Natural Gas Price Impact on Irrigated Agriculture Water Demands

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Executive Summary

Rising natural gas price has lead to a noticeable decrease in irrigation; however, the magnitude of the reduction in water pumped was unknown. The primary objective of this project was to estimate the reduction in irrigation water pumped resulting from high natural gas prices in Region A in an effort to determine whether a more rigorous study is warranted in the future to refine projected water use estimates for future water planning efforts.

Farm Service Agency (FSA) irrigated acreage data were utilized to analyze change in crop composition and abandonment scenarios. Crops were placed into eight major crop categories including corn, wheat, sorghum, cotton, soybeans, peanuts, hay, and pasture and other. The years having a January natural gas price below $3.00 were grouped together as the "low price years" and included 1998, 1999, 2000, and 2002. The years where the January price was above $3.00 were grouped together and designated the "high price years" and included 2001, 2003, and 2004. These two groups were then compared and contrasted for changes in crop composition and abandonment due to rising natural gas prices.

Overall, water pumped for irrigation in Region A was estimated to decrease 17.8 percent from the low natural gas price years to the high natural gas price years. Of this total decrease, changing crop composition accounted for 2.3 percent, crop abandonment 4.1 percent with the remaining 11.4 percent being attributed to lower water use by crop. The reduction in water pumped on irrigated crops over the 60-year planning horizon is expected to total 1.67 million acre-feet. Realistically, these estimates understate what the total reduction in irrigation would be over time. High natural gas prices will reduce the number of producers able to cover their fixed cost associated with irrigated production. As crop specific and irrigation equipment gets older and begins to wear out, they may consider producing lower water use crops or may not be able to economically justify replacing irrigation equipment increasing the level of abandonment from what was estimated.

The change in water pumped in high natural gas years is significant enough to warrant additional study despite the forecast that natural gas prices will moderate somewhat in the future. A more sophisticated study that includes additional years of data, more data on water use by crop, factors in rainfall, identifies/evaluates fixed and variable costs associated with irrigation, and takes into account the impact of crop prices on irrigation water use is necessary for a better projection of how natural gas prices will affect crop composition, abandonment, and water use. In addition, the full impact

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analysis needs to be conducted on a county level basis to be more useful to the Region A water planning group.

Introduction

Population in the United States has increased from 23 million to over 221 million since 1870. Coupled with industrial growth, we now use 33 times more energy than we used 130 years ago (Natural Gas Facts, 2004). Today, we are more dependent upon energy than ever before. Natural gas is a very important component of the energy mix and is a driving force in our economy, heats American homes, and plays a vital part in U.S. agriculture. Natural gas meets one-fourth of the United States' total energy needs (AGA, 2004). In agriculture, natural gas represented four percent of the total energy consumed on U.S. farms in 2002 (Miranowski, 2004).

Volatility in natural gas prices has had a noticeable impact on agriculture. Agriculture Secretary Ann Veneman stated, "Price volatility in natural gas and liquid petroleum gases such as propane impacts farmers who rely heavily on heating, drying and irrigation, and affects the cost of other energy intensive inputs such as fertilizers and pesticides." High natural gas prices have had a huge impact on the price of nitrogen fertilizers and the fertilizer industry in general. Natural gas accounts for 75 to 85 percent of the cost of producing anhydrous ammonia (Fee, 2003). As a result, the price spike in 2000 and 2001 led to a 25 percent reduction in domestic production of nitrogen and a 43 percent increase in nitrogen imports (GAO, 2003). According to The Fertilizer Institute, 15 nitrogen production facilities representing more than 22 percent of U.S. capacity have closed since 2000.

In addition to high fertilizer prices, farmers who rely on natural gas for irrigation must also deal with increased irrigation cost. In today's dynamic environment, farmers must be willing to change and adapt in order to be successful. Due to the spike in natural gas prices, many farmers have adapted by limiting irrigation or changing their cropping pattern.

Scope of Work

In the Texas Senate Bill 1 (1997) planning effort it was determined that 89 percent of current and 86 percent of projected water use was by irrigated crop production. Several of the heavily irrigated counties were not projected to meet the current maximum 1.25 percent annual depletion rate recommended by the Region A water planning group. However, conditions may have changed. Fluctuating natural gas prices have had a noticeable impact on agricultural irrigation water demands. Natural gas price spikes starting in 2000 and 2001 have led to changes in crop composition, water use, and therefore, future water supplies in the region.

Natural gas is the major source of energy used to power irrigation pumps in Region A and is an important factor in determining irrigation costs. Natural gas powers 28.7 percent of the irrigation wells in Texas (Marek et al., 2004). However, in Region A,

natural gas is far more important. It is estimated that 60 percent of the irrigation wells are powered by natural gas and these wells account for 80 percent of all irrigation water pumped (New, 2004-personal communication).

In the summer of 2000, natural gas prices more than doubled, leading producers to limit irrigation and alter crop composition to favor lower water use crops for the 2001 season. Prices retreated during late summer of 2001 to previous levels before more than doubling in late in 2002 and have remained at that level through 2004. This phenomenon had also occurred once in the early 1980s where natural gas prices declined in the subsequent years.

The escalating natural gas prices are currently having an adverse affect on irrigated producer profitability. For example, the estimated cost of natural gas used for irrigating corn in the region rose from $78.40/acre to $140.00/acre from 2003 to 2005 (Amosson et al., 2004). Similarly, the cost of anhydrous fertilizer used in corn production increased from $20.80/acre to $38.00/acre while the projected price for corn remained unchanged.

While it is widely known that a change in water use is occurring, the magnitude of this change is unknown. The overall objective of this study is to quantify the impact on irrigated water use demand in Region A that has occurred as a result of natural gas prices. Results of this study could have implications to current as well as future water planning efforts in the region. Specific objectives of this regional study are to:

A. Evaluate the change in crop composition, abandonment and water use by crop due to rising natural gas prices;
B. Estimate and project the change in water use due to higher natural gas prices;
C. Prepare a report on the findings and other identified variables affecting future water demand projections.

