Ground Water Marketing: Economic Explorations Involving the Edwards Aquifer

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Water has been salable as a commodity in Texas for many years. However, water sales have largely been restricted to surface water. Ground water trades have not occurred due to the water rights structure (ground water has changed hands in association with land sales). Interest in groundwater sales is rising, largely due to developments in the Edwards Aquifer (EA) region. In this paper, I discuss economic issues and analyses regarding past experience with and potential future developments regarding water transfer and marketing in the EA context.[1]

The paper is divided into three sections. The first deals with the general set if issues regarding a market for EA water. The second reports on an analysis of provisions under Texas Senate Bill 1477 which enable the water market. The third deals with an analysis of the 1997 Irrigation Suspension Program carried out in the EA region.

Issues Regarding Emergence of a Edwards Aquifer Water Market?

Here I examine

1) Whether the provisions in Texas Senate Bill 1477 (SB1477) coupled with the natural characteristics of the EA have created the conditions favorable for a market.

2) The possible forms an emerging market might take

Texas Bill 1477, the EA and a Water Market

A market organizes economic activity using prices to communicate commodity values across market participants so as to bring about coordinated economic decisions. In order for a market to work, the commodity being sold and the participants in the market must meet particular characteristics. Three such characteristics important in the water marketing context are:

1) Rights must be established with respect to the commodity which allow market participants to buy and sell the commodity,

2) The market must be comprehensive not excluding any willing buyers or sellers, and

3) The commodity which is the subject of the market must be homogeneous.

Traditionally EA water has not been sold in the marketplace with the overall usage of EA water suffering from what economists call market failure. Parties that might otherwise have sold water have not had rights to that water allowing a water sale while allowing the aquifer to convey it (a failure of condition 1 above). Furthermore, not all the parties potentially interested in the water could gain access to it. Namely, interests who were the beneficiaries of spring flows could not express their demand for water such that their use values would be factored into pumping decisions by those withdrawing water from the Edwards (a failure of condition 2 above).

Today things are changing. SB1477 establishes a mechanism by which water rights are being defined. As Ellis'

[1]Discussion in this paper draws on material arising out of a number of studies funded by the Texas Water Resources Institute as well as studies funded by the State of Texas through the Advanced Technology Program and the Water Development Board.

paper in this session likely discusses, the Edwards Aquifer Authority is establishing rights. Shortly thereafter water marketing activity will proceed. However, there are a few features of the legislation and some physical features of the EA itself which could partially constrain the effectiveness of the water market.

Constraints on Condition 1 -- Rights to Sell

SB1477 contains some attributes that cloud or restrict the rights of historic users to sell water. Namely it

1) Limits water sales to that created by water conservation equipment, although perhaps a cap on a well is a water conservation device.

2) Restricts water leasing from agricultural parcels to no more than 50 percent of the amount permitted which probably means one acre foot per acre.

3) Requires that total water use be reduced to 450,000 acre feet now and be further reduced to 400,000 acre feet within a decade. These amounts are well below the quantity for which permits will be initially issued. This means that the rights to sell may be cloudy until the permitted use is somehow reduced to the mandated amount. However it is likely that the water market will be used to reduce permitted usage through permit retirement purchases by the EA Authority.

Constraints on Condition 2 -- Inclusion of All Potential Buyers and Sellers

Senate Bill 1477 contains attributes that may exclude certain buyers from the market. Namely it

1) Has somewhat conflicting statutes where water withdrawn from the aquifer must be used within the boundaries of the EA Authority, but permits for the water are allowed in the Guadalupe River downstream from the springs.

2) Seems to restrict water sales to those who divert the water excluding non-consumptive uses. For example, it does not appear to directly allow an environmental group to buy water rights to facilitate in stream flow either for the preservation of endangered species at the spring heads or for other uses along the river course or in the estuary. However such groups may well enter into partnerships with consumptive users to achieve environmental gains regarding water flow between the springs and the point of consumptive use.

Constraints on Condition 3 – Homogeneous Commodity

Historically water has been recognized as a commodity that is homogeneous at a given time and place but heterogeneous across time and space. This has led to numerous features in Texas water law including the fundamental first in time first in right concept to deal with water availability fluctuations as well as the third party test for water transfers. SB1477 is setup somewhat differently. Namely SB1477

1) Does not follow the rest of Texas water law and grant any seniority to water rights. All users will apparently be placed on an equal footing.

2) Does not contain any wording relative to third party effects

3) Does contains some wording relative to critical management, discretionary and nondiscretionary uses, priorities of use by different user classes, and the granting of term permits in periods of excess. Apparently a very different basis from seniority will be used. This may make water market purchases more valuable to some groups than to others.

Beyond that the EA itself also enters physical peculiarities into the situation.

1) Water recharge has been highly variable ranging in recorded data from 50 thousand to over two million acre feet of recharge averaging some are around 630 thousand acre feet.

2) Water does not move freely between the eastern and western parts of the EA due to flow restrictions commonly called the Knippa gap. In my work the spring of flow effect of reductions in pumping in the western EA have been found to have about 1/7th the effect of pumping reductions in the eastern part of the aquifer.

What Form Might the Market Take?

Experience in much of the West indicates two different forms of markets can arise. This includes a permanent sale market and a short-term, drought driven leasing market. The permanent sale market would involve for example the San Antonio water system purchasing the rights to water from Lone Star Brewery. The leasing market would include drought or water level motivated actions to cause certain users to pay other users to temporarily halt water use so that their water might be available to others. An example of this was the early 1997 irrigation suspension program. The structure of the sale program is relatively straightforward where one-party goes out and buys water from another party.

The structure of a short-term leasing program leads to a number of questions regarding

1) when leasing might be employed

2) what the terms of the lease might be? Will the program be like the irrigation suspension program which was an apriori negotiated price for total irrigation cessation during the lease year or whether an option program could be employed under which users might be paid a given amount now with the understanding and later point the option could be exercised and water use interrupted.

Some of this is treated in the analyses that led to the material presented below.

Economic Analysis of SB1477 Market Related Questions

As stated above, SB1477 imposes pumping limits of 450,000 acre feet (af) in the near future and 400,000 af in the longer term. I studied these and other provisions of SB1477 in McCarl et al (1999). When I impose these limits on the region under a fully functioning water market, the total loss in regional welfare is $300,000 per year under the 450,000 af limit and $1.1 million under the 400,000 acre limit. Under the 400,000 af limit agriculture loses $1.2 million or 18.7% of base income while municipal interests lose $4.3 million. Simultaneously, an additional $4.55 million dollars a year accrues to water agencies or water rights holders. Thus, the pumpers lose $5.68 million dollars a year whereas the agencies and rights holders gain $4.55 million leaving a net regional loss of $1.13 million. For society to gain as a whole, this $1.13 million must be recouped through the value of the additional activities stimulated by the increased spring flow. Thus, at least $1.13 million dollars must be gained annually through the value of the continued existence of the endangered species, the increased aquifer elevation, and the benefits of increased spring flows including the improved ecological characteristics in the rivers fed by spring flows, the increased recreational and other social values stimulated by expanded instream flows, and the value of additional downstream water consumption permitted by the increased spring flows.

These results indicate to me that the permits will be valuable traded commodities particularly when enough have been purchased that only 400,000 af worth are outstanding.

Agricultural Water Use Guarantees

The above results arise from a scheme which allocates limited EA water so as to maximize total regional welfare. The model allocates water in a manner that implies that agriculture would forego pumping to allow higher valued users

access to water. In practice, that would be unlikely without compensation. Further, most of the agricultural use is west of the municipal use and EA water flows from west to east. Thus, agriculture generally has first access to the water.

Here I explore the implications of agriculture being guaranteed the amounts suggested in SB1477. Namely, agricultural water use will be no less than either: 1) the base unrestricted level of usage adjusted down proportionally; or 2) two acre feet per acre irrigated. The results demonstrate water use and welfare tradeoffs between sectors. Under guarantees, average agricultural welfare is 22-35% higher. These welfare gains occur due to 15 to 50% higher agricultural water use associated with the guarantee particularly in the east. However, total welfare is reduced by $0.3 to $3 million with the agricultural gains achieved at the expense of nonagricultural users. Equivalently, without an agricultural guarantee, the gains by nonagricultural users are achieved at agriculture's expense (in the absence of compensation for reduced water use).

Water Markets

The results under the agricultural pumping guarantees show there is room for the establishment of water markets. Some combination of two market forms is relevant in such a setting. These forms are temporary (lease) and permanent (sale) markets. I examined potential trades between agricultural and non agricultural interests under the 400,000 af limit. In particular, I examined four water marketing related scenarios under the 400,000 af limit.

1) Agriculture does not trade any water and is guaranteed its proportional share. (the second column in Table 1).

2) Agriculture is deeded its proportional share and can sell water to nonagricultural interests, but the same amount of water is required to be transferred across all states of nature simulating a permanent water sale of a given number of af (the next to last column in Table 1).

3) Agriculture realizes the guarantees of case 2 but must retain usage of one af per acre following a restriction appearing in SB1477 (the last column in Table 1).

4) Agriculture sells whatever it wants with the volume sold varying by state of nature (the first column in Table 1).

Table 2 presents results on water marginal value product (MVP), derived as a weighted average of monthly and recharge dependent shadow prices for water less the pumping cost under these scenarios. In the absence of a water transfer mechanism, there is about a $70 per af difference in MVPs. Allowing permanent sales but no leasing reduces the MVP disparity to about $5 per af. When leasing is allowed, the MVPs are almost equal with slight differences due to seasonality in water use intensities.[1] The data in Table 1 for the water market scenarios show that most of the losses in the municipal and industrial areas can be mitigated by water markets. However, these results do not consider the magnitude of the transaction costs involved in the parties finding each other or factor in the agricultural and municipal welfare implications of water payments. Hence, we conclude that the emergence of an active market is likely.

Irrigation Suspension Program Analysis

The EA Authority implemented a pilot irrigation suspension program in 1997. The Texas Water Resources Institute funded a study to examine the effects of the program on an ex post basis (Keplinger et al, 1998b). The discussion here is largely drawn from that report but it also draws on a report arising out of a Water Development Board funded project (Keplinger at al 1998a).

The pilot irrigation suspension program was implemented in 1997 on 9,669 acres mainly in Medina and Uvalde counties with the objective of increasing spring flow at Comal Springs, and providing relief to municipalities in meeting Critical Period (drought) Management Rules. The EA region, however, experienced a wet Spring in 1997, so that even irrigators not enrolled in the program applied little or no irrigation water.

Based on calculations with historic pumping rates, if conditions were dry in Spring 1997, suspending irrigation on enrolled acreage would have reduced pumping by 23,206 acre-feet and would have augmented Comal spring flow by 6,498 acre-feet during the program year and by 17.7 cfs in August. The level of the eastern portion of the Aquifer would have been expect to rise by about 3.8 feet. The cost per acre-foot of suspended irrigation would have been about $99. Payments to irrigators totaled $2,350,000 or $234 per acre.

This price is much higher than regional lease rates and average cropping profit margins. Factors which may have accounted for the high bids include:

1) lack of experience with an ISP,
2) its late start up,
3) the belief that bids might affect future water prices or offers,
4) tendencies to bid high enough to cover costs under a worst case scenario of a total loss of dryland crops,
5) collusion and need to bid high enough to compensate all under current land lease arrangements.

Bids in future ISP solicitations might be lower, or might not. Given the substantial difference between local irrigated land rental rates and ISP bids, it seems unlikely that the EAA could attract sufficient acreage by capping bids at rental rates. There may be, however, some latitude for the EAA to set a maximum per acre rate somewhere between local rental rates and the ISP bids. This, combined with announcing the program and executing contracts in October or November, has the possibility of substantially reducing program cost.

The EAA may also want to consider offering an option contract which when implemented would suspend irrigation in April or May. Waiting until April or May would provide the EAA more information on current year weather allowing better information on whether irrigation suspension is really necessary since: 1) more time would have elapsed allowing administrators to know Aquifer elevation at a later date, and 2) information of weather, irrigation use to date and projected irrigation for the remainder of the cropping year is increased this point. The cost of a single implementation of such a program may be substantially higher than a January 1 contract, since irrigators may sustain greater loss as shown in Keplinger et al (1998b). Expected program cost, however, could be lower, since this option would be exercised less frequently, offsetting over higher cost of implementation.

Good alternatives to an ISP are limited. We evaluated the potential of 1) implementing more efficient irrigation technology and 2) buying land and leasing it back during wet or average years. The ISP is a more cost effective source of critical water than is the use of subsidized irrigation efficiency largely because the ISP can put in place only when water is needed. Also, while not considered here, evidence in areas such as the High Plains suggests that irrigator pumping is not reduced by the amount an increase in irrigation efficiency would imply. This is because irrigators may choose to irrigate more water intensive crops and/or irrigate more acreage when efficiency is increased. The high bids experienced in the 1997 program compared to price of land in the Aquifer region suggests that a buy-leaseback arrangement could substantially reduce the cost to the EAA of suspending irrigation. This, of course, would require an alternate set of administrative costs by the EAA and may be less expensive than the ISP. Also the picture may be altered by the adjudication of water rights in the Aquifer which will likely be finished within three to five years. After water rights adjudication, however, buying and leasing back water rights may be a very appropriate and cost effective strategy for the EAA.

The 1997 pilot ISP was a reasonable response to the drought condition experienced in 1996. Fine-tuning the selection criteria, bid arrangement, allowing greater lead time, and/or implementing an ISP or option contract later in the year, holds the potential for reducing the cost of program implementation.

A land-based ISP is an interim arrangement that can be implemented in the absence of a fully functioning permit system. After water rights are adjudicated in the region, ISP and option contracts will take on more conventional forms involving buy, lease, and option contracts for water rights. It is expected that water-based versus land-based arrangements would likely facilitate the transfer of water at lower rates.

Conclusions

Three different investigations were reported in this paper all relative to water markets in the Texas Edwards aquifer region. The bottom-line conclusions out of these three studies are that it appears that a EA water market will arise. However there are likely to be some impediments to total efficient market function due to agricultural guarantees. However, market forces may largely be able to overcome these inefficiencies. We also have seen a willingness to overlook the 50 percent leasing provision in, for example, the implementation of the Iirrigation Suspension Program. The seniority issue and the lack of any priority scheme attached to the water rights other than an administrative scheme attach to priority by user will be another important impediment which is not fully factored in here.

The analysis also shows there's room for both permanent sale and temporary lease based markets. The lease based markets offers the potential for achieving the greatest economic gains but there are many questions regarding program cost and timing which are not analyzed here but are the subject of the some of my additional work (Williams, Keplinger et al 1998b). Overall however I can only say adoption of a market based scheme for transferring water offers an efficient means for conveying water from those who currently have rights to it to those who are willing to pay higher prices for its use.

Table 1. Welfare Effects of Agricultural Guarantees and Water Markets 400,000 Pumping Limit

			Guarantee			
		Optimal	Proportion	2 acre ft	Proportion with Market	Prop/1af with Market
Average Welfare Measures			----------Change from Optimal----------			
Ag Income	(10^6 $)	5.17	1.14	1.82	0.18	0.62
percent change			22.04	35.13	3.46	12.05
Mun Surplus	(10^6 $)	466.84	-9.89	-16.57	-1.18	-5.03
percent change			-2.12	-3.55	-0.25	–1.08
Ind Surplus	(10^6 $)	2.64	-0.26	-0.43	-0.03	-0.13
percent change			-9.83	-16.41	-1.07	-5.09
Authority Surplus	(10^6 $)	11.54	7.92	13.09	0.97	4.08
percent change			68.66	113.46	8.38	35.34
Total Surplus	(10^6 $)	486.20	-1.09	-2.09	-0.06	-0.47
percent change			-0.22	-0.43	-0.01	-0.10
Agricultural Measures						
Irrigation Develop	(10^3 acres)	52.91	17.39	26.31	2.76	14.65
Dryland Usage	(10^3 acres)	26.98	-17.39	-26.31	-2.76	-14.65
Water Use						
Ag. East	(10^3 acre feet)	18.44	42.79	55.59	6.20	28.55
Ag. West	(10^3 acre feet)	73.33	-3.50	4.64	-0.92	-6.79
Nonag East	(10^3 acre feet)	299.51	-38.04	-58.31	-5.13	-21.08
Nonag West	(10^3 acre feet)	8.72	-1.25	-1.92	-0.15	-0.69
Hydrological Measures						
Comal Spr flow	(10^3 af)	281.47	-9.16	-1.79	-1.82	-11.16
San Marcos Spr flow	(10^3 af)	83.72	-0.97	-0.06	-0.20	-1.26
Ending Elevation j17	(ft)	685.84	-1.38	0.79	-0.31	-2.17
Min. Comal Spr flow	(cfs)	250.56	-5.31	1.85	-1.06	-7.64

Note the scenario definitions are as follows: Proportion means agriculture gets its proportional share; 2 acre feet indicate no more than 2 acre feet of water can be used per acre (as opposed to 2.12 in the base scenario), with market means that permanent sale of water is allowed and prop/1 af means that agricultural gets its proportional share but must retain use of at least one af per acre.

Table 2. Marginal Value of Water under Three Water Marketing Scenarios at the 400,000 af Limit

		Base 400-- No Guarantee (Leasing)	No Market	Permanent Sale
Ag Water Value East	($/af)	38.23	26.15	37.55
Ag Water Value West	($/af)	30.21	21.23	28.02
Non-Ag Water Value East	($/af)	37.66	99.93	41.64
Non-Ag Water Value West	($/af)	30.28	90.93	33.73

Note that the Base 400–No guarantee scenario allows agriculture to vary water sold across state of nature while the Permanent Sale scenario depicts the same amount of water sold by agriculture in each and every state of nature.

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