustainable future. Therefore, rising costs can slow the future growth rate in consumption, thereby extending the life of the aquifer. An additional benefit is to landowners that benefit from selling water that would otherwise be prevented from selling water by existing GCD regulation.

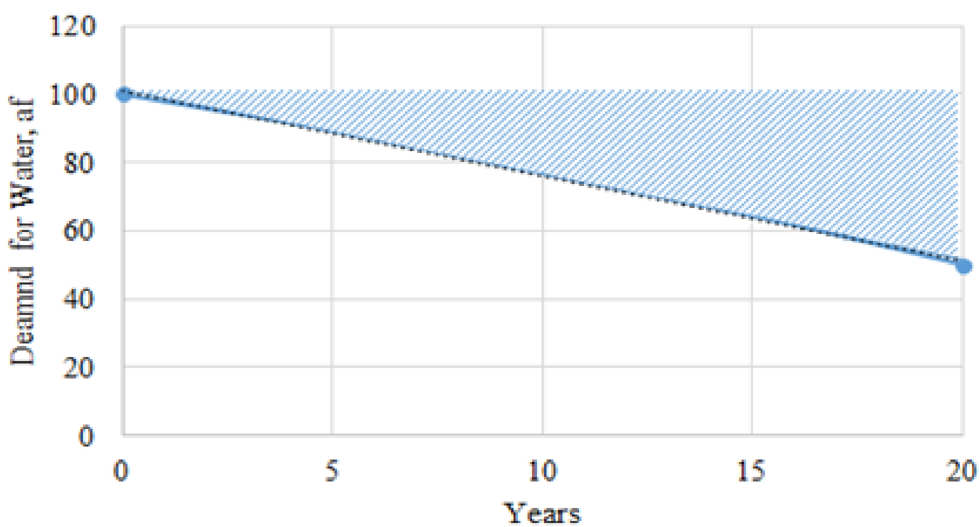

Figure 4 – Effect of Rising Prices on Water Consumption

Mandatory Metering - A Prerequisite to Prudent Aquifer Management

Another common feature of all proposals to improve regulation will be the need for mandatory metering for wells pumping from the major aquifers. This is a necessary measure if water is to be used efficiently in the future. Under the current system it is impossible for GCDs or the TWDB to obtain accurate numbers about water usage, particularly for agricultural users and exempt wells. Municipalities are the only users who report the quantity pumped. Beyond that, all the GCD has to go off of is an estimate based on the quantity of permitted pumping and maps showing irrigated areas. By adding mandatory metering the GCDs will be able to know the amount of water being pumped in their district and they will be able to enforce the permits of individual users, ensuring no individual is using more than their permitted amount.

Compared to the well cost and maintenance, the cost of these meters does not appear to be high;[23] they will be borne exclusively by the pumper. After installation water usage would be reported on an annual basis. The most effective way of doing this will be an electronic reporting system where pumpers submit their annual usage online. The relevant regulatory agency would have the authority to perform random spot checks to ensure pumpers are accurately reporting their usage. If a pumper is found to be making fraudulent reports they will be subject to severe enough fines to discourage under-reporting.

Four Policy Options to be Considered

The remainder of this report explores four quite different regulatory options without any consideration of the political feasibility of these options. Too often, political feasibility or one's perception of political feasibility completely dominates the policy choices. Policy makers then mistakenly choose among a restrictive set without ever asking the more fundamental questions. Instead we will explore a diverse set of options and propose criteria for their evaluation.

Policy Option One maintains the existing GCD structure but modifies the existing allocation system designed (1) to return water as a property right, (2) to end the threat of protracted takings lawsuit and (3) to replace the existing reverse-engineered determination of pumping rights with a simple formulaic approach.[24]

23. The costs of meters range from $600 to $2500 depending on diameter of discharge pipe and yearly maintenance is estimated at $200 per year. http://texas living waters.org/wpcontent/uploads/2013/04/water metering in texas.pdf.

24. Option One was written by Ross Brady, Wayne Beckermann, and Amber Capps.

Policy Option Two considers regionalization of aquifer authority. This option incorporates many of the key features of option one, but shifts regulatory authority away from the GCDs and places it at the aquifer level.[25] Therefore, these "aquifer authorities", would become the primary regulatory mechanism for the groundwater found within its confines.[26]

Policy Option Three explores the efficacy of a statewide regulatory agency as the central agency required to protect, conserve, and regulate groundwater use across the State of Texas. In this option, either a newly created agency or the TWDB could assume the role of preventing groundwater waste, protecting the correlative rights of landowners, and dealing with aquifer management issues.[27]

Policy Option Four proposes the creation of a groundwater bank account. The idea is that each landowner would have a bank account based on the water storage under his/her property and would have maximum flexibility to utilize it as he/she wishes.[28]

Four General Criteria for Evaluating these Policy Options

In order to guide policy makers, we developed four criteria for evaluating each of the above four policy options. In effect, a framework of analysis is needed and the four criteria we propose are as follows:

1. *Respect all landowners' property rights subject only to correlative rights.*
2. *Utilize water in its highest and best use.*
3. *Mitigation available for pumpers severely impacted by changes to the system.*
4. *Prudent aquifer management. Prudent aquifer management will seek a reasonable balance between current pumping and the needs of future generations.*

25. Option Two was written by Peyton McGee and Kayla Northcut

26. This option was added to the original scope of the project in response to the suggestions of several persons experienced in this area.

27. Option three was written by Braden Kennedy and Shuting Shan

28. Option four was written by Mason Parish and Abdullilah Qadeer.

Note that criteria 1 is a legal criteria based upon existing groundwater law that clearly establishes groundwater as a private property right.[29] Criteria 2 is based on the economic principles of using the low cost resources first and allocating a resource to its highest and best use.[30] Criteria 3 is based on the value judgment that those substantially injured from increased pumping should receive partial mitigation. Criteria 4 is a subjective management criteria based in part on hydrology and economics to arrive at prudent aquifer management.[31]

[29] See Beckermann, op. cit., pp. 45-54.
[30] J. M. Griffin and H. B. Steele, *Energy Economics and Policy, 2nd Edition* (Orlando: Academic Press, 1986), Ch. 2.3.
[31] The term "safe yield" is also commonly used by water experts to mean that pumping rates fall within this threshold. This concept is akin to prudent aquifer management and can be interpreted interchangeably.

Policy Option One: Working Within the Existing GCD Structure

Basic Proposal

Local GCDs are primarily motivated by maintaining local control. The following proposal aims to work within the existing regulatory framework to continue this system of local governance. The following section will offer four foundational alterations, which will improve groundwater governance statewide, while still maintaining the same structure of local control through GCDs.

- The most necessary change within the current GCD system is for groundwater to be governed and managed unequivocally as a property right, respecting *all* property through a correlative rights system.
- As noted in the introduction, mandatory metering will be a necessity.
- Permits shall be issued irrespective of use.
- GCDs should implement a uniform and nondiscriminatory fee structure, which will support mitigation funds to protect affected pumpers.
- By returning groundwater to its appropriate property right status, a market will emerge allowing water to go to its highest and best use.

How it Would Work

The proposed system presents several advantages compared to the current system. Fundamentally, the benefit of these alterations is a re-emphasis of groundwater as a property right, using many of the features of the Post Oak Savannah GCD (POSGCD). Restoring groundwater to its property right status, to be determined by the pumper rather than the GCD, is essential to allow every pumper an "equal chance for a fair share". The property right management strategy will increase the entrepreneurial nature of water, as pumpers will be free to use their water for whatever purpose they deem best.

