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Implementing three-dimensional groundwater management in a Texas groundwater conservation district

Hilmar Blumberg[1] and Gabriel Collins[2*]

Abstract: The Guadalupe County Groundwater Conservation District has implemented a 3-dimensional water management solution that allocates pumping rights based on actual volumes in place under a tract. This new regime treats the aquifer as a "constant level lake" where rights holders are awarded the right to a percentage of the inflow (recharge) based on the volume of saturated sands underneath their property.

Three-dimensional management can improve Texas groundwater governance by strengthening property rights, promoting conservation, and unlocking economic value by promoting water trading and collateralization. It is also cost-effective and can be rapidly implemented: the Guadalupe County Groundwater Conservation District created its initial 3-dimensional ruleset in approximately 4 months at a cost of roughly $15,000. Larger districts or districts that could not benefit from an existing property parcel map created by an appraisal district would face higher costs. Creating the type of property ownership maps used by local tax appraisal districts can cost as much as $100,000. Yet the intensive property tax regime in Texas means that even the least-populous counties typically already have such information available in digital form.

Quantifying the available water volume beneath each property and making pumping rights transferrable between wells profoundly transforms groundwater management and confers clear vested rights to water in place. As such, it can provide economic recourse to smaller water holders even in areas where municipalities and other large pumpers enter the district. In short, this forward-looking, conservation-oriented new ruleset provides a way for Texas groundwater stewards to move past flat surface acreage-based allocations and move into an era where a handful of large pumpers in a district do not erode the property rights of smaller holders. Quantifying water in place involves averaging and making certain approximations and generalizations because of the inevitably complex nature of geologic formations. Over time, groundwater conservation districts and their constituent members will determine how deeply to engage that complexity. The bottom line is that 3-dimensional management offers an exponential degree of improvement over existing Texas groundwater management models. The Guadalupe County Groundwater Conservation District's ruleset embraces a philosophy of iterative learning and improvement and acknowledges that employing models as tools of governance always involves approximations. It handles this by including the capacity to rapidly update and revise its approach as the district obtains additional data points and insights through operational implementation of its rules.

Keywords: rule of capture, groundwater governance, conservation, dormant rights, collateralization, water market, cap and trade

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The Texas Supreme Court's landmark *Day* decision in 2012 held that surface owners have the right of absolute ownership to groundwater underlying their tracts.[1] Yet *Day* only establishes the ownership right to groundwater; it does not set forth guidelines on how to practically allocate and manage groundwater resources in a rapidly growing state with volatile weather conditions.

As such, the challenge moving forward is to find a way of maximizing groundwater's value to the predominantly rural property owners under whose tracts it lies while also helping that water flow to thirsty urban areas that are the engines of Texas' demographic and economic growth.

Groundwater conservation districts should seek to create fully developed systems of property management for their constituents, aiming to maximize and preserve property value while supporting a right to exclude. For groundwater, unlimited, perfect exclusion is presently impossible, as water molecules flow in response to changing pressure gradients. Yet with a developed free market with broad and predictable participation, like that which 3-dimensional groundwater management seeks to catalyze, a reasonable facsimile is possible that protects property rights, preserves precious water resources for future generations, and unlocks collateralization and other new forms of value-accretive economic activity. This is a key underpinning of the property right and an important shortcoming of the *Day* opinion, which in many ways gives groundwater owners an absolute ownership right but no practical remedy to enforce it.

"GOING 3-D"

Groundwater offers a dependable water source that is less rapidly affected by drought than surface water and buys municipalities and other non-agricultural users time to adjust to a long-term dry cycle, such as the one Texas experienced in the 1950s. A 3-dimensional groundwater management system that strengthens property rights and increases water's value while it still sits in an aquifer would offer a strong tool for inducing conservation of the resource and would benefit future generations of Texans.

For its portion of the Carrizo Aquifer, the Guadalupe County Groundwater Conservation District has created a transparent and cost-effective management solution that empowers local water owners. This solution entailed mapping the resource and equitably dividing it based not on flat surface acreage but rather on the available volume of saturated Carrizo Aquifer sand under each tract. By adopting this approach, the District has found a clear and powerful way potentially to transform Texas groundwater governance, moving from the old 2-dimensional regime of surface-based flat extraction limits to a new 3-dimensional model that visualizes the geological arrangement of groundwater in-place under a surface tract, quantifies its volume, and grants extraction rights accordingly, pro rata.

Each groundwater conservation district faces unique local hydrological, economic, and political conditions. The changes the Guadalupe Groundwater Conservation District made to its ruleset might not, without further suitable adjustment or alteration, be universally applicable across other groundwater conservation districts. Yet this solution offers a working model that leverages existing legal precedent and statutory powers to create a better way to manage groundwater resources for the benefit of both private owners and the consuming public. In brief, the Guadalupe County Groundwater Conservation District operationalized the *Day* decision, which affirmed surface owners' absolute ownership rights to the groundwater underlying their tracts. Its method of doing so focuses on meeting 3 core criteria essential for reshaping groundwater management in a fair, sustainable, and value-maximizing manner.

First, **legal and political feasibility.** The need for a better groundwater governance system is a "here and now" issue in Texas, and potential solutions must reflect this reality. The desire for perfection cannot be allowed to prevent something clearly forward-looking from being created. To that point, there is a need for a system that can be timely built and implemented in the state's current legal and political climate. Because inclusivity enhances feasibility, delineating the resource and using a transparent, market-based allocation system protects rural property owners who control much of the access to Texas groundwater supplies and positions them to monetize their water resources in a market-based system that favors the highest-value uses.

Second, **flexibility and scalability**. In Texas, underground water governance needs a system that can react nimbly to climate changes, water demand imposed by a fast-growing economy, and population growth, which is among the highest in the nation in both rate and scale. To give a sense of how profoundly and rapidly a drought can affect water demand in Texas, groundwater use rose by more than 2.7 million acre-feet year-on-year in 2011, according to Texas Water Development Board data.

A mapping and volumetric rights allocation system offers a strong and actionable solution among the currently available alternatives for managing increasingly scarce groundwater resources. Each of Texas' dozens of underground water-bearing formations is geologically and hydrologically different. Likewise, the politics of each groundwater conservation district and groundwater management authority differ as well. In that spirit, this case study is not intended to offer a "one size fits all" solution. Rather, it acknowledges that to succeed in the long run, groundwater management regimes need to be rooted in and reflect local conditions—the same reality that under-

[1] *Edwards Aquifer Auth. v. Day,* 369 S.W.3d 814 (Tex. 2012)

pinned the Groundwater District Act of 1949 (discussed in greater detail below).

