The Value of Water Rights in Western Kansas

Background

At present, approximately 3.6 million acre-feet of water are extracted annually from the Ogallala. Due to aquifer characteristics, the Ogallala receives only 1.5 million acre-feet of water in recharge (Docking, 2001). The steady decline of the aquifer's saturated thickness raises concerns about the long-term viability of the irrigation based economy of Western Kansas. The public policy debate over the sustainability of the aquifer is significant. Several policy alternatives have been suggested, including water taxes, mandatory reductions in current water allocations, voluntary water retirement programs, incentive programs aimed at reducing the planted acreage of water intensive crops, incentive programs aimed at increasing irrigation efficiency (end gun removal, installation of water meters, low energy precision application, sub-surface drip irrigation, etc), and incentive programs aimed at temporarily converting irrigated land to dryland production.

One potential policy alternative is the Voluntary Water Rights Transition Program currently under consideration by the State of Kansas. In October of 2000 the *Committee Report on Federal Actions Necessary for the Conservation and Environmental Preservation of the High Plains Aquifer*, often referred to as the "Mayo Report," was presented to the Kansas Water Office. The report provided advice and recommendations to the Kansas federal delegates for development of legislation to address problems associated with the High Plains Aquifer decline within Kansas as well as the other six states the aquifer underlies. The report was approved by the Kansas Water Authority, endorsed by Governor Graves, and supported by the State Legislature through Concurrent Resolution 5009. Representative Jerry Moran and Senator Sam Brownback have introduced federal legislation incorporating concepts from this report. One of the recommendations included in this report was that "federal financial assistance should be provided to each High Plains State for incentive based, binding agreements with landowners to permanently stop irrigating specific tracts of land for the purpose of reducing consumption in groundwater declines areas of the High Plains aquifer" (pg 6).

In October of 2001 the Ogallala Aquifer Management Advisory Committee released the report *Discussion and Recommendations for Long-term Management of the Ogallala Aquifer in Kansas*. In this report, the committee endorsed the concept of a water rights retirement program as outlined in the "Mayo Report". Additionally, it recommended that State funds be allocated to the water rights purchase program.

In September of 2003 the Kansas Water Office released the *Kansas Water Plan Concept Paper: Groundwater Marketing.* The Water Plan Storage Act of 1974 provides authority for the State to purchase "conservation water supply" within the basic framework of the Water Marketing Program. This program operates primarily in the eastern half of Kansas. There is no provision in the current Act to allow the purchase of groundwater rights. The concept paper suggested that "the State may want to expand the current Marketing Act to include the ability to purchase groundwater rights for aquifer restoration, and for resale in anticipation of diversified regional economic development" (pg 2).

Momentum in favor of the concept of purchasing water rights appears to be accelerating. At the present time the Voluntary Water Rights Transition Program has been included in the Kansas Water Plan. Additionally, HB 2620 has been introduced and is now in the Legislature. Basically, in lieu of permanently abandoning and dismissing a water right, the proposed legislation offers to pay an amount not to exceed the difference between the fair market value of the converted irrigated acres to similar, non-irrigated land. The determination of fair market value will be determined by an independent appraiser or appraisal process. After a transition period, not to exceed three years, the water right is forfeited and the well is plugged. Funding is proposed to come from multiple sources including the Legislature, a portion of the KS v CO settlement, federal government sources, and/or local entities. The first buyout program will be funded as a pilot program resulting from federal legislation and monies as sponsored by Senator Brownback. This program will have approximately $2,000,000 and be used to purchase approximately 2,500 acres of water rights. The second more comprehensive program will be funded with state monies as a result of HB 2620.

In order to implement the Voluntary Water Rights Transition Program, policy makers need an in-depth understanding of the factors that impact the value of water rights. The purpose of this analysis is to review valuation techniques that are appropriate for placing a monetary value on water rights. This analysis will be conducted for the Crop Reporting Districts (CRD) NW-10, WC-20 and SW-30 as illustrated in Figure 1. The CRDs approximately correspond to Ground Water Management Districts four, one and three respectively, as illustrated in Figure 2.

Existing Voluntary Retirement Programs

For the majority of the 20th century, state and federal water policies were designed to encourage settlement and to develop the agricultural industry in western states. As a result, in most arid western states, agriculture consumes between 70% and 95% of the available water resources. As we move into the 21st-century, public concerns over decreasing wildlife populations, the desire for more water oriented recreational facilities, the water needs of an expanding industrial sector, and increased population concentration call into question the current allocation of water resources. With increasing frequency, policy makers are asked to decide how to equitably transfer water rights from the agricultural sector to competing sectors. One popular method often considered is the voluntary retirement (rights are procured by willing buyers, from willing sellers) of agricultural water rights. Unfortunately the literature in this area is limited. As a result, this section will review not only the voluntary retirement of agricultural water rights, but also comparable voluntary retirement programs in other areas.

The Food Security Act of 1985 authorized the Conservation Reserve Program (CRP). The CRP program is a voluntary cropland retirement program aimed at removing environmentally sensitive lands from production. In this program the government agrees to rent land (based on a fair market bid process), and the land owner agrees to remove the land from crop production for 10 years and maintain a variety of conservation measures. Konyar and Osborn (1990) applied a discrete choice model to evaluate the determinants of participation. The authors found that as the difference between expected crop production income and the CRP payment increased, producers were less willing to participate in the program. Additionally, as the value of the land increased or as the age of the land owner increased, the probability of participation decreased. The probability of participation increased as land quality decreased, or for absentee landowners.

During the 1970s and 1980s a combination of government agricultural policies and high grain prices led to the rapid conversion of pastureland to cropland in the Canadian Prairie Potholes region. This conversion resulted in the destruction of significant amount of waterfowl habitat. In 1986 a joint US and Canadian effort was implemented with the goal of restoring this habitat. Producers were encouraged, by monetary incentives and moral persuasion, to restore 40 acre plots to dense nesting cover located on prime agricultural land. Kooten and Schmitz (1992) evaluate the program and determined that it failed because the economic incentives offered to the agricultural producers were inadequate. They concluded that moral persuasion could not be used as a replacement for monetary incentives.

In 1990 Congress passed Public Law 101-618, which authorized the purchase of agricultural water rights in the Lahontan Valley of Nevada. This was a result of rapidly declining wetlands and migratory bird populations in the area. The procurement of the rights was carried out through a cooperative effort between the United States Fish and Wildlife Service (USFWS), the state of Nevada, and The Nature Conservancy (TNC). Water rights were purchased at a fair market value of approximately $500 per acre foot of water allocation. If the water rights were sold with its appurtenant land the fair market value was approximately $1750 per acre. As of 1997 approximately 40 water rights had been transferred, accounting for 18,960 acre feet of water allocation.

Using a discrete choice model, Ise and Sunding (1998) evaluated the characteristics of water right holders that sold their rights to the government in the Lahontan Valley project. The authors found that the probability of selling was statistically increased if the seller had significant off farm income, low annual farm income, a high discount rate, a short planning horizon, and expressed a low consumption value of farming. In a qualitative evaluation the authors found that those agents who refused to sell were most concerned about the potential for the government to receive a financial windfall by reselling the water rights to municipal and industrial concerns.

Estimating the Value of Water

Modeling the demand for water generally yields a quantitative measure of water use. Modeling the value of water assigns a monetary price to the quantity. As the demand for water has increased and supplies have decreased the need to ensure efficient use and/or efficient reallocation of water resources has increased. As a result, a body of literature has developed for estimating the value of water. Unfortunately there is no well-defined market for water. Additionally water rights are fuzzy, and as a result, the reallocation of these rights is difficult due to technical, legal and political constraints. The absence of a well functioning market for water creates two problems. First, efficiency gains are lost due to the difficulty of reallocation and second, price signals necessary for reallocation are absent.

Economic models used to estimate the value of water fall into two classes. The first class uses observed market data to estimate the value of water. Typically, hedonic modeling techniques are used to quantify the impact that various hydrological factors have on the observed price of irrigated land. The second method, commonly referred to as the income approach, uses crop yields, crop prices, fixed cost, and variable cost of production to estimate the value of the marginal product of water in the production process.

It is a commonly held belief that if there is a market for water rights, separate from the associated land market, the allocation of water will be Pareto optimal (no one can be made better off without making someone worse off) and the market will be efficient. A portion of Weld County, Colorado was used to test this hypothesis. In this area, water rights, defined as share ownership in ditch companies, could be traded without transferring the title of the associated land. Crouter (1987) hypothesized that where laws and institutions permit separate water transfers, the hedonic priced function would be separable and linear in water. The resulting Box-Cox hedonic model, as a function of land quantity, water quantity and distance to the nearest town, suggested that the land/water markets were neither separable nor competitive. The authors suggested that this counterintuitive result was due to high transaction costs. The implicit value of water rights was estimated as $79.11 per acre. The author did not provide data on the acre feet allocation per year.

As aquifer levels decline and irrigated cropland reverts to dry land production, one important economic impact for landowners will be a reduction in their land values. In 1965, the Fifth Circuit Court of Appeals, in United States v. Marvin Shurbet et ux., held that groundwater in the Ogallala Aquifer, in the southern high plains of Texas and New Mexico, was a depletable mineral and natural deposit (McEowen and Harl, 2004). To qualify for this depletion allowance, aquifer drawdown had to be measured by state representatives. Torell, Libbin, and Miller (1990) used hedonic methods to place a dollar value on this drawdown. The research used data obtained from the Farm Credit Service and included farm sales from Colorado, Kansas, Nebraska, New Mexico, and Oklahoma for the 1979-1986 time period. Independent variables included a measure of income generating potential of the land, annual precipitation, depth to water, annual aquifer recharge, and a volumetric measure of water in storage. In this study, coefficient estimates, on measures of water depth and water in storage, proved statistically significant in explaining land price. The authors point out that this is contrary to findings of Hartman and Taylor (1989) and Sunderland, Libbin, and Torell (1987).

In the Torell, Libbin, and Miller (1990) study two models were estimated, one for irrigated land and one for non-irrigated land. The value of water per acre foot was the difference between the two estimates, divided by the total water in storage. Water values varied across regions between $8.35 and $1.52 per foot of saturated thickness. A consistent finding across all regions was that the per-acre difference in value between irrigated and non-irrigated was declining over time. As a result, per acre water values declined overtime. The causes of these declines in value were declining water levels and increased cost of pumping. Additionally, it was noted that higher water values tended to occur in areas where dryland production was severely limited due to the lack of natural rainfall.

There is an active market for water rights trading in the South Platte River Basin of Colorado. The demand for water, generated by population growth in metropolitan areas, has enticed producers of agricultural commodities to sell their shares in ditch companies. Goodman and Howe (1997) used hedonic techniques to value these water rights. The authors considered only those transactions where land was not transferred with the water right. Evidence suggests that the share price of a ditch company could be explained by the size of the share (appropriated quantity), the reliability of the share (seniority), and the transportation losses to the new diversion point. Surprisingly, the value of a share was not dependent upon the price of agricultural commodities, and was statistically different between competing purchasers. While not discussed by the authors, these two points might imply that the market for water rights is not necessarily competitive.

Faux and Perry (1999) recognized that the observed sale price of irrigated land represented a bundled good which includes the value of land and the value of water. Incorporating this hypothesis, they used hedonic methods to estimate the implicit value of water. The study focused on the value of surface water rights, from several ditch irrigation districts in Malheur County Oregon, for the period 1991-1995. The authors assumed that the price difference between irrigated land and non-irrigated land, divided by the average annual water use of 3.5 acre-feet per year, represented the value of water. Statistical analysis showed that the value of this water depended on the Natural Resource Conservation Service land classification. Water values ranged from $9 per acre foot to $44 per acre foot per year. The present value of water rights, on a per acre basis, ranged from $514 to $2551. Land with a higher productive classification had higher values of water.

The Docking Institute of Public Affairs (2001) estimated that the total economic impact of an acre foot of water in the Southwest Kansas Groundwater Management District Number Four was approximately $80 per acre foot on an annual basis.

In conclusion, we see that the value of water for agricultural purposes depends upon the spatially fixed, site-specific characteristics of the land on which the water is used. These factors include water source, soil type, crop type, depths to water, saturated thickness of the aquifer, the seniority level of the right, and local precipitation.

Valuing Water Rights Based on the Fair Market Value Approach

The fair market value approach assumes that the value of water rights is represented by the price differential between irrigated cropland and non-irrigated cropland as observed in the marketplace. Table 1 provides time series data obtained from the Kansas Agricultural Statistic Service (KASS) on the value of irrigated land, non-irrigated land, and the differential, defined as the value of water. Table 2 provides comparable data obtained from the Property Valuation Division of the Kansas Department of Revenue (PVD). Both the magnitude and time trend are comparable between the two data sources. These data provide several counterintuitive results. As the saturated thickness of the Ogallala Aquifer decreases and the cost of extracting water increases we would expect to see the value of water decline. Surprisingly, contrary to conventional wisdom and published literature the value of water appears to be increasing in both nominal (5.3% per year) and real (2.3% per year) terms. One possible explanation is that the rate of technological advancement in water use efficiency and crop production is increasing the value of the remaining stocks of water faster than the aquifer is being depleted.

Economic theory would also imply that the district with the lowest annual rainfall, lowest nonirrigated crop yields, and highest irrigated crop yield would have the highest value of water. This theory would imply that the value of water in SW-30 should be the highest; however, the data indicate that NW-10 has the highest water value. It is hypothesized that this discrepancy is due to the fact that the majority of irrigation in NW-10 uses center pivot technology, which is sold with the land, while SW-30 has a higher percentage of flood irrigation and leased center pivots, which would add little value to the price of irrigated land. Additionally, it should be noted that, on average, irrigated parcels in SW-30 tend to be substantially larger than the other two CRDs. As tract size increases the price per acre of land typically decreases.

Quantitative measures on specific tracts of land can be obtained through either a conventional appraisal, by a qualified agent, or through hedonic models as often applied by the economics profession. Both methods offer the advantage of being based on observed market data and thus are appealing to all stakeholders.

While local market participants probably would prefer appraisal by agent, this process is not without its shortcomings. The literature reveals that the value of water rights is to a large part determined by the stock and flow characteristics of the existing water well, that is, the flow capacity of the well, the depth of water, and the remaining saturated thickness. It is doubtful that local appraisal agents would be familiar with these components or capable of evaluating their relative worth when applying the comparative method to property valuation.

The appraisal by agent method also is limited by the availability of comparative sales necessary to complete the process. Golden and Tsoodle (2004) have illustrated that the market for irrigated cropland in Western Kansas can be categorized as thin and thus potentially volatile. Using the year 1999 and Crop Reporting District NW-10 as an example, they found that, while 126,100 acres of farm land were sold, only 22.2% were classified as fair market value sales. The remaining sales were primarily forced sales and sales to relatives. Of the roughly 28,000 acres of fair market sales, approximately 9.1%, or 2,550 acres was irrigated land. If this irrigated acreage were equally divided among the eight counties in CRD NW-10, we would estimate that only 300 acres of irrigated land per county, classified as a fair market transaction, sells each year.

The hedonic appraisal technique allows for the unbiased estimate of the value of water rights based both on the conventional site-specific characteristics as well as hydrological characteristics. The hedonic technique assumes that the value of a product is equal to the sum of the value of the product's component parts. The estimation of the value of water rights could be conceptualized as a three-stage hedonic process. In the first step the value of non-irrigated land is estimated as a function of its site-specific characteristics:

$$SPA_{NI} = \beta_1 + \sum_{i=4}^{n} \beta_i Control_i \ ,$$

where SPA_{NI} is the observed sale price per acre of non-irrigated land. The parameter estimates on β_I would represent the average value of nonirrigated land after other factors are controlled for. *Control* variables would include such things as soil type, population density, local rainfall, total acres in the sale, access quality, irrigation technology, etc. The first stage estimation process of our proposed model generates an estimate of the implicit price of non-irrigated land. In the second stage, the sales price of each observed sale of irrigated land is estimated based on its nonirrigated value. The difference between the irrigated parcels' observed sales price (SPA_I) and its estimated nonirrigated value (SPA_{NI}) represents the implicit value of the water right (*VWR*)

$$VWR = SPA_I - SPA_{NI}\ .$$

In the third stage of the model the differential between these two components, defined as the value of water rights, can then be estimated as a function of the specific hydrological characteristics:

$$VWR = \beta_0 + \beta_1 GPM + \beta_2 SWL + \beta_3 ST + \beta_4 SR\ ,$$

where *VWR* is the value of the water rights, *GPM* is the gallons per minute per acre capacity of the well, *SWL* is the static water level, *ST* is the remaining saturated thickness, and *SR* is the seniority level of the water right.

The data necessary to generate a hedonic model are currently available from a variety of state and private agencies. Since 1985, when Use-Value Appraisal for agricultural land in Kansas was adopted, the Property Valuation Division (PVD) of the Kansas Department of Revenue (KDR) has maintained extensively detailed sales records for each parcel of land in Kansas. Kansas statutes require any land transaction be reported to the KDR. The County Appraiser, using a standardized method, collects these data and provides them to KDR on an annual basis.[1] The data contain information on parcel identification number, county number, sales class, certificate of value, month, year, sale type, sales price, sales validity code, agriculture use type, soil mapping unit, agriculture size, acres, agricultural use-value, building value, topographical codes, utility codes, and access codes. Definitions and descriptions of these codes are contained in KSCAMA Residential/Agricultural Data Collection Course 1-104-2. The Water Information Management and Analysis System (WIMAS) data set compiled by the Kansas Division of Water Resources and data sets available from the Kansas Geological Survey contained the necessary data on well capacity,

[1] KSCAMA Residential/Agricultural Data Collection Course 1-104-2

technology parameters, depth to water, and saturated thickness. At the present time researchers in the Department of Agricultural Economics at Kansas State University, in cooperation with various state agencies, are working toward the development of a suitable hedonic model for valuing water in Western Kansas.

Valuing Water Rights Based on the Income Approach

The income approach assumes that the value of land is the discounted net present value of the future income stream accruing to the property. The value of water rights is then represented by the income differential between irrigated cropland and non-irrigated cropland. To quantify the differential, income and expense data are obtained and differentiated by region, crop type, soil type, and water source characteristics. By assuming a landlord's share of this income differential, growth rates for income and expense categories, and a capitalization rate, the current value of water rights can be calculated. This method has been used by Golden, Tsoodle, and Kastens (2003) to quantify the impact of limited irrigation on landlord net income for the Property Valuation Division of the Kansas Department of Revenue. Dhuyvetter, Golden, and Kastens (2003) used a similar method to generate estimates of the value of water rights in Western Kansas for the Kansas Water Office.

There are several advantages to the income approach to valuing water rights. Data availability is excellent. The State of Kansas maintains extensive databases relative to income and expenses delineated by location, soil type, irrigation method, well capacity, and water depth. Additionally, the methods used to calculate landlord net income (LNI) are currently being used by other state agencies, and as a general rule accepted by the public.

There are several disadvantages to the income approach. Since the estimation of the value is normally based on aggregate level data, the results may not be applicable to specific parcels of land. The method assumes that a parcel of irrigated land will maintain its income stream indefinitely. This may not be the case in areas where saturated thickness has reached critical levels. Also, appropriate capitalization rates and expected future growth rates in production are a matter of subjective opinion. And finally, the specification of which income variables to include in the calculations can sometimes be controversial. As an example, government program payments are not included as income for property tax appraisals, but generally viewed as being capitalized into the value of land.

In order to implement the income approach to water valuation and determine the impact that irrigation has on LNI, two questions need to be answered. First, what is the impact of water use on crop yield, and second, what is the impact of yield on LNI? It is generally accepted that water has a diminishing marginal effect on crop yield, and an asymptotic plateau functional form is often used to model this relationship (crop yield increases with more water, but at a diminishing rate, and eventually plateaus). In order to fit an asymptotic plateau, depicting the relationship between yield and water use, it was necessary to generate or derive data consistent with our objectives.