These changes can be achieved through a simple modification of the existing use of MAGs. As shown subsequently, the best method of regulating pumping is on an acre-foot per surface-acre basis with proportional cutbacks when necessary. Having a common system in which all pumpers understand the rules will greatly increase both the fairness and certainty of the system. In the six confined aquifers the process of arriving at each pumper's groundwater allocation can be demonstrated by the following two formulas which take into account the aquifer's recharge, recoverable storage, and the number of surface acres overlying the aquifer. Due to hydrological and regulatory differences, the unconfined Ogallala and Hueco-Mesilla Aquifers will require a different formula and the Edwards Balcones Fault Zone is regulated separately by the Edwards Aquifer Authority. Thus, what follows is primarily directed towards the six major confined aquifers.

First, in Step 1, the local GCD would calculate its MAG as follows:

MAG= 0.1% TERS + Annual Precipitation Recharge[32]

In step 2, the GCD computes the number of permitted acres.

In step 3, the correlative factor (c) is calculated by computing the lesser of two numbers: 2 AF/SA or MAG/ Permitted Acres as follows:

C = Lesser of (2 AF/SA or MAG/Permitted Acres)

In step 4, individual landowners who have applied for pumping permits for their permitted acres would receive an allocation for the following year by simply multiplying the correlative factor C by their surface acres as follows:

Individual Pumping Limit = C x Individual's permitted surface acres

To illustrate graphically how this would work, Figure 5 shows a hypothetical case of a GCD with a MAG equal to 600,000 AF, with .1% TERS of 550,000 AF and 50,000 AF of precipitation recharge. The blue line shows that in year zero, only 100,000 acres were permitted. Even though the ratio of MAG to surface acres is 6 AF/SA, by step 3 the correlative factor would be the lesser of 2 AF/SA and 6 AF/SA. Thus pumpers would be restricted to 2 AF/SA. Thus 200,000 AF would

32. Note that recharge would only include the precipitation recharge entering the aquifer within that particular GCD.

be pumped along the red line in Figure 5. The graph assumes that with landowners being free to apply for additional permitted acres, the number of permitted acres increases every 10 years by 100,000 acres reaching 600,000 after 50 years. Note that the correlative factor is two for the first 20 years. After that, as new permits continue to grow, the correlative factor declines to 1.5 AF/SA in year 30 and ultimately to 1.0 AF/SA after 50 years. All pumpers are forced to cut back proportionally. With all pumpers sharing proportionally, GCDs avoid the political pressures of choosing among alternative user categories.

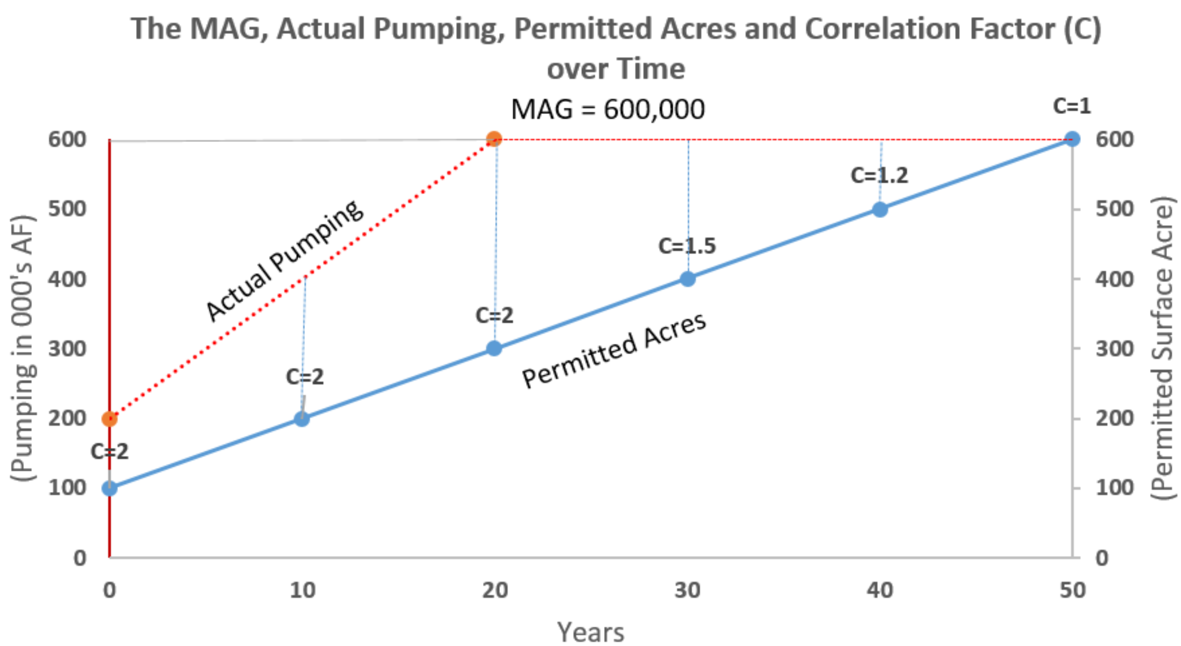

Figure 5: An illustration of How the Process would Work

MAG Calculation

The simple elegance of basing the MAG on the sum of .1% of TERS plus estimated annual precipitation recharge deserves considerable discussion because it represents a radical departure from existing methods. Few could argue with the importance of including precipitation recharge into the MAG calculations, the question is why use TERS and why .1% of TERS? The alternative of never drawing down any of TERS violates the economic principle of utilizing the low cost water resources first and giving time for technology to bring down the cost of brackish and other water sources. As shown in Table 1, Texas is blessed with six major confined aquifers which can provide water for many years. So the question is not whether to dip into TERS but rather how much and how fast.

We have conservatively used .1% of TERS in determining the MAG formula because .1% per year results in a *5% drawdown in TERS over 50 years*. As noted in the introduction, TERS is normally reported by the TWDB at 25% and 75% of TERS to reflect the practicality of recovery. As an aquifer is de-watered, pumping costs will increase more or less linearly as the water must be pumped from greater depths. However, at some threshold costs rise exponentially as more infill wells must be drilled to recover equivalent amounts of water. While this point of exponentially rising costs will vary between aquifers, this point is likely to be far in excess of 5% TERS.[33] Thus taking 5% of TERS over 50 years or equivalently, .1% TERS, is both prudent and conservative. Yet another factor to suggest that this approach is conservative is that by capping the correlative factor at 2 AF/SA, the permitted average is not likely to lead to actual pumping at the MAG rate. In Figure 5, pumping did not reach the MAG until year 20.

Correlative Factor

Our initial calculations for various GCDs show that the MAG divided by existing permitted acres substantially exceeds 2 AF/SA as in Figure 3. Therefore, initially in these GCDs, the correlative factor would be set at 2 AF/SA. An important feature of this system is that new permits based on surface acres would be issued without discrimination and irrespective of use. Thus, in the future, it is possible that when permitted acres exceed half of the MAG, the correlative factor would fall below 2. In this case, all landowners would cut back proportionally below 2 AF/SA as shown in Figure 5.