Third, **fairness and protection of private property rights.** Under more familiar rules, especially those with overly generous, flat, surface-based correlative rights, groundwater resource development typically only benefits a handful of owners whose tracts overlie the thickest section of a water-bearing formation. Once a developer comes in, drills a well field, and begins pumping, a relatively small surface holding can absorb a significant portion of the allowable water extraction for the entire district. This ultimately means that many landowners who sit atop thinner sections of the aquifer, but have a property right in the water nonetheless, are effectively precluded from ever developing or monetizing the water assets underlying their land.

In contrast, the Guadalupe County Groundwater Conservation District's approach aims to make rights from throughout the district—even those over thinner saturated sands—to be marketable. The District provides significant information about the local groundwater resource and ownership characteristics, including saturated sand thickness on a tract-by-tract basis, which accrues to the benefit of local water owners.[2] Providing owners a solid base of information to inform their decisions helps protect private property rights. Along these lines, a groundwater conservation district that has mapped and subdivided its resource base is operating at a high standard of stewardship in full compliance with Chapter 36 of the Texas Water Code, which, among other things, demands that groundwater conservation districts "use the best available science in the conservation and development of groundwater through rules developed, adopted, and promulgated by a district in accordance with the provisions of this chapter."[3]

While some of the District directors may not have intended to create a water market when they adopted a new ruleset in 2004, those who authored the rules understood their deeper implications. The greater availability of information, combined with the fact that each water rights owner now possesses a protected slice of the Carrizo Aquifer pie in the District, sets the stage for a functional commodity market in water rights. As a robust market develops, better information availability will enable the market to function more efficiently and fairly—especially from the perspective of landowners atop valuable groundwater assets whose political buy-in is essential to the long-term legitimacy of new water resource governance models.[4]

Information transparency maximizes the total net economic value of the resource under the District's jurisdiction, while safeguarding against disproportionate rent transfers driven by the information asymmetry between sophisticated, well-capitalized buyers and sellers who might lack the means to ascertain what their resource is truly worth. This in turn helps create a fairer market, which generally helps cement local buy-in and drive grassroots political support that ultimately reduces risk to the big capital interests needed to finance large-scale water supply projects. Market-oriented groundwater conservation district rulesets also help promote conservation by shifting users' views from being purely extraction-based to being self-sustaining, commerce-based. In essence, owners have a fully vested property right that can be bought, sold, inherited, and used in other value-accretive ways. Marketable water rights can become a long-term asset that motivates owners of these rights to evince ever-greater interest in the election of forward-looking, conservation-minded groundwater conservation district directors.

For these reasons, the Guadalupe County Groundwater Conservation District's new ruleset closely adheres to the Texas Legislature's stated purposes behind the creation and empowerment of groundwater conservation districts, as outlined in Chapter 36 of the Texas Water Code. The District formed the new ruleset to protect property rights.[5] It is also balancing the conservation and development of groundwater resources to meet the state's interest in future, sustainable development.[6] Finally, the District's innovative use of the saturated volume model and commensurate division of water rights represents an application of "the best available science" to help find a proper balance between the conservation and development of groundwater.[7]

[2] Guadalupe County Groundwater Conservation District, "Water Rights," http://www.gcgcd.org/water-rights.html

[3] Texas Water Code, Chapter 36.0015(b). In this statute, "best available science" means "conclusions that are logically and reasonably derived using statistical or quantitative data, techniques, analyses, and studies that are publicly available to reviewing scientists and can be employed to address a specific scientific question." We firmly believe the Guadalupe County Groundwater Conservation District's creation of a saturated sands volumetric model and subsequent allocation of rights based on a recharge-driven annual production cap clearly meets the Water Code's standard.

[4] See, for instance: Damodaran, Aswath. "The value of transparency and the cost of complexity." Available at SSRN 886836 (2006).

[5] "Groundwater conservation districts created as provided by this chapter are the state's preferred method of groundwater management in order to protect property rights, balance the conservation and development of groundwater to meet the needs of this state, and use the best available science in the conservation and development of groundwater through rules developed, adopted, and promulgated by a district in accordance with the provisions of this chapter." Tex. Water Code Ann. § 36.0015 (West)

[6] Id.

[7] Id.

HOW AND WHY THE DISTRICT CHOSE TO CREATE A 3-DIMENSIONAL MODEL

The Guadalupe County Groundwater Conservation District was created in 1997 by Chapter 1066, Acts of the 75th Texas Legislature and was then amended in 1999 by House Bill 3817.[8] House Bill 3817 created the District in its present form with 7 directors elected from 7 single member districts and limited the District geographically to the portion of Guadalupe County that lies outside the boundaries of the Edwards Aquifer Authority.[9] Guadalupe County Groundwater Conservation District lacks taxing authority and raises all of its income from fees imposed on municipal and commercial groundwater transactions in the district.[10]

The District oversees groundwater extraction in an area with a population of more than 140,000 people and lies on the periphery of the rapidly growing San Antonio metropolitan area. Guadalupe County has grown from 89,000 residents in 2000, to more than 131,500 in 2010, and an estimated 147,250 in 2014, according to the U.S. Census Bureau. Approximately a third of these people live within the District boundaries.[11] Groundwater from the Carrizo Aquifer provides the baseline groundwater supply in the District. The Wilcox Aquifer also underlies the District, but there is no reported production from that layer to date in the portion of Guadalupe County under the District's jurisdiction. Upon its creation, the Guadalupe County Groundwater Conservation District board initially adopted rules directly derived from other, pre-existing groundwater conservation districts atop the Carrizo and Wilcox aquifers that also underlie Guadalupe County. Specifically, these rules relied upon (1) overly generous surface acreage-based production limits bound by a District-wide upper production limit set purposely low relative to the amount of water rights distributed; (2) wells being spaced far apart; and (3) water rights contiguity, meaning that rights had to be around the wells and connected.[12]

[8] "Groundwater Management Plan," Guadalupe County Groundwater Conservation District, 8 November 2012.

[9] Id.

[10] Id.

[11] Allison, Bass & Associates, LLP report Dec. 2011 GCGCD Voting Rights Submission/Election boundaries

[12] Id. The general rules enumerated above these rules were designed for an environment of very low demand and very large supply, with a few local users using water for irrigation, livestock, and other limited volume domestic supply. They were not designed to handle the issues that arise when nearby municipalities seek to extract and export tens of thousands of acre-feet per year of water from the area.

THE CALL TO ACTION

Certain Guadalupe County Groundwater Conservation District board members began to reconsider their rule structure as they watched several large municipal water suppliers—the San Antonio Water System, Schertz-Seguin Local Government Corporation, and Canyon Regional Water Authority—begin industrial-scale water rights acquisition and extraction in neighboring Gonzales County. Of particular concern, the Board saw that the Gonzales County Underground Water Conservation District's outdated ruleset led to a small handful of surface owners atop the thickest aquifer sections striking deals with the municipal suppliers, at which point the district essentially hit its annual production ceiling. As such, the few landowners who owned tracts atop the thick sections of the Carrizo Aquifer in Gonzales County effectively locked up the resource and locked out other groundwater holders. The latter's water lost much of its economic value because the District had reached its annual production cap and owners who had not yet entered the market were thus precluded from leasing their water.