The required data are generated through a process of deductive reasoning. The first data point was obtained based on the assumption that if there is no water available for irrigation, then the crop yield will be the average non-irrigated yield for that crop in the district. The second and third data points were generated based on data provided by the Department of Biological and Agricultural Engineering at Kansas State University, which identifies the initial yield response to water. The fourth data point was identified based on the assumption that the average irrigated yield for a crop was generated based on the average water use for that crop. The fifth data point is based on the water requirement for optimal production as per the Natural Resource

Conservation Service. The maximum average yield was based on a survey of Extension Economists. The process is summarized in Figure 3. This process of data generation yields five data points for the five primary crops in the three Western Crop Reporting Districts in Kansas. Non-linear least squares estimation techniques were used to fit an asymptotic plateau to this data. The asymptotic plateau was constrained to pass through data points one and four:

$$
\begin{aligned}
&Yield = \alpha(1-\gamma e^{-\beta x}) \\
&x = Water\ Use \\
&\alpha = DY/(1-\gamma) \\
&\beta = (-AGPM^{-1})\left[\ln\left[(1-AIY(1-\gamma)DY^{-1})/\gamma\right]\right] \\
&DY = Dryland\ Yield \\
&AIY = Average\ Irrigated\ Yield \\
&AGPM = Average\ GPM
\end{aligned}
$$

After estimating the impact that well capacity has on crop yield, LNI can be calculated for irrigated land based on the specific gallons per minute capacity of the well:

$$LNI^{*}_{kj} = \left[\left[\sum_{i=1}^{5}(P_{ij}\cdot Y^{*}_{ij}\cdot LSI_{j} - V^{*}_{ij}\cdot LSE_{j})CS_{ij}\right]PI_{k} - LSF^{*}_{j} + LSGP^{*}_{j}\right]$$

$LNI_{kj} = Landlord\ Net\ Income\ (\$/ac)\ for\ landowner\ k\ in\ district\ j$

$\quad j = 1, \ldots, 6\ (western\ crop\ reporting\ districts)$

$P_{ij} = Price\ (\$/bu)\ of\ crop\ i\ in\ district\ j\ \ (Kansas\ Agricultural\ Statistics)$

$\quad i = 1, \ldots, 5\ (corn, milo, wheat, soybeans, alfalfa)$

$Y_{ij} = Yield\ (bu/ac)\ of\ crop\ i\ in\ district\ j\ \ (Kansas\ Agricultural\ Statistics)$

$LSI_{j} = Landlord\ Percent\ Share\ of\ Income\ in\ district\ j\ \ (survey)$

$V_{ij} = Variable\ Expenses\ (\$/ac)\ for\ crop\ i\ in\ district\ j\ \ (survey)$

$LSE_{j} = Landlord\ Percent\ Share\ of\ Expenses\ for\ crop\ i\ in\ district\ j\ \ (survey)$

$CS_{ij} = Crop\ Share\ Percentage\ of\ crop\ i\ in\ district\ j\ \ (Kansas\ Agricultural\ Statistics)$

$PI_{k} = Productivity\ Index\ of\ land\ for\ landowner\ k\ \ (KIPI)$

$LSF_{j} = Landlord\ Percent\ Share\ of\ Fixed\ expenses\ district\ j\ \ (survey)$

$LSGP_{j} = Landlord\ Percent\ Share\ of\ Government\ Payments\ district\ j\ \ (survey)$

$* = Adjustment\ based\ on\ flow\ capacity\ of\ the\ well\ and\ associated\ yield\ adjustment.$

Within this formulation, the income components associated with crop yield and government payments are based on the flow capacity of the well. Additionally, the variable expenses associated with fertilizer, seed, harvesting, and pumping are adjusted based on yield expectations. The difference between irrigated landlord net income at various well capacity levels and the landlord net income based on dryland production define the yearly value of water. Dividing this quantity by a capitalization rate yields the expected value of the water right as illustrated in Table 3.

The income approach yields results consistent with the belief that the more productive a unit of water is, the higher its associated value will be. As a result, Table 4 illustrates that, on average, the value of water in SW-30 is higher than the other two CRDs.

Conclusion

The implementation of the Water Rights Transition Act will require the development of fair and equitable means of appraising the value of water rights. In order to accomplish the program goals this appraisal method should incorporate information on the stock and flow characteristics of the existing water well. Specifically, the method should account for the gallons per minute flow capacity of the well, the static water level, current decline rates, and the remaining saturated thickness. The existing market data on the value of irrigated land are limited in nature, and in all likelihood do not do an adequate job of valuing the hydrological characteristics of the property. Both the hedonic and income approach to valuing these characteristics offer the potential of supplementing existing market data.

References

Crouter, J.P. “Hedonic Estimation Applied to a Water Rights Market.” *Land Economics*. August, 1987. 63(3):259-271.

Docking Institute of Public Affairs. 2001. “The Value of Ogallala Water in Southwest Kansas.” Hays, Kansas: Docking Institute of Public Affairs.

Dhuyvetter, K., B. Golden, and T. Kastens. 2003. “Brief analysis of the value of irrigation water in Western Kansas.” Unpublished White Paper.

Faux, J., and G.M. Perry. “Estimating Irrigation Water Value Using Hedonic Price Analysis: A Case Study in Malheur County, Oregon.” *Land Economics*. August, 1999, 75(3): 440-452.

Golden, B., L.Tsoodle, and T. Kastens. “Landlord Net Income Estimation Under Limited Irrigation.” Unpublished White Paper.

Golden, B., and L. Tsoodle. 2004. “Data on Agricultural Land Sales in Kansas.” Kansas State University, Department of Agricultural Economics, Extension Bulletin

Goodman, D.J., and C.W. Howe. “Determinants of Ditch Company Share Prices in the South Platte River Basin.” *American Journal of Agricultural Economics*. 79(1997): 946-951.

Hartman, L. M. and G. Taylor. 1989. “Irrigated Land Values in Eastern Colorado: An Analysis of Farm Sale Prices for Pumped Irrigated Land Overlying the Ogallala Aquifer.” Colorado State University, Agricultural Experiment Station, Technical Bulletin LTB89-1.

Ise, S., and D.L. Sunding. “Reallocating Water from Agriculture to the Environment under a Voluntary Purchase Program.” *Review of Agricultural Economics*. 1998. 20(1): 214-226.

Konyar, K. and C.T. Osborn. “ A National Level Economic Analysis of Conservation Reserve Program Participation: A Discrete Choice Approach.” *The Journal of Agricultural Economics Research*. 42(1990): 5-12.

Kooten, G.C. and A. Schmitz. “ Preserving Waterfowl Habitat on the Canadian Prairies: Economic Incentives Versus Moral Suasion.” *American Journal of Agricultural Economics*. 74(1992): 79-89.

McEowen, R.A., and N.E. Harl. <u>Principles of Agricultural Law</u>. Eugene, Oregon: Agricultural Law Press, 2004.

Sunderland, D. H., J. D. Libbin, and L. A. Torell. 1987. “Estimated Water Value for Tax Depletion Allowance in New Mexico.” New Mexico State University, Agricultural Experiment Station, Research Report 559.

Torell, L. A., J. D. Libbin, and M. D. Miller. “The Market Value of Water in the Ogallala Aquifer.” *Land Economics*. May, 1990. 66(2): 163-175.

Tables

Table 1. Prices for Irrigated and Non-irrigated Land in Western Kansas (Source: Kansas Agricultural Statistic Service)

	Irrigated			Non-Irrigated			Value of Water		
YEAR	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30
1980	$930	$889	$894	$551	$484	$483	$379	$405	$411
1981	$1,051	$976	$939	$625	$554	$502	$426	$422	$437
1982	$1,050	$916	$943	$592	$560	$545	$458	$356	$398
1983	$977	$885	$870	$612	$529	$485	$365	$356	$385
1984	$951	$874	$861	$544	$545	$487	$407	$329	$374
1985	$721	$657	$780	$426	$429	$437	$295	$228	$343
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	$716	$623	$759	$434	$383	$434	$282	$240	$325
1990	$780	$690	$783	$448	$409	$428	$332	$281	$355
1991	$744	$663	$725	$434	$412	$411	$310	$251	$314
1992	$747	$690	$747	$418	$411	$405	$329	$279	$342
1993	$829	$646	$730	$442	$394	$395	$387	$252	$335
1994	$889	$702	$753	$480	$426	$445	$409	$276	$308
1995	$1,188	NA	$772	$536	NA	$458	$652	NA	$314
1996	$1,141	$705	$884	$526	$437	$430	$615	$268	$454
1997	$1,140	$775	$900	$530	$440	$430	$610	$335	$470
1998	$1,090	$820	$930	$525	$435	$420	$565	$385	$510
1999	$1,110	$825	$935	$520	$440	$420	$590	$385	$515
2000	$1,120	$835	$945	$525	$445	$430	$595	$390	$515

Table 2. Prices for Irrigated and Non-irrigated Land in Western Kansas (Source: Property Valuation Division of the Kansas Department of Revenue)

	Irrigated			Non-Irrigated			Value of Water		
YEAR	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30
1986	$562	$574	$779	$359	$342	$318	$203	$232	$460
1987	$755	$576	$937	$358	$313	$341	$397	$263	$596
1988	$840	$519	$731	$381	$341	$373	$460	$178	$358
1989	$703	$790	$737	$398	$352	$414	$306	$437	$323
1990	$821	$472	$852	$412	$372	$381	$409	$100	$470
1991	$790	$607	$792	$403	$363	$362	$388	$244	$430
1992	$755	$588	$731	$424	$365	$373	$331	$223	$358
1993	$859	$1,110	$881	$400	$374	$365	$459	$736	$516
1994	$808	$710	$770	$432	$400	$376	$377	$309	$395
1995	$933	$577	$817	$466	$390	$370	$467	$187	$447
1996	$1,082	$849	$791	$480	$399	$397	$602	$450	$394
1997	$1,097	$614	$929	$479	$415	$398	$618	$199	$531
1998	$1,203	$1,066	$895	$512	$461	$403	$692	$605	$492
1999	$1,304	$882	$1,074	$512	$431	$440	$792	$450	$634
2000	$1,607	$782	$1,014	$518	$459	$442	$1,089	$322	$572

Table 3. The Value of Water at Different Well Capacities Based on the Income Approach (based on 8% capitalization rate)