This report is presented in the following manner. First a discussion of the history of natural gas prices, as well as an estimate of future prices is presented. This is followed by an analysis of the impact that recent increases in natural gas prices has had on irrigation water use and these impacts are extrapolated over the entire planning horizon (2060). Furthermore, impacts are delineated and estimated by the cause of reduction, i.e., change in crop composition; irrigated acreage abandonment; and water use by crop.

Natural Gas Price History / Forecast

The New York Mercantile Exchange nearby monthly futures indicates that during the 1990s, the price of natural gas was relatively stable at around $2 per thousand cubic feet. Since the summer of 2000, however, prices have been rather volatile and have averaged about $4.75 per thousand cubic feet, with a high of $9.78 in December 2000 and a low of $2.01 in January 2002. The current trend in natural gas prices is increasing as the average price in 2003 was $5.51, whereas, the average price in 2004 was 15 percent higher at $6.31 (Figure 1).

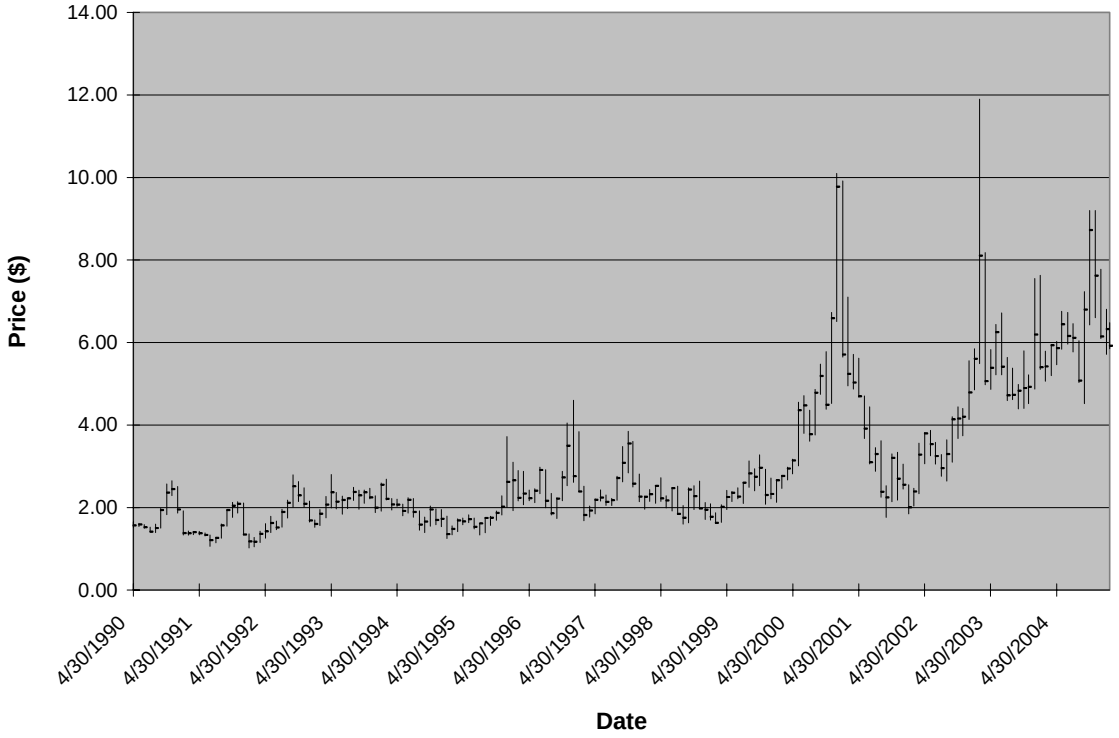

Figure 1. Natural Gas Futures Price (Nearby Monthly, 04/1990 – 02/2005).
Source: New York Mercantile Exchange

There are numerous underlying factors that have contributed to persisting high natural gas prices, most relating to supply and demand. The natural gas market is currently experiencing a tight balance between supply and demand. Natural gas is a relatively clean-burning fuel that is increasingly being used to generate electricity (AGA, 2004). Another factor that has led to increased demand is that high oil prices have caused large-volume customers to switch from other petroleum fuels to natural gas. In effect, this shift in demand to natural gas has driven prices upward (EIA, 2004).

On the supply side of this equation, production is increasing, but not at a fast enough rate to compensate for the increase in demand (Figure 2). It is important to note that the United States is not running out of natural gas resources. There is approximately 1,338 trillion cubic feet of technically recoverable natural gas resources in the U.S. as of January 1, 2003. This is expected to be sufficient to support projected production increases (EIA, 2005). However, natural gas production has been weak due to the depletion of older wells and lower production from new gas wells. According to the American Gas Association, the number of gas wells has tripled since 1971, yet production has declined. In addition, public policies that have made it difficult for energy producers to keep up with demand. Even producers that hold valid leases can experience months of delays and red tape when obtaining federal or state permits to begin production.

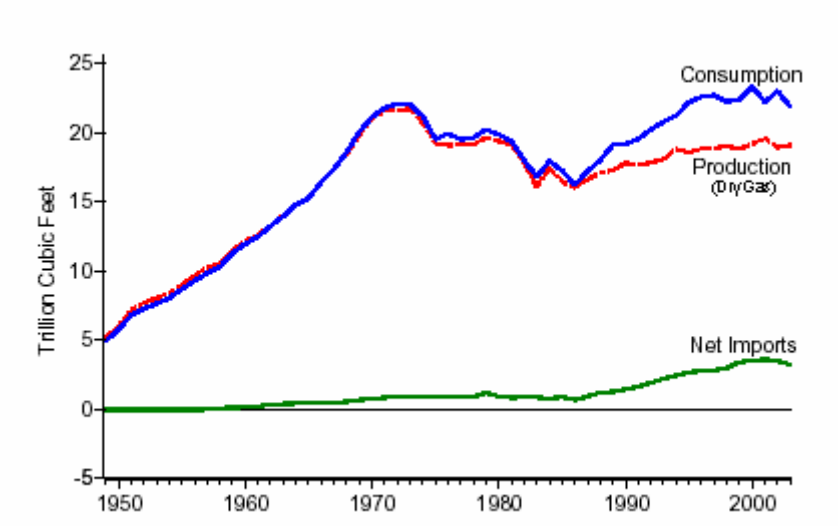

Figure 2. U.S. Natural Gas Consumption, Production, and Net Imports, 1949-2003.
Source: Energy Information Administration, 2003.

This growing imbalance between supply and demand will most likely be met with liquid natural gas imports. However, even if the United States starts permitting new import facilities today, it will take five to ten years to meaningfully increase our supply of liquid natural gas. Therefore, importation of liquid natural gas is a long-term solution, yet an important one (DPC, 2003). Currently, there are four existing liquid natural gas terminals in the United States. Three of these expect to expand by 2007 and new terminals are projected to start coming into operation in 2006. As a result, liquid natural gas imports are projected to increase from 0.4 trillion cubic feet in 2003 to 6.4 trillion cubic feet in 2025. Additional supply of natural gas is expected to come from Alaska. The North Slope Alaska natural gas pipeline is projected to start transporting Alaskan gas to the lower 48 States in 2016. Total Alaskan gas production is projected to be 2.2 trillion cubic feet by 2025 (EIA, 2005).

The feasibility of increasing natural gas imports appears realistic. Natural gas prices are significantly lower in other parts of the world. In countries with high domestic and industrial demand such as the United States and Europe, natural gas prices are higher and are $5.50 and $3.70/MMBtu, respectively. On the other hand, in regions where there is an abundant natural gas supply and demand is relatively small or where natural gas is produced as a byproduct of oil, prices are lower. This appears to be the case in regions/countries such as North Africa, Middle East, Venezuela, and Russia where prices are $0.40, $0.60, $0.70, and $0.80/MMBtu, respectively (Figure 3).

Figure 3. Natural Gas Prices, 2003 – $US/MMBtu.
Source: PotashCorp, 2004.

The Energy Information Administration's "Annual Energy Outlook 2005" projects wellhead prices[2] for natural gas in the United States generally to decrease (Figure 4). The 2003 wellhead price of $4.98 per thousand cubic feet is expected to decrease to $3.64 (2003 dollars) by 2010 as new import sources become available and drilling increases, expanding supply. Prices are then projected to increase gradually to $4.79 (2003 dollars) per thousand cubic feet in 2025 as the increase in imports and production is not expected to offset the impacts of resource depletion and increase in demand.

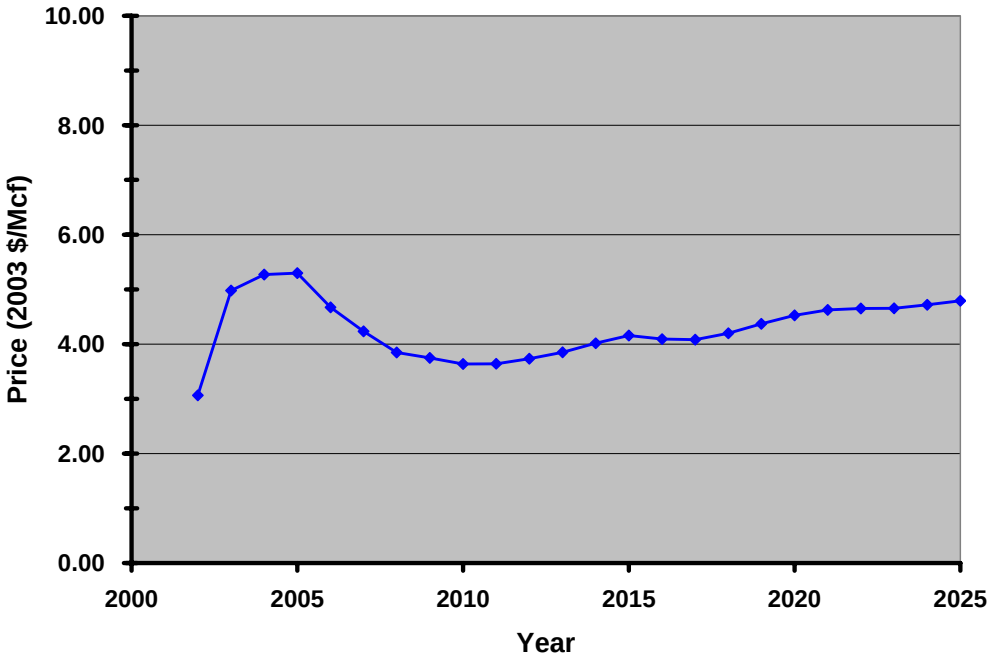

Figure 4. Forecasted Natural Gas Prices to 2025.
Source: Energy Information Administration 2005.

[2] Wellhead price is the price received by natural gas producers for marketed gas (Budzik, 2002.)

In summary, natural gas prices are expected to retreat from the current levels in the next couple of years as a sufficient number of import facilities capable of handling liquid natural gas are opened. However, due to increasing demand and the increasing cost of tapping remaining domestic natural gas reserves, it is highly doubtful that natural gas prices will ever return to the levels observed in the 1990s. Local prices (basis adjusted) are expected to drop to the $4.00 to $4.50/Mcf level before a steady gradual increase in price is expected through 2025. These prices ($4.00 to $4.50/Mcf) represent approximately a 50 to75 percent increase over the price paid in the 1990s but 50 to 75 percent under current price estimates for the 2005 season.

Data Sources and Study Methodology

This analysis evaluates the potential impacts of rising natural gas prices on irrigation water use demand in Region A. Farm Service Agency (FSA) was the source utilized for irrigated acreage data in this study. Crops were grouped into eight major crop categories including corn, wheat, sorghum, cotton, soybeans, peanuts, hay, and pasture and other. The New York Mercantile Exchange was the source used for nearby monthly natural gas futures prices. Annually, most farmers within Region A make their planting decisions in January. Accordingly, the years having a January natural gas price below $3.00 were grouped together as the "low price years" and include 1998, 1999, 2000, and 2002. On the other hand, the years with a January price above $3.00 were grouped together as the "high price years" and include 2001, 2003, and 2004. These two groups were then compared and contrasted for changes in crop composition and abandonment due to rising natural gas prices.

Similar year groupings were made of the Agri-Partner data (New, 1998-2004) to estimate the impact on water use by crop resulting from high natural gas prices. However, only years with similar rainfall data for the growing season were used. Rainfall data were taken from the National Climatic Data Center's annual climatological summaries for the Amarillo International Airport Station. As a result, the 2000 and 2002 Agri-Partner water use by crop data were grouped together for the low price years, whereas, 2001 and 2003 data were used for the high price years. Due to the differing growing season for wheat, 2003 and 2004 data were utilized for the high price years due to similar rainfall amounts received for the September through May periods. Since there was no Agri-Partner data available for water use by crop for hay and pasture and other, the water use for these crops were decreased by the same amount as corn, which was a modest decrease.

The Region A Water Use Demand Model (TAMA model, Marek et al., 2004) developed in Senate Bill 2 – Task 2 was the source used in this analysis to determine the change in total irrigation water use from the low price base years to the high price base years. It was also used to project the change in future irrigation water demand due to higher natural gas prices. To determine the change in total water use, four scenarios were analyzed. First, total water use during the low price base years was determined using the low price acreage and crop composition. Then, the low price acreage was combined with the high price crop composition to establish the effect of the change in crop composition

on total water use. Next, high price acreage and crop composition were used to determine the impact of abandonment on water use. Finally, the high price base was combined with the Agri-Partner data to identify the effect of change in water use by crop on total water use.

Results and Discussion

Total irrigation water use was evaluated for the baseline years of 1998, 1999, 2000, and 2002, which experienced relatively low natural gas prices. These years were compared to the years of 2001, 2003, and 2004, which had relatively high natural gas prices. The components that make up this change in water use were analyzed and presented on an individual basis and include change in crop composition, abandonment, and change in water use by crop. Finally, the potential impact on projected water use is presented over a 60-year planning horizon.

Crop Composition

The FSA planted irrigated acres by crop for the 21 counties in Region A are shown below (Figure 5) for the years 1998 through 2004. The initial price spikes in 2000 and 2001 did appear to alter crop composition somewhat. The most significant change as a result of higher natural gas prices was that corn acreage decreased 28 percent (163,543 acres) from 2000 to 2001. In that same time period, wheat acreage increased 7 percent and sorghum acreage increased 35 percent.

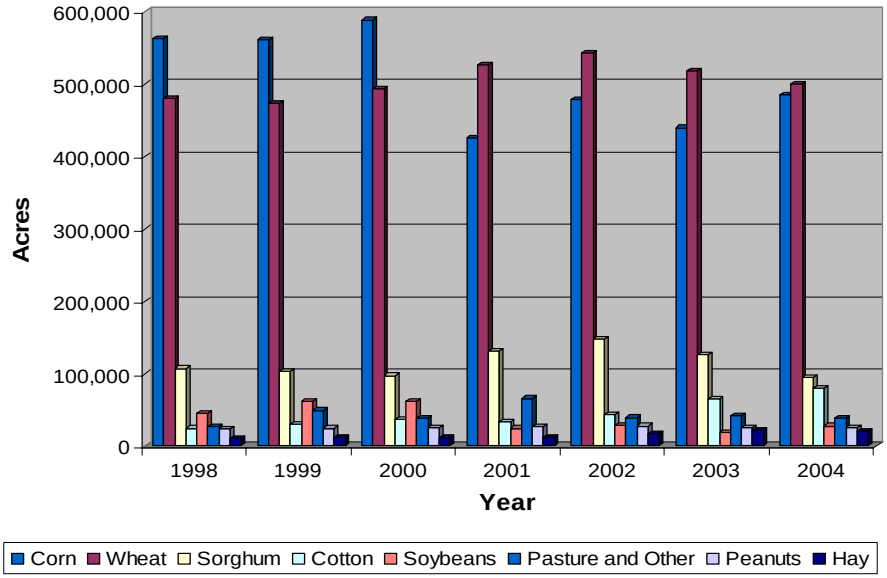

Figure 5. FSA Planted Irrigated Acres by Crop in Region A, 1998-2004.
Source: Farm Service Agency

A comparison was made regarding the crop composition during the low price years versus the high price years (Figures 6 & 7). The corn and soybean acreage as a percentage of total crop composition, decreased by five and two percent, respectively. Corn is considered a high water use crop, and it appears that most of the corn acreage was

replaced with either wheat or cotton of which both can utilize considerably less water per irrigated acre. In effect, wheat acreage increased four percent, cotton acreage increased two percent, and pasture and other acreage increased one percent. Sorghum, peanuts, and hay acreages remained unchanged relative to their percentage of total crop composition.

The estimated change in total irrigation water applied due to the change in crop composition was determined by comparing two scenarios. In the first scenario, the total water use during the low price base years was determined with the TAMA model using the low price acreage and crop composition. Then, another scenario was completed with the TAMA model keeping the low price total acreage constant while changing to the high price crop composition. The net change between these two scenarios resulted in a decrease in total water use of 36,316 acre-feet or 2.3 percent (Figure 8).

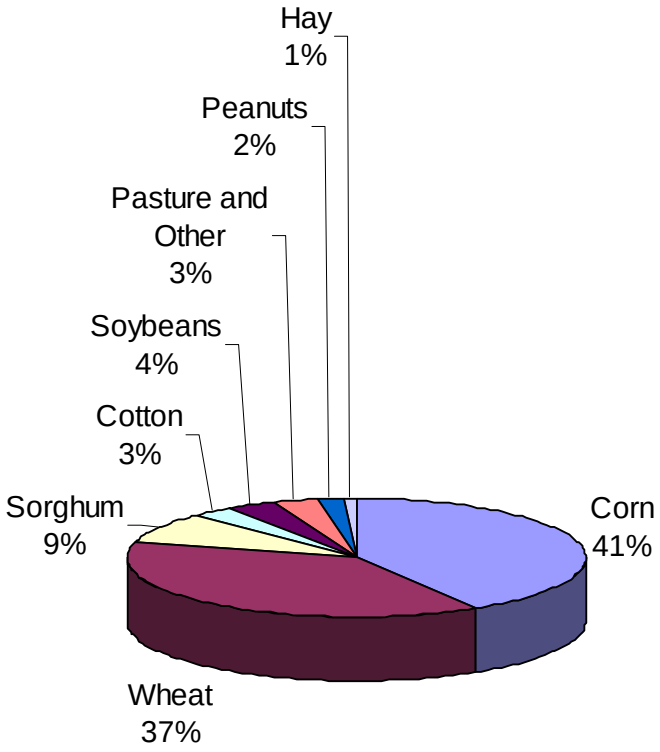

Figure 6. Crop Composition during Low Natural Gas Price Years, Region A.

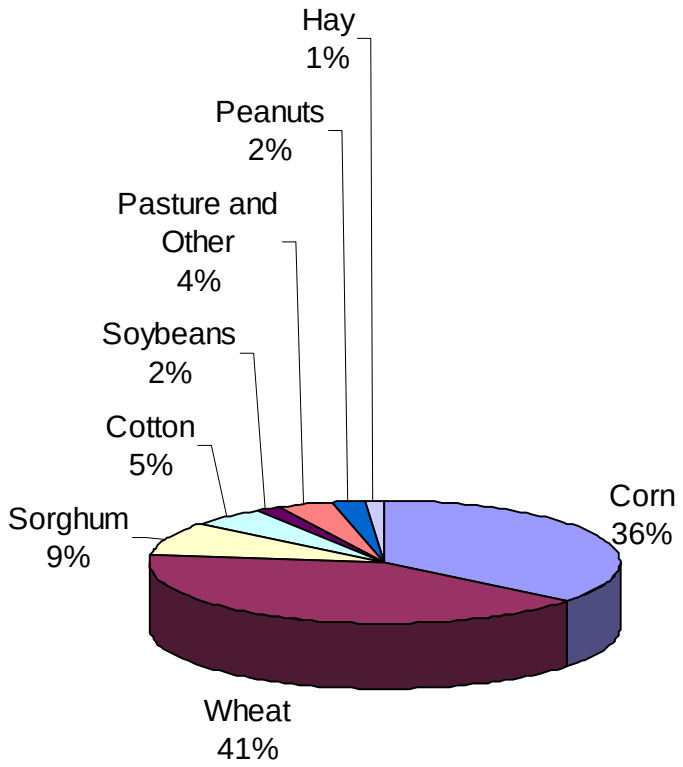

Figure 7. Crop Composition during High Natural Gas Price Years, Region A.

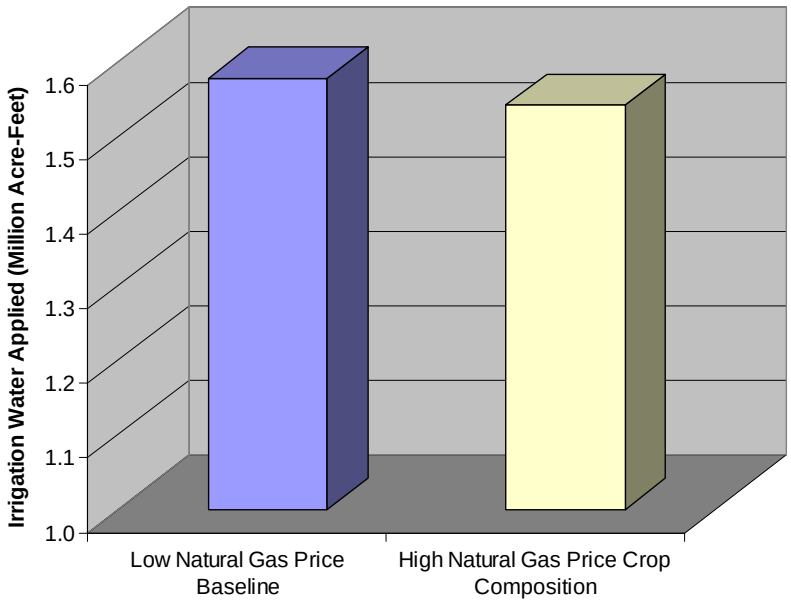

Figure 8. Estimated Change in Irrigation Water Use Due to Modification in Crop Composition during High Natural Gas Price Years, Region A.

Abandonment

The amount of irrigated crop acreage was compared between low and high natural gas price years to determine the level of abandonment in irrigated acreage (Figure 9). Total average irrigated acreage decreased 4.6 percent from 1,319,861 acres during the low price years to 1,259,165 acres during the high price years. This resulted in a total loss of about 60,696 irrigated acres during high natural gas price years.

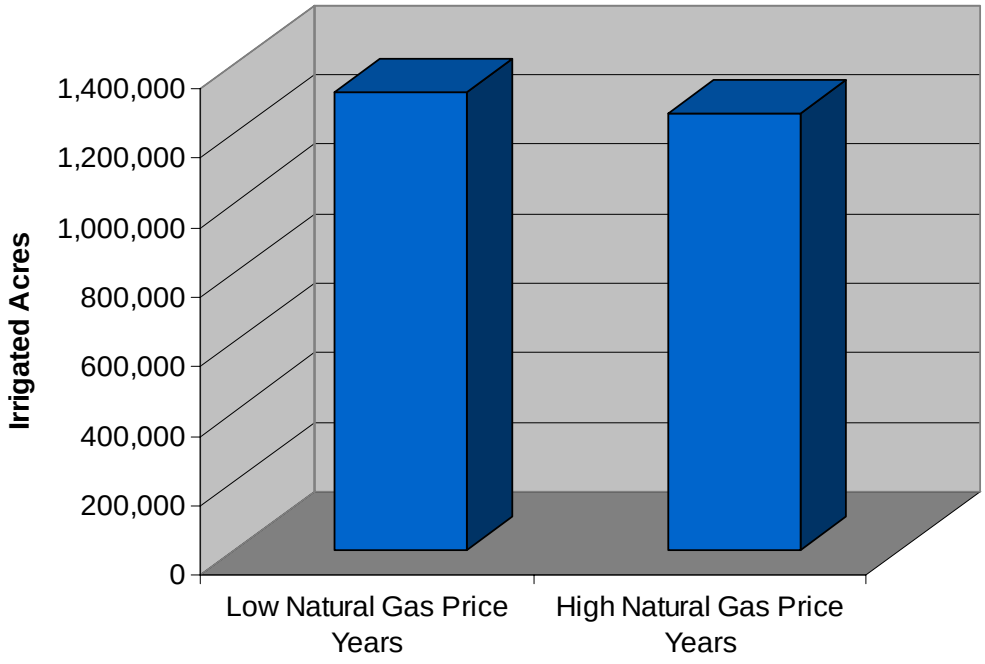

Figure 9. Average Total Irrigated Acreage during Low and High Natural Gas Price Years, Region A.

The reduction in irrigation water applied due to abandonment was estimated by the difference in the water pumped between the low natural gas price crop acreage and the high natural gas price acreage assuming the same crop composition. The impact of acreage abandonment on total water use was an additional decrease of 63,876 acre-feet or 4.1 percent (Figure 10).

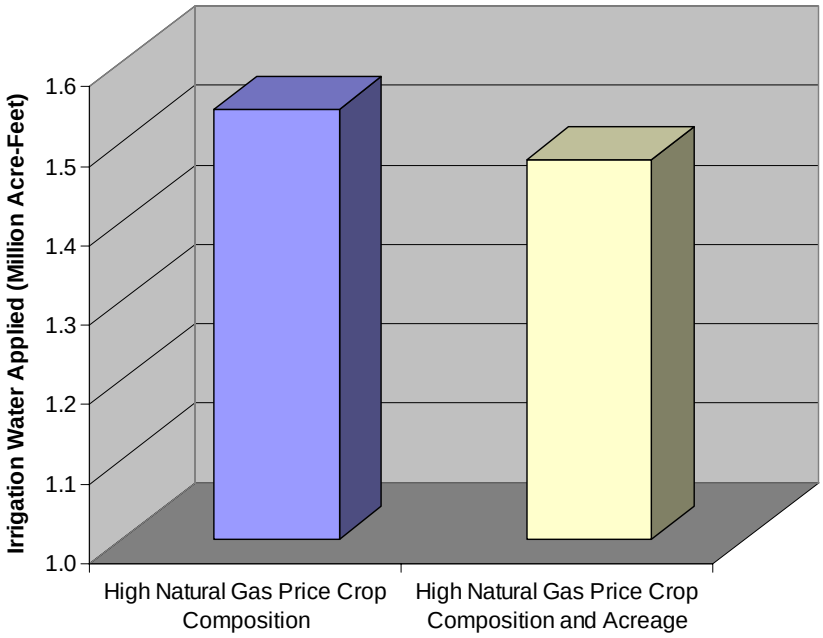

Figure 10. Estimated Change in Irrigation Water Applied Due to Abandonment during High Natural Gas Price Years, Region A.

Water Use by Crop

Four years of Agri-Partner data (2000-2003) were used to estimate the impact on water use by crop resulting from high natural gas prices (New, 1998-2004). These four years were selected because of the similar variance in natural gas prices and similar rainfall totals that occurred during the respective summer cropping seasons. For wheat, the 2001 data was dropped from the analysis and replaced with 2004 data which experienced similar natural gas prices as that of 2001 but received rainfall during the growing season more consistent with the other three years. Agri-Partner water use by crop data were grouped together with the years 2000 and 2002 representing the low price years, and 2001 and 2003 as the high price years.

The results indicate that irrigation water applied to each crop decreased during the high natural gas price years. However, the reduction in water pumped was more significant in some crops than in others. For example, water applied to peanuts, corn and cotton decreased 4.7 percent, 8.1 percent and 8.6 percent, respectively; whereas, soybean, wheat and grain sorghum irrigation was reduced 18.2 percent, 18.7 percent and 22 percent, respectively (Table 1). While the magnitude of the irrigation decrease was unknown, the relative results between crops were consistent with expectations. Producers reduced irrigation less on the higher marginal value crops and more on the lower marginal value crops, where marginal value is defined as the price of the crop multiplied by the change in production due to the application of an additional inch of irrigation water.

Table 1. Water Applied by Crop Through Center Pivot Irrigation During Low and High Natural Gas Price Years.			
	Low Natural Gas Price Years Average Ac-In (2000, 2002)	**High Natural Gas Price Years Average Ac-In (2001, 2003)***	**% Change**
Corn	20.45	18.81	-8.05%
Grain Sorghum	12.84	10.02	-21.99%
Cotton	12.22	11.17	-8.62%
Peanuts	19.89	18.96	-4.66%
Soybeans	16.82	13.76	-18.16%
Wheat	10.61	8.63	-18.71%

* High natural gas price years used for wheat were 2003 and 2004 due to similar rainfall amounts for the Sept - May periods.
Source: Agri-Partner Demonstration Results (New, 1998-2004)

The estimated reduction in total irrigation water applied due to the change in water use by crop was determined utilizing the high price base acreage and crop composition. The long-term average irrigation pumped by crop in the TAMA model was reduced by a similar percentage as was observed between low and high natural gas price years (Table 1) to estimate the reduction in irrigation. The largest decreases in irrigation water applied by crop occurred in wheat, corn, and sorghum with reductions of 82,260 acre-feet, 55,968 acre-feet, and 20,658 acre-feet, respectively. The remaining crops exhibited only slight decreases due to the limited amount of acreage of these crops within the region. The estimated total effect of change in water use by crop on irrigation water applied was a considerable decrease of 180,019 acre-feet or 11.4 percent (Figure 11).

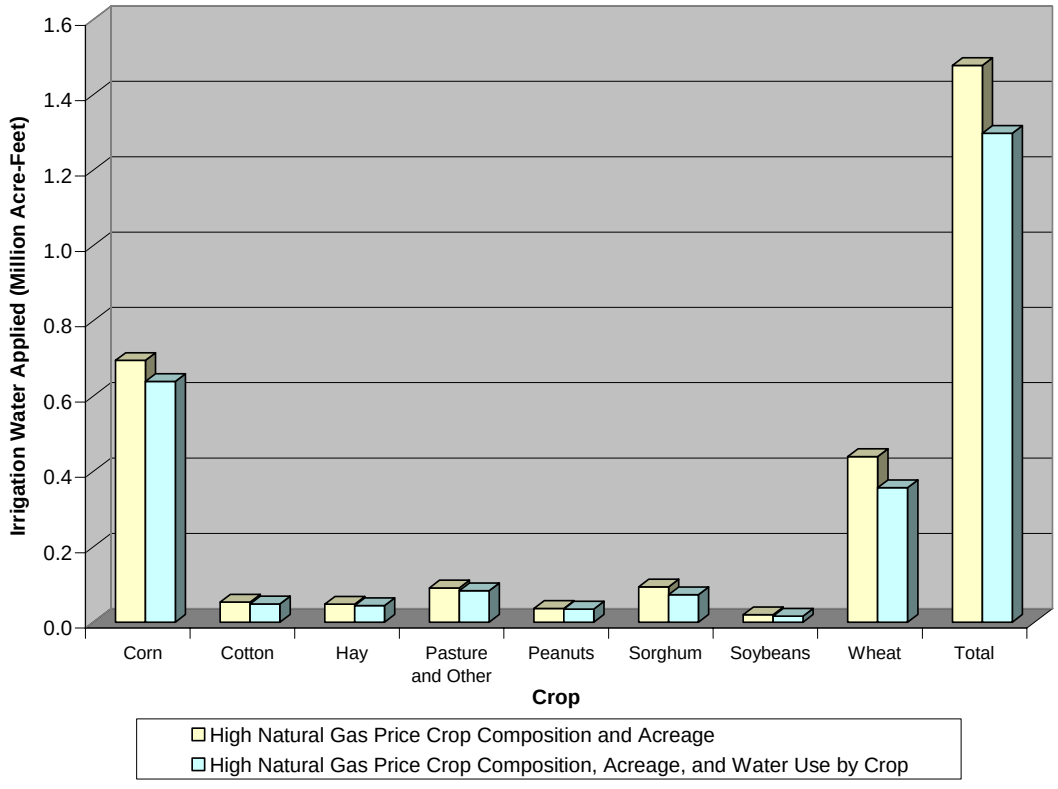

Figure 11. Estimated Change in Total Irrigation Water Applied by Crop Due to Change in Water Use by Crop during High Natural Gas Price Years, Region A.

Potential Impact on Future Irrigation Demand

The total effect on irrigation water applied considering the change in crop composition, abandonment, and water use by crop during high natural gas price years is a total annual decrease of 280,211 acre-feet or 17.8 percent (Figure 12). Of this total decrease, changing crop composition accounts for 2.3 percent (36,316 acre-feet), crop abandonment 4.1 percent (63,876 acre-feet), and the remaining 11.4 percent (180,019 acre-feet) is attributed to the lower water use by crop.

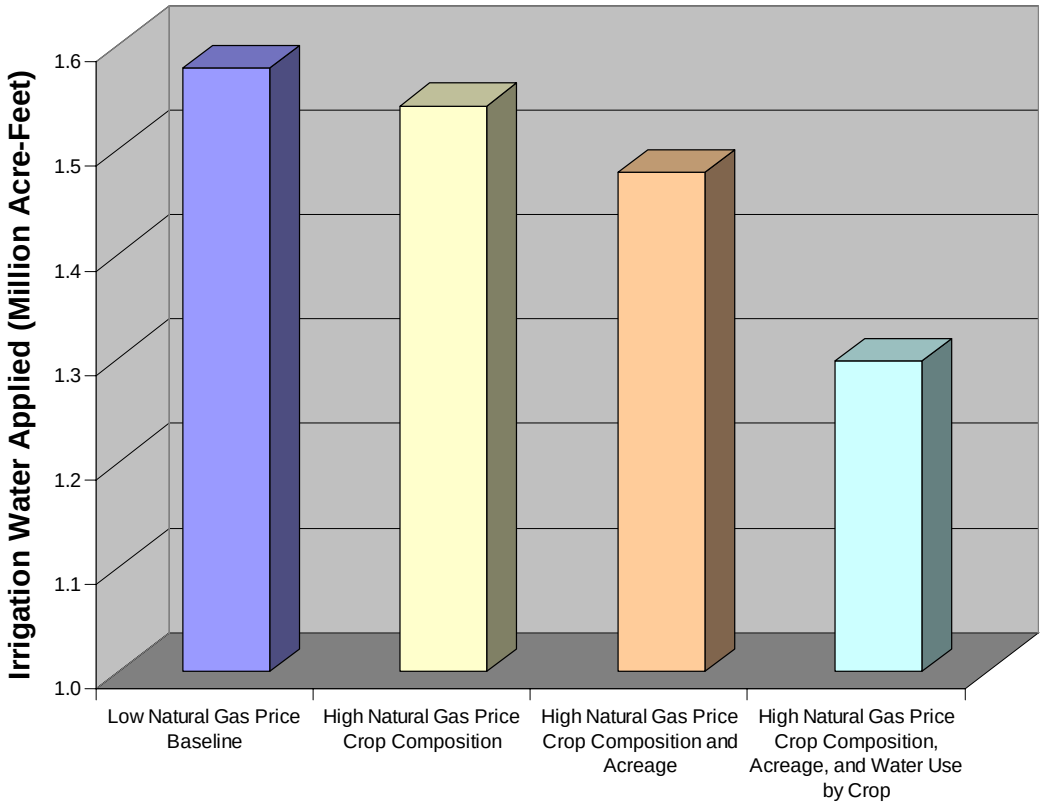

Figure 12. Estimated Change in Annual Irrigation Water Applied Due to Change in Crop Composition, Abandonment, and Water Use by Crop During High Natural Gas Price Years, Region A.

It is clear that high natural gas prices do, in fact, have an effect on water use in Region A. As a result, persistent high prices will likely cause future water demand to also be lower. To measure this effect, the acreage, crop composition, and water use by crop from the high natural gas price base years were projected in terms of annual irrigation water applied through 2060. The total water use resulting from the low natural gas price baseline over the planning horizon is 9,429,787 acre-feet, whereas, the total water use from the high natural gas price baseline is 7,755,525 acre-feet. The reduction in water pumped consists of 216,987 acre-feet from the change in crop composition, 381,662 acre-feet from abandonment, and 1,075,613 acre-feet from the change in water

use by crop. Therefore, the total water savings generated over the 60-year planning horizon is estimated to be 1,674,262 acre-feet (Table 2).

Table 2. Estimated Water Savings (Acre-Feet) Generated with Persistent High Natural Gas Prices.

	Base	2010	2020	2030	2040	2050	2060	Total
Low Natural Gas Price Baseline Water Applied	1,578,207	1,538,752	1,499,297	1,420,386	1,262,566	1,104,745	1,025,835	9,429,787
Reduced Water Pumped:								
Crop Composition	36,316	35,408	34,500	32,684	29,053	25,421	23,605	216,987
Abandonment	63,876	62,280	60,683	57,489	51,101	44,714	41,520	381,662
Water Use by Crop	180,019	175,518	171,018	162,017	144,015	126,013	117,012	1,075,613
Total Water Savings	280,211	273,206	266,201	252,190	224,169	196,148	182,137	1,674,262
High Natural Gas Price Baseline Water Applied	1,297,996	1,265,546	1,233,096	1,168,196	1,038,397	908,597	843,697	7,755,525

Summary and Conclusions

Rising natural gas price has lead to a noticeable decrease in irrigation; however, the magnitude of the reduction in water pumped was unknown. Significant changes in irrigation could invalidate current water use projections made by the regional water planning group. The primary objective of this project was to estimate the reduction in irrigation water pumped resulting from high natural gas prices in Region A in an effort to determine whether a more rigorous study is warranted in the future to refine projected water use estimates for future water planning efforts. Specific objectives of the project were: 1) Evaluate the change in crop composition, abandonment and water use by crop due to rising natural gas prices; 2) Estimate and project the change in water use due to higher natural gas prices; and 3) Prepare a report on the findings and other identified variables affecting future water demand projections.

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Overall, water pumped for irrigation in Region A was estimated to decrease 17.8 percent from the low natural gas price years to the high natural gas price years. Of this total decrease, changing crop composition accounted for 2.3 percent, crop abandonment 4.1 percent with the remaining 11.4 percent being attributed to lower water use by crop. The reduction in water pumped on irrigated crops over the 60-year planning horizon is expected to total 1.67 million acre-feet. Realistically, these estimates understate what the total reduction in irrigation would be over time. High natural gas prices will reduce the number of producers able to cover their fixed cost associated with irrigated production. As crop specific and irrigation equipment gets older and begins to wear out, they may consider producing lower water use crops or may not be able to economically justify replacing irrigation equipment increasing the level of abandonment from what was estimated.

It should be noted that according to Energy Information Administration natural gas prices are expected to retreat from the current levels in the next couple of years. However, due to increasing demand and the increasing cost of tapping remaining domestic natural gas reserves, it is highly doubtful that natural gas prices will ever return to the levels observed in the 1990s. Local prices (basis adjusted) are expected to drop to the $4.00 to $4.50/Mcf level before a steady gradual increase in price is expected through 2025. These prices ($4.00 to $4.50/Mcf) represent approximately a 50 to75 percent increase over the price paid in the 1990s but 50 to 75 percent under current price estimates for the 2005 season.

The change in water pumped in high natural gas years is significant enough to warrant additional study despite the forecast that natural gas prices will moderate somewhat in the future. Failure to account for the affects of higher natural gas prices may lead to inaccurate projections of future water use resulting in the adoption of errant policies. A more sophisticated study that includes additional years of data, more data on water use by crop, factors in rainfall, identifies/evaluates fixed and variable costs associated with irrigation, and takes into account the impact of crop prices on irrigation water use is necessary for a better projection of how natural gas prices will affect crop composition, abandonment, and water use. In addition, the full impact analysis needs to be conducted on a county level basis to be more useful to the Region A water planning group.

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