In most GCDs, east of I-35 the current number of acre feet being pumped is substantially less than the proposed MAG shown in Step 1. For example, Table 2 shows the Neches Trinity GCD, which covers the northern end of the Carrizo-Wilcox Aquifer, would have a MAG of 454,758 acre feet. With approximately 10,822 permitted acres the Neches Trinity GCD would then have an allowable

33. Informal conversations with hydrologists lead us to believe 5% TERS is well within the safety margin.

pumpage allocation of 42 acre-feet per surface acre. Even towards the southern end of the Carrizo-Wilcox Aquifer, the same holds true. By our formula, the Evergreen GCD has a potential pumpage of 560,850 acre feet with only about 93,060 permitted acres.[34] While, this would result in an allocation of six AF/SA, such an allowance would be far in excess of what is used for irrigation. Prudent aquifer management suggests a maximum allocation of 2 AF/SA. This cap, which is currently used in the POSGCD, will be useful by creating an element of certainty in the market. It ensures that new pumpers will be able to enter the market without lowering the allocations of existing pumpers for a considerable number of years. When so many new pumpers have entered the market that the allocation is driven below two acre feet per surface acre, the new allocation would be determined by the aforementioned formula with all pumpers sharing alike.

Furthermore, this system will include the ability to hold pumpers accountable through compulsory metering. Any allocation system without this feature is a paper tiger at best. Once a pumper has been given an allocation based strictly on the size of their property, then the GCD can begin to monitor actual pumping compared to allowed pumping. Fines for the first infractions and pumping limitations for further infractions represent possible tools for GCDs to use in response to pumpers who exceed their allocation. Compulsory metering, while somewhat costly and complex, will ensure every pumper operates honestly and fairly.

Fee Structure & Mitigation Fund

Table 4 illustrates a fee structures based on permit applications and permit use, each applicant would pay a one-time fee of $10 per surface acre associated with filing a permit, and then once approved, there would be a $3 annual fee associated with each acre-foot of groundwater pumped. Of the $3 usage fee, $2/AF would go to administration and $1/AF would go to mitigation. These fees are based on two key ideas. First, the initial application fee will be a one-time payment going towards a mitigation fund because it is new users entering the market who contribute to the need for mitigation through the further depletion of the aquifer. Secondly, the usage fee provides an inherent incentive to conserve groundwater because those who pump less water will be charged less in GCD fees. Note that as the amount of permitted acres increases each year in Table 4 by

34. Note that permitted acres are not normally reported to the GCDs. Based on rates for irrigation of 2 AF/SA, we estimated permitted acres. In reality, actual permitted acres if known would be even less.

100 acres, the mitigation fund rises over time to cover potential future issues. Fee structures based solely on permit applications and utilization are concepts inspired by current governance of the POSGCD. The same GCD also manages groundwater somewhat as a property right, although the GCD currently continues to treat agricultural and exempt well users uniquely. The premise is to clarify and expand POSGCD's practices by treating all pumpers equally and requiring GCDs statewide to adopt such practices.

Time Period	Permitted Acres	Application fee = $10/SA	Usage Fee = $3/AF	Allocation To Administrative Fund = $2/AF	Allocation to Mitigation Fund = $1/AF	Cumulative Mitigation Fund
Year 1	100	$1,000	$300	$200	$100	$1,100
Year 2	200	$1,000	$600	$400	$200	$2,300
Year 3	300	$1,000	$900	$600	$300	$3,600
Year 4	400	$1,000	$1,200	$800	$400	$5,000
Year 5	500	$1,000	$1,500	$1,000	$500	$6,500
Year 6	600	$1,000	$1,800	$1,200	$600	$8,100
Year 7	700	$1,000	$2,100	$1,400	$700	$9,800
Year 8	800	$1,000	$2,400	$1,600	$800	$11,600
Year 9	900	$1,000	$2,700	$1,800	$900	$13,500
Year 10	1000	$1,000	$3,000	$2,000	$1000	$15,500

Table 4 - Fee Structure Example

Creation of water markets

Finally, by granting water permits in a nondiscriminatory fashion, a vibrant water market should emerge. By returning groundwater to its appropriate property right status, trade will occur naturally. Given the drastic differences in groundwater availability between the Panhandle, East

Texas, and South Texas, a market for trading and transporting groundwater seems likely. To this end, GCDs will be forbidden from prohibiting the exportation of water from a GCD.

Water markets could potentially flourish *within* GCDs. The GCD boards could in principle establish zones of transferability based on the transmissivity of the aquifer; thus, pumpers could trade their water rights *within* a GCD. This creates even more opportunities for trade. Interestingly, within the Edwards BFZ Aquifer where permits are predetermined, an active market for trading water permits exists. While the transmissivity of this aquifer lends itself to such trading, it would seem possible on a smaller scale within zones in other aquifers regulated by GCDs.

Positive Attributes

Fairness, Certainty, and Transparency

The process of arriving at a MAG under this policy proposal is different from the current system, which often relies on the reverse engineered DFC and MAG process designed to limit pumping and protect incumbent stakeholders. The revised system will allow GCDs to determine their MAG, in a transparent manner, based on readily available data from the TWDB. Furthermore, with a uniform fee structure, GCDs will no longer be able to discriminate based on groundwater use and to protect historical pumpers. Once each pumper's allocation has been set, the GCDs will act as an enforcer of the policy, ensuring no pumper exceeds their allocation. Fines and other deterrents can be issued in order to maintain the new system's integrity. Pumpers must know GCDs are vigilant and empowered.

The formula-based allocation system will also ensure each landowner has an equal chance at a fair share. This has not occurred under the current system which has resulted in preferential treatment given to historic users, irrigators, and municipalities. These disparities would not exist under the proposed allocation system.

Mitigation Funds

While the existing system will have many winners there will also be losers. As shown in Table 4, funds will accumulate in a mitigation fund which while not needed today would become important with long-term increased pumping. This fund will assist pumpers who are no longer able to pump a previously possible quantity as a result of decreased artesian head or a lowered water table. In such a case, the injured pumper could apply to their GCD for assistance. Our thought would be that it would work like an insurance policy with for example a $1500 deductible and a 25% co-pay. Maintaining a socially equitable system is of the utmost importance, especially because of the amount pumpers vary in their habits and uses. As discussed in Figure 4, shallow wells in the confined portion of a steeply down-dipping aquifer could find their well running dry. While this option creates large gains to landowners generally by making their water more valuable, it is important to provide mitigation funds for individuals like Farmer Jones in Figure 4.

Dealing with the Issues:

No solution is without problems; yet, with proper planning many problems may be minimized or prevented altogether. The following section attempts to anticipate problems the previously mentioned policy may create, and offer solutions to the issues.

If the suggested system alterations were to be implemented in the early years there may be some confusion and unwillingness to change. Additionally, GCDs may continue experiencing pressure to allow exemptions for certain users by ignoring meter readings for said users or even misreporting readings. In order to avoid both of these problems, it will be important for the TWDB to closely monitor actions of GCDs during the first five to ten years of the new system's implementation. For minor violations of the policy or for first offences, the GCD should be warned of their infraction and given time to make corrections. If a GCD continues to resist the new policy, or they engage in severe mismanagement, the Board of the GCD should be removed and a special election held to replace them.

Even though as a property right it is each pumper's prerogative to decide if they wish to trade or not, most resistance seems to come from the inaccurate belief there is a shortage of water in the state. As the data in Table 1 of this report reveals, Texas has relatively abundant groundwater resources, particularly in the most populous parts of the state. Therefore, to combat this misconception, this policy should involve a program of adult and youth education. Adult education could be primarily handled through agencies such as the Agricultural Extension Service and the

Natural Resource Conservation Service. Youth education could be conducted through local 4-H and FFA programs.

A third possible difficulty with this policy is the inability of GCDs to address mitigation and discrimination through equitable application of uniform usage fees. To prevent this problem, these fees might be legislatively set within brackets stating the upper and lower bound a GCD could charge.

The final problem we have identified is the areas of the state which are currently ungoverned by a GCD, known as "white areas." In these regions, the rule of capture continues to prevail. These areas do not account for a large portion of water use, yet nevertheless to ensure each landowner truly has an equal and fair share of groundwater they must be brought under some form of governance. Therefore, as the state transitions to this revised GCD system these areas would need to be either absorbed into existing nearby GCDs or would need to form their own. Once this policy is adopted these areas could be allowed one year to form their own GCD. If they have not done so by the conclusion of that period they would be absorbed by the surrounding GCDs.

Unintended Consequences

By its nature, unintended consequences often turn out to be unpredictable and have dire effects. A potential circumstance could arise in the proposed system if after 30, 40, or 50 years of pumping based on the calculated MAG, some unanticipated negative aquifer impacts occur. In this situation, mitigation costs will rise sharply as the winners would no longer be able to compensate the losers. In such an event, the GCD would have two options. First, it could raise the mitigation fees which would discourage pumping for the aquifer. Another option, when the impacts were localized as with subsidence areas, the GCDs could prescribe for those areas a lower percent of TERS, thereby reducing the MAG, forcing users in that particular area to be subject to a lower correlative factor and lower pumping rates. Even though these situations are difficult to predict, the formula approach laid out above retains enough flexibility to deal with a variety of unforeseen events.

Policy Option Two: Aquifer Wide Management

Basic Proposal

The policy alternative discussed in the following section focuses on a regionalized approach to regulation based on the actual aquifer configurations of the nine major aquifers.[35] This proposal is designed to move regulatory authority away from the GCD level and place it at the aquifer level. These aquifer authorities, therefore, would become the primary regulatory apparatus for the groundwater within its confines. Several key features comprise this proposal. Under this option:

- Eight aquifer authorities would exist: one for each major aquifer in Texas.[36]
- Within each aquifer authority would exist sub-aquifer regions established to reconcile the hydrological variation that may exist within an aquifer.[37]
- Each aquifer authority will also maintain either a supervisory or administrative (or both) relationship with those minor aquifers that interact closely with each respective major aquifer.

Each authority will establish one central board that would act as the aquifer's seat of power. The board would retain seven members —three members appointed by the governor and the remaining four elected by the County Commissioners affected by each respective aquifer. To allow for regional representation, each aquifer would be divided into four districts with the County Commissioners from those four regions electing their own directors. Like Option 1, the aquifer authority would regulate on the basis of acre foot/surface acre (AF/SA) to assure all property rights are protected. This system of regionalization would offer open access to permits

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35 This option was added to the original work plan based on the suggestion of several knowledgeable individuals who thought this option should at least be considered.

36. Nine major aquifers exist in Texas; however, the Edwards Aquifer Authority (EAA), which manages the Edwards Balcones Fault Zone Aquifer, is federally established and will remain unchanged under this policy proposal.

37. The Carrizo-Wilcox is a major aquifer that geologically varies greatly within itself, and therefore, has four different sub-aquifer regions to deal with this variance. Accounting for variance, like that found in the Carrizo-Wilcox, should lead to efficient and effective management of each major aquifer.

and proportional sharing on an AF/SA basis, while also encouraging the development of water markets to ensure water is used at its highest and best use.

- Aquifer authorities would have the authority to utilize hydrological science to assure prudent aquifer management, and be able to set fee structures in a nondiscriminatory fashion.

How it Would Work

Operational Responsibilities

Because primary authority of groundwater management rests with the central board of the aquifer authority, there would be minimal oversight from the TWDB in this system. In concordance with this facet of the policy, MAGs would no longer involve TWDB approval. Even within the aquifer authority, there would be one MAG for each sub-aquifer region. Again, sub-aquifer regions are created to account for the geological differences within an aquifer. So, mandating a MAG for each sub-aquifer region, based on the MAG formula discussed in Policy Option One, would provide the board with a more realistic understanding of what is going on within the aquifer at each area of geological uniqueness.[38] Each MAG would be based on the following formula:

$$\text{MAG} = .1\%\ of\ TERS\ of\ aquifer\ subregions + aquifer\ subregion\ annual\ recharge.$$

Likewise as in Option 1, individual pumping rights would be determined on an AF/SA basis using the correlative factor (C). Individual pumping rates would be determined by multiplying

38. Note that this MAG formula differs slightly from the MAG prescribed in Policy Option One in that .1% of TERS would cover the whole aquifer sub-region, and not just that of the GCD. Particularly important is that this formula would use aquifer sub-region recharge, which from a hydrological perspective is preferred for its precision over just the precipitation recharge captured by a particular GCD.

the correlative factor times the individual's permitted acres., where C, the correlative factor, would be calculated as follows: C= minimum of [2 AF/SA or $\frac{MAG}{Permitted\ Acres}$]

Just as the MAG would be managed at the aquifer authority level, minor aquifers could be managed at this level as well. Minor aquifers may not require regulation due to their small size, but for minor aquifers located primarily within the major aquifer, the aquifer authority could exercise regulatory power at its discretion. Nonetheless, whether the aquifer authority board votes to manage a minor aquifer or not, for the sake of transparency of resources there would need to be some form of representation from the minor aquifer within the aquifer authority.[39]

In addition to MAG creation, each aquifer authority would be responsible to ensure some local monitoring of metering, well conditions, and test-well conditions. Monitoring of test-well conditions are especially important in the unconfined regions of aquifers because these unconfined areas most accurately depict how fast the aquifer is depleting.

Offices located within each district of the aquifer would monitor local metering for compliance and also observe test-well conditions. In this way, these management groups are the enforcement mechanism at the local level for the aquifer authority.

Fee Structure and Groundwater Export

Under this policy alternative, the board of each aquifer authority can establish its own fee structure —with one major stipulation. The fee must be uniform across the jurisdiction. In addition to keeping the fee structure consistent across each aquifer authority, water utilized by municipalities and agriculture should be equally charged. One type of fee that is common under

39. For example, the Blaine (minor) Aquifer is in close proximity to the Seymour (major) Aquifer. Yet, the Blaine Aquifer does not yield much water. In this case, the Seymour Aquifer Authority may choose not to regulate the Blaine's groundwater resources due to the low yield; however, the Seymour Aquifer Authority could hire an employee that specifically works to understand how much groundwater is in the Blaine and where it goes to maintain total transparency of Texas' groundwater resources.

the current GCD system that would not be allowed under this policy alternative is any fee that discriminates against water export outside of jurisdictional boundaries. As previously discussed,[40] any limits on trade diminish economic efficiency and total societal benefits.

It is also important to note that like in Option One, each aquifer authority would have a mitigation fund. The mitigation fund of an aquifer authority is used to cover costs of some pumpers potentially losing access to water due to aquifer depletion.[41] The fee structure of the mitigation fund would include principles of cost sharing – similar to those in Policy Option One. The mitigation fund, as outlined in Policy Option One, would compensate those severely impacted with the affected party paying the first $1500 deductible and a 25% co-pay on additional expenses.

Water Allocation

As noted above, under this alternative, water would be allocated on an AF/SA per year basis with proportional sharing. The key to water use in this alternative is that producers will be able to consolidate pumping for all allocated water use on contiguous acres onto a single well as long as two conditions are met that will prevent impact on neighboring producers' wells or land:

1. Wells must be spaced so that the cone of depression will have minimal impact on neighboring wells
2. Wells must not cause substantial land subsidence

Each sub-aquifer region's management group would be responsible for making sure the above conditions are met and determining spacing requirements and pumping rates to prevent negative impacts on neighboring wells.

Differential Correlative Factors

40. Beckermann et al, op.cit., pp. 55-61.

41. This may include aquifer activities such as water export (internal or external the aquifer), which could result in a well going dry. The authority's mitigation fund would help cover expenses like this on the behalf of the individual landowner.

Keeping in mind that groundwater production will impact sub-aquifer regions in different ways, there will be separate per acre water allocations for each sub-aquifer region. The following scenario will be used to provide clarity. Producer A has 450 contiguous acres of land with 300 acres over sub-aquifer region A, 50 acres over sub-aquifer region B, and 100 acres over sub-aquifer region C. Assume that the aquifer authority, in collaboration with the sub-aquifer region management groups, determines that sub-aquifer region A producers may produce 1 AF/acre, sub-aquifer region B producers may produce 2 AF/acre, and sub-aquifer region C producers may produce .5 AF/acre. Assuming Producer A can meet the two conditions listed above, she can consolidate pumping into a minimum of three wells, one for each sub-aquifer region. The well tapping into sub-aquifer region A will produce a maximum of 300 AF/year (300 acres x 1 AF/acre), the well over sub-aquifer region B will produce a maximum of 100 AF/year (50 acres of land x 2 AF/acre), and the well over sub-aquifer region C will produce a maximum of 50 AF/year (100 acres x .5 AF/acre) for a total of 450 AF per year. Under this option, municipalities may be presented with an extra challenge. Because some cities have wells outside of the city limits on small plots of land, municipalities may be required to lease the acreage surrounding their wells to receive the amount of water necessary to sustain itself.

Positive Attributes

In comparison with the current system, there are several positive attributes regionalized aquifer authorities offer to existing groundwater management practices in Texas. This method of groundwater management, using AF/SA and uniform fees, offers both benefits of certainty and elements of fairness. Regionalization will provide a reasonable amount of certainty that would allow long-term development of the aquifer based on the formula of water allocation discussed above. This formula will allow people to know how much water they actually have to utilize on a long-term basis.

Additionally, this system would reconcile the differences amongst adjacent GCDs and reduce the balkanization that often occurs amongst the GCDs. With authority concentrated at the aquifer level, aquifer authorities would be forced to make decisions for the good of every citizen that comes into contact with the aquifer, not just for those who reside in a certain jurisdiction within the aquifer, and only care to protect certain stakeholders in that jurisdiction. Instances such as this are often the source of management gridlock under the current system. Basing rules on hydrology, as opposed to political pressure, would also alleviate many of the previous differences amongst neighboring GCDs.

Dealing with the Issues

Under this alternative, there will be less local bureaucratic control than exists under the GCD system. However, because county commissioners will be in charge of electing district representatives in the aquifer, there will still be a mechanism for local constituents. Additionally, there may be cities that will not have access to the same amount of water under the new system that will need to acquire water rights in order to meet their needs. This will not be such a strenuous process, as it is today, because attempts to limit water export will no longer be allowed. Exporting decisions will be made by individual landowners, and no longer for the good of one GCD and its primary stakeholders. Through this acquisition process, nearby cities adjacent to GCDs can end up with access to more water than is possible to acquire under the existing system. Furthermore, landowners can benefit by selling their water subject to the limitations of correlative rights.

Unintended Consequences

Possible unintended consequences of this alternative are similar to Policy Option One. For example, the potential for falsifying metering reports will always be present. Still, enforcing strict fines and penalties and spot-checking has the potential to keep this type of mis-behavior under control. However, with authority further removed from the local level, monitoring may be less effective. It is also possible in the process of allowing increased pumping may cause any number of landowners' artesian head to drop on their well. However, the mitigation fund should be able to shoulder these costs, making it the responsibility of the aquifer to determine how to reconcile this type of consequence. With any system, there may arise unintended impacts on the aquifer and subsidence. Having authority rest at the aquifer level seems likely to offer more flexibility in responding to such conditions. Since hydrology models are adopted to each sub-aquifer region, this structure seems likely to provide more science-based decisions and be better able to deal with such unforeseen conditions.

Policy Option Three: Statewide Regulation

Basic Proposal

In an attempt to solve many of the inefficiencies found in the current GCD system, a Statewide Groundwater Agency (SGA) would be created to regulate Texas groundwater. This idea has been proposed by a number of persons knowledgeable about groundwater and is motivated by the success the Texas Railroad Commission has had in regulating oil and natural gas production. Note that the SGA could be a newly created agency, or, the TWDB could simply be granted additional responsibilities.

- The SGA would have authorization to protect, conserve, and regulate groundwater use across the state of Texas.
- The SGA would perform a statutory role of preventing the waste of groundwater, protecting correlative rights of property owners, prudent management of Texas aquifers, and ensuring the safety of pumping.
- The SGA would create sixteen district offices across the state to handle the metering of well production, overseeing monitoring wells, and enhancing the communication between individual pumpers and the SGA.

How It Would Work

The Texas Legislature would delegate groundwater regulation authority to the SGA. The SGA would:

- Be managed by three board members serving six year terms and elected in alternating, two-year statewide elections;
- Create sixteen district offices along current Groundwater Management Areas (GMA), which would:
    - Collect mandatory metering reports from users within the district
    - Oversee monitoring wells
    - Serve as the first point of contact by local pumpers and citizens

- Provide in-house hydrological experts who monitor and study aquifers and create sound, scientifically-based regulations;
- Issue well permits based on:
    - Well spacing
    - Amount of land owned
    - Aquifer conditions
    - Hydrological makeup
    - Safety of pumping
- Set a uniform, non-discriminatory fee structure
- Encourage the development of a water market

Positive Attributes

There are several positive attributes that come from having the groundwater regulatory apparatus centralized at the state level in comparison to the existing system, which focuses on local authority.

Encouraging the *creation of water markets*

This system would allow for the creation of a statewide water market, which, in turn, would ensure water is put to its highest and best use. Because groundwater would be viewed from the state level instead of from the lens of rigid district lines, the SGA would be able to identify both areas of abundance and areas of scarcity in order to encourage trade between the regions. Additionally the state would have the ability to regulate areas of need and areas of abundance, differently. For example, in areas of abundance, the state could encourage groundwater use and exportation. In areas of scarcity, the state could impose more stringent regulations to prolong the life of the aquifer and encourage water imports.

Making statewide regulations

Under the current system, some areas of the state remain unregulated because GCDs have not yet been established. These "white spaces" operate under the rules of capture. GCDs have not been established in many of these areas due to the hindrance of local politics designed to protect small groups of stakeholders. Even in GCDs, local politics have played a role in setting rules, regulations, and fee structures. Having a statewide agency would take local politics out of the decision-making process and allow for a more fair, uniform, and transparent system.

Creating 16 local district offices

The SGA would be able to create district offices across the state. These districts offices would align with the TWDB's GMA breakdown, which is based on sub-aquifer regions. These 16 offices would be the first point of contact at the SGA and would handle local issues. Also, these offices would collect self-metering reports from all of the groundwater users in the district while occasionally spot checking wells for compliance. Each respective district office would also oversee monitoring wells installed within the district. Monitoring wells would allow hydrologists to study what is occurring underground in areas where more information is needed; the district offices would simply check on the wells four times a year and report back to Austin.