Well Capacity GPM/AC	Irrigated LNI			Non-Irrigated LNI			Annual Value of Water			Value of Water Rights		
	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30	NW-10	WC-20	SW-30
2	$45.66	$45.14	$53.48	$23.12	$14.78	$16.38	$22.54	$30.36	$37.10	$281.70	$379.46	$463.76
2.25	$47.41	$46.14	$55.62	$23.12	$14.78	$16.38	$24.29	$31.36	$39.24	$303.61	$391.98	$490.51
2.5	$49.16	$47.14	$57.76	$23.12	$14.78	$16.38	$26.04	$32.36	$41.38	$325.53	$404.50	$517.25
2.75	$50.70	$47.99	$59.71	$23.12	$14.78	$16.38	$27.58	$33.21	$43.34	$344.79	$415.17	$541.72
3	$52.24	$48.85	$61.67	$23.12	$14.78	$16.38	$29.12	$34.07	$45.30	$364.05	$425.85	$566.20
3.25	$53.60	$49.57	$63.47	$23.12	$14.78	$16.38	$30.47	$34.79	$47.09	$380.94	$434.92	$588.64
3.5	$54.95	$50.30	$65.26	$23.12	$14.78	$16.38	$31.83	$35.52	$48.89	$397.83	$443.98	$611.09
3.75	$56.13	$50.91	$66.91	$23.12	$14.78	$16.38	$33.01	$36.13	$50.54	$412.60	$451.63	$631.71
4	$57.31	$51.52	$68.56	$23.12	$14.78	$16.38	$34.19	$36.74	$52.19	$427.38	$459.28	$652.34
4.25	$58.34	$52.03	$70.08	$23.12	$14.78	$16.38	$35.22	$37.25	$53.71	$440.26	$465.68	$671.35
4.5	$59.37	$52.55	$71.61	$23.12	$14.78	$16.38	$36.25	$37.77	$55.23	$453.15	$472.09	$690.36
4.75	$60.28	$52.97	$73.02	$23.12	$14.78	$16.38	$37.16	$38.20	$56.65	$464.55	$477.45	$708.10
5	$61.20	$53.40	$74.44	$23.12	$14.78	$16.38	$38.08	$38.63	$58.07	$475.96	$482.81	$725.84
5.25	$62.00	$53.78	$75.79	$23.12	$14.78	$16.38	$38.88	$39.00	$59.41	$486.04	$487.52	$742.64
5.5	$62.81	$54.16	$77.13	$23.12	$14.78	$16.38	$39.69	$39.38	$60.76	$496.11	$492.22	$759.45
5.75	$63.60	$54.46	$78.38	$23.12	$14.78	$16.38	$40.48	$39.69	$62.00	$505.99	$496.08	$775.03
6	$64.39	$54.77	$79.63	$23.12	$14.78	$16.38	$41.27	$39.99	$63.25	$515.86	$499.93	$790.61
6.25	$65.23	$55.18	$80.50	$23.12	$14.78	$16.38	$42.10	$40.41	$64.12	$526.31	$505.07	$801.49
6.5	$66.06	$55.60	$81.37	$23.12	$14.78	$16.38	$42.94	$40.82	$64.99	$536.76	$510.20	$812.37
6.75	$66.20	$55.98	$81.52	$23.12	$14.78	$16.38	$43.08	$41.21	$65.14	$538.47	$515.07	$814.31
7	$66.34	$56.37	$81.68	$23.12	$14.78	$16.38	$43.22	$41.59	$65.30	$540.19	$519.94	$816.25
7.25	$66.34	$56.72	$81.72	$23.12	$14.78	$16.38	$43.22	$41.94	$65.34	$540.27	$524.23	$816.77
7.5	$66.35	$57.06	$81.76	$23.12	$14.78	$16.38	$43.23	$42.28	$65.38	$540.35	$528.52	$817.29

Table 4. The Average Value of Water Based on the Income Approach (based on 8% capitalization rate)

CRD	GMD	Average Well Capacity (gpm)	Average GPM/Ac	Average Value of Water/Ac
NW-10	4	523	4.3	$442.84
WC-20	1	332	3.2	$433.11
SW-30	3	712	4.2	$667.54

Figures

Figure 1. Crop Reporting Districts

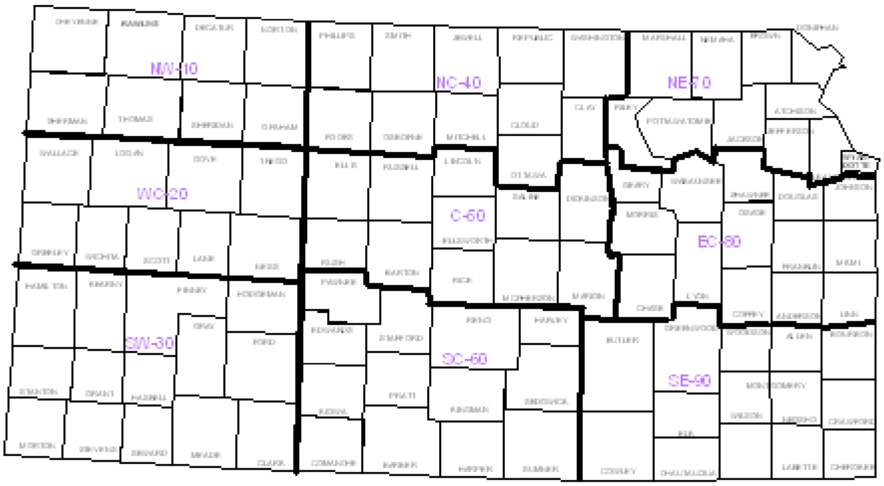


Figure 2. Groundwater Management Districts

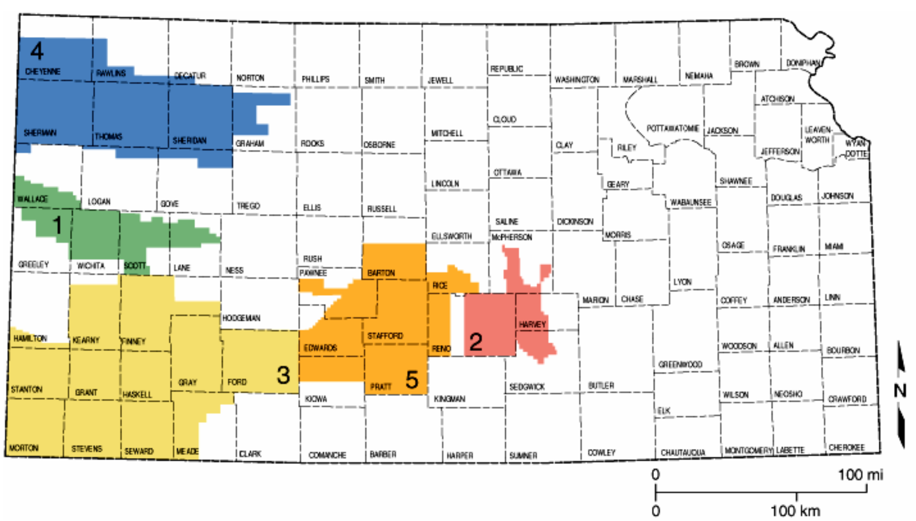
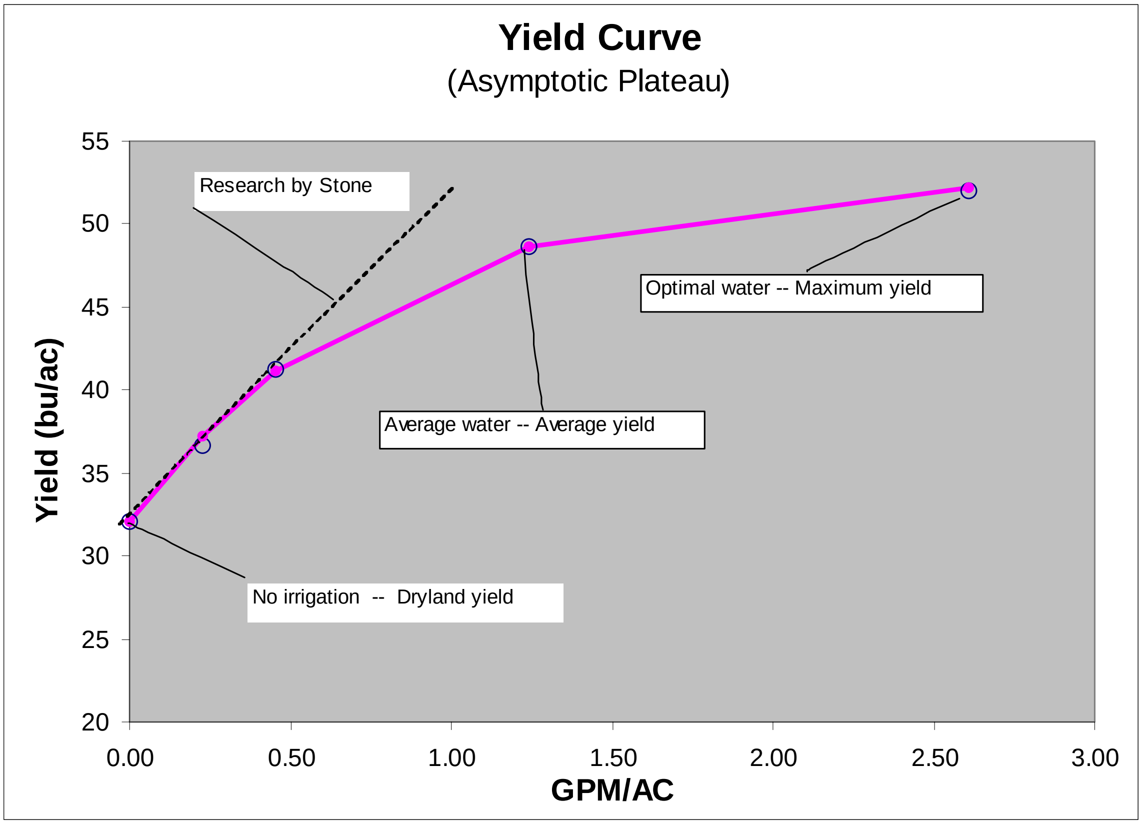


Figure 3. Derivation of the Impact of Well Capacity on Crop Yield


Yield Curve
(Asymptotic Plateau)
Yield (bu/ac)
55
50
45
40
35
30
25
20
0.00
0.50
1.00
1.50
2.00
2.50
3.00
GPM/AC
Research by Stone
Optimal water -- Maximum yield
Average water -- Average yield
No irrigation -- Dryland yield