Surface acreage-based correlative water rights, combined with contiguity requirements and caps on production imposed by groundwater conservation districts, break down when municipal-scale water extraction projects enter the picture.

Two primary factors drive this reality. First, just as the subsurface geology does not correspond with the surface topography, neither does the subsurface hydrogeology generally correspond with the distribution of surface holdings. Some tracts lie atop thin spots of saturated sand, while others sit atop the down-dip "sweet spots" in the aquifer where there may be several hundred feet or more of accessible water. The natural, extreme variations of saturated sand thickness and productivity within a connected aquifer system illustrate a critical flaw in the correlative, flat, surface acreage-based withdrawal regulation system used by many groundwater conservation districts in Texas.

Second, water migrates in response to pressure changes. When a developer sinks large-bore wells into the sweet spots and begins extracting large volumes of water, migration in the aquifer favors the down-dip holders at the expense of those owners atop thinner sands, who may find their property completely pumped away. Under Texas case law, such owners generally have no legal recourse to prevent neighbors from pumping the same groundwater that those same cases also clearly—and ironically—state is their "real property."[13]

Motivated by the events in Gonzales County, Guadalupe

[13] Gabe Collins, Blue Gold: Commoditize Groundwater and Use Correlative Management to Balance City, Farm, and Frac Water Use in Texas, 55 Nat. Resources J. 441, 448 (2015); See also *Sipriano v. Great Spring Waters of Am., Inc.*, 1 S.W.3d 75, 76 (Tex. 1999)

County Groundwater Conservation District has moved to rectify this inconsistency through exercise of the substantial powers conferred upon groundwater conservation districts under the Texas Water Code. The legal authority for the District's action is examined in greater detail later in the paper.

The Guadalupe County Groundwater Conservation District faced the same concentrated water rights ownership situation that had created such an inequitable outcome in Gonzales County, as only 25% of the District's acreage sits atop the thickest water-bearing strata: 350 feet thickness or greater (Figure 1). In the thickest intervals—350 feet to 662 feet—the ownership concentration level is very high. The 10 largest surface acreage holders account for 55% of total surface acreage atop water that is thicker than 350 feet, and the 5 largest surface owners in this group account for nearly 42% of all acreage atop the water layer that is 350 feet or thicker.[14]

The uneven distribution of water-bearing strata is precisely what makes the Guadalupe County Groundwater Conservation District's 3-dimensional management system so necessary. The thick aquifer sections are exactly the sweet spots that a water developer seeking to supply a municipality will want to drill into. Under the traditional management model based on flat correlative rights and district-wide production caps based on desired future conditions, these are the parties who would stand to reap most, if not all, of the economic returns, albeit in a shape-shifted version of the old, unadulterated "rule of capture," while the well field inexorably dries up their neighbors' groundwater holdings.

Yet, if a large water exporter comes into the Guadalupe County Groundwater Conservation District, the outcome will be very different. Each landowner sitting over various sections of the aquifer possesses a monetizable interest. Because water rights are transferrable without restriction to any well, the specific distribution of each cubic foot of saturated sand matters less than it would in a simple surface acreage-based allocation system. Money from water sales will flow to the owners of that cubic foot so long as they choose to participate in the market. Owners who sit atop thicker sections of the aquifer will still make more money if they lease. Unlike under a uniform surface-acreage system, where the thick water owners receive everything, under the 3-dimensional management model, owners of thinner sections now also have rights that allow them to participate in the marketplace.

[14]Data on water rights holders sourced from the Guadalupe County Groundwater Conservation District. Guadalupe County Groundwater Conservation District, "Water Rights," http://www.gcgcd.org/water-rights.html. (last accessed on 9 August 2016)

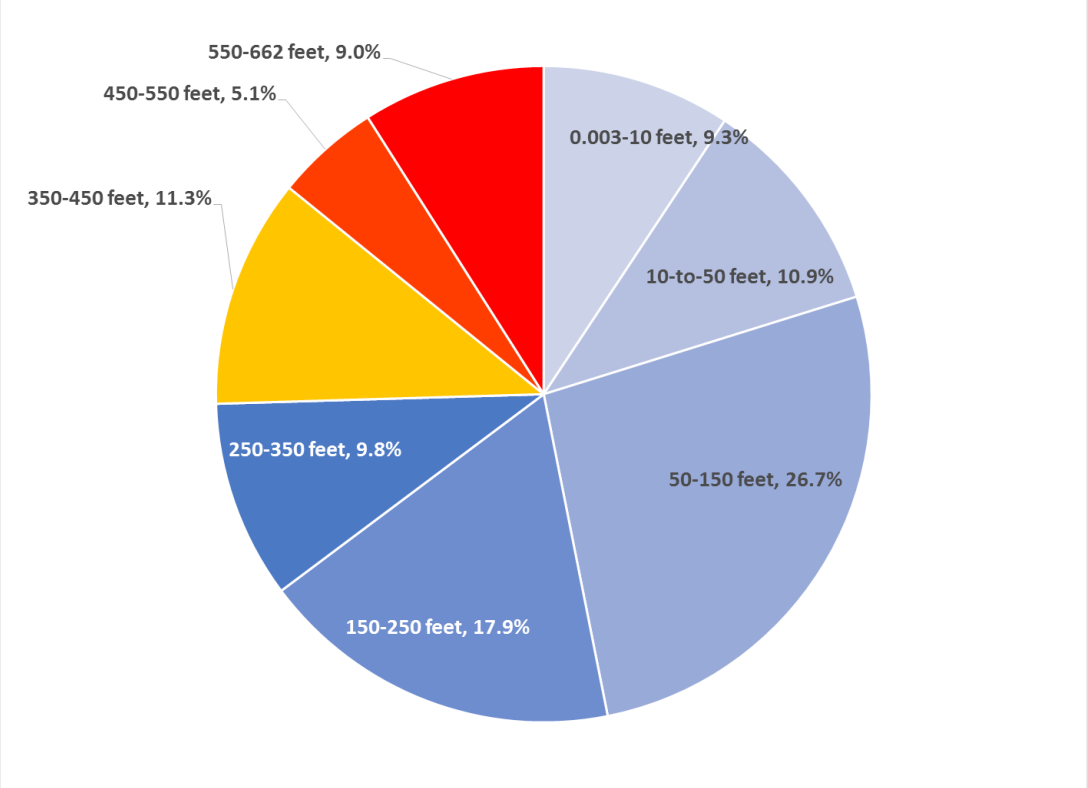

Figure 1. Guadalupe County Groundwater Conservation District acreage holdings classified by the thickness of water-bearing layer. Source: Guadalupe County Groundwater Conservation District, Authors' Analysis.

HOW THE DISTRICT REFORMED ITS RULESET

Guadalupe County Groundwater Conservation District board members moved rapidly in the wake of the Gonzales County water deals to restructure their management system so that future water commercialization would be fairer to property owners in the District. In contrast to legal and legislative solutions that often require years to craft and implement, the District needed a much shorter time—approximately 6 months—to develop its policy proposal, map the resource, and have the idea ready for public presentation and adoption. The proposal's sponsors operated under the philosophy that "the perfect should not be the enemy of the good" and sought to craft a system that would work immediately, but also could be improved as the District's demographic and hydrological characteristics evolved. Some of the District's directors ultimately voted for the new ruleset not to create a water market but rather to ensure that they were fully discharging their duties as groundwater resource stewards, as prescribed by Chapter 36 of the Texas Water Code.

Step one involved crafting the intellectual framework. First, the District recognized that a flat correlative rights system based solely on surface acreage fails to account for the reality that some property owners over an aquifer lie atop deeper, thicker saturated cross-sections of the aquifer, and can thus access more water and enjoy greater market functionality. In accounting for this, the District was in line with the Texas Supreme Court's analysis in *Day*, specifically the Court's position that "regulation that affords an owner a fair share of subsurface water must take into account factors other than surface area."[15]

Developing a more sophisticated allocation approach that goes beyond simple surface area divisions takes into account that deeper, thicker water is easier to produce. Someone who owns property over 10 feet of saturated sand generally cannot pump as much water as someone who owns property over 800 feet of saturated sand. Hence, in the aquifer situation, the thickness of saturated sand beneath a property does have a market implication to be reckoned with in the general water rights equation. For up-dip water holders, the key difference between the 3-dimensional management system and traditional management systems is that water molecules are treated as a vested property right before they are ever pumped. In addition, owners know with certainty how large their share of the District's total allowable water extraction volume is. This paves the way for up-dip owners to be compensated for water pumping that may not involve wellbores on their tract but drains water in place that would have never been monetizable in a non-3-dimensional system.

Moving beyond the old correlative rights system and the "rule of capture" ideas it was paired with democratizes groundwater assets and allows even small holders to monetize what they own rather than following the traditional development model. In the traditional model, a minority of landowners atop thick sections of the aquifer make a lot of money while others' water is effectively cut off from potential sales opportunities because the deep-dip holders have occupied the entire annual production quota. In such a worst case scenario, some water holders up dip would receive no compensation at all while their remaining water is drawn away by large extraction projects.

In essence, the District's new ruleset makes all groundwater rights under its jurisdiction into something akin to royalty interests in a pooled oil and gas lease. In both cases, leased rights owners—even if the wells are not on their tract—still receive a share of production proportional to their acreage holdings.[16] In both cases, land owners with export-oriented well fields on their tracts can also negotiate additional payments for damages, right of way access, and other matters. But the underlying groundwater resource is monetizable in a way that allows all groundwater owners to lease their rights and proportionally earn income from industrial-scale water sales.

From a resource conservation perspective, the most important difference between pooling of water interests and pooling of oil and gas interests is that oil and gas production expressly seeks to extract as much of the resource as economically possible. To the contrary, the 3-dimensional groundwater management philosophy is predicated upon setting an annual withdrawal limit based on recharge and then allocating this inflow volume based on the amount of saturated sand underneath each tract and allowing trading of rights within the volume parameters established by the annual production cap.

Step two required the District to map its groundwater resources. District members began working on the project in early 2004. To improve its ability to allocate the resource, the District modeled the saturated sands beneath every property located above the Carrizo Aquifer. It did so by cross-vectoring, that is, blending together, an extant digital property surface map from the Guadalupe County Appraisal District with a computer-generated saturated section thickness (isopachous) map, which, after integration, can easily assign every property over the aquifer a certain percentage of the entire saturated section volume in the district (Figure 2).

The Carrizo and the Wilcox aquifers under the Guadalupe County Groundwater Conservation District's jurisdiction feature major bands of more transmissive sands interlaced with less transmissive bands of sandy clays, but the entire aquifer,

[15] *Edwards Aquifer Auth. v. Day*, 369 S.W.3d 814, 841 (Tex. 2012)

[16] A central tenet of pooling for oil and gas development is that "production anywhere on a pooled unit is treated as production on every tract in the unit." *Key Operating & Equip., Inc. v. Hegar*, 435 S.W.3d 794, 799 (Tex. 2014)

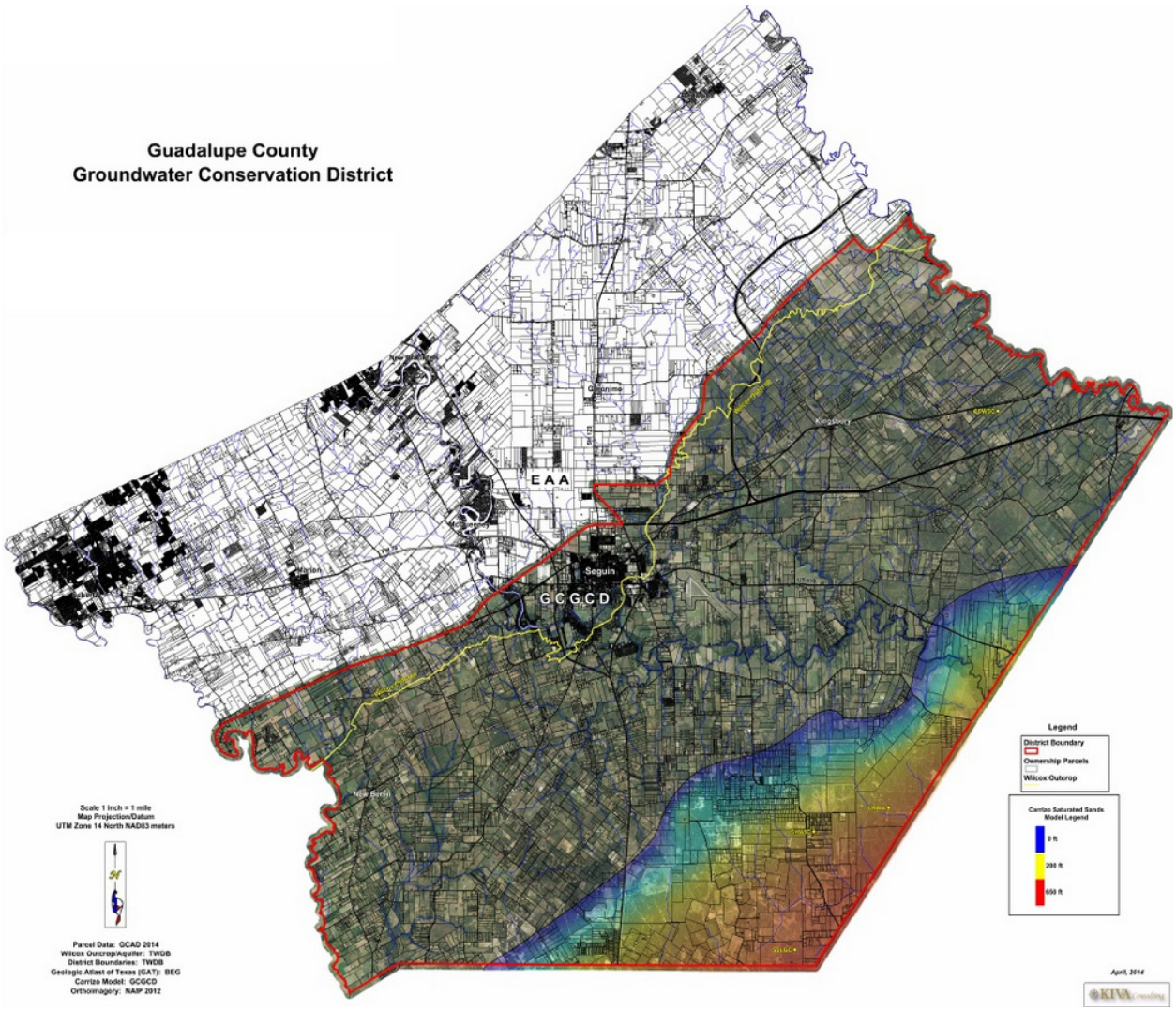

Figure 2. Guadalupe County property tracts superimposed on Carrizo Aquifer saturated sands depth. Source: Guadalupe County Groundwater Conservation District.

all of the Carrizo and all of the Wilcox, is really a connected, saturated collection of sands and clays. The District based its model on the thickness of the saturated sections, assuming that everyone with any saturated Carrizo had about the same amount of water per cubic foot of saturated matrix. This assumption was predicated on the reality that the aquifer is heterogeneous within fairly predictable limits; therefore, the model would yield useful results that far more closely mirror reality than 2-dimensional, flat surface acreage-based allocation models ever could.

The GIS database and 3-dimensional model of the saturated thickness were created using contour data, water level measurements and other relevant data provided by the District's hydrologist.[17] The computer-generated saturated sands model became part of the District's rule set on August 12, 2004.

The saturated sand volume was modeled using 16 feet by 16 feet square surface cells projected down through the saturated section exactly below, yielding the total estimated saturated section volume correlated to a given property. The District

[17] As currently conceived, the model does not account for artesian pressure in the aquifer. Under 3-dimensional management as implemented by the District, the aquifer may be thought of as a static-level lake with a certain inflow (recharge) that is divided fairly to all property owners "on the bank of the lake." The constant-level lake is owned by no one, only the inflow (recharge). The inflow is distributed *pro rata*, depending on how many feet of bank each owner owns and the "lake" (i.e. the aquifer) is only a temporary holding tank for the inflow. With the 3-dimensional model, the recharge (or some percentage of it) is distributed to every property owner *pro rata*, depending how many water molecules are under each property owner's property, not how deep those water molecules are, or how much pressure they are under. Awarding value (extra rights) because of artesian pressure is really part of the old order that is rooted in rulesets that award the deepest water most, if not all, of the selling rights.

then calculated the total volume of the saturated section under its jurisdiction by summing up the saturated volume total of all properties and assigned each individual property owner a percentage of the total. Subsequently, the District determined its total annual allowed production should equal 62.5% of the Carrizo Aquifer's assumed annual recharge in the District boundaries, yielding a maximum annual extraction volume of 12,600 acre-feet (62.5% x 20,000 acre-feet/year = 12,600 acre-feet/year). Note: This production limit was a politically determined and therefore malleable amount that generally tracks the desired future conditions that are reviewed at least annually as a result of the District's meetings with other members of Groundwater Management Area 13, which spans 17 counties and multiple aquifers in South-Central Texas between Austin and Laredo.[18]

Accordingly, from the leading edge of the saturated section under the recharge zone to the deepest, thickest sections in the confined zone, the properties gradually get more water rights per given surface area. However, once the thickness of the saturated section becomes constant moving down the dip (i.e., the sandstone beds cease to get thicker as they get deeper), the amount awarded per unit of surface area also stops increasing.[19]

MAPPING COSTS

While each aquifer exhibits different local characteristics, a core point of the Guadalupe County Groundwater Conservation District's methods is that its cost is surprisingly modest and lies within the budgetary means of most Texas groundwater conservation districts (Table 1). Digitized property maps are the most expensive component required for creating a 3-dimensional groundwater management system, but these costs have often already been borne by the local appraisal district. In the Guadalupe County Groundwater Conservation District's case, the local appraisal district spent approximately $100,000 to create its digital properties map but allowed the groundwater conservation district to use the property map for a nominal fee.

Appraisal districts across Texas are increasingly moving toward digitized parcel mapping and are likely to share their assets with the local groundwater conservation district if it chooses to create a property-based saturated volume model.[20] Indeed, if the implications of the *Day* decision percolate further and local tax authorities began to view groundwater as a form of taxable property, local appraisal districts may become enthusiastic allies of groundwater conservation district boards who seek to map and delineate local groundwater resources.[21]

A hydrologist charged approximately $4,000 for creating the saturated thickness map of the Carrizo Aquifer in the relevant portion of Guadalupe County. A mapper then charged approximately $7,000 to integrate the appraisal district property map with the aquifer thickness data and create an actual picture of saturated volume by tract.

Structuring the Marketplace

Essentially free transferability of water rights is a central premise of the District's contemporary ruleset. Under this ruleset, water rights are initially tied to surface tract ownership. Water rights become "producible" when they are linked to a well for which the District has authorized a production permit.[22] This has resulted in setting the stage for a largely unfettered water marketplace in which every water rights owner in the district may participate. Because a groundwater conservation district acting totally within the bounds of established statutes and case law can create a defined pool of fully transferrable water rights, it profoundly transforms traditional Texas groundwater management.

Under the old regime, it was possible for a small number of landowners above the deeper, more water-laden portion of an aquifer to "lock up" nearly the entire annual permitted productive capacity of the aquifer in a particular district—akin to what transpired in Gonzales County and motivated the Guadalupe County Groundwater Conservation District to adopt its novel approach. Under the Guadalupe County Groundwater

[18] "Groundwater Management Area 13," Texas Water Development Board, http://www.twdb.texas.gov/groundwater/management_areas/gma13.asp

[19] The authors note that in more complex aquifers with variable confined units and other heterogeneous structures, groundwater volume models must also account for hydraulic conductivity.

[20] For an illustration of the digitization trend, see "Parcel Mapping," Texas Tech University Center for Geospatial Mapping, http://www.depts.ttu.edu/geospatial/center/cadastral.html as well as "County Appraisal Districts Maps Online," OGIGov, http://www.ogigov.com/onlinemaps.html (including a large number of rural Texas counties with substantial groundwater resources).

[21] We raise this point because the Texas Legislature has affirmed that it "recognizes that a landowner owns the groundwater below the surface of the landowner's land as real property." *Tex. Water Code Ann. § 36.002 (West)*. Texas law also recognizes a severable groundwater estate. *City of Del Rio v. Clayton Sam Colt Hamilton Trust*, 269 S.W.3d 613, 617 (Tex. App.—San Antonio 2008) ("the Trust was entitled to sever the groundwater from the surface estate by reservation when it conveyed the surface estate to the City of Del Rio."). In turn, if the groundwater is "real property" and can be treated as a severable estate and the Texas Constitution and/or Legislature makes no exemption, then it is very likely subject to taxation. See for instance, *City of Beaumont v. Fertitta*, 415 S.W.2d 902, 912 (Tex. 1967) ("Our Constitution requires all private property to be taxed except that which must be specifically exempt by the Constitution and that which the Legislature may or may not exempt."). See also *Matagorda County Appraisal Dist. v. Coastal Liquids Partners, L.P.*, 165 S.W.3d 329, 332 (Tex. 2005) (severable real property estates can be taxed separately even though all are part of the same surface tract.)

[22] The District Rules, 5.3, provide a detailed explanation of the permitting requirements and process for issuing a production permit.

Table 1: Key tasks and their cost.

Task	Provider	Estimated Cost	Notes
Mapping property tracts in the groundwater conservation district	Local appraisal district	$100,000	Cost likely to have already been borne by the County and/or local appraisal district
Creating the saturated thickness dataset for the local aquifer(s) in question	Hydrologist	$4,000 to $15,000	
Integrating the datasets to create a saturated volume model	GIS specialist	$7,000 to $15,000	
Miscellaneous administrative costs, meetings, etc.	Groundwater conservation district board members	$3,000	
Total cost (high case)		$133,000	
Total cost (most likely case)		**$14,000 to $20,000**	

Conservation District system, the only way the District can hit its annual production limit is for every property owner over the saturated section of the aquifer in the district to participate in the marketplace.

The system offers 2 distinct benefits for more effective resource management. First, the system has high local legitimacy because it was developed by directors elected by District landowners. Second, it fosters preservation of the District's water resources because water rights unsold become water preserved—at least until the price of water climbs sufficiently to induce reluctant sellers to enter the market.

The 3-dimensional management system does not place the entire volume of water contained in the regulated portion of the Carrizo Aquifer up for sale. Rather, the volume that could potentially be traded cannot exceed the annual recharge-based production cap imposed by the Guadalupe County Groundwater Conservation District Board.

The District builds flexibility into its management regime, acknowledging that demographic and climate conditions can be volatile and require rapid adjustment. For instance, the District rules mandate that the District shall regularly update its calculations of the approximate volume of saturated Carrizo sands under its jurisdiction. Along with updating its calculations to reflect potentially shifting conditions, the District must also "continually adjust" the total amount of water that may be annually withdrawn from the Carrizo Aquifer within the District ("the annual production cap").[23]

[23] District Rules, 5.4(d)

District's Legal Authority to Reform its Groundwater Management Rules

Guadalupe County Groundwater Conservation District stands on firm legal footing as it develops and enforces its market-based groundwater management system. Groundwater conservation districts are the Texas Legislature's preferred groundwater management tool and are vested with strong legal powers to achieve this policy goal.

Article XVI, Section 59 of the Texas Constitution says "the preservation and conservation of all such natural resources of the State are each and all hereby declared public rights and duties; and the Legislature shall pass all such laws as may be appropriate thereto." Such language suggests that the Texas Legislature has chosen to delegate a meaningful degree of its state police powers on groundwater issues to local groundwater conservation districts, subject to the provisions set forth in Section 36 of the Texas Groundwater Code. This conferral of authority is important because the U.S. Supreme Court has repeatedly upheld states' ability to exert their regulatory police powers "to prevent waste and to protect the 'coequal rights' of the several owners of a common source of supply."[24]

The history of Texas groundwater conservation districts reflects a delicate dance between the need for regulatory power and the reality that rural interests viewed groundwater as real property even before the Legislature and Supreme Court classi-

[24] See, for instance: *Ohio Oil Co. v. Indiana*, 177 U.S. 190; *Lindsley v. Natural Carbonic Gas Co.*, 220 U.S. 61; *Walls v. Midland Carbon Co.*, 254 U.S. 300; *Bandini Petroleum Co. v. Superior Court*, 284 U.S. 8; *Champlin Refining Co. v. Corporation Commission*, 286 U.S. 210; *Hunter Co. v. McHugh*, 320 U.S. 222; *Republic Gas Co. v. Oklahoma*, 334 U.S. 62 (1948).

fied it as such, and were less than enthused by any central interference. The Legislature passed the Groundwater District Act of 1949 to authorize the creation of underground water conservation districts for the purpose of "conservation, preservation, protection, and recharging and the prevention of waste of the underground water of an underground water reservoir or subdivision thereof."[25] The Act permitted creation of districts with the power to:

- make and enforce regulations for the conservation and recharging of underground water reservoirs;
- make and enforce rules against "waste" of underground water, as "waste" is defined in the act;
- issue permits for the drilling of wells within the reservoir;
- impose spacing rules and prorating withdrawals;
- require reports on the drilling, equipping, and completion of wells;
- acquire lands for the purpose of carrying on recharging operations;
- make surveys and plans and carry on research relative to groundwater;
- enforce, by injunction or other appropriate process, the duly adopted regulations of the district.[26]

The Act expressly recognized the landowners' "ownership and rights" in groundwater under their tracts.[27] Moreover, the language of the Groundwater Conservation District Act of 1949 influenced Senate Bill 1, a landmark water bill passed in 1997, which amended Chapter 36 of the Texas Water Code to say groundwater conservation districts "are the state's preferred method of groundwater management."[28] Senate Bill 1's explicit endorsement of groundwater conservation districts opened the door to a period of rapid groundwater conservation district formation. Indeed, while the first 38 Texas groundwater conservation districts were formed between 1951 and 1996, 60 districts came into existence between 1997 and 2012.

The Legislature's approach to groundwater conservation districts draws upon a strong historical preference among the Texas electorate for local control, shown in other areas such as school boards. Particularly in the Texas Panhandle, where the Ogallala Aquifer dominates supply, users elected to organize into local groundwater conservation districts because they feared that if they did not, harsher regulations would be imposed on them by the State of Texas or other political entities that, from a local perspective, were "outsiders."[29]

Clearly delineating groundwater resources and making them freely transferrable within groundwater conservation district boundaries introduces healthy transparency to the management system and de-fangs many potential lawsuits. To date, litigation between groundwater conservation districts and water owners has primarily focused on projects seeking to export groundwater beyond district boundaries, with some disputes centering on tract size relative to volumes pumped and some focused on takings claims by landowners within the districts. Guadalupe County Groundwater Conservation District's approach likely blunts both approaches.

A 3-dimensional management system built upon a defined pool of rights applying to all water owners can dramatically reduce the risk that a groundwater conservation district will be accused of favoring 1 set of water users over another. Creating a pool of water volumes that owners can then trade freely reduces the administrative burden on groundwater conservation districts by devolving decisions to the players on the field (the water owners). It also lessens the need for a rules committee to draft new regulations each time the game evolves, since traded markets tend to be adaptable to varying conditions. In a market system, the owners' economic self-interest, not administrative decree, allocates water. As such, a district using this system is in many ways protected from having to continually exercise administrative discretion and the risk of incurring lawsuits from exercising that discretion.

Even before the *Day* decision affirmed landowners' absolute right to water under their tracts, the Texas Supreme Court already had decided a case that highlighted the litigation risks a decree-based philosophy of groundwater conservation district operations can create. *Guitar Holding*, decided in 2008 by the Texas Supreme Court, involved a ranch located approximately 100 miles east of El Paso in Hudspeth County that sought to drill 52 new water wells and obtain a permit to transfer water out of the groundwater conservation district.[30] The groundwater conservation district linked its transfer permits to validation permits that favored historical or existing uses of groundwater within the district, most of which consisted of irrigation. Guitar argued that by doing this, the groundwater conservation district effectively granted farmers with existing or historical irrigation a preferential right to convert their irrigation

[25] Edward P. Woodruff, Jr. and James Peter Williams, Jr., *The Texas Groundwater District Act of 1949: Analysis and Criticism*, 30 Tex. L. Rev. 862 (1952).

[26] *Id.*

[27] *Id.* at 867.

[28] Amendments to Texas Water Code § 421, available at http://www.legis.state.tx.us/tlodocs/75R/billtext/html/SB00001F.htm

[29] Mark Somma, *Local Autonomy and Groundwater District Formation,* 24 Publius: The Journal of Federalism 53 (Spring 1994). Such fears of influence by outsiders or a higher political power are a recurrent theme in Texas water governance. Indeed, the Edwards Aquifer Authority Act was created in response to the federal government's threat to bring the management of the aquifer under its control if the state of Texas failed to act. To forestall federalization of the Edwards Aquifer, the state legislature promptly passed the Act in 1993.

[30] Id. at 915-916.

wells to export wells without facing more restrictive conditions applied to non-irrigator water owners such as Guitar. The Texas Supreme Court agreed with Guitar, noting that because the limitations were not uniformly applied to various water owners' applications to export water and were not necessary to protect existing uses, the District's transfer rules exceeded its statutory authority and were thus invalid.[31]

A Guadalupe County Groundwater Conservation District-style groundwater management system also protects the interests of local water owners if a large exporter wishes to develop water resources in a groundwater conservation district. One legally important way that it does so is by affirming water owners' property rights in an aquifer system in the district. To have standing, owners likely no longer need to be directly within the "area of influence" that an export-oriented well field would exert. Rather, the simple act of owning a quantifiable, marketable portion of a target aquifer layer in the district would very likely be sufficient.

Ownership of defined water rights based on a saturated sand volume model also has important implications for district boards. As the law stands, groundwater conservation districts cannot explicitly prohibit the export of groundwater.[32] Yet groundwater conservation districts can impose export fees that, in many cases, rise high enough to inhibit project development and can restrict exports based on aquifer depletion and other factors outlined in Chapter 36 of the Texas Water Code.[33] Notwithstanding the Water Code, district members can ultimately vote in directors who are willing to implement export-friendly rulesets. This could become a trend if more groundwater conservation districts adopt the Guadalupe County approach and its comprehensive distribution of economic rights in the groundwater layers in question. Unless the Texas Legislature revises the Water Code to rescind groundwater conservation districts' authority to control extra-district transfers, which would seem a reasonable next step, given that the extracted asset is private property, the decision to allow freer exports will be a district-by-district determination marked by politics and, potentially, significant litigation.

In *Meyer v. Lost Pines Groundwater Conservation District*, No. 29,696 (in the 21st District Court, Bastrop County, Texas, filed Nov. 7, 2014), a group of landowners who owned groundwater in the Simsboro Aquifer claimed they would be adversely affected by the proposed actions of an investment partnership that sought to drill 14 wells and pump 56,000 acre-feet of water annually.[34] The State Office of Administrative Hearings judge denied the plaintiffs claim for standing in a September 2015 decision, saying they had failed to demonstrate a "particularized interest" that was "distinct from that sustained by the public at large."[35]

In a district managed like the Guadalupe County Groundwater Conservation District, the legal issues would shift significantly, and most likely, in the landowners' favor. Rather than needing to demonstrate in court that the proposed withdrawal project would severely impair their own access to water, the water owners could instead seek compensation for their respective defined shares of the water resource as it is drawn down over time. In this respect, the information transparency provided by the saturated volume model helps increase regulatory and legal predictability while defusing potentially protracted and expensive courtroom fights.

Market-based groundwater conservation district management can help reduce litigation costs

Litigation poses a significant financial burden for most groundwater conservation districts. Under Section 36.066 of the Texas Water Code, a groundwater conservation district can seek fees and costs only if it prevails in court.[36] Thus, if a groundwater conservation district loses, it must pay its own costs, which would be financially disastrous for many districts. For instance, the Hudspeth County Underground Water Conservation District mentioned above incurred nearly $75,000 in attorney fees and expert costs in litigating the district court and court of appeals stages of the Guitar Holding case.

Many groundwater conservation districts only allot a fraction of this amount annually for legal bills, meaning that the high cost of litigation may either: (1) force them to consider whether it is worth suing at all or (2), if they do become embroiled in litigation, they may be forced to burden local water users with significant increases in taxes and/or fees to offset the litigation costs. Such actions would likely spark significant backlash, especially since local users may often be adverse parties in groundwater conservation district-related litigation. As the above post-*Day* cases show, a groundwater conservation district may be subject to a lawsuit by neighboring landowners if it grants an application or may be subject to a lawsuit by the

[31] Id. at 918.

[32] "(o) A district shall adopt rules as necessary to implement this section but may not adopt rules expressly prohibiting the export of groundwater." Tex. Water Code Ann. § 36.122 (West)

[33] "(f) In reviewing a proposed transfer of groundwater out of the district, the district shall consider:(1) the availability of water in the district and in the proposed receiving area during the period for which the water supply is requested;(2) the projected effect of the proposed transfer on aquifer conditions, depletion, subsidence, or effects on existing permit holders or other groundwater users within the district; and(3) the approved regional water plan and approved district management plan." Tex. Water Code Ann. § 36.122 (West)

[34] Plaintiffs' Petition for Judicial Review, 3-4.

[35] Docket No. 952-13-5210. ALJ Michael O'Malley; *S. Tex Water Auth. V. Lomas*, 223 S.W.3d 304, 307 (Tex. 2007).

[36] Texas Water Code, http://www.statutes.legis.state.tx.us/Docs/WA/pdf/WA.36.pdf

applicant if it denies the application in whole or in part.

Adopting a Guadalupe County Groundwater Conservation District approach by defining the district's resources, allocating them based on saturated volume, and managing them with a liberally traded market helps immunize groundwater conservation districts against many of the potential legal claims demonstrated above. Marketization is thus not only a preferable management tool for the water resources but also a way to manage more effectively a groundwater conservation district's legal risk. A $20,000 to $25,000 upfront investment in mapping and marketization can potentially pre-empt hundreds of thousands of dollars in future legal bills.

Now that the Guadalupe County Groundwater Conservation District has operated with its new ruleset for more than a decade, it appears that the 3-dimensional groundwater management concept functions well in practice. The rules are inherently forward-looking but must also protect preexisting uses and commitments of water resources under the District's jurisdiction. The Guadalupe County Groundwater Conservation District recognizes "historic use" permits that are not immediately subject to the District's new ruleset. [37]

However, such rights are only protected until January 1, 2025.[38] After that date, all water producers must possess a production permit obtained from the District for any water produced. In order to obtain such a permit, the producer must submit a sufficient amount of attached water rights. The District's "historic use" water volumes have been known for more than 10 years because historic-use claims had to have been made by September 30, 2011. These claims can only be based on beneficial use of groundwater made during any consecutive 12-month period between November 6, 1978, and August 11, 2004.[39]

Three-dimensional groundwater management increases water's economic value

The 3-dimensional groundwater management approach also opens the door to enhancing water's economic value to property owners by allowing it to be used potentially as collateral for loans and other financial transactions. A saturated volume-based management model does 2 important things in this regard. First, it defines an actual volume of water that is available for extraction in association with a particular property tract. Second, it places a much stronger "fence" than previously existed around groundwater that has not yet been pumped, which is likely to increase potential lenders' confidence that groundwater can serve as collateral in-situ. The rule of capture undermines most potential groundwater reserve collateralization deals because a neighbor with a larger and deeper well can draw the collateral away without the lender or borrower having any practical legal recourse to halt the drawdown.

Reserve-backed loans are loans for which the borrower puts up collateral (in this case estimated water reserves underneath his land) and then gets a loan amount based on the present value of expected future sales. The loan process takes account of factors such as the level of reserves, expected water prices, a discount rate, assumptions for operational expenditure, capital expenditure, and any tax optimization and/or price hedging employed.[40]

IMPLICATIONS FOR OTHER DISTRICTS

The Guadalupe County Groundwater Conservation District's saturated volume-based rights allocation model is the first step toward creating a Texas groundwater management system where water in the ground is properly valued and where owners are not incentivized to enter a "biggest pump wins" competition with their neighbors. A saturated volume model-based 3-dimensional rights allocation system offers real potential for replication across Texas' other 99 groundwater conservation districts. A core strength of the Guadalupe County Groundwater Conservation District's saturated volume model is that it is highly adaptable and can be molded to fit a wide range of local conditions. Such flexibility is important because each groundwater conservation district in Texas faces a unique set of hydrological, economic, and demographic conditions. While to our knowledge no other groundwater conservation district has yet modernized its rules the way that the Guadalupe County Groundwater Conservation District has, it is very likely that as awareness of the 3-dimensional management model and its benefits spreads, additional districts will adopt similar approaches. The Guadalupe County Groundwater Conservation District has high confidence in its management system and may extend a similar management system to its Wilcox Aquifer layer as well.

In brief, the saturated volume model operationalizes the absolute ownership rights granted by the *Day* decision and creates a structure to which many aspects of existing Texas oil and gas law can be easily applied. The practical outcome that followed ratification is that the new ruleset lays the foundations of a more robust water market, reduces takings claims and other litigation risks to the groundwater conservation district, and sets the stage for courts to apply more easily well-established oil and gas law to settle disputes.

Moving to a saturated volume model-based allocation of

[37] "Section 5.9(h) of the District Rules addresses Historic Use.

[38] District Rules, 5.4(h)

[39] District Rules, 5.9(b)

[40] Reserves-Based Lending, SUMITOMO MITSUI BANKING CORPORATION, https://www.smbcgroup.com/emea/eu/lending/index. (last visited April 8, 2014).

water rights (also known as 3-dimensional management) using recharge rate-based withdrawal limits would help improve the balance between traditional consumption uses as well as environmental and conservation endeavors. For parts of Texas on the Interstate-35 corridor and further east—where higher precipitation levels generally promote more rapid recharge rates—using recharge rates to set withdrawal limits would mark a significant departure from the traditional use of desired future conditions that are predicated on mining groundwater. Harmonizing rulesets between adjacent districts tapping common aquifer layers would further multiply the benefits of more broadly adopted 3-dimensional management rules.

Setting withdrawal rates based on recharge encourages users to find the highest and best uses they can for their water and trade based on their respective comparative advantages. Such activity generally puts a price on water that better reflects its underlying value and fosters conservation by inducing high-volume, low-value users to reduce use and free up water for sale into sectors that add greater economic value per unit of water consumed. Water owners could also potentially "rent" their water to conservation interests seeking to incentivize lower water use.

Furthermore, a hydrological equivalent of "cap and trade" would pave the way for the emergence of greater groundwater asset collateralization and freer trading of water rights. Rural groundwater owners could finally begin cementing their property rights and maximizing their property value in preparation for interactions with thirsty cities seeking groundwater supplies. The new 3-dimensional management system helps balance private property rights and the public interest in secure water supplies and conservation in a much more equitable and transparent manner and deserves serious consideration by all Texas groundwater conservation districts. To protect Texas water resources for future generations and avoid a California-style water crisis, a new approach is badly needed, and the 3-dimensional model marks a significant step toward a more adaptable and effective water resource governance system.