Financial strength of the SGA

The SGA would not be as financially limited as many GCDs are today. Along with the allocation of funds from the State, fees collected from permit sales would allow the SGA to mitigate landowner losses and finance the new administrative costs. In the current system, landowners have experienced harm from excessive pumping by their neighbors and they are not being compensated. It is important that the SGA is capable of mitigating landowners substantially harmed by the pumpage of others.

One way to address this issue is creating a policy where the state pays for 75% of any cost over $1,500 incurred due to the decrease in water levels. The biggest threat to landowners is the cost of lowering the pumps to the dropped water table. Often, landowners can do this for under $1,500. However, when there are large decreases in the water levels due to a massive cone of depression or if wells go completely dry, landowners would be facing large damage costs. At this point, the state can step in, using the fees it collects, to subsidize 75% of these costs in excess of the initial $1,500 deductible.

Additionally, many GCDs struggle to pay the bill for lawsuits that occasionally arise. A state agency, which operates on a much larger scale, will be more capable to fight litigation because of its greater resources. When the Texas Railroad Commission moved to state regulation of oil and natural gas in the 1930's, litigation initially increased in an attempt to avoid any limits on pumping. It is likely that litigation would actually decrease because the SGA could use correlative rights and scientifically-based regulations in determining pumping rates. When lawsuits do arise, a statewide agency would be better equipped to finance these cases.

In-house hydrological expertise

A great advantage of this system is the capability the SGA would have to house a large group of water professionals and hydrologists. These specialists would be able to work together to provide better management based on the collected data from metering reports and monitoring wells. This provides substantial opportunities to conduct comprehensive studies on all aquifers to maintain viable aquifer conditions. Hence, the new data would provide a strong basis for setting scientifically based regulation. Additionally, having these hydrologic models available at one location and being subject to periodic refinement would in principle be a substantial improvement over the existing system.

Statewide regulation of brackish groundwater

The SGA would be able to create a different regulation system for the state's abundant supplies of brackish groundwater. Under present circumstances, desalinating brackish water is not economically efficient in areas with abundant fresh groundwater. While very small today, desalination is occurring in certain municipalities.[42] Furthermore, in the future it may well be necessary to use the state's large reserves of brackish groundwater. The SGA would seem particularly adapted to setting a reasonable timeline and regulation plan for the use of brackish groundwater.

Dealing with the Issues

Accurate metering reports are a key aspect to the SGA management system. Instances may arise where the landowners understate their pumping rates. This will lead to a series of problems for

42. Beckermann, op. cit., Appendix A.

groundwater management; for instance, the hydrologists could update their models using false data. This may be even a larger problem in this policy option than in policy options one and two because the SGA is even further removed from the individual pumpers.

Next, GCDs were established to maintain local control over groundwater. Creating a statewide system to manage groundwater is in direct conflict with the rationale for local control and GCDs. It should be pointed out that there was initially great opposition to the Texas Railroad Commission regulation of oil and gas; today it works reasonably well. Local producers may complain about the price of oil and natural gas, but statewide regulation is not an issue.

Unintended consequences

Like local control by GCDs, statewide regulation will not be immune to “regulatory capture” by special interest groups.[43] The SGA would face strong presences from a variety of interest groups such as water marketers seeking a return to rule of capture, environmental groups seeking minimal pumping, and local NIMBY (Not In My Back Yard) groups that are not opposed to pumping and economic development as long as it is not in their area. The possibility of regulatory capture by any one of these groups cannot be discounted nor predicted.

43. George Stigler, “The Theory of Economic Regulation”, *Bell Journal of Economics*, 2, 1971, pp.3-21.

Policy Option Four: A Groundwater Bank Account System

Basic Proposal

Texas has had a rich history of well-defined property rights, which has benefited the state's economic growth. Nonetheless, current policies regarding groundwater have left ownership of the resource largely undefined. Therefore, to define ownership and to ensure groundwater is utilized at its highest and most efficient use, a groundwater bank account framework is proposed. The idea of a groundwater bank account is not new. Variants thereof can be traced back to Nobel Laureate economist, Vernon Smith,[44] and have been recently applied in Australia by Michael Young.[45]

The fundamental characteristics of this policy option are as follows:

A groundwater account would be created for each landowner within a major aquifer. This account would allow the owner to buy, sell, or save his/her groundwater.

- Initially, each landowner's account would be allocated based on the water located directly beneath their property. Like a conventional bank account, water use would be debited and recharge would be credited with a running balance over time. However, a landowner can never pump more than their bank balance.
- In doing so, a water market would be created allowing users to pump water from their account, transfer it to a neighbor, save it for their grandchildren, or sell it to a nature conservancy.
- In transitioning from the existing system to this policy option, scarcity would develop as supply is limited and ownership is defined, fostering the right conditions for a water market to be born.

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44. Vernon L. Smith, "Water Deeds: A Proposed Solution to the Water Valuation Problem," Arizona Review, Vol. 26, No. 1, 1977.

45. Young, M.D. 2015. "Unbundling Water Rights as a Means to Improve Water Markets in Australia's Southern Connected Murray Darling Basin." In *Use of Economic Instruments in Water Policy: Insights from International Experience,* edited by Manuel Lago, Jaroslav Mysiak, Carlos M. Gómez, Gonzalo Delacámara, and Alexandros Maziotis. London: Springer.

- Groundwater bank accounts create an incentive to keep water in the ground, since if you don't use it today, it is available for you in the future.

How it Would Work

Groundwater Bank Account Authority (GWBAA)

The GWBAA would serve as the regional authority responsible for the management of the aquifer through the groundwater bank account system. There will be a GWBAA for each of the eight major aquifers (excluding the Edwards Aquifer for legislative reasons) within the state. The GWBAA will be responsible for the creation and maintenance of an electronic banking system and for governing all GCDs located within the aquifer's geographic boundary. In addition, the GWBAA will be responsible for registering the initial allocation of water for a particular property, providing support to local GCDs, and ensuring the overall integrity of the aquifer.

Although the GWBAA will not directly perform functions like adding recharge credits, monitoring and recording water pumping activity, and recording the sales and purchase of water rights, it will provide direct governance over the GCDs who will be responsible for these tasks. Additionally, the GWBAA will be responsible for setting transaction fees collected by the local GCDs.

The Role of Groundwater Conservation Districts (GCDs)

The local GCDs seem ideally suited for the role of the local banker. Much like a regional bank with branch offices, the GWBAA will work with each GCD within their respective aquifer. The GWBAA will assist GCDs with overarching task like the creation of water registers and the initial water allocation. Tasks such as maintaining water accounts and transaction, applying recharge credits, and determining withdrawal impact radius will be enforced and managed through the local GCDs. Additionally, GCDs will be responsible for collecting the transaction fees and penalties for misreporting on water pumping. Currently, some areas within the state are not under the governance of a GCD. To ensure the proper management of the aquifer, these areas must either create a new GCD or be annexed into a pre-existing GCD.

Groundwater Bank Account Statement

The GWBAA will issue annual water statements, like the one below, to property owners in each aquifer showing balances at the end of the year. The statement will reflect groundwater activity recorded (deposits and withdrawals) for a particular property during the year.

