Appraisal Level Economic Analysis for the ESPA Comprehensive Aquifer Management Plan - Demand Reduction Options

Draft Report

WestWater Research LLC

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Prepared for

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Purpose and Objective

To address concerns associated with aquifer drawdown and reduced groundwater discharge to surface water sources in the Eastern Snake River Plain Aquifer (ESPA) region, the state of Idaho and stakeholders are working to develop a Comprehensive Aquifer Management Plan (CAMP). The CAMP is being developed in an effort to minimize the potential for future regulatory curtailment of water users in accordance with water right priority dates. The goals and objectives established by the CAMP committee are as follows:

Goal: Sustain the economic viability and social and environmental health of the Eastern Snake Plain by adaptively managing a balance between water use and supplies.

Objectives:

- Increase predictability for water users by managing for reliable supply
- Create alternatives to administrative curtailment
- Manage overall demand for water within the Eastern Snake Plain
  - Increase recharge to the aquifer
  - Reduce withdrawals from the aquifer

Currently, the CAMP Committee is considering a number of options to achieve a change in the overall water budget within the ESPA. The management options include increasing spring and fall recharge to the aquifer, converting agricultural water users from ground water to surface water sources, and reducing ground water withdrawals through implementation of a demand reduction program. The objective of this study is to inform the CAMP Committee of the potential direct costs of pursuing a demand reduction program.[1] The demand reduction options being considered include the permanent purchase and retirement of groundwater rights, annual leases of groundwater rights, and payments to agricultural producers to change to a less water consumptive crop mix.

Figure 1 provides a general summary of the different information used to estimate the potential costs of the demand reduction options. To asses the potential range of costs associated with the demand reduction options, this report estimates the potential cost of permanent acquisitions of irrigation water supplies through analysis of agricultural land sales in the region. Shorter term demand reduction options are

[1] This analysis does not consider the administrative costs of operating a demand reduction program or the indirect costs to the regional economy associated with changes in agricultural output.

addressed through consideration of crop production budgets and operating water leasing programs in other states.

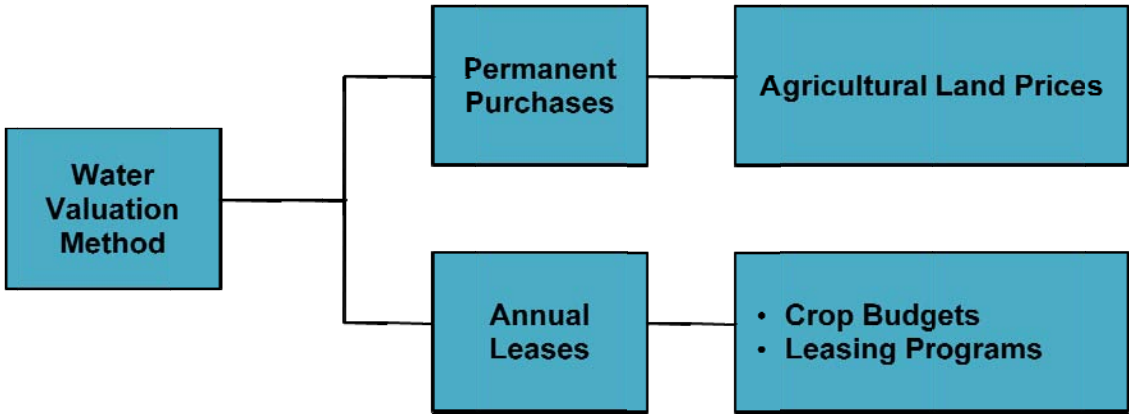

Figure 1: General Analysis Approach

The estimated values are intended to provide an initial comparison to other water management alternatives being considered by the CAMP committee and identify potential program funding requirements. The results of the analysis indicate that there is significant variation in water values within the region and that pricing of short-term water acquisitions will fluctuate with hydrologic conditions and crop prices and production costs. Future research on water values and the hydrologic effect of demand reduction activities could help inform the structure and cost-effective implementation of a demand reduction program in combination with other available water management options.

General Approach

The value of irrigation water is measurable through a variety of analytical methods including market analysis of water right sales and leases, estimation of the net income generated from use of the water, and consideration of agricultural land prices in the region. Where available, negotiated prices for water rights between willing buyers and sellers represent a preferred source of information to estimate market values for water rights and the likely direct costs of an ESPA demand reduction program. At this time, price information from water right trading activity in the ESPA region is too thin to rely upon as the sole method for estimating the likely market prices for water rights purchased through a demand reduction program. Due to the limited water right trading activity, this study uses hedonic price analysis to measure the implicit value of water in agricultural land sales by comparing the sale prices of property with and without irrigation. Hedonic price analysis is a preferred method to estimate the potential cost of permanent water acquisitions when land sales information is available and the water rights market is not well developed because it relies upon observable market data rather than estimates of crop prices, yields, and costs of production. The range of potential costs of water leasing options is estimated by considering the costs of leasing activities in developed demand reduction programs in other states. In addition, the payments required to induce a change in crop mix to lower water-using crops is considered through a crop production budget approach.

Permanent Water Acquisitions

In this study, hedonic pricing analysis (HPA) was used to estimate the costs of permanent water acquisitions from agricultural land overlying the Eastern Snake River Plain Aquifer (ESPA). The analysis uses observed market data from agricultural land sales and adjusts for differences in location and hydrologic characteristics to estimate the value that water rights contribute to land prices. HPA has been applied in previous economic research to estimate the value of water in agricultural regions. Crouter (1987) used hedonic pricing models to determine if the water rights market in Weld County, Colorado, was separate and competitive.[2] Veeman et al. (2001) used a hedonic model to estimate the price of water in southern Alberta and Faux and Perry (1999) used the model to estimate water values in Malheur County Oregon.[3],[4] Veeman et al. (2001) estimated the value of irrigated water at $190 per acre in Alberta while Faux and Perry (1999) estimated the marginal value of water for irrigation between $514 and $2,551 per acre depending upon land quality in Malheur County, Oregon. Torrell, Libbin, and Miller (1990) used hedonic pricing to estimate the effects of declines in aquifer levels on agricultural land prices overlying the Ogallala Aquifer in Colorado, Kansas, Nebraska, New Mexico, and Oklahoma.[5] The authors found that land prices were declining over time due to declining water levels and the associated increase in the cost of pumping groundwater.

Model Data

WestWater Research obtained land sales data for 411 transactions in the ESPA region between 2003 and July 2008. The data includes total sale price, estimated improvement value, primary land use, primary commodity, acres irrigated, and township, section and range, among other values. For this analysis, the sales were limited to those larger than 20 acres and properties with agriculture as the highest and best use. Application of these criteria eliminated 78 sales from the data set. Spatial analysis was used to determine additional characteristics that can affect land values such as location and aquifer depth.

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2 Crouter, Jan P. 1987. Hedonic Estimation "Applied to a Water Rights Market." *Land Economics* Vol. 63.

3 Faux, John and Perry, Gregory M. 1999. "Estimating Irrigation Water Value Using Hedonic Price Analysis: A Case Study in Malheur County, Oregon." *Land Economics* Vol. 75.

4 Veeman, T.S. and Veeman M.M. with Adamowicz, W.L., Vinery, Royer B., Freeman, R. Baggs, J. 1997. "Conserving Water in Irrigated Agriculture: The Economics and Valuation of Water Rights." *Rural Economy Project Report* 97-01.

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

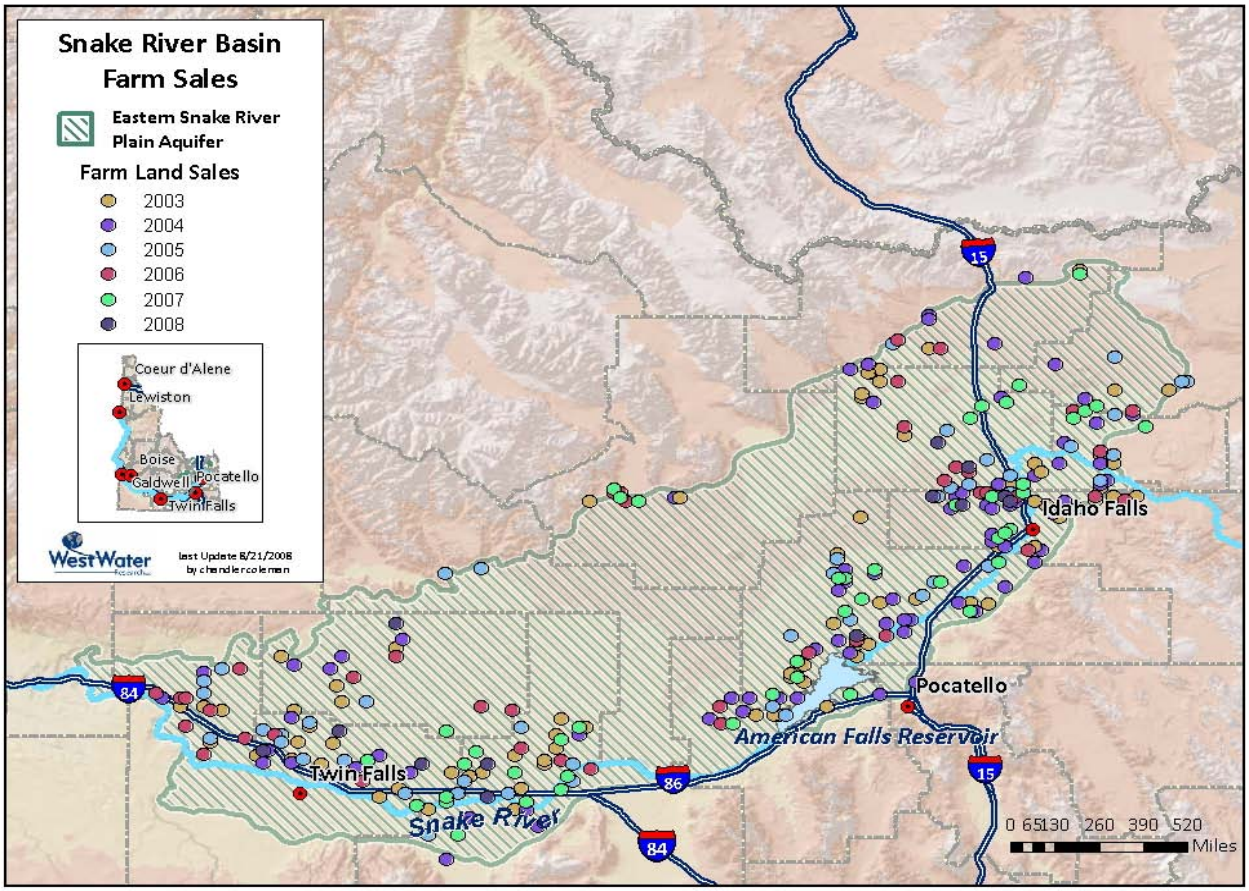

Figure 2: Agricultural Land Sales in the ESPA

The hedonic pricing model that measures land values according to the sale price per acre (PRICE). Using the per acre sale price as the dependent variable allows each sale to considered equally in the regression analysis rather than alternative specifications that can result in large sales dominating model results. The model considers water use, improvement values, crops, location and water availability, among other factors, to determine PRICE.

The average price for agricultural land in the ESPA was $2,794 per acre but ranged from $125 to $13,567 per acre (including the value of improvements). Land values vary according to the estimated value of improvements, total land area, percent of land irrigated, and distance to town. Table 1 provides summary statistics for the land sales data. As shown, the "average" sale included 611 acres, was 23 miles from a town with more than 10,000 residents and had an estimated improvement value of $365 per acre. Approximately 82% of the land involved in the sales was irrigated, on average. All sale prices were adjusted to current dollars using the Consumer Price Index (CPI).

Table 1: Sales Summary Statistics

	Number of Observations	Mean	Standard Deviation	Min	Max
Price ($/acre)	333	$2,794	$1,674	$125	$13,567
Estimated Value of Improvements ($/acre)	333	$365	$693	$0	$4,335
Sale Size (acres)	333	611	1,094	22	12,000
Percent of Land Irrigated	333	82%	23%	0%	100%
Distance to Town (miles)	333	23	14	3	64

Note: Prices are adjusted to 2008 dollars using the U.S. Consumer Price Index

Variable Identification

A variety of explanatory variables were developed and considered in the model to represent the attributes affecting agricultural land sale prices in the region. Some of the key variables considered are described below.

Irrigated Acres

A majority of the farm sales were irrigated. More than 97 percent of the 333 land sales included some irrigated acres. However, the percent of the total acres in each sale that were irrigated ranged from 0-100 percent. The model uses the percent of acres irrigated to capture the value of water. Farms with a higher percentage of irrigated land are expected have a higher sale price per acre.

Table 2 shows that the farms with 75 percent or more acres irrigated on average sold for $912 per acre more than farms with 50-75 percent of the land irrigated. Moreover, properties without irrigated land sold for nearly $2,000 less per acre than those lands with at least some irrigation, on average.

Table 2: Price per Acre Summary Statistics by Percent of Land Irrigated

	Number of Observations	Mean	Std. Dev.	Min	Max
Water <25%	16	$1,221	$1,424	$125	$4,426
Water 25%-50%	16	$2,076	$1,738	$351	$5,922
Water 50%-75%	40	$2,125	$1,538	$352	$7,837
Water 75%-100%	261	$3,037	$1,618	$498	$13,567
All Observations	*333*	*$2,794*	*$1,674*	*$125*	*$13,567*

Location

Previous economic studies have shown that the value of water for agricultural purposes depends upon the characteristics of the property that the water is applied to such as location, rainfall, evapotranspiration, and land quality. There are a variety of ways in which spatial components can be incorporated into the model. In order to capture spatial differences in land and water values and allow the information to be used directly with the existing ESPA aquifer model, the land sales were divided into five zones. The Zones are based on the reach gains to the Thousands Springs reach and measured using the ESPA aquifer model run in long-run equilibrium mode. The reach gains were calculated throughout the ESPA, and then grouped into five zones based on quintiles. Zone 1 has the largest reach gain to the Thousands Springs reach. Zone 5 has the lowest reach gain. Figure 3 displays the zones.

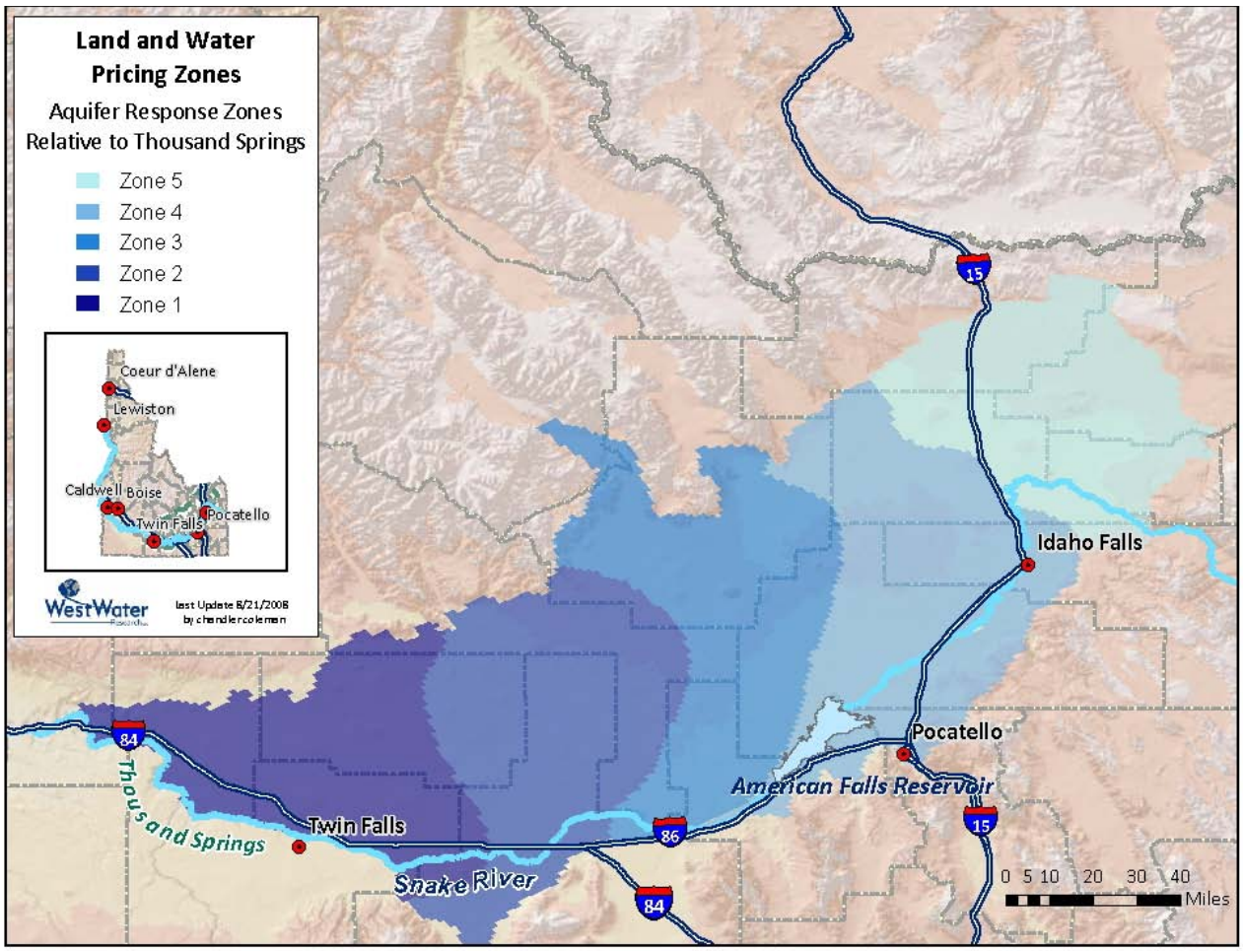

Figure 3: Economic Model Zones

Distance to Cities

The impact of urban centers on sale price was captured in the hedonic model by including the distance (in miles) to the nearest town with a population over 10,000. Towns with current populations above 10,000 include Twin Falls, Pocatello, Blackfoot, Idaho Falls and Rexburg. Previous studies have shown that the impact of urban centers on sale price diminishes as distance increases. Consequently, the distance variable was transformed in the hedonic model to the natural logarithm of distance to the nearest town.

Distance to Dairies

The dairy industry has been increasing steadily in the ESPA. While the number of dairies in the ESPA region has decreased in recent years, the total number of dairy cows has increased, indicating a trend toward larger operations. Figure 4 shows the number of dairy cows by county from 1998 through 2007.

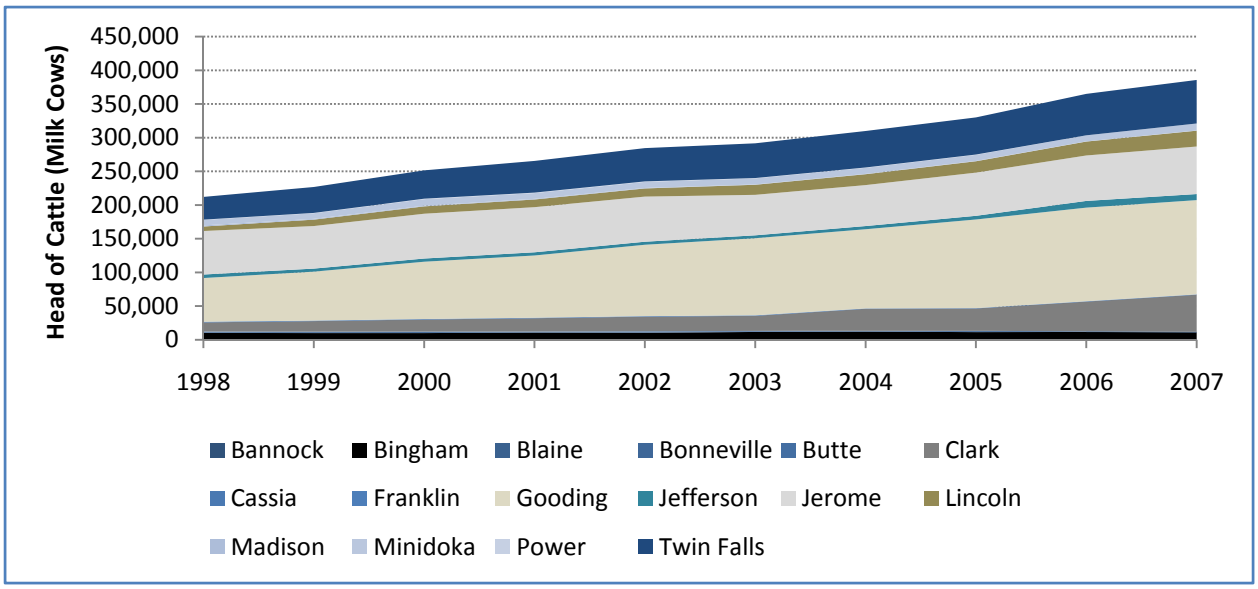

Figure 4: Number of Milk Cows by County, 1998-2007

Source: USDA, National Agricultural Statistics Service.

The increasing number of dairy cows has increased the demand for alfalfa and silage crop production. In turn, it is possible that this has had an effect on the price of agricultural land in the vicinity of the dairy operations. To test this, the spatial location of the dairies was mapped and different zones were created according to "clusters" of dairies. The location of each sale relative to the nearest dairy zone was then tested in the hedonic model. Figure 5 shows the dairy zones that were created and applied in this analysis.

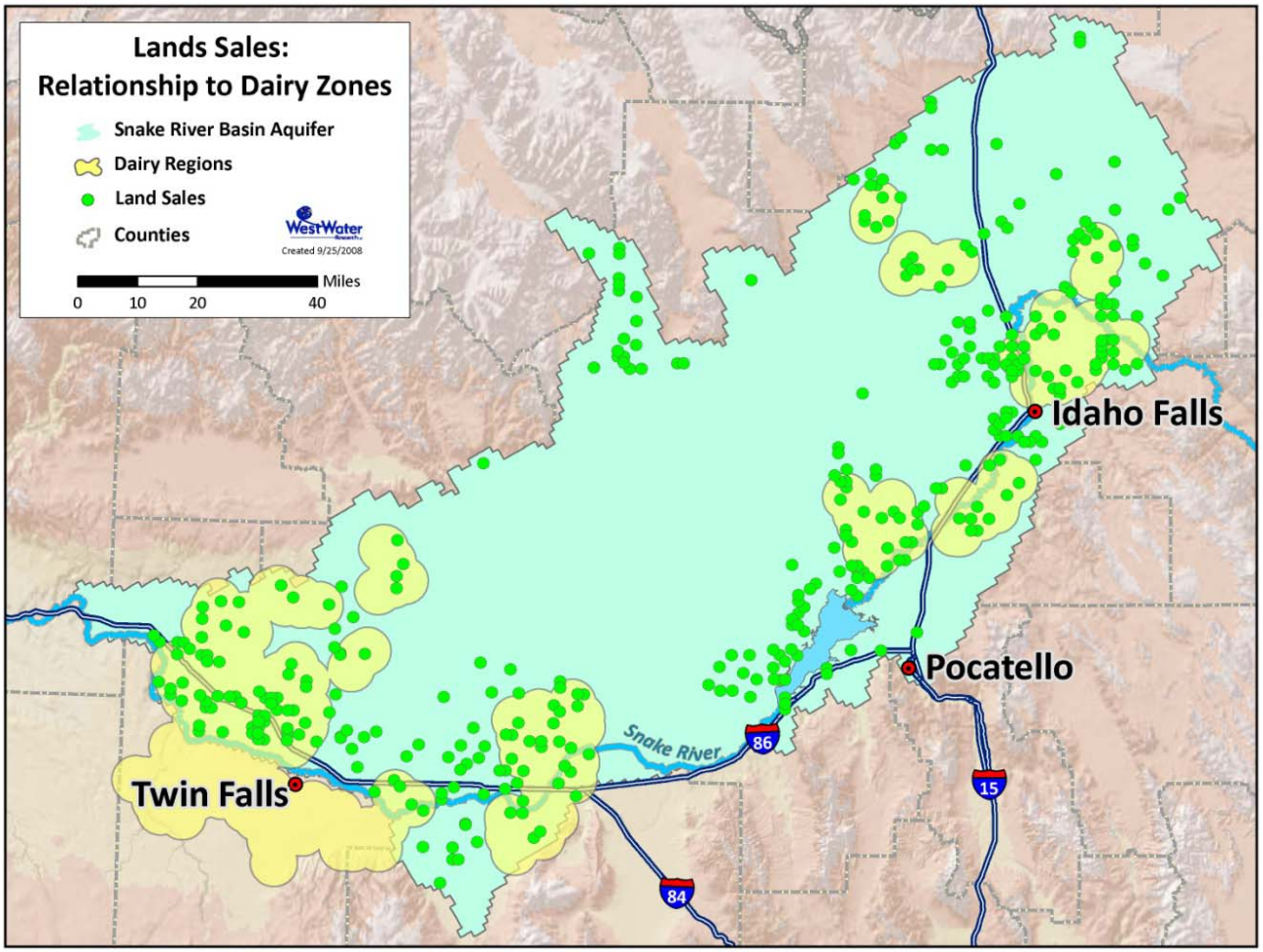

Figure 5: Dairy Regions in the ESPA

Improvement Value

The intent of this analysis is to estimate the value that water rights contribute to agricultural land prices in the region. As such, it is important to control for the value of farm and residential buildings. The data set provided the estimated value of improvements for each sale. For consistency, the improvement value was divided by the total acres involved in each sale. The type and quality of irrigation system on a property can also affect sale price. However, the available information did not allow for a complete description of irrigation systems for each sale and therefore was not included in the model.

Sale Size

Previous studies have shown that the size of a transaction can influence the per acre sale price. Figure 6 illustrates this relationship between PRICE and acres. As shown, price per acre exhibits a negative, non-linear relationship to the size of the transaction. In order to capture this relationship, transaction size was included in the hedonic model as the logarithm of total sale acres.

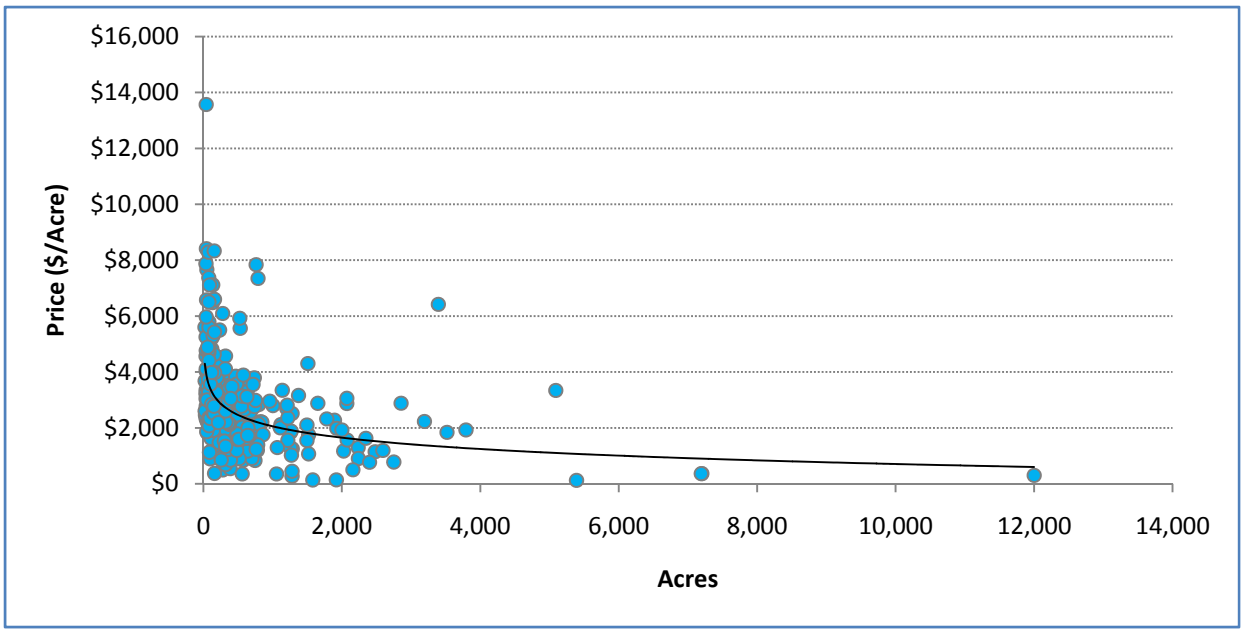

Figure 6: Price per Acre and Number of Acres Sold

Primary Crops

The land sales data includes a description of the primary crops grown on the property. In general, it is expected that farmland that is suitable for producing high-valued crops such as potatoes generally sells for more than farms with lower value crops. Due to differences in reporting methods for individual sales, each sale was categorized as "high value" or "low value" according to the primary crops identified on the sales sheets.

Sale Year

As previously described, PRICE was adjusted to 2008 dollars using the CPI to capture inflationary effects. This adjustment is necessary because the data spans a period of more than five years during which there have been changes in market conditions for agricultural outputs and land devoted to agricultural production. In addition to the CPI adjustment, the hedonic model also includes a time trend variable to capture non-inflationary influences on agricultural land prices. The time trend variable helps to capture land price changes caused by changes in crop prices and production costs. An index of crop prices was also considered for inclusion in the model. However, the crop price index was highly correlated with sale

year, preventing inclusion of both variables in the model. In addition, it is likely that land prices are determined, in part, by the expectation of future rather than current crop prices and production costs. Figure 7 shows the average prices for selected crops from 2003 through 2007. As shown, the prices for each of the selected crops have increased significantly in recent years.

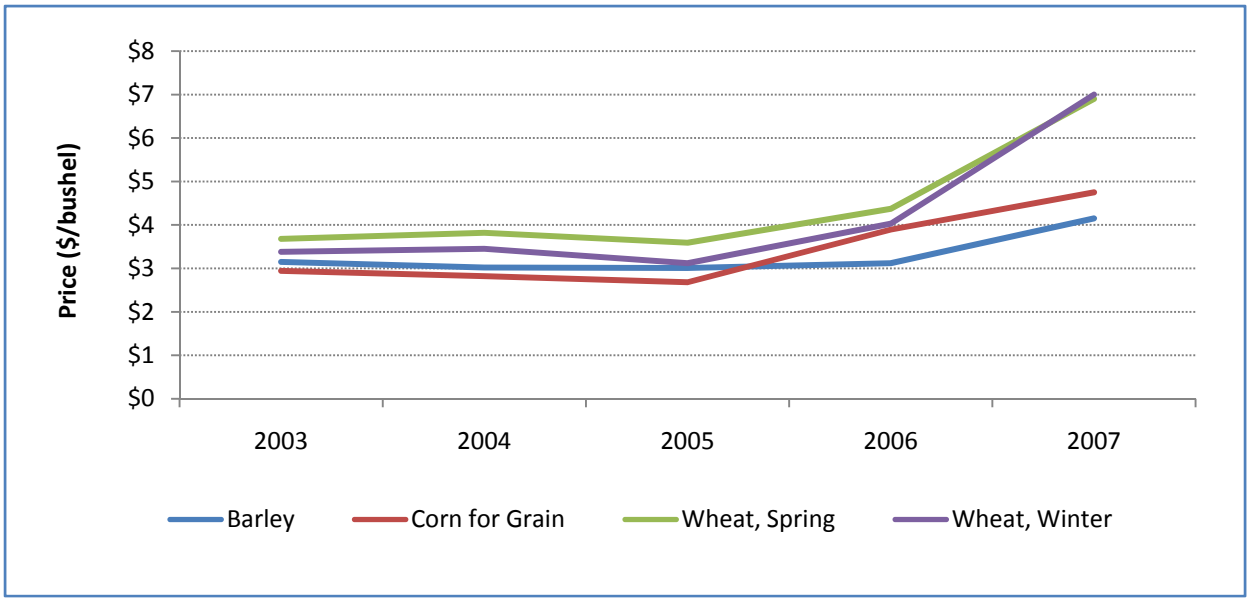

Figure 7: Crop Price per Acre over Time

Source: U.S. Department of Agriculture National Agricultural Statistics. 2003-2007.

Water Source and Aquifer Depth

A primary focus of any demand reduction effort will be to reduce the level of groundwater withdrawals from the ESPA. In order to help inform decision-makers of the likely costs associated with acquiring groundwater rights, this analysis included the depth to groundwater in the hedonic model. It is expected that land prices will decline with increases in depth to groundwater due to higher pumping costs and lower expected profits.[6] Figure 8 shows the land sales in the analysis are distributed by aquifer depth.

6 Water source and pumping depth were obtained from land sale sheets. Missing data was supplemented with GIS data developed by Idaho Water Resources Research Institute, received January 2008.

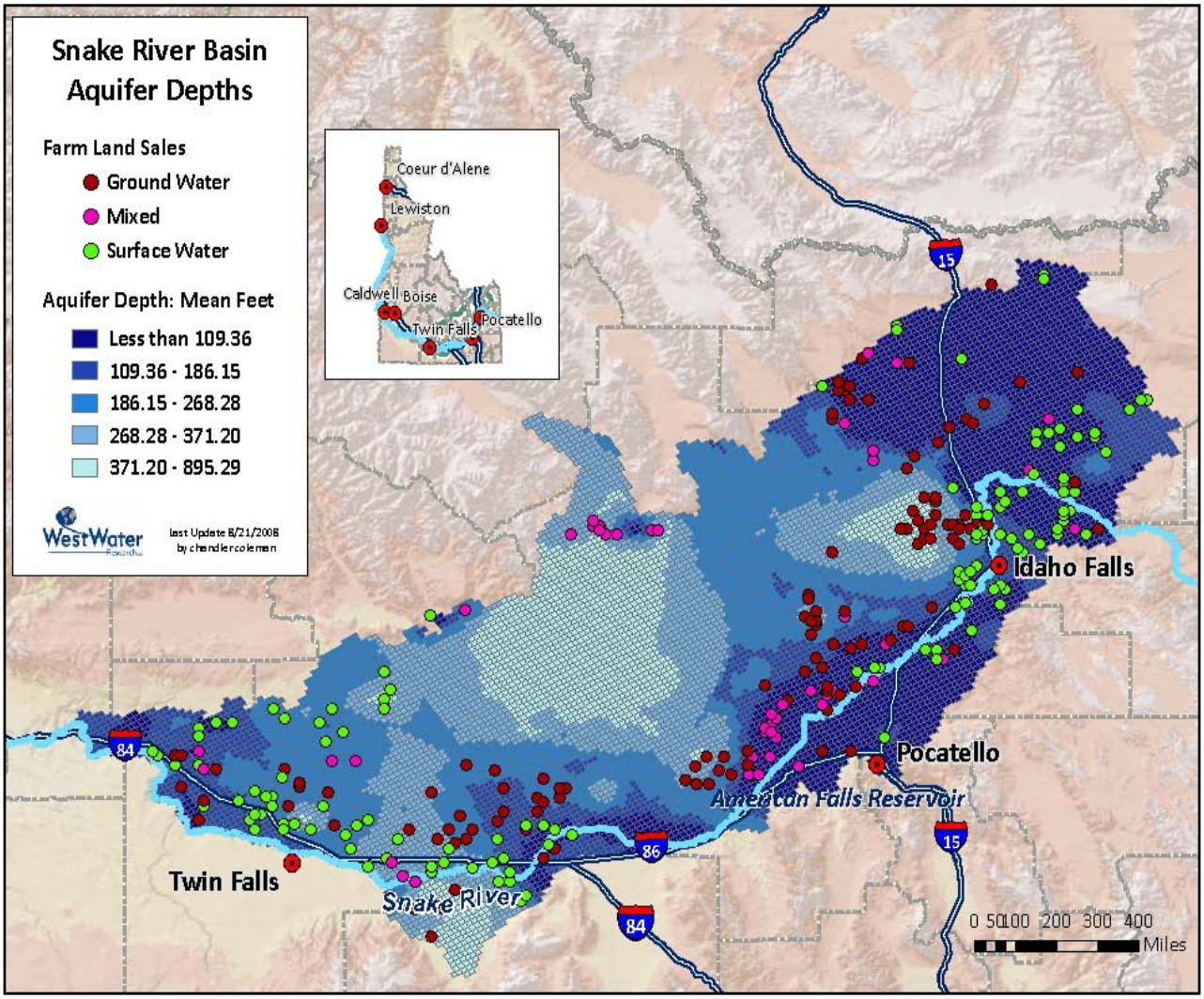

Figure 8: East Snake River Basin Aquifer Depths

Figure 9 allocates the land sales according to selected ranges of aquifer depths. The figure indicates the number of land sales included in this analysis that fall within each of the aquifer depth ranges. As shown, the land sales involve properties with groundwater pumping depths that vary from less than 50 feet to nearly 500 feet. Relatively few sales involved properties with pumping depths in excess of 350 feet however. For comparison purposes, the estimated annual energy cost for a farm with a pumping depth of 50 feet is $20 per acre compared to $180 per acre for a 500 foot pumping depth.

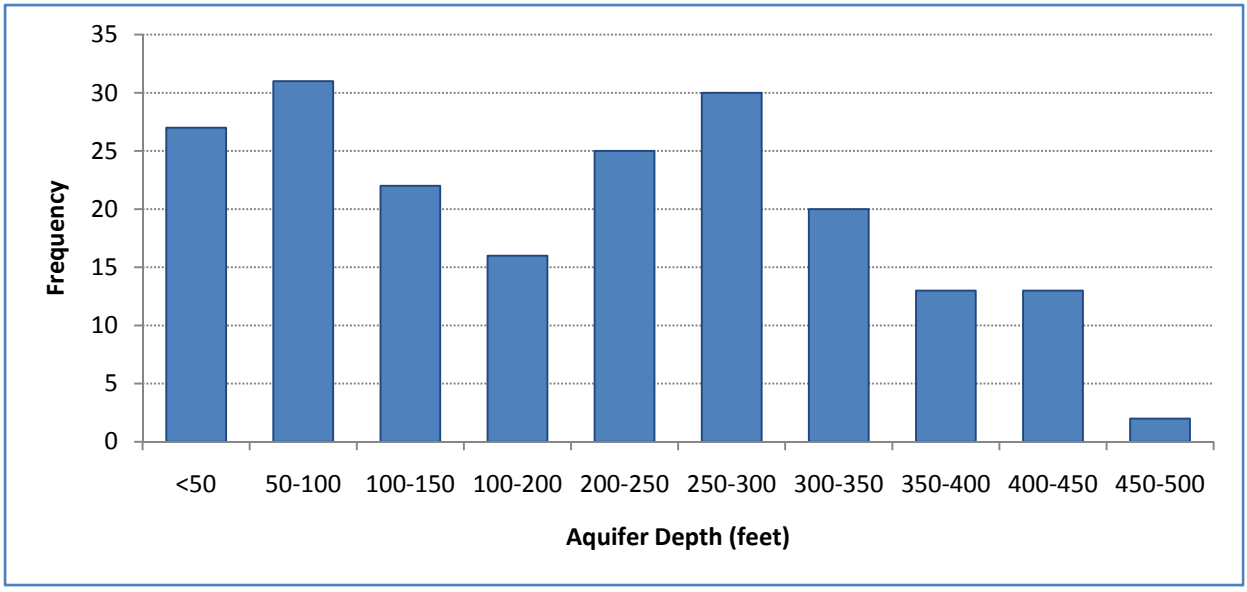

Figure 9: Agricultural Land Sales by Aquifer Depth

Irrigation District

The hedonic model was also used to test if location within an irrigation district affected sale price. It was expected that sales of land within an irrigation district may exhibit higher prices due to the establishment of physical infrastructure and shared costs and the potential for economies of scale associated with crop marketing and transport.[7]

Water Right Priority Date

Previous studies have shown that the priority dates of water rights appurtenant to a property are an important determinant of land price and water value. Attempts were made in this study to identify the seniority/reliability of water rights associated with the sale properties. However, the information could not be reliably developed due to data limitations concerning the spatial location of the sale properties and water rights.

Table 3 provides a summary of the variables that were tested in the model and the expected influence on price per acre. As indicated, the percent of land irrigated within each sale was combined with the economic model zone that the sale resides within to create a single variable for each economic model zone (Zone 1, Zone 2, etc.).

[7] Irrigation company boundaries came from the Idaho Department of Water Resources, May 1, 2008.

Table 3: Selected Variables

Variable	Definition	Expected Sign
LACRES	Logarithm of the total acres sold	-
IMPROVED	Estimated value of improvements per acre (adjusted to 2008 dollars)	+
YEAR	Year of sale (1 = 2003, 2=2004, etc.)	+
IRRC	Sale is located inside an irrigation company (1= yes, 0 = no)	+
LDTOWN	The logarithm of the distance from the closest town with 10,000 people or more (miles)	-
DEPTH	The average depth from the land surface to the aquifer (feet) for farms that use groundwater	-
Zone 1	Percent of Acres Irrigated Zone 1	+
Zone 2	Percent of Acres Irrigated Zone 2	+
Zone 3	Percent of Acres Irrigated Zone 3	+
Zone 4	Percent of Acres Irrigated Zone 4	+
Zone 5	Percent of Acres Irrigated Zone 5	+
DAIRIES	Proximity to Dairies	+
HVCROP	Land produces a high value crop (1=yes, 0=no)	+

Model Results

Table 4 shows the results of the statistical analysis. The hedonic model explains 74 percent of the variation in PRICE, according to the adjusted R-squared. All the variables are significant at the 10-percent confidence level.[8] DAIRIES, HVCROP, and IRRC were dropped from the model for lack of statistical significance. Table 4 provides the results of the regression analysis.

8 The model was tested for multicolinearity using a correlation matrix and a computation of the uncentered variance inflation factors. Multicolinearity between the independent variables was not found. However heteroskedasticity was identified using a Breusch-Pagan test for heteroskedasticity. The presence of heteroskedasticity was addressed by using White's correction.

Table 4: Hedonic Model Results

		Coefficient	Std. Error	t-stat	P>|t|
IMPROVED	Improved Value/Acre	1.4	0.133	10.73	0.00
Zone1	Percent of Acres Irrigated Zone 1	1,788.3	281.630	6.35	0.00
Zone2	Percent of Acres Irrigated Zone 2	2,047.2	279.332	7.33	0.00
Zone3	Percent of Acres Irrigated Zone 3	2,239.5	308.429	7.26	0.00
Zone4	Percent of Acres Irrigated Zone 4	1,259.8	251.841	5.00	0.00
Zone5	Percent of Acres Irrigated Zone 5	1,317.6	287.399	4.58	0.00
LACRES	Logarithm of Acres	-91.2	54.936	-1.66	0.10
YEAR	Year Index (1,2,3, ect.)	186.9	32.417	5.76	0.00
LDTOWN	Logarithm of Distance to Town	-934.7	114.186	-8.19	0.00
DEPTH	Depth to Aquifer for Farms Using Groundwater	-1.7	0.378	-4.50	0.00
Constant	Constant	3,891.5	516.620	7.53	0.00

The coefficients for the Economic Model Zones (Zone 1, Zone 2, etc.) estimate the per acre value of water by region. As shown, the estimated average value per acre in Zone 3 is approximately $2,240 and $1,318 in Zone 5 holding all other factors such as depth to aquifer and distance from the nearest town constant. Based upon recent crop statistics, Zone 3 contains a higher proportion of potato acreage than the other zones and also contains fewer dairies. Zone 4 contains a relatively high proportion of acres enrolled in the CREP program, possibly providing an indication that some land within the region has poorer quality. Figure 10 converts the estimated per acre water values to a per acre-foot value assuming an average consumptive water use of two acre-feet per acre for all zones.

The estimated values provide an indication of the direct costs that will potentially be required to permanently reduce the consumptive use of groundwater in the ESPA.[9] These values can be compared with the cost estimates of other options being considered (e.g. aquifer recharge, water source conversions) to assist in development of a preferred management plan. As previously described, the estimates provided here do not address the full costs associated with implementation of a demand reduction program targeting permanent water acquisitions. Experience from other programs suggests that project management and implementation costs can be significant. In addition to project management costs, the estimates provided here do not address the potential regional effects associated with the purchase and retirement of agricultural water rights.

9 Actual costs will be determined through negotiations between willing sellers and buyers and may differ from those presented in this analysis.

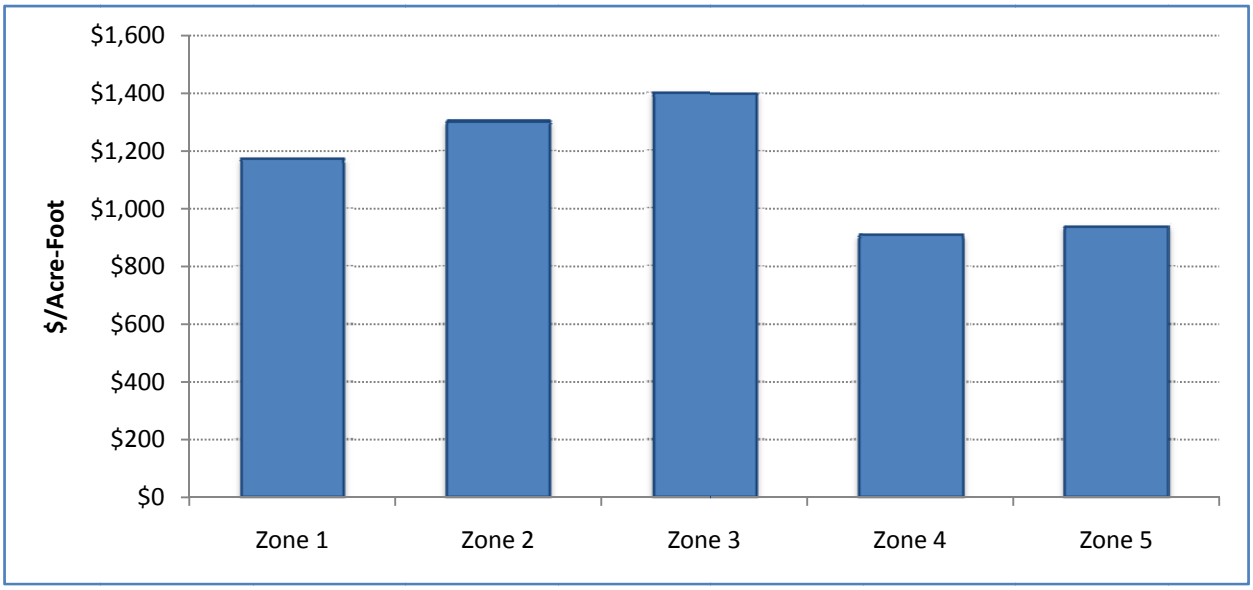

Figure 10: Estimated Water Value by Economic Model Zone.

Note: Estimated assuming a uniform consumptive water use of 2 acre-feet per acre.

The coefficient on DEPTH estimates that PRICE decreases by $1.70 for every one foot increase in the depth to groundwater. Table 5 provides a summary of the estimated value of water by economic model zone and pumping lift. As shown, the estimated water value varies from $205 per acre-foot for water pumped from a depth of 500 feet in Zone 4 to $1,077 per acre-foot for water pumped from a depth of 50 feet in Zone 3.

Table 5: Estimated Value ($/AF) of Water by Zone and Pumping Lift

Pumping Lift (ft)	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
50	$852	$981	$1,077	$587	$616
100	$809	$939	$1,035	$545	$574
150	$767	$896	$992	$502	$531
200	$724	$854	$950	$460	$489
250	$682	$811	$907	$417	$446
300	$639	$769	$865	$375	$404
350	$597	$726	$822	$332	$361
400	$554	$684	$780	$290	$319
450	$512	$641	$737	$247	$276
500	$469	$599	$695	$205	$234

The coefficient on YEAR indicates that the per acre price of agricultural land has been increasing (in real terms) by nearly $190 per acre annually between 2003 and 2008. As expected, LACRES has a negative effective on PRICE, indicating that the sale price per acre decreases as transaction size increases but at a diminishing rate. Similarly, LDