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DAVID TODD*

Common Resources, Private Rights and Liabilities: A Case Study on Texas Groundwater Law

ABSTRACT

In light of recent efforts to provide market solutions to environmental problems, this paper offers Texas groundwater law, use, and environmental effects as an example of the difficulties in defining, contracting, and enforcing private rights in common-pool resources. The paper first discusses the link from various environmental impacts, including drawdown, mining, saltwater intrusion, baseflow reduction, and land surface subsidence, to excessive groundwater use (Section 2). Excessive groundwater use is in turn attributed to the failure of private agreements to coordinate well sites and flow rates, to reduce groundwater demand, and to compensate any of those harmed by withdrawals. Sections 3-5 examine the private, judicial, and statutory factors that inhibit coordination or discourage agreements among private groundwater rights holders. Last, the paper suggests ways that Texas groundwater law can give lines of inquiry into other privately based forms of environmental regulation, such as that offered under the Clean Air Act (Section 7).

1. INTRODUCTION

The 1990 amendments to the Clean Air Act illustrates recent efforts to use economic analysis and market solutions to treat environmental problems.¹ While these efforts promise flexible and efficient answers to pressing pollution and natural resource problems, they may create a raft of new and difficult questions. The troubled experience of Texas in controlling groundwater use and limiting related environmental damage by relying on private self-help and contract, and eschewing tort and regulatory solutions through the courts and legislature, may be instructive. Overuse of Texas groundwater and related environmental harm shows the difficulty of efficiently and equitably defining, allocating and pro-

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1. Clean Air Act of 1990, 42 U.S.C. § 101 (1990).

testing rights to a common, fluid resource through market mechanisms without guidance from publicly agreed and enforced rules.

2. GROUNDWATER USE AND EFFECTS

2.1 Groundwater Use

Groundwater is water held underground in clay, sand, gravel, and other porous strata. It is a heavily used resource in Texas, providing 9.7 million gallons per day, or 61 percent of the total state water supply in 1980.² Moreover, groundwater use is expected to increase. State water planners have predicted a 47.9 percent increase in total state water demand from 1975 to 2030.³ Much of the increase can be reasonably expected to come from groundwater sources: while only 770 wells were drilled in the state in 1962, 12,554 new wells were registered during 1989.⁴

2.2 Environmental Effects of Groundwater Use

The extensive use of groundwater in Texas has caused a series of environmental problems in various parts of the state, including water level drawdown, aquifer mining, saltwater intrusion, stream baseflow reduction, and land surface subsidence. The following examples are offered as illustrations of the scope, severity and widespread nature of these effects.

2.2.1 Environmental Effects—Drawdown

As groundwater is pumped, the water table, or the top edge of the saturated media, will typically decline. If pumpage greatly exceeds recharge (flow into the aquifer), drawdown can be significant.

Extensive drawdown has been measured in the Houston-Galveston area. From 1943 to 1977, water levels declined as much as 250 feet in wells completed in the Chicot aquifer, and as much as 300 feet in wells drawing from the Evangeline aquifer.⁵ Drawdown at this scale is a concern for two reasons: first, lift costs increase, and second, if the water table

2. D. Moody, J. Fischer, E. Chase, *National Water Summary 1984—Hydrologic Events, Selected Water-Quality Trends and Groundwater Resources* 397 (United States Geological Survey Water-Supply Paper 2275, 1985).

3. Library of Congress, *Congressional Research Service, State and National Water Use Trends to the year 2000: A Report* 188 (Senate Committee on Environment and Public Works, no. 96-12, 1980).

4. Telephone interview with Gerald Adair, Texas Water Development Board, Groundwater Department, State Well Numbering and Driller Logs Section (March 19, 1990).

5. R. Gabrysch, *Ground-water Withdrawals and Land-Surface Subsidence in the Houston-Galveston Region, Texas, 1906-80* 66 (United States Geologic Survey Open-File Report 82-571, 1982).

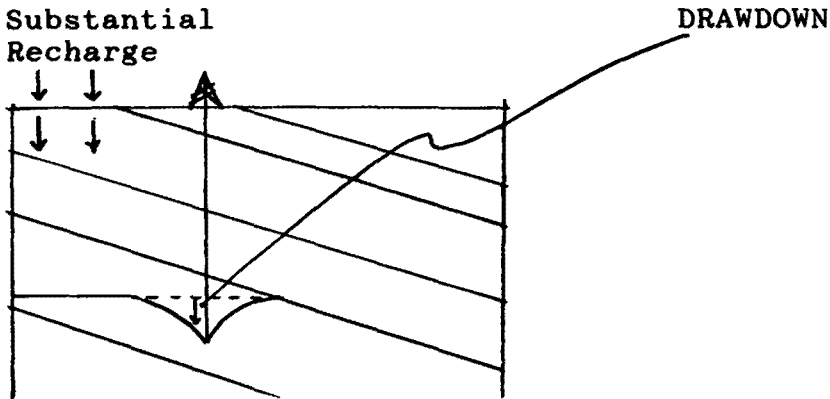


Figure 1: Drawdown

drops below the screened depth of the well, the well may have to be reworked or even abandoned and replaced.⁶

2.2.2 Environmental Effects—Mining

Aquifer mining refers to the withdrawal of groundwater from confined aquifers, aquifers with minimal recharge rates, resulting in aquifer storage decreases. Two examples might be offered: mining for agricultural purposes in the High Plains, and for municipal use in the El Paso area. In both cases, groundwater miners must face continually higher lift costs as water levels decline, and ultimately, must turn to alternative surface water sources, reuse schemes, conservation plans, or abandonment of the water-intensive use (as happened in the Pecos valley during the 1950s).

Castro and Parmer counties are typical of High Plains farming areas which face problems of aquifer overdraft. Of 1,144 operating farms, 931 relied on irrigation to produce crops, with 915 principally using groundwater and 822 exclusively using groundwater.⁷ During the 1975-83 period, farmers in the two counties withdrew 11,269,000 acre-feet of water,

6. Lift costs are estimated to increase by \$0.00125 per 1,000 gallons pumped per foot of lift. Telephone interview with Joseph (Bud) Holzschuh, Harris Galveston Coastal Subsidence District, Groundwater Hydrology division (March 7, 1990). Based on Houston's 1978 use rates, the cost to the City would exceed \$103,000 per year per foot of drawdown. Gabrysch, *supra* note 5 at 65. Drawdown in local wells varied but ran as high as seven feet per year in 1978. *Id.* at 64. Lift costs can be particularly significant for agricultural users who do not have chlorination, tank and pipe costs to consider. In a suit for conversion, the plaintiff estimated that one fifth of the groundwater value consisted of lift costs. *Gifford v. Howell*, No. 6996, slip op. at 2 (Tex. Civ. App. El Paso Oct. 15, 1980).

7. United States Bureau of the Census, Data User Services Division, 1982 Census of Agriculture County Data, CD-ROM format (1990).

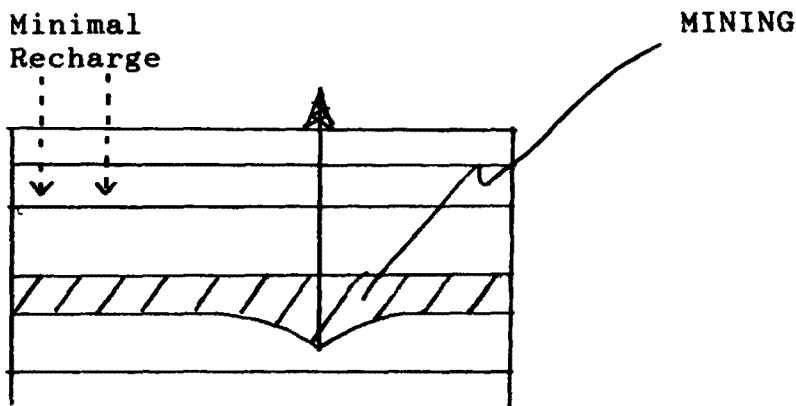


Figure 2: Mining

reducing storage by 5,158,000 acre-feet, representing a 19.6 percent loss in storage for the Ogallala aquifer within those counties.⁸

El Paso is also heavily dependent on groundwater supplies, but in this case principally for municipal uses. Wells completed in the Hueco bolson and the Rio Grande alluvium produced 164,354 acre-feet in 1980, compared to only 20,057 acre-feet drawn from surface sources.⁹ Of this groundwater use, most is mined, that is, drawn from storage. For example, the groundwater withdrawals from the Hueco exceeded 1980 recharge by a factor of 23.¹⁰ Mining at these rates has caused significant storage declines in the region's aquifers: declines for the 1906-80 period are now estimated at 23 percent.¹¹

2.2.3 Environmental Effects—Saltwater Intrusion

Saltwater intrusion can result as fresh groundwater is drawn down and saline water flows in to replace it. As fresh water supplies are contaminated, new wells must be drilled, coastal injection wells installed, and/or the brackish groundwater treated with costly osmosis or catalysis methods.

Kingsville, Texas, to the southwest of Corpus Christi, and about 35 miles from the Gulf coast, offers an example. With pumpage occurring at some 275 local wells, water levels in the Evangeline aquifer underlying

8. G. Mackey, *Comparison of Irrigation Pumpage and Change in Water Storage of the High Plains Aquifer in Castro and Pärmer Counties, Texas, 1975-83* 22,34,38,41 (United States Geologic Survey Water-Resources Investigations Report 87-4032, 1987).

9. D. White, *Summary of Hydrologic Information in the El Paso, Texas, Area with Emphasis on Groundwater Studies, 1903-80* 1,72 (United States Geologic Survey Open-File Report 83-775, 1983).

10. *Id.* at 7, 71

11. *Id.* at 1, 72.

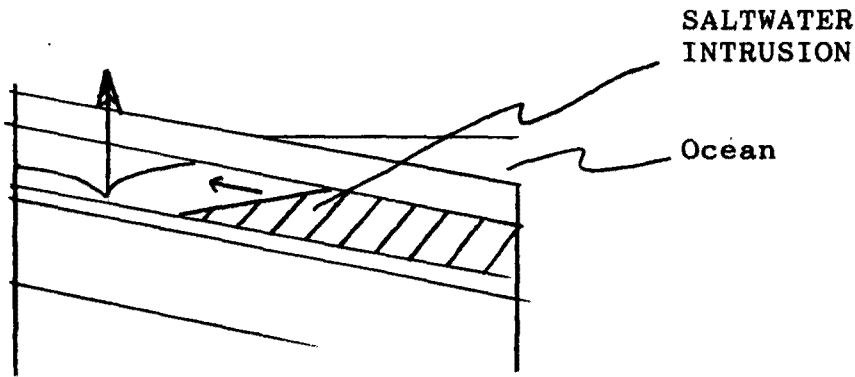


Figure 3: Saltwater Intrusion

Kingsville have dropped as much as 219 feet.¹² As a result, saline water from deeper and coastward aquifers has migrated in and caused salinities in the wells to rise. Readings of 4,485 mg/L total dissolved solids (TDS), in the range of moderately saline water, have been made in Kingsville area wells.^{13,14,15}

2.2.4 Environmental Effects—Stream Baseflow Reduction

Surface streams can include artesian springflow from underlying aquifers. However, if the aquifers are pumped in excess of their recharge rates, the springflow, or stream baseflow, can be reduced. Pumpage by upland or upriver well owners can seriously interfere with use by those who hold rights to downstream surface water flows.

This has occurred in the area around San Antonio, Texas. From 1934 to 1984, well pumpage in the San Antonio portion of the Edwards aquifer increased from 101,900 acre-feet per year to 529,800 acre-feet per year.¹⁶ By 1984, springflow was estimated at 175,575 acre-feet, less than the

12. P. Rettman, *Water Levels and Salinities of Water within the Evangeline Aquifer in an area southwest of Corpus Christi, Texas* 3, 9 (United States Geologic Survey Open-File Report 82-174, 1983).

13. *Id.* at 25. To put these readings in perspective: ocean water averages 35,000 mg/L TDS, while drinking water maximum limits are commonly set at 1,000 mg/L TDS.

14. R. Reeves, G. Ozuna, *Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1983-84, with 1934-84 Summary 10* (Edwards Underground Water District, Bulletin 43-44, prepared in cooperation with the United States Geologic Survey and the Texas Department of Water Resources, 1986).

15. V. Chow, *Handbook of Applied Hydrology* 2-3 (McGraw-Hill 1964).

16. G. Nalley, P. Rettman, *Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio, Texas with 1934-87 Summary 50, 51* (Edwards Underground Water District, Bulletin 47, prepared in cooperation with the United States Geologic Survey and the Texas Department of Water Resources, 1988).

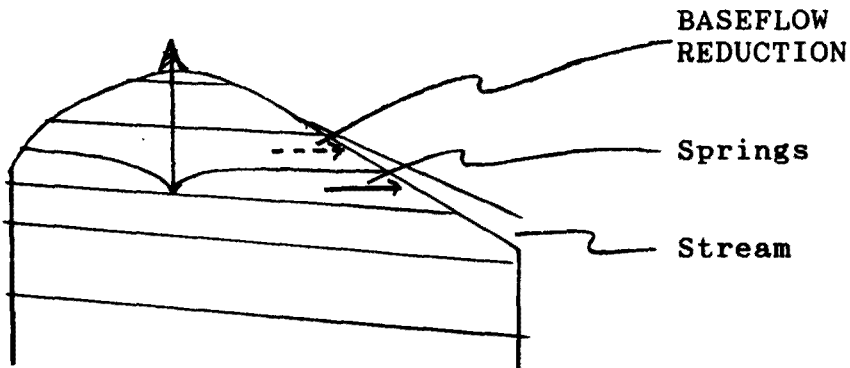


Figure 4: Baseflow Reduction

recharge rate of 197,900 acre-feet, and significantly less than historic springflows of over 300,000 acre-feet per year.¹⁷ Since springflow makes up a large portion of streamflow (62 percent of streamflow in 1983), law suits have ensued, pitting well owners against downstream holders of surface water rights.¹⁸ Recently, governmental entities and environmental groups have also charged that pumpage has decreased flow to Comal Springs and other artesian pools and thus threatened populations of rare pupfish, darters, and salamanders.¹⁹

2.2.5 Environmental Effects—Land Surface Subsidence

As groundwater is pumped and withdrawn from the pore spaces of aquifer clays, sands, and other media, these spaces often collapse. When they collapse, overlying strata, and ultimately the land surface as well, drop. Land surface subsidence in coastal areas can cause inundation, and in inland regions, it can damage building and road foundations. In extremely flat areas such as the Texas Gulf Coast plain, where slopes of only one foot per mile are common, subsidence can reverse the slopes of streams and so interfere with drainage.

The Houston-Galveston area has witnessed extensive subsidence. By 1974, groundwater withdrawals had neared 600,000 acre-feet per year.²⁰ Related subsidence of 0.5 to 8.5 feet had by then affected a 4,700-square mile area.²¹ Subsidence as great as 10 feet has been recorded in isolated areas over the 1906-78 period.²²

17. *Id.* at 51.

18. *Id.* at 51, 184-235.

19. *Guadalupe-Blanco River Authority v. City of Lytel*, No. 89-281 (22d Jud. Dist., Tex. filed 1989).

20. Gabrysch, *supra* note 5, at 65.

21. R. Gabrysch, C. Bonnet, *Land-Surface Subsidence in the Houston-Galveston Region, Texas* (Texas Water Development Board Report no. 188, 1975).

22. Gabrysch, *supra* note 5 at 66.

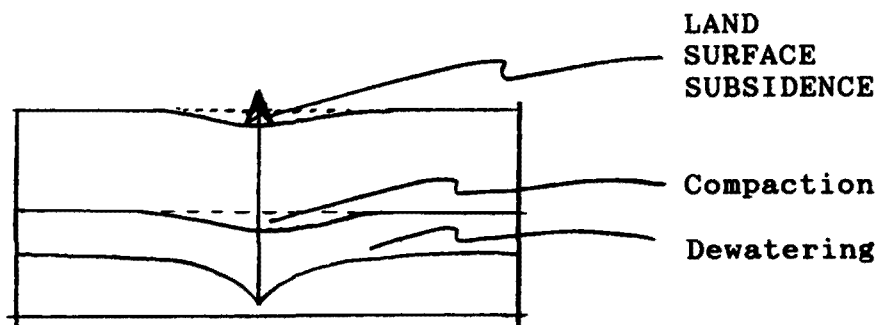


Figure 5: Land Surface Subsidence

3. NORMS AND GROUNDWATER USE

It is doubtful that groundwater pumpers are unusually irrational or perverse. Judicial and statutory regimes aside, why do well owners continue to pursue heavy groundwater use, despite attendant problems such as drawdown, mining, salinization, baseflow reduction, and subsidence? Why do pumpers appear to ignore these problems and fail to take steps to reduce the damage or compensate those harmed? Why have efficient well supply schemes, such as coordinated spacing arrangements, not been more widely adopted? Why have more efficient water use policies and conservation devices not been employed? Failing these measures, why haven't those responsible for the harm faced injunctions or damage judgments?

The nonlegal, norms-based answer to some of these questions may simply be that the problems just are not severe enough to merit concern or response. However, the difficulties regarding groundwater use and related environmental effects seem quite severe and widespread. It is more likely that the problems and feasible solutions are seen, but cannot be agreed upon. Mitigation of these harms would require at least three types of agreements: 1) deals to coordinate supply well sites and flow rates, 2) bargains to collectively reduce groundwater demand in agricultural, municipal, and industrial applications, and 3) agreements to allocate costs and compensate for harms.

A number of nonlegal factors reduce the likelihood that voluntary agreements will be initially sought, then negotiated, and finally enforced and obeyed. The following section discusses plausible factors in the non legal realm, including ignorance, transaction costs, the prisoner's dilemma, the limits of self-help, the tragedy of the commons, the effects of racing, and the unfeasibility of most options. Section 4 considers some of the legal rules of ownership and liability developed by the courts which may bear on the existence and strength of agreements. Section 5 discusses statutory supervision, support and replacement of such agreements.

3.1 Ignorance and Initiating Agreements

For many years, there was little understanding of groundwater sources, quantities, and behavior. Pumpers were unaware of the effects of groundwater use and unlikely to consider, much less enter in on agreements to coordinate their use with affected parties. An early British opinion on groundwater rights, *Acton v. Blunder*, stated, "no man can tell what changes these underground sources have undergone in the progress of time."²³ An American court echoed, "the laws of its existence and progress . . . cannot be known or regulated."²⁴ Another nineteenth century United States decision laments, "the existence, origin, movement and course of such waters, and the causes which govern and direct their movements, . . . are secret, occult, and concealed. . . ."²⁵

As time has passed, understanding of groundwater dynamics has improved greatly, and ignorance has become less of an excuse for groundwater abuse. Still, though, knowledge is somewhat restricted to theoretical generalities and aggregate supply and use figures. Unfortunately, key factors in groundwater availability and flow often turn on site-specific and widely varying parameters such as storativity and conductivity. Storativity is a function of the pore space volume in an aquifer and a good indicator of the amount of water held in the aquifer, and can vary by a factor of close to 3,000.²⁶ Similarly, hydraulic conductivity, an expression of the ease with which water will flow through an aquifer, can fluctuate by a factor of over 5,000,000.²⁷ Often, monitoring wells do not exist, pump tests have not been run, and results have not been reported, compiled and published to make such groundwater data available. In that sense, ignorance may remain a good alibi.

3.2 Transaction Costs and Negotiating Agreements

Knowledge about groundwater may have improved in recent years, but it remains costly. In fact, relative to the immediately apparent, somewhat small benefits of coordinated well spacing, knowledge and other transaction costs involved in coordinating may seem very high. Transaction costs may appear to be so high as to foreclose any bargaining.

If one assumes that an aquifer is isotropic and homogeneous, there is no advantage to cooperation among pumpers. The effect of additional wells is merely cumulative. Neglecting near-well effects, coordinated sets

23. *Acton v. Blunder*, 152 Eng. Rep. 1223, 1233 (Ex. 1843).

24. *Roath v. Driscoll*, 20 Conn. 533, 541, 52 Am. Dec. 352 (1850).

25. *Frazier v. Brown*, 12 Ohio St. 294, 311 (1861).

26. Chow, *supra* note 15, at 4-21.

27. P. Bedient, W. Huber, *Hydrology and Floodplain Analysis* 496 (Addison Wesley 1988).

of wells will not reduce aggregate aquifer drawdown, saline inflow, or subsidence.²⁸ However, most aquifers are uneven. Some sections have highly porous sands storing vast amounts of water, while other parts have dense media with low storage values. Some sections are made up of relatively rigid gravels that are not vulnerable to subsiding, while other parts may have clays which shrink badly and settle after dewatering. Some portions of the aquifer may have high conductivity, allowing great flow through the stratum, while other sections are highly impermeable.

28. Assuming a perfectly homogeneous, isotropic aquifer, it can be shown that drawdown, saline inflow, and subsidence are purely cumulative effects. That is, the marginal effect of each added well is the same as that due to the first well. A set of n wells pumping x gallons per day will have the same aggregate effect as a single well pumping nx gallons per day. Consider the following equations:

Drawdown in an unconfined aquifer [Bedient & Huber, *supra* note 27, at 517; W. Viessman, Jr., T. Harbaugh, J. Knapp, *Introduction to Hydrology* 255 (Intext Educational Publishers 1972); Chow, *supra* note 15, at 13-17] can be found using the equation given below. Please note that Q_i is just a first order term.

$$d = \sum_{i=1}^n \frac{Q_i}{2\pi K b} \log_e \left[\frac{r_0}{r_2} \right]$$

Where:

d = drawdown (feet)

i = number of wells

K = permeability (gallons/day/square foot)

Q = pump flow (gallons per minute)

r_0 = radius of no influence (typically 500-1000 feet)

r_2 = radius of pumping well to monitoring well

For drawdown in a confined aquifer, the following equation can be used (Bedient & Huber, *supra* note 27, at 516; Viessman, *et al.*, at 255; Chow, *supra* note 15, at 13-16). Again, note that Q_i is only a first order term.

$$d = \sum_{i=1}^n \frac{Q_i}{2\pi K b} \log_e \left[\frac{r_0}{r_2} \right]$$

Where:

b = aquifer thickness (feet)

Saline intrusion can be calculated from drawdown through the following equation (Viessman, at 262; Chow, *supra* note 15, at 13-48). Note that saline inflow varies directly and on a first order basis with drawdown, and hence with well flow.

$$z = 40 * d \quad (\text{Ghyben-Herzberg})$$

Where:

z = saltwater head (feet)

Subsidence can be estimated on the basis of this equation (Gabrysch, *supra* note 5, at 64). Subsidence varies proportionately, in a first order relationship with drawdown and well flow.

$$s = k * c * d$$

Where:

s = land surface subsidence (feet)

k = specific-unit compaction (/foot)

c = dewatered clay thickness (feet)

In other words, some parts of an aquifer, or, to an extent, any fluid-bearing reservoir, are much more conducive to safe and efficient development than other parts.²⁹

However, the logically recognized benefits of cooperation are difficult to demonstrate until after time consuming tests of the aquifer. At the start, the up-front transaction costs of cooperation are painfully apparent. The costs include technical expenses such as well monitoring and aquifer computer modeling. Legal costs for negotiating and drawing contracts for surface canal and tank easements and for allocation of yield shares may also arise. Many pumpers may consider that a deal cannot be worth these transaction costs.

3.3 The Prisoner's Dilemma and Complying with Agreements

If a bargain can be reached for coordinating or reducing pumpage, a pumper faces a dilemma about complying with the deal he has made. He confronts what might be called a prisoner's dilemma.

A prisoner's dilemma typically has three features.³⁰

1. The game is not zero-sum. If both individuals cooperate (A, in the matrix immediately below), they both do better, in absolute (though not inrelative) terms, than if both defect (D). Total profits are greater if both cooperate.
2. Defecting alone (B) is best; cooperating together (A) is second best; defecting together (D) is next best; cooperating alone (C) is worst.
3. The joint reward for both cooperating (A) is more than the total gain for one individual cooperating and the second defecting (C).

The dilemma can be shown by the following table:

Own behavior	Other's behavior	
	COOPERATE	DEFECT
COOPERATE	A	C
DEFECT	B	D

- Where:
1. $A > B$ AND $D > C$
 2. $A > C$ AND $B > D$
 3. $(A_{own} + A_{other}) > \text{ANY OTHER PAIR SUM}$

Table 1: The Prisoner's Dilemma

29. J. Weaver, *Unitization of Oil and Gas Fields in Texas: A Study of Legislative, Administrative, and Judicial Policies* (Resources for the Future, 1986).

30. P. Huber, *Competition, Conglomerates, and the Evolution of Cooperation*, 93 Yale L.J. 1147, 1151, fn.16 (May 1984) (book review).

In turn, the dilemma can be used to frame the options facing one pumper considering whether to cooperate with a second pumper.

The benefits of defection (B and C) are tempting: a prompt supply of water at an individually convenient flow rate and location can be developed immediately. The risks of defection are quite slight. Monitoring compliance with a well pumpage scheme would be difficult, given the great number, wide spacing and private location of wells. Since getting caught defecting is difficult, freeloading on the cooperator(s) in the near term is certainly attractive. Even if one is caught, a defector can probably extort exorbitant concessions to prevent wholesale defection from the delicate network of contracts among remaining cooperators.

Conversely, the benefits of cooperation are difficult to show (A seems only slightly better than D, and even less clearly better than B or C). As discussed in sections 3.1 and 3.2, the benefits of a coordinated pumping scheme rely on site-specific aspects of an aquifer and on data-intensive monitoring of pump flow rates, well sites and screen depths. Furthermore, the carefully calculated benefits may be slow to appear. Also, the benefits of cooperation will only be evident in comparison with the lone-ranger pumping scheme which the contracting pumpers have supposedly abandoned. Thus, to a degree the benefits of cooperation must be taken on faith, particularly in the early stages. It should not be surprising if a pumper feels perplexed and torn by a choice between defecting and cooperating.

3.4 Self-help and Enforcing Agreements

If a pumper suspects that his neighbor is not complying with a supply or use agreement, he has few effective ways to enforce that agreement (please note that nonpumpers, such as those who hold surface rights to artesian spring water, have even fewer self-help options). First, it is difficult to identify who is defecting from the agreement and causing water levels to drop or land to subside. It is unclear which neighbor he should seek to persuade or coerce. In cases where norms have been effective, tracking the evildoer is easier. For example, in Ellickson's article, *Of Coase and Cattle*, one could look to a roving cow's brand and know who was responsible for breaking the grazing agreements.³¹

Second, even if a pumper knew who the culprit was, he would have limited means of forcing his cooperation. Gossip might be one option, but would probably be limited in its effectiveness by two factors. First, the installation of wells and pumps is costly, and their operation quite deliberate. Most well owners would probably have already considered

31. R. Ellickson, *Of Coase and Cattle: Dispute Resolution among Neighbors in Shasta County*, 38 Stan. L. Rev. 623, 676 (1986).

and dismissed the possible gossip and criticism that might result from harmful use of the aquifer. Second, gossip is most effective in small, homogeneous, tightly bound communities, such as the whale-hunting fleets of the nineteenth century.³² In the large, diverse, and often urban communities where many groundwater conflicts arise, gossip would probably have little impact.

Even if a pumper decided to be more aggressive, and turned to fight back, an eye-for-an-eye, he might only hurt himself. His goal would be to pump enough to hurt his deviant neighbor. However, to do this, he would have to increase the number and size of his wells and the power and flow rate of his pumps. The cost could be substantial. And then, as he turned on the pumps, his own wells would be the first hurt, and the most substantially hurt.³³ For the minimal impact on the defector, and the sizable harm to the cooperator, self-help is not a promising way of enforcing groundwater agreements against parties.

3.5 The Tragedy of the Commons and Outsiders to Agreements

The difficulties of negotiating a cooperative agreement with another pumper and subsequently complying with that agreement are compounded if other, third-party pumpers are considered. The individual harms of shunning agreements or subsequently defecting from agreements will seem small relative to the cumulative aquifer effect and the pumper's foregone wellwater.

Here, the pumper may face a situation similar to the paradigm posed in Garrett Hardin's article, *The Tragedy of the Commons*.³⁴ Hardin laid out the choices facing a rational herdsman seeking to graze additional stock on a single, commonly held pasture. Considering his options, the herdsman would ask himself, "what is the utility to me of adding one more animal to my herd?" Recognizing that he garnered all the profit from selling the animal and suffered only a pro rata loss in his incremental harm to the pasture, he would rationally add another (and another) animal to his grazing herd.

In our example, the commons consists of a relatively few aquifers, just seven principal reservoirs and sixteen minor ones within the state.³⁵ The animals might be seen as water supply wells in this case, of which there are over 369,000 registered in Texas.³⁶ The herdsman might be

32. R. Ellickson, *A Hypothesis of Wealth-Maximizing Norms: Evidence from the Whaling Industry*, 1 J. Law, Econ., and Org. 83, 85 (1989).

33. The elegant solutions of killing the trespassing cow or the wrongly claimed whale are not available here as means of effective self-help and revenge. It is hard to take revenge on missing water.

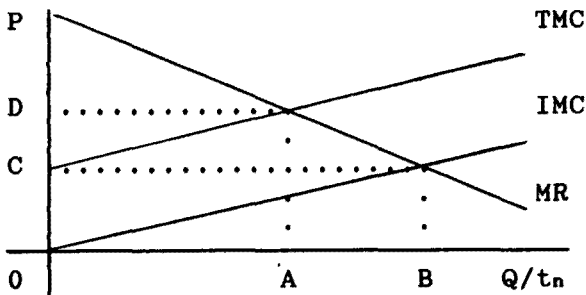
34. G. Hardin, *The Tragedy of the Commons*, 162 Science 1243-48 (1968).

35. Moody, *et al.*, *supra* note 2, at 397.

36. Adair, *supra* note 4.

characterized as an agricultural well owner, since about 81 percent of Texas groundwater was withdrawn for irrigation in 1986.³⁷ Extrapolating from well (7,923 wells registered in 1979) and farm statistics (1,149 irrigated farms in 1978) for Castro and Parmer counties, we might expect as many 53,000 well owners in Texas.^{38,39} Although this is a crude estimate, it should show that there are indeed many pumpers sharing use of only a few aquifers. There are certainly enough pumpers and a limited enough mutually held resource to create the tragedy of the commons that Hardin discussed.

For example, as each pumper approaches the decision whether to pump an extra gallon or even whether to sink another well, he will likely recognize that he gains all of the additional water produced yet individually is directly responsible for only a small portion (C) of the total harm (D) to the aquifer. The cumulative harm (D) to the aquifer will not be apparent to him, and he will proceed to pump more (B rather than A). His situation might be depicted below:



Where: TMC = Total marginal cost (sum of marginal costs imposed by all pumpers)
 IMC = Individual marginal cost (includes only the individual's separate drilling, pumpage, and storage costs, in addition to the pro-rata harm to the aquifer)
 MR = Marginal revenue recognized

Figure 6: The Tragedy of the Commons

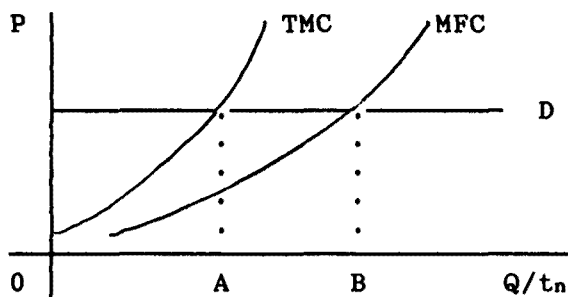
37. Telephone interview with Norman Allfred, Texas Water Development Board, Water Use and Projections office (March 23, 1990).

38. Mackey, *supra* note 8, at 8.

39. United States Bureau of the Census.

3.6 Racing and Conditions after the Agreement

The difficulty of reaching and enforcing agreements to control groundwater use rises as the effects of time are considered. Ideally, when a well owner uses water from an aquifer today, he should weigh the opportunity cost of not having that water available tomorrow. Although the opportunity cost would be discounted by the current interest rate or by other alternative investment returns, this cost would be quite significant. The opportunity cost of future use foregone would act as a strong check on today's use, as a limit on current groundwater pumpage. A pumper might analyze his situation as follows, consider his opportunity cost, and decide to pump at a reduced rate of A, not B:⁴⁰



Where: D = Demand
 MFC = Marginal factor cost, exclusive of opportunity cost
 TMC = Total marginal cost, inclusive of opportunity cost

Figure 7: Racing

However, if the pumper shares his groundwater supply with others, the scenario is quite different. In that case, he can no longer be sure that unused groundwater will remain for his use tomorrow: another pumper may have already pumped it. His opportunity cost quickly becomes uncertain, and more so as the number of competing pumpers grows and the size of the aquifer diminishes. Other, more general factors may also reduce the opportunity cost: high interest rates and dubious survival of the groundwater-dependent business may contribute.⁴¹ Ultimately, there may

40. A. Friedman, *The Economics of the Common Pool: Property Rights in Exhaustible Resources*, 18 UCLA L. Rev. 855, 858 (1971).

41. It is interesting to note that just this combination of factors (double-digit interest rates and record farm bankruptcies) confronted farmers in the early 1980s. However, racing did not occur in Parmer and Castro counties. In fact, agricultural groundwater consumption fell by 29 percent from

remain little reason to forestall today's pumping to allow future withdrawals. The race begins!

3.7 Options outside Groundwater Use and Agreements

Viable alternatives to groundwater use might relieve the pressure to compete with individual, group, and future pumpers. Possible options include: 1) reducing consumption needs through conservation measures, 2) restoring the quantity and quality of groundwater to allow future use, and 3) turning to surface sources. Each, however, has significant costs which make these options unattractive.

3.6.1 Conservation

For agricultural users, water conservation can be expensive. Measures may include lining canals and tanks with concrete, plastic or impermeable clays, grading and levying croplands to a precisely even and bounded level, using more pesticides (for example, flooding is currently used to reduce weeds in rice fields), or even switching to less profitable dry-land crops (for instance, changing from sugar beets to winter wheat).⁴²

For municipal users, conservation can be equally unattractive. Residential consumers are loath to change their lifestyle and resist the initial investment in more water-efficient devices. Also, mission-oriented public works agencies have often slighted conservation efforts in favor of supply increases, which tend to enhance consumer demand and agency budget and staffing.⁴³ In short, conservation is an option with high real or imagined costs and often has not been pursued.

3.6.2 Aquifer Maintenance and Restoration

Some commentators have argued for protecting aquifers from excessive demand by enhancing supply, that is, by returning water to the aquifers. However, the cost of treating the water, drilling injection wells, and

1980 to 1983. Mackey, *supra* note 8, at 41.

It is difficult to say why this happened. Perhaps short-term racing is uncommon due to fixed long-term investments in land and wells. Or, maybe farmers were so over leveraged that their businesses collapsed before a race could begin. Also, it may be that secular trends are responsible for the failure of a race to occur, *i.e.*, an increase in the cost of electricity for pumpage or more common use of low-loss irrigation methods, such as drip or bubble techniques.

Conceivably, though, it is partly due to the great size of the governing District. Castro and Parmer counties are within the 13-county, 5,000,000-acre territory of the High Plains Underground Water Conservation District. As discussed in Section 4.3, the larger the size of a District's jurisdiction, the more likely that it will be successful in controlling groundwater abuse.

42. *Id.* at 29.

43. M. Reisner, *Cadillac Desert: The American West and its Disappearing Water* (Viking Press, 1986); E. Kolbert, *The Drink of Millions*, N. Y. Times, March 4, 1990, Magazine, at 32.

constructing rapid infiltration ponds has been discouraging.⁴⁴ Also, the well injection flow rates and infiltration velocities are slowed by clogging, scaling, bacterial growth, and conductivity limits inherent to the aquifer.⁴⁵ Finally, many aquifers settle after production, lose their former storage capacity, and cannot be recharged at any rate. Due to the high costs, slow rate, and reduced capacity, aquifer maintenance and restoration programs have not been widely adopted.

3.6.3 Surface Water Development

For many Texas groundwater users, turning to surface water for supplies would be difficult. First, many of the heavy withdrawals are in dry sections of the state where there may simply be no nearby lake or stream.⁴⁶ Second, surface water rights may well have already been assigned to riparian and/or senior users.⁴⁷ Third, it is unlikely that stream flow would exceed water rights; typically, the converse is true. Fourth, even if surface water were physically and legally available, the cost and delay of permitting and building a reservoir, canal, pump, and treatment system could easily be prohibitive.⁴⁸ In fact, recently, the cost of reservoirs has risen still further for municipalities and farmers due to decreases in cost-sharing by the Army Corps of Engineers and the Soil Conservation Service. Finally, some water users fear the monopolistic pricing and political control that a surface water supplier may be able to exert.⁴⁹

4. TEXAS CASE LAW ON GROUNDWATER

Texas common law increases the difficulties of initiating, negotiating, complying with and enforcing groundwater agreements, and so acts to

44. Chow, *supra* note 15, at 13-42.

45. Hydraulic conductivity values for silts and clays in the Houston subsurface may range from 0.26 to as low as 0.00066 feet/day. Considering that local producing wells draw from strata as deep as 1,000 feet, natural (unpressurized) infiltration rates may create long lags in restoring an aquifer: in this case, 11 to 4,100 years. Bedient & Huber, *supra* note 27, at 496.

46. Moody, *et al.*, *supra* note 2, at 401.

47. *In re Adjudication of the Water Rights of the Upper Guadalupe Segment of the Guadalupe River Basin*, 642 S.W.2d 438,442 (Tex. 1982).

48. A 1977 study estimated that groundwater cost the City of Houston 6¢ per 1,000 gallons at the wellhead. Treated (groundwater typically does not require filtration or sedimentation, as does surface water) surface water at a major distribution line cost 20.3¢ per 1,000 gallons, 236 percent more. By using groundwater rather than surface water, Houston saved \$8,164,000 per year at 1974 consumption rates. J. Teutsch, *Subsidence in the Houston-Galveston Region: A Comprehensive Analysis 7* (December 1977) (unpublished M.S. thesis, Rice University (Houston)).

49. The City of Bellaire, a small municipality located wholly within Houston, has continually lobbied the Texas Legislature during recent years to limit the power of the Harris-Galveston Coastal Subsidence District to restrict pumpage by Bellaire. Bellaire has been concerned that reductions in groundwater supplies will force them to buy surface water from the City of Houston at confiscatory prices or with extensive concessions in political control.

worsen groundwater use problems such as drawdown, mining, salination, baseflow reduction, and land subsidence. Texas groundwater law only endorses ownership based on capture and only recognizes liability in restricted subsidence cases. With such limited ownership and liability, groundwater users have similarly limited incentive and compulsion to contract for efficient and environmentally safe pumpage.⁵⁰

4.1 Texas Rule of Groundwater Ownership

Texas courts employ the English rule of absolute ownership of groundwater, which regards groundwater to be "the absolute property of the owner of the freehold, like the rocks, soil and minerals that compose it, so that he is free to withdraw it at will and do with it as he pleases. . . ." ^{51,52} This doctrine amounts to a rule of capture or first possession, since groundwater is not effectively owned until pumped or "captured."⁵³

50. The law particularly fails in forcing groundwater users to bargain with smaller pumpers and nonpumpers, who have minimal means of retaliating under the non legal regime.

One commentator pointed out that the Houston ruling leaves ineffective self-help as the sole remedy for small well operators, e.g., "construction of a well powerful enough to pull water from the railroad's well, a prohibitively expensive remedy for one who needs water only for household uses." C. Johnson, *The Continuing Voids in Texas Groundwater Law: Are Concepts and Terminology to Blame?*, 17 St. Mary's L.J. 1281, 1282-82 (1986).

As it rejected the English Rule after over 130 years of use, the Ohio Supreme Court similarly noted the vulnerability of the small operator under that Rule. The court found that the English Rule assured that the landowner who obtains the water is merely the one who is able to drill the deepest or biggest well. *Cline v. American Aggregates Corp.*, 474 N.E.2d 324, 326 (1984), cited in Note, *A Modern Approach to Groundwater Allocation Disputes: Cline v. American Aggregates Corporation*, 7 Journal of Energy L. & Pol'y 361, 370 (1986).

51. Restatement (Second) of Torts, Ch.41, §857, topic 4, at 256 (1979).

52. Control over water rights has generally been a concern of state, not federal, law. However, federal law will take precedence in cases where water flows, is pumped or trucked across state lines and state law attempts to block its movement, so interfering with interstate commerce. *City of Altus v. Carr*, 255 F. Supp. 828, 837 (W.D. Tex. 1966). Federal courts have also carved out niches of preclusion for water quality, *Riverside Irrigation Dist. v. Andrews*, 758 F.2d 508, 513 (10th Cir. 1985); endangered species, *Cappaert v. U.S.*, 426 U.S. 128 (1976); navigation, *U.S. v. Rio Grande Dam & Irrigation Co.*, 174 U.S. 690, 709 (1899); hydropower, *U.S. v. Appalachian Elec. Power Co.*, 311 U.S. 377, 419-20 (1940); and reclamation of dry lands, *California v. U.S.*, 438 U.S. 645, 653 (1978). For a good discussion of the interplay of federal and Texas state water law, see D. Frownfelter, *The International Component of Texas Water Law*, 18 St. Mary's L.J. 481 (1986).

Arguments could be made that groundwater rights should come within federal jurisdiction. For example, many aquifers, such as the Ogallala, underlie several states. Texas state laws which allow waste of groundwater pumped from the Ogallala may interfere with use by out-of-state pumpers, hence unduly burdening interstate commerce. Second, overpumpage can threaten aquifers with salinization and migration of toxic chemicals, and so might come within the federal realm for water quality. Last, groundwater supports much of the agriculture in dry areas of Texas and so might come within the reclamation category of federal jurisdiction. If Texas state courts are reluctant to give up the absolute ownership doctrine, perhaps a case could be brought in federal court requesting some sort of intercession.

53. C. Rose, *Possession as the Origin of Property*, 52 U. Chi. L. Rev. 73, 75 n.13 (1985).

The English rule was first adopted by Texas courts in the 1904 decision of *Houston & T.C. Railway Co. v. East*.⁵⁴ The court there considered a claim for damages to a preexisting homestead well that had been drained by a second and much larger well supplying railroad locomotives and machine shops. In its opinion, the court declared that "the person who owns the surface may dig therein and apply all that is there found to his own purposes, at his free will and pleasure", and dismissed the claim.⁵⁵

4.1.1 Groundwater Ownership—Precedent

The *Houston* court supported its position by indicating the age and breadth of precedential cases, the persuasive policy arguments, and the inadequacy of the competing theory of groundwater ownership. In citing early origins of the rule of absolute ownership, the court acknowledged the classic British statement in *Acton v. Blundell*: "immediately below is his property, whether it is solid rock, or porous ground, or venous earth, or part soil, part water."⁵⁶ The *Houston* court also cited an 1861 American opinion, *Frazier v. Brown*, as proof that the rule had early been adopted in the United States as well.⁵⁷ In the *Frazier* decision, an Ohio court considered the scope of "ownership of surface waters which, without any distinct and definite channel, ooze, filter and percolate", and announced that "the maxim, '*cujus est solum ejus est usque ad coelum et ad infernos*,' applies to its full extent."⁵⁸ The surface estate owner owns to the bowels of the earth, including the groundwater.

4.1.2 Groundwater Ownership—Supporting Policy Rationale

The *Houston* court emphasized that its opinion was not based solely on principles of *stare decisis*, but was also supported by policy arguments. The court mentioned two reasons, one technical, the other economic. First, rules governing groundwater would be "hopelessly uncertain" and "practically impossible" due to the poor understanding of groundwater's "existence, origin, movement, and course."⁵⁹ And second, abandonment of absolute ownership would "interfere, to the material detriment of the commonwealth, with drainage and agriculture, mining, the construction of highways and railroads, with sanitary regulations, building, and the general progress of improvement in works of embellishment and utility."⁶⁰

54. 81 S.W. 279 (Tex. 1904).

55. *Id.*

56. *Acton v. Blundell*, 152 Eng. Rep. 1223, 1235 (Ex. 1843).

57. 81 S.W. at 280.

58. *Frazier v. Brown*, 12 Ohio St. 294, 304 (1861).

59. 81 S.W. at 281.

60. *Id.*

4.1.3 Groundwater Ownership—Rejection of Alternate Theory

Finally, the *Houston* court dismissed the other major ownership theory: "in the absence of express contract and a positive authorized legislation . . . the law recognizes no correlative rights in respect to underground waters percolating, oozing, or filtrating through the earth."⁶¹ The correlative rights doctrine, also known as the reasonable use or American rule, limits groundwater ownership rights of an overlying user to "his proportionate share of the total amount available based upon . . . his current reasonable and beneficial need for water."⁶² The *Houston* court made clear that this approach would not apply in Texas.

4.1.4 Groundwater Ownership—Current Law

The *Houston* case continues to be good law. The Texas Supreme Court directly reaffirmed *Houston* and the absolute ownership doctrine as recently as 1983.⁶³ A Texas Court of Appeals again endorsed *Houston* in May 1989.^{64,65} With such strong and current endorsement of his right to all the groundwater he can pump, a well owner wants for very little and has little incentive to bargain with others.

4.2 Texas Rules of Liability for Groundwater Use

A well operator's absolute ownership of pumped groundwater, "for use at his free will and pleasure", implies that a resulting "inconvenience to his neighbor falls within the description of *damnum absque injuria*, which cannot become the ground of an action."⁶⁶ In fact, Texas rules of groundwater ownership do tend to immunize users from a number of types of liability. The argument of absolute ownership has been used to bar claims for well drawdown, baseflow reduction, land surface subsidence, and, perhaps most tellingly, waste. Also, capture-based ownership has been used to interfere with legal methods of recovery, blocking nuisance suits, barring most suits under negligence theories, and imposing

61. *Id.* at 280.

62. F. Trelease, G. Gould, *Cases and Materials on Water Law* 427 (West Publishing 1986).

The correlative rights theory is sometimes linked closely or confused with the reasonable use doctrine. Accurately speaking, they are not the same. The correlative rights theory limits pro rata shares to an amount which will not harm sharing users. By contrast, the reasonable use doctrine allows a landowner to take his full pro rata share, despite harm to another sharing user, if he can show that the water was drawn for a beneficial purpose. J. Castleberry, Jr., *A Proposal for Adoption of a Legal Doctrine of Ground-Stream Water Interrelationship in Texas*, 7 St. Mary's L.J. 503, 507-08 (1975).

63. *City of Sherman v. Pub. Util. Comm'n*, 643 S.W.2d 681, 686 (Tex. 1983).

64. *Denis v. Kickapoo Land Co.*, 771 S.W.2d 235, 236 (Tex. Civ. App.—Austin 1989).

65. The Texas Legislature has continued to approve and defer to this court-created system of ownership. Tex. Water Code Ann. § 52.002 (Vernon 1990).

66. 81 S.W. at 280.

stiff presumptions which make proof quite difficult. In turn, such a large degree of immunity leaves pumpers with little to fear and little compulsion to enter or comply with agreements.

4.2.1 Groundwater Liability—Drawdown

Texas courts do not recognize claims for aquifer drawdown. In its *Houston* decision, the Texas Supreme Court rejected such a claim, although the plaintiff had presented a strong case.⁶⁷ The court conceded that the drawdown was due to the defendant's pumpage, and found that the water in the plaintiff's well was entirely drained, not just lowered. Causation and damage seemed clearly proven. Still, the court found that there was no cause of action.

4.2.2 Groundwater Liability—Surfacewater Flow Reductions

Texas courts generally do not recognize claims against pumpage that decreases surface flows. A Court of Civil Appeals in El Paso considered a case in which well withdrawals caused Commanche Springs to be "materially reduced in flow and at times completely dried up."⁶⁸ The court refused to enjoin or fine the pumpers, holding that ownership of the Springs only obtained "at and after their emergence from the ground" and did not extend to rights to exclude others from water before it emerged.⁶⁹

4.2.3 Groundwater Liability—Land Subsidence

In *Friendswood Devel. v. Smith-Southwest Indus.*, a Texas court rejected a claim for pumpage-related subsidence.⁷⁰ The claim was brought by a number of landowners along the coast of Galveston Bay, charging that Exxon and Friendswood Development pumped large amounts of groundwater and caused the plaintiffs' land to sink, in many cases, to drop below sea level. They alleged that the defendants pumped excessive amounts from wells too tightly packed and too close to common boundaries. Furthermore, they claimed that the defendants had prior knowledge from engineering studies that indicated the pumpage would cause subsidence and inundation. Nevertheless, the Texas Supreme Court rejected the plaintiffs' claim. The court characterized the damages as "suffered without the invasion of legal right or the violation of a legal duty."⁷¹

67. *Id.*

68. *Pecos County Water Control and Imp. Dist. v. Williams*, 271 S.W.2d 503, 505 (Tex. Civ. App.—El Paso 1954).

69. *Id.*

70. *Friendswood Devel. v. Smith-Southwest Indus.*, 576 S.W.2d 21 (Tex. 1978).

71. *Id.* at 28.

4.2.4 Groundwater Liability—Nuisance

Nuisance has been described as substantial and unreasonable interference with the use or enjoyment of land.⁷² The *Houston* court is not hospitable to the theory: stating that "no action lies against the owner for interfering with or destroying percolating or circulating water under the earth's surface."⁷³ Restrictions on groundwater availability would presumably interfere with uses such as irrigation and agriculture, cooling and industry, and municipal supply and residential development. However, in Texas, interference of this kind appears to be *per se* insubstantial, reasonable and no grounds for a nuisance suit.⁷⁴

4.2.5 Groundwater Liability—Negligence

In *Turner v. Big Lake Oil Co.*, the Supreme Court of Texas wrote "the law imposes [a duty] upon all persons to use due care in the use of their property or the conduct of their business to avoid injury to others."⁷⁵ The *Friendswood Development* court endorsed this negligence theory of recovery and announced that it would apply in future subsidence cases.

However, the *Friendswood Development* court refused to apply it in the case then at bar due to concerns about reliance in property cases.⁷⁶ Also, the argument has not appeared in any subsequent cases. It is possible that the argument requires proof of such high levels of negligence or foreseeability that it simply has not been used. In addition, the negligence theory was expressly restricted to subsidence, and only that occurring after 1978. So, the argument cannot be used to press claims for previous subsidence, nor for drawdown, mining or other groundwater related damages during any period.⁷⁷

72. W. Page Keeton *et al.*, Prosser and Keeton on the Law of Torts §§ 86, 88 (5th ed. 1984).

73. 81 S.W. at 281, citing with approval *Pixley v. Clark*, 35 N.Y. 520, 91 Am. Dec. 72 (1866).

74. The dissent in *Friendswood* unsuccessfully argued for courts to use a nuisance analysis, weighing the severity of the harm caused against the utility of the water use. 576 S.W.2d at 35; Note, *Sinking Fortunes: Texas Remedies for Victims of Land Subsidence*, 20 Nat. Res.J. 375, 386 (April 1980).

75. *Turner v. Big Lake Oil Co.*, 96 S.W.2d 221, 223 (Tex. 1936).

76. 576 S.W.2d at 30.

77. "The addition of negligence as a ground of recovery shall apply only to future subsidence proximately caused by future withdrawals of ground water from wells which are either produced or drilled in a negligent manner after the date this opinion becomes final." *Id.*

The rejection of negligence as a basis for recovering for most types of abusive groundwater withdrawals is particularly odd when one considers that Texas law recognizes negligence in oil and gas pumpage. While petroleum is held under an identical theory of absolute ownership, the Texas Supreme Court has still been willing to state, "under the common law, and independent of the conservation statutes, the respondents were legally bound to use due care to avoid the negligent waste or destruction of the minerals imbedded in petitioners' oil and gas-bearing strata." *Elliff v. Texon Drilling Co.*, 210 S.W.2d 558, 563 (Tex. 1948). It is difficult to explain away the inconsistency between the treatment of groundwater and oil and gas. Perhaps the lower value of groundwater simply does not merit courts' involvement in settling negligence-based disputes.

4.2.6 Groundwater Liability—Waste

Texas courts have long condemned waste of groundwater. In its 1904 *Houston* decision, the Supreme Court of Texas suggested that it might honor claims against wasteful groundwater use.⁷⁸ A 1948 state appeals court ruling condemned groundwater storage in "an earthen tank which leaks badly", noting that "waste of natural resources is against the public policy of this State."⁷⁹ In 1978, the Supreme Court of Texas expressly granted the right to recovery "if the landowner's manner of withdrawing ground water from his land . . . is willfully wasteful."⁸⁰

And yet, when faced with a quite convincing case of waste, the Texas Supreme Court backed down and removed an injunction against the allegedly wasteful use.⁸¹ In that case, *City of Corpus Christi v. City of Pleasanton*, Corpus Christi had drilled a set of wells whose production was discharged into the Nueces River to flow 118 miles to Lake Corpus Christi, where it was used for water supply and recreation. En route, an estimated 63 to 74 percent of the wellwater was lost to evaporation, transpiration, and seepage.⁸²

The *Corpus Christi* court recognized the right to use or sell water for any legal purpose off premises, as well as the right to transport the water to its use site by any of various means, including by "river, creek, . . . bayou, . . . sewer, street, road."^{83,84} The court announced that the "percentage of the escape through evaporation, seepage, et cetera is wholly immaterial."⁸⁵ Much as in the court's attitude toward negligence, the court appeared to accept the theory of waste but reject its application.

4.2.7 Groundwater Liability—Presumptions and Proof

One of the peculiarities of Texas water law is that groundwater is held under the absolute ownership doctrine, while surface water rights are governed by the correlative use theory.⁸⁶ Groundwater underlying a land parcel is held outright by the private owner of the surface estate and is subject to use as he sees fit. On the other hand, surface waters running

78. The Court quoted a Minnesota court injunction with approval. The injunction was imposed against a defendant who "made no use whatever of the water, but for no useful purpose, drained it away, and discharged it through the sewers of a town." 81 S.W. at 281.

79. *Cantwell v. Zinser*, 208 S.W.2d 577, 579 (Tex. Civ. App.—Austin 1948).

80. 576 S.W.2d at 30. See 56 Am.Jur. Torts § 119, at 602 (1947).

81. *City of Corpus Christi v. City of Pleasanton*, 276 S.W.2d 798 (Tex. 1955).

82. *Id.* at 800.

83. 771 S.W.2d at 236.

84. 276 S.W.2d at 802.

85. *Id.* at 803.

86. *In re the Adjudication of the Water Rights of the Upper Guadalupe Segment of the Guadalupe River Basin*, 642 S.W.2d 438, 445 (Tex. 1982).

past or over his land are kept in trust by the state and allocated by seniority and riparian status under a permit system.⁸⁷

The distinction is particularly relevant because some water that lies underground may be treated as surface water within the control of the state. Precisely, "water flowing in an underground stream . . . [or] springs which form the source of a flowing stream or which add perceptibly to the flow of water in a stream" are considered to be "non-percolating water" and hence subject to the authority of the state.⁸⁸

However, in absence of contrary evidence, underground waters are presumed to be percolating and thus governed by absolute ownership rules.⁸⁹ This presumption puts a heavy burden on the plaintiff to sufficiently show a connection between underground and surface waters. While the hydrologic cycle, the flow of streams to aquifers and oceans to rain and back, may seem to be common knowledge, Texas courts refuse to take judicial notice or to require only superficial proof.

In *Pecos County Water Control & Imp. Dist. v. Williams*, the burden of proof was a great deal higher. The Supreme Court of Texas required the plaintiff, owner of surface rights to Commanche Springs, to "state sufficient facts to identify the claimed well defined [underground] channel, either as to surface indications, probable route, source or destination."⁹⁰ The court added that the "mere fact that the wells of one man dried up springs or the wells of another, neither proves nor indicates a well defined channel of underground water."⁹¹

The burden of proof is further increased by the nature of the remedy sought. Typically, a plaintiff will seek an injunction to stop the abusive pumping. The *Pecos County* court warned, however, that "the petition in an injunction suit must negative every other reasonable hypothesis except this one advanced by plaintiff."⁹² Coupled with the burden of persuasion and production that a plaintiff normally carries, the additional weight of first overcoming the presumption that groundwater is perco-

87. "The waters are in trust for the public: first, for navigation purposes, which concerns all the public and is ordinarily regarded as a superior right; second, the riparian waters of the stream are held in trust by the state for the riparian owners along its margins; third, the nonriparian waters in the stream are held by the state in trust, to be controlled and disposed of by the state for the best interests of all the people; fourth, the waters are in trust for uses and benefits not here involved." *Mott v. Boyd*, 286 S.W. 458, 468 (Tex. 1926).

88. *Bartley v. Sone*, 527 S.W.2d 754, 760 (Tex. Civ. App. San Antonio 1975).

89. *Texas Co. v. Burkett*, 296 S.W. 273, 278 (Tex. 1927).

90. *Pecos County Water Control & Imp. Dist. v. Williams*, 271 S.W.2d 503, 506 (Tex. 1954).

91. *Id.* at 507.

92. The court conceded that the plaintiff in *Pecos County* proved that Commanche Springs had flowed for at least the previous 90 years and had been used continually during that time for irrigation and domestic use until the District sunk its wells. After the wells began operation, the springs went dry. For lack of proof, the *Pecos County* court refused to enjoin pumpage by the Water District. *Id.*

lating, and then satisfying the prerequisites for an injunction, can stymie quite valid claims.

5. TEXAS STATUTORY LAW ON GROUNDWATER

Much like common law in the state, Texas legislation has failed to support or substitute for private agreements against excessive groundwater use and related environmental problems. The state Legislature has been willing to yield, defer and delegate in the groundwater area. Although a will to cooperate and trust is usually commendable in politics, such delegation may not work in this case. The Legislature appears to have given authority to institutions and groups which are largely not willing or empowered to accept responsibility for the problem. The discussion below treats statutes which exclude the Legislature and agencies from involvement, which defer to judicial control, and which delegate to local districts.

5.1 Groundwater Statutes—State Legislative Abdication

In terms of ownership, policy, and regulation, the state has expressly given up interest and control. In 11.021(a) of the Texas Water Code, the Legislature describes the waters of the state at length and nowhere mentions percolating waters:

“the water of the ordinary flow, underflow, and tides of every flowing river, natural stream, and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, floodwater, and rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state is the property of the state.”⁹³

Considering the difficulties and disagreements which face private owners of a right to exploit a common resource, this omission and effective cession may be a mistake.

While a series of technical studies commissioned by the state and federal governments has recognized problems related to groundwater use, the Legislature has failed to respond with a general, state-wide policy concerning aquifer protection.^{94,95,96,97} Also, the Legislature has failed to

93. Texas Water Code Ann. § 11.021(a) (Vernon Supp. 1990). Please note that, strictly speaking, the state does not own waters of the state, but rather holds them in trust for the public. See 642 S.W.2d at 445 and 286 S.W. at 468.

94. “The legislature recognizes that certain areas of the state are experiencing and will experience in the future critical underground water problems. . . .” Tex. Water Code Ann. 52.051 (Vernon Supp. 1990).

95. Moody, *et al.*, *supra* note 2; Library of Congress, *supra* note 3.

96. Gabrysch, *supra* note 5; Mackey, *supra* note 8; Reeves & Ozuna, *supra* note 14; Nalley & Rettman, *supra* note 16.

97. Johnson, *supra* note 50, at 1284.

set more specific guidelines on aquifer lifetimes, use priorities, conservation devices, well spacing calculations, and other aquifer management methods.⁹⁸

The state has also stripped itself of authority to directly regulate groundwater. Section 11 of the Texas Water Code concerns authority for regulation of water rights in the state. The Section begins, however, with the proviso, "nothing in this code affects vested private rights to the use of water."⁹⁹ Since surface waters are considered state rights granted by permit to individuals, the "private rights" excluded from the Code refer only to percolating groundwater.

The state has also expressly surrendered the means to directly manage groundwater. Section 52 of the Water Code outlines the administrative institutions and procedures for administering water use in the state. It too, however, exempts groundwater from the extensive regulation common to surface water. Section 52.003 states, "the laws and administrative rules relating to the use of surface water do not apply to underground water."¹⁰⁰

The discussion below in sections 5.2 and 5.3 suggests that the abandonment of state responsibility for setting policy and writing regulations may not be the most successful approach to groundwater problems. The other parts of government involved in groundwater management, the state agencies, courts, and the Districts, seem either unwilling or unable to substitute for the Legislature.

5.2 Groundwater Statutes—State Legislative Deference

In Texas, the state Legislature came late to addressing groundwater rights and uses. By 1904, the Supreme Court of Texas had already decided *Houston*, and had pronounced absolute ownership as the controlling doctrine.¹⁰¹ The Legislature did not become involved until after serious droughts occurred in 1910 and 1917.¹⁰² Its principal efforts consisted of passage of a Conservation Amendment and a law requiring plugging and capping of flowing artesian wells.¹⁰³ Stung perhaps by the court's 1921 rejection of a surface water regulation scheme, the Legislature went no further with direct regulation than the rather exhortatory Amendment and the limited statute.¹⁰⁴

98. Texas Water Code Ann. § 52 (Vernon Supp. 1990).

99. Texas Water Code Ann. § 11.001(a) (Vernon 1988).

100. Texas Water Code Ann. § 52.003 (Vernon Supp. 1990). A recent Texas attorney general's opinion (Op. Tex. Att'y Gen. No. DM-54 (1991) appears to broaden the legislature's ability to delegate administrative rulemaking authority in the groundwater area.

101. 81 S.W. 279 (1904).

102. *In re Adjudication of the Water Rights of the Upper Guadalupe Segment of the Guadalupe River Basin*, 642 S.W.2d at 440 (Tex. 1982).

103. Tex. Const. art XVI, § 59; Tex. Water Code Ann. § 11.021-.207 (Vernon 1988).

104. The Court's rejection of the legislature's early regulatory attempts is found in the case *Board*

Instead, the Legislature codified court-made law. According to Section 52.002 of the Water Code,

"[t]he ownership and rights of the owner of the land and his lessees and assigns in underground water are hereby recognized, and nothing in this code shall be construed as depriving or divesting the owner or his lessees and assigns of the ownership or rights."¹⁰⁵

Yet, the courts have not seemed to welcome this deference. In *Houston*, the Supreme Court of Texas quotes its principal precedential case, *Frazier v. Brown*, as requiring the absolute ownership rule only "in the absence of express contract and a positive authorized legislation."¹⁰⁶ More than 70 years later, the same court prefaced its analysis of the *Friendswood Development* case by noting, "regulation of ground water production is primarily a legislative, not a judicial problem."¹⁰⁷

Courts resist involvement in groundwater disputes for good reason. First, the Texas Supreme Court has worried that the potential number of suits could clog the courts.¹⁰⁸ Second, the courts have been concerned that the ad hoc nature of adjudication could result in equal protection problems due to variations from case to case.¹⁰⁹ Third, judges seem to fear that the complexity and technical nature of groundwater disputes are beyond their expertise.¹¹⁰ Other plausible reasons for faulting judicial control include the awkwardness of joining all affected parties before a

of *Water Engineers v. McKnight*, 111 Tex. 82, 229 S.W. 301 (Tex. 1921).

In response to an April 15, 1992 declaration by the Texas Water Commission that the southern Edwards Aquifer was an underground river and thus subject to Commission regulatory authority, one state representative lamented the Legislature's continued inability to be equally aggressive in regulating groundwater. State Representative Libby Linebarger, a Democrat from Manchaca, Texas, said, "Our repeated efforts have always resulted in gridlock. The move by the Water Commission was taken only as a last resort." D. Graves, *Commission's Act to Redefine Aquifer Called Courageous*, *Austin Amer.-States.*, Apr. 22, 1992 at B1, B5.

It should be noted that the Commission's attempt to regulate the aquifer is at best limited and at worst, stillborn. Upon announcing his agency's bid to regulate Texas groundwater, Chairman John Hall of the Texas Water Commission said, "It is not our goal to regulate groundwater on a statewide basis. Our goal is effective management of the Edwards." Furthermore, the chairman conceded, "we do anticipate that what we have done today will be challenged in court, anticipating one opponent's view (State Senator Bill Simms, chairman of the Senates Natural Resources Committee): "it is inconceivable that a state agency has the right to overrule well-established property rights without judicial or legislative authorization." D. Matustik, *Water Commission Takes Control of Aquifer*, *Austin Amer.-States.*, Apr. 16, 1992, at A1, A15.

105. Tex. Water Code Ann. § 52.002 (Vernon Supp. 1990).

106. *Houston & T.C. Railway Co. v. East*, 81 S.W. at 280 (Tex. 1904); *Frazier v. Brown*, 12 Ohio St. at 304 (1861).

107. 576 S.W.2d at 26 (Tex. 1978).

108. "[O]ur courts are not equipped to regulate ground water uses and subsidence on a suit-by-suit basis." *Id* at 30.

109. *Beckendorff v. Harris-Galveston Coastal Sub. Dist.*, 558 S.W.2d 75, 81 (Tex. Civ. App.—Houston 1977).

110. 81 S.W. at 281; 576 S.W. 2d at 29.

suit and the need for continuing management after the suit.¹¹¹ With these objections in mind, it may not be best for the Legislature to so willingly cede power and responsibility for groundwater to the courts.

5.3 Groundwater Statutes—State Legislative Delegation

The Legislature has placed the chief political responsibility for regulating groundwater withdrawals on local Underground Water Conservation Districts.¹¹² The Districts have been granted authority to control well-spacing, reduce wasteful uses, recharge aquifers, and pursue research, monitoring and education.¹¹³

Many of the districts have not been potent. Their main shortcomings include limited research and monitoring resources for calculating optimum pumping strategies, minimal state guidelines for regulatory approaches, and limited territory. The size of District territory is probably the most critical problem. Most Districts consist of a single county, far smaller than most aquifers.¹¹⁴ Hence, many of the impacts on a District's groundwater are beyond its jurisdiction and control.¹¹⁵ Moreover, it is burdensome to enlarge a District, since it requires a majority vote of both the original District and the annexed area.¹¹⁶

It is even hard for a District to maintain control within its recognized boundaries. Extremely large well owners may control jobs or votes and

111. J. Teutsch, *Controls and Remedies for Ground Water—Caused Land Subsidence*, 16 Hous. L. Rev. 283, 312 (1979).

112. "It is also the purpose of the legislature to assure that the local areas will determine the best methods for handling underground water problems. . . ." Tex. Water Code Ann. § 52.051 (Vernon Supp. 1990). The willingness of the state legislature to divide its authority among local units of government may be a result of gridlock at the state level. One state legislator, Sen. Gonzales Barrientos (D-Austin), spoke of the state's impasse over groundwater regulation in the following way: "The problem is that this is not an issue where there are two sides. It is an issue where there are at least five sides, and each has enough clout in the legislature to keep any proposal from passing." Graves, *supra* note 104, at B5. While local government still holds the bulk of control over groundwater withdrawal in Texas, recent efforts by the Texas Water Commission to become involved should be noted. See also notes 100 and 104.

113. Tex. Water Code Ann. § 52.117 (Vernon 1988); Tex. Water Code Ann. § 52.169 (Vernon Supp. 1990).

114. In 1978, ten districts had been set up in West Texas alone. 576 S.W.2d at 30. This pattern of numerous small districts independently trying to control a single shared aquifer appears to be continuing. A review of 1989 legislation indicated that ten new districts had been proposed for the State in that year. 1989 Tex. Gen. Laws 514, 515, 519, 524, 653, 654, 669, 673, 712, 715. None included more than one county.

115. A clear example of extrajurisdictional problems would involve interstate or international aquifers. For instance, a major aquifer such as the Ogallala stretches into Oklahoma, Kansas, Colorado, and New Mexico while another major reservoir, the Evangeline, reaches into Louisiana and Mississippi. Teutsch, *supra* note 48, at 234. Minor shallow Texas aquifers lying beneath rivers are shared with Mexico, New Mexico, Colorado, Oklahoma, Arkansas, and Louisiana. Frownfelter, *supra* note 52, at 488.

116. Tex. Water Code Ann. § 52.052(d,g) (Vernon Supp. 1990).

so hold sway over a small territory, making it difficult for the District board to restrict their pumpage. Many other well owners may be expressly exempt from control. For example, pumpers of 25,000 to 100,000 gallons per day are entitled to an automatic permit. Those withdrawing less than 25,000 gallons per day, or those who are pumping to water livestock or recover hydrocarbons, may not be permitted or limited in their pumpage at all.¹¹⁷ Lastly, and somewhat ironically, the state has retained the right to exclude its lands from control.¹¹⁸ The state itself seems to lack confidence in the Districts' ability to manage groundwater.

It should be pointed out that some of the Districts have been quite successful. The Harris-Galveston Coastal Subsidence District has been particularly effective.¹¹⁹ Reasons for its success include its large size, its few (though large) pumpers, its ability to fine, and its access to surface water. Its territory stretches over two counties, and extends to a third through informal agreements, thus giving the District adequate jurisdiction to manage the underlying aquifers. Local wells are principally owned just by the City of Houston and a few smaller municipalities, thus limiting transaction costs and freeloader problems. The ability to fine gives the District an administratively cheap, but closely calibrated, means of enforcing the law. Access to surface supplies on the San Jacinto and Trinity Rivers has made up for required reductions in groundwater pumpage, hence limiting the need to persuade a balky public to change its dissolute lifestyle or install costly conservation devices.

6. SUMMARY OF GROUNDWATER STATUS QUO

6.1 Environmental and Economic Effects of Groundwater Use

The preceding discussion should show that all is not well with groundwater in Texas. Groundwater use imposes serious impacts on adjoining landowners and on the environment in general. Drawdown causes increased lift costs and, if a entirely new well needs to be made, may lead to the cost of redrilling, recasing, installing new submersible pumps, and relocating above-ground piping and housing. Salinization can cause similar problems if a new well must be sunk. Even if pumpage can be continued at the old location, operators will face the cost of treatment methods such as osmosis or distillation. Operators and neighbors may

117. Tex. Water Code Ann. § 52.170(a)(1),(a)(3,4),(d),(h) (Vernon Supp. 1990). Average flow per well was 2400 gallons per day in 1987, exempting most wells. Allfred, *supra* note 37.

118. Tex. Water Code Ann. 52.065 (Vernon Supp. 1990).

119. Depth to water measurements in Pasadena, Baytown, and near the Johnson Space Center rebounded by about 20 feet during 1973-77, and rates of subsidence in those areas have slowed due to pumpage controls. Gabrysch, *supra* note 5, at 66. Also, it appears that the High Plains Underground Water Control District has been effective (*see* note 41).

also encounter subsidence impacts, such as flooding due to coastal inundation and watershed slope changes.¹²⁰ If pumpers are not discouraged and the aquifer is mined until effectively depleted, well owners will confront costs related to conversion to surface water sources, such as construction of dams, canals, piping and purification systems. Alternatively, miners may face major economic changes, such as abandonment of water-intensive crops and practices. Reduction in surface baseflows may even foreclose use of surface water sources after groundwater supplies are exhausted.

6.2 Failure of Norms to Cure Groundwater Problems

While many agree as to the harmful effects of groundwater use, voluntary practices and agreements do not seem to be an adequate response. As mentioned above, a number of reasons may limit the success of norms. Ignorance about the physical principles underlying groundwater behavior, or about the specific characteristics of a particular groundwater source may blind an individual to the need for or value of an agreement. Even if negotiations toward an agreement are initiated, transaction costs of monitoring, modeling, and allocating rights to an aquifer may be seen as prohibitive. Provided that an agreement is signed, one's own compliance may be hindered by a Prisoner's Dilemma, made especially hard when the difference between the benefits of cooperation and defection appears to be slight in the short, immediate term. The feebleness of self-help may also bar forcing another's compliance, as well. Compliance becomes doubly difficult when the competition of outsiders to the agreement is considered, as exemplified by the Tragedy of the Commons and by the racing paradigm. Finally, although pumpers may admit difficulties with groundwater use and agreements, they likely see no ready escape from reliance on groundwater. Demand reduction through conservation practices and devices, aquifer restoration through injection and infiltration, and development of surface water sources each have drawbacks which may be fatal in the pumpers' view.

6.3 Failure of Common Law to Treat Groundwater Problems

As outlined above, the courts have not been successful in offering adequate solutions to groundwater disputes due to reigning conceptions

120. A 1975 study estimated that annual costs related to subsidence in a 945 square mile region in Houston amounted to \$31.7 million. If these external costs were added to the 6¢ per 1,000 gallon internal cost of groundwater, the true economic cost would rise to 25¢ per 1,000 gallons. L. Jones, J. Larson, *Economic Effects of Land Subsidence due to Excessive Groundwater Withdrawal in the Texas Gulf Coast Area 4* (Texas Water Resources Institute, Technical Report 67, Texas A&M University 1975).

of ownership and liability. The doctrine of absolute ownership allows full use of underlying water, so long as there is not overwhelming evidence of waste or malice. This rule of ownership simply does not admit of some types of harm, including drawdown, surface water flow reductions, and non-negligent subsidence. Absolute ownership also effectively precludes most kinds of remedy besides self-help. For instance, the theory of nuisance has been outright rejected, while other means of recovery, such as negligence and waste have been closely limited by heavy burdens of proof. No Texas ruling discusses or awards a remedy for a malice-related pumpage claim.

6.4 Failure of Statutory Law to Resolve Groundwater Problems

Despite the severity of the groundwater problem, and the minimal answer of norms or case law, the Legislature has not offered strong solutions. Statutes have relinquished state groundwater ownership, general policy-making interest, and direct regulatory authority. Legislation has typically deferred to court-made law, though courts have expressly stated their reluctance to become involved in such disputes. Where statutory authority has been preserved, it has been placed with Underground Water Conservation Districts. Unfortunately, the Districts' powers have been critically limited by shortfalls in funding for monitoring and enforcement, restrictions on territory, and exemptions for wells of varying sizes and uses.

7. CONCLUSIONS ON TEXAS GROUNDWATER LAW

This analysis suggests that there are serious problems related to groundwater use in Texas, including drawdown, mining, salination, baseflow reduction, and subsidence. Private, voluntary practices and agreements have been unsuccessful due to problems with ignorance, transaction costs, prisoner dilemmas, self-help measures, commons effects, racing, and limited supply and use options. Also, agreements have had little backing from the judiciary due to its use of the absolute ownership doctrine and liability immunity. Legislative programs have been ineffective in setting standards that might support or act as proxies for such agreements, on account of limits to District authority and territory.

8. LESSONS LEARNED ON RIGHTS, MARKETS, AND THE ENVIRONMENT

The law and problems relevant to Texas groundwater are distinctive, but not unique: there may be a moral to the story that we can apply in other situations. As one of the very few natural resource systems in the nation which has long been effectively unregulated by any central, public

agency, Texas groundwater and its governing law should offer a good model or warning as the country moves to more private sector-oriented, market-based environmental regulation.

The amendments to the Clean Air Act of 1990 provide the clearest and most fully formed example of a market-based federal system of pollution control. In analyzing the effectiveness of market approaches such as that offered in the Clean Air Act, the experience with Texas groundwater may help frame the questions and assess the answers.

For instance, will the award of rights for pollution emissions, rather than for clean air, inhibit the market function, considering the transaction costs and difficulty of self-help that have plagued victims of groundwater damage? Second, will all those fouling or taking from the commons be included in rights-trading: for example, will car users or manufacturers remain outside the market, much as many pumpers have managed to avoid responsibility for their effects on shared aquifers? Third, will pollution rights be correctly valued to reflect all externalities, or will cross-media, inter-system effects be underpriced: for instance, will sulfur dioxide rights be priced to fully include acid rain costs, unlike Texas groundwater rights' exclusion of surface water baseflow effects? Fourth, will pollution rights actually be bought by victims or rivals of the polluters, unlike in Texas, where victims of groundwater harm have been unwilling to invest in making their neighbors' use of groundwater more efficient and less harmful? And, finally, in amending or adding rules regarding these rights, how courageous can we expect political agencies to be, whether they are representative, like the Congress, or more insulated like the EPA or judiciary, in view of the Texas Legislature's and state courts' reluctance to intervene in Texas groundwater ownership and liability disputes?

Many of these questions regarding the Clean Air Act will not be answered until complete regulations are issued, interpreted and enforced. Nor, of course, is the Clean Air Act the exclusive form which market-based environmental regulation might take. And, it is also unclear to what extent the difficulties of Texas groundwater exactly translate to the problems of air quality or other natural resources. However, this writer would strongly suggest that the Texas experience with absolute rights to groundwater can provide valid questions to ask of market-based environmental protection.