Evergreen GCD

EUWCD

Groundwater Bank Account

Date:	January 1, 2029
Statement #	[100]
Customer ID:	[ABC12345]
Page 1 of	1

Bill To:

Property Name: Smith Farm
Individual Owner: Mr. Todd Smith
21779 Farm to Market 1774
Todd Mission, TX 77363
(979) 000 0001

Account Summary	
Previous Balance	3,000.00
Debit (AF)	3,200.00
Credit (AF)	200.00
Total Balance (AF)	**0**
As of Date	30-Dec-2028

Date	Description	Debit (AF)	Credit (AF)	Line Total (AF)
1-Jan-20	Opening Balance			3000
1-Jan-21	Yearly Pumpage (2020)	100	0	2900
1-Jan-22	Yearly Pumpage (2021)	150	0	2750
1-Jan-23	Yearly Pumpage (2022)	75	0	2675
1-Jan-24	Yearly Pumpage (2023)	80	0	2595
1-Jan-25	Yearly Pumpage (2024)	80	0	2515
1-Jan-25	Recharge Credits (2025 - 2030)		100	2615
1-Jan-26	Yearly Pumpage (2025)	75		2540
1-Jan-27	Water Rights Sold to Brown Farm (ID#123)	100		2440
1-May-27	Water Rights Procured from Jones Farm (ID#456)		100	2540
7-Jul-28	Water Rights Sold to Nature Conservancy	2540		0
			Account Current Balance	**0**

Figure 6- Groundwater Bank Account Statement Example

The above groundwater bank account statement provides a hypothetical example of water activity within a particular property in the Evergreen GCD. The statement lists all the completed water transactions by the "Smith Farm" account. The statement includes the initial opening balance (3,000 AF), yearly pumping, recharge credits, sales of ownership rights, purchases of ownership rights, and the current balance as of the issued date. The initial opening balance is the amount of water available in the account of the property owner as of January 1st, 2020 based on 5% of TERS for the square mile underlying his/her property. Yearly pumping is captured by adding the amount of pumped water in the debit section of the statement. The periodic recharge credits and procurement of water rights from Jones Farm is captured by crediting the account.

It is important to note that the transaction with Jones Farm is a unique situation only made possible by the parties' geographical proximity. In this case, Jones Farm happened to be within the transfer zone set by the GCD, allowing the transaction to take place. Selling of water rights to another owner, such as a nature conservancy, is captured by debiting the account on the 7th of July in 2022. This transaction represents Smith Farm's decision to sell his entire water balance to the nature conservancy, leaving the account balance at zero. The nature conservancy would then become the owner of Smith's water rights.

As illustrated above, an important characteristic of this system is its natural tendency to encourage conservation. Account owners who elect to deplete the water in their account will be forced to stop pumping, while account owners who save the resource will have water for the future. By clearly defining and enforcing groundwater ownership, conservation is incentivized as the consequences of pumping vary between each individual pumper.

Determining Initial Bank Balances

Currently, the TWDB maintains hydrological models that provide estimates of TERS on a one-square mile basis. Landowners located in that square mile would be allocated initial bank balances proportional to TERS. In this case, the thicker and more prolific the zone, the greater the quantity of water that will be allocated to the property. This approach differs from Option One which assumes the same AF allocation per SA and in effect assumes that all landowners have equal water saturation.

Transaction Fees

A transaction fee will be charged every time water is withdrawn from the aquifer. The magnitude of this fee will be directly tied to the amount of water pumped. No fees will be levied for transfers of ownership in order to incentivize trade. The revenue generated from these fees will be used to fund administrative needs, maintain hydrology models, and expenses for mitigation. To prevent fraud, spot checks will be conducted by the local GCDs on a regular basis. Misreporting of water pumping would result in hefty penalties and, if persistent, legal proceedings would be pursued against the property owner.

Aquifer Management Considerations

In order to assure prudent aquifer management, limiting aggregate pumping to 5% of TERS over a 50 year period is recommended. Thus the initial balance for a landowner would be equal to 5% of TERS underlying his/her property. Within that 50 year time period, the landowner would have freedom to allocate pumping at his/her discretion. At the conclusion of the 50-year period, the overall condition of the aquifer will be evaluated and an additional allocation based on some percentage of TERS would be credited to each bank account, based on aquifer conditions at that time. The water remaining from the initial allocation at the end of the 50-year period would remain in the bank account, creating an incentive for conservation.

Defining Water Transfer Zones

Another desired feature of the groundwater bank account system is the flexibility to transfer pumping rights between the bank accounts of nearby neighbors. The idea is that pumping could be maintained on Farmer Smith's property if he borrowed water from his neighbor, Farmer Jones. Smith's account would be credited and Jones' account would be debited. These types of transactions are desirable in aquifers with high transmissivity. The local GCD will be responsible for defining and enforcing water transfer zones. Basically, within a transfer zone, Farmer Jones could pump from his well using water that would have alternatively been pumped from Farmer Smith's well. Thus water would not require transportation from one pumper to another providing the two are located in the same transfer zone. To mitigate negative impacts to neighboring properties, GCDs would determine minimum well spacing and maximum pumping rates as well as transfer zones. In many cases, transfer zones will be extremely important as water users work to secure additional water permits to fill shortages in their consumption needs.

Recharge Credits

Periodically, bank accounts would receive credits for recharge. Based on data from the TWDB's hydrologic models, the GWBAA will determine aquifer wide recharge credits and allocate them in proportion to the original allocation of water placed in the account at the start of the 50 year period. On average, recharge credits would be issued every five years because the administrative costs of more frequent allocations would likely be prohibitive.

Strategy for Execution

To ensure the successful implementation of this policy, a pilot program will be conducted to better understand the potential impacts of the change. Best practices will be identified from this pilot program allowing for modification before releasing a statewide program in 2020.

Positive Attributes

Correlative Rights

The current system utilizes a blended approach to correlative rights — incorporating both high pumping rates historically obtained under the rule of capture and restraints on new pumpers through GCD regulations. Unfortunately, this system has resulted in unclear property rights, taking lawsuits, and a network of balkanized governing agencies. Under the groundwater bank account idea, the ownership of groundwater is clearly defined, resulting in greater incentives to conserve the resource. Furthermore, groundwater bank accounts would end the existing costly and wasteful takings lawsuits.

Highest and Best Use

By removing differentiated user fees, all uses of water are treated equally under the new system. The implementation of a water market allows for groundwater to be used for its highest and best use. In this system those willing to pay the highest price for water will be the recipient of the resource. This is in contrast to the previous system where certain water uses benefited from reduced fees, while others were eventually foreclosed from pumping. Under the groundwater bank account option, water is encouraged to follow the market, resulting in a more efficient use of the resource both today and in the future.

Mitigation

This policy solution ensures each user has fair access to their property right by determining the amount of water that may be pumped without causing neighboring wells to run dry due to cones of depression or subsidence. However, as aquifers are drawn down over time, there will be cases where wells do run dry. To provide assistance in these situations, the mitigation plan discussed in Option One would be applied; yet, in this policy option the GWBAA will provide oversight for all applications and the GCDs will ensure the execution of projects.

Prudent Management of the Aquifer

Implementation of this policy option provides for the overall prudent management of the aquifer due to the system's natural propensity to promote conservation. As discussed earlier, as the finite quantity of water owned by each property holder becomes clear, and as trade becomes more prevalent, conservation will naturally emerge as account holders manage the resource for future use. Additionally, conservationists interested in protecting the resource for the future will have the right to procure water rights and restrict them from being placed into production.

Dealing with the Issues

Those benefiting most from this policy option will be the property owners located in prolific water-bearing zones, conservationists, and existing producers with currently low pumping rates. First, the property owners located in a water-bearing zone, an area that is capable of transmitting water in ample quantity, will benefit from this system because ample supply will be reflected in their issued water balance. Second, conservationists will benefit because they can leave their water in the ground by not producing and can also procure rights from neighboring properties. Conservationists can continue adding water to their balance without worrying about it being withdrawn by other property owners. Lastly, existing property owners who are not maximizing their total water allocation will have that reflected in their water statement, which will allow them to trade their water rights with neighbors, sell it, or leave it in the ground for use at a later date.

Those who will suffer the greatest negative impacts from this policy include the property owners who are currently exceeding their water pumping limits, municipalities with service area comprising small groundwater allocations, and properties located in a non-prolific water-bearing zones. The properties currently exceeding their water allocation will have to procure additional water rights from property owners within the defined zone established by the local GCD. Without procuring additional water rights, the properties will not be able to produce water at their current rate. Furthermore, municipalities with a service area comprised of limited groundwater allocations will need to lease additional water rights from nearby landowners. Currently, these municipalities typically pump large quantities of water from small plots of land. Under this system, municipalities would incur additional costs as they work to secure enough groundwater to provide services to their residents. Similarly, properties located in non-prolific water-bearing zones will have a lower initial balance and will have to procure water rights within a defined zone to increase their water balance.

Unintended Consequences

In implementing a new policy, it is crucial to consider potential unintended consequences. An evaluation of this policy reveals three unintended consequences. The first unintended consequence arises when removing the differentiated user fee structures. By removing this structure, some parties will no longer benefit from discounted water prices. An increase in water cost for historically protected users, such as large irrigators, could decrease some operations' profitability and divert land to other uses. On the other hand, they could at least be able to sell their water for other uses. Additionally, the approach envisioned here houses all water, both fresh and brackish, in the same bank account. We believe that buyers and sellers of groundwater would take account of water quality differences. A possible complicating factor, however, would be whether pumping rates would affect the landowners on the margin between the fresh and brackish water zones. Finally, by setting bank accounts of 5% of TERS over 50 years provides both certainty and some important flexibility as one nears the end of 50 years and bank accounts would be re-adjusted. At this point, it will be important to be able to respond to unforeseen impacts.

Facilitating the Dialogue

In an effort to assist policy makers, each of the proposed policy options is graded against the four criteria deemed necessary to make meaningful improvements to the current system of groundwater regulation. These factors are: respecting the status of groundwater as a private property right, allowing water to serve its highest and best use, mitigating damages from rising costs of groundwater, and prudently managing each aquifer to ensure its continued existence. However, due to their structure, each policy option addresses the above criteria in a varying manner. Table 5 below provides a side-by-side comparison of each policy option with grades of equal weight given by the authors for all four policy options.

Protect all Property Rights

Each of the four policy options provides greater protection for property rights in comparison with the existing system. Under the current system, the ownership of groundwater is a subject of conflict as GCDs and individual property owners attempt to make decisions regarding the best use of the resource. Options One, Two, and Three clarify the ownership of groundwater by establishing a standard process that treats all applicants equally. Additionally, Option Four goes further in protecting property rights by allocating all groundwater proportionally to the amount of water located directly below their parcel of land. Due to these factors, Options One, Two, and Three all received a B+, while Option Four was awarded an A. The major differentiating factor between the first three options and Option Four is that this option assumes every person's groundwater is homogeneous. Overall, implementation of one of the four policy options would result in more clearly defined property rights, and in turn, increased economic development as owners of groundwater benefit from greater certainty.

Highest and Best Use

The authors concluded that utilization of water for its highest and best use is best facilitated under Policy Options Three and Four. The state-wide approach taken in Option Three allows for comprehensive management of the resource, while the market features of Option Four allow for economics to reallocate water to its most efficient use. Therefore, under both of these options, the transfer of the resource from water abundant areas to water scarce areas is made easier.

		Policy Options				
Evaluation Criteria	**Existing Regulatory System with Local Control**	**Option One Modifying the Existing GCD Regulatory Process**	**Option Two Regional Aquifer-Specific Regulatory Agencies**	**Option Three Statewide Regulatory Agency**	**Option Four Groundwater Bank Accounts**
Protect All Property Rights	D	B+	B+	B+	A
Allocate Water to Highest & Best Uses	D+	B	B+	A-	A-
Mitigation of Rising Costs	C-	B+	B	B-	B+
Prudent Aquifer Management	D	B	B+	A	B
Political Feasibility					

Table 5 - Grading the Existing System and the Four Policy Options

Options One and Two are graded marginally lower than Options Three and Four because as management of the resource is divided among multiple authorities in the state, the ability to utilize the resource for its highest and best use decreases with increased balkanization. However, in comparison to the existing system, each of these systems results in a much more effective framework to allow groundwater to be used for its highest and best use.

Mitigation

Under the current system there is no established policy to mitigate the loss if an individual pumper loses access to their groundwater due to increased pumping in the aquifer. However, this section was given a grade of C- rather than D because the discriminatory policies and arbitrarily set MAGs serve to preserve the quantity of water existing in the GCD, preventing the pumping of water which would necessitate mitigation. These discriminatory policies are however an inefficient system of resource preservation and can only loosely be considered mitigation.

All of the proposed policy options increase the availability of resources for mitigation. There is a clear downward slope from Policy Option One to Policy Option Three. This corresponds with the growing distance between the governing body of the groundwater and the governing body's constituents. With the continuation of the current GCD structure featured in Policy Option One the individuals would be fairly close to their government making it easy for them to communicate their needs should a loss of access to groundwater occur. These channels of communication narrow as the level of government controlling groundwater rises. Policy Option Four, which governs water through a bank account system uses the same mitigation structure as Policy Option One. Thus, Policy Options One and Policy Option Four received the same grade.

Prudent Management

Of the four policy options, the authors concluded that the statewide regulatory agency described in Policy Option Three, would most prudently manage the major aquifers of Texas. This is the result of the state's ability to take a big picture approach to aquifer management with the entire state hydrology and economy in mind. While Option Two has the advantage of managing aquifers as a whole, it did not score as high as Option Four because there may be some inter-aquifer relationships that are overlooked. Options One and Four fall around the same grade because aquifer-wide planning in these options seems likely to be more difficult. Finally, the current system received the lowest score because management decisions are primarily politically driven.

Key Takeaways

After evaluating the overall impact of each policy option, our group recognizes none of these policy options are perfect in every dimension. We realize that it is easy to point to the unintended consequences of the existing system, yet it is extremely difficult to anticipate those for the four alternatives. Nevertheless, we believe considerable improvements are possible with the four proposed policy options.

Political Feasibility

Although this analysis evaluated these policy options based on our four key criteria, we note that Table 5 leaves ungraded a fifth criteria—*political feasibility*. We are aware that evaluation of a change to regulatory policy is not complete without considering political feasibility. Our team elected to intentionally leave this section blank for several reasons. First, it is beyond the scope of our assignment. Second, we recognize that the feasibility of any option varies greatly with the ever changing political climate of the state and changing priorities of its citizenry.

By presenting the four policy options, our team hopes to simply initiate a dialogue among the key decision makers in the state regarding groundwater policy. In facilitating this dialogue, we would urge decision makers to first assign their own grades to the four criteria and four policy options in Table 5. After completing those steps, then proceed to fill in their assessment of political feasibility. Too often, we consider the latter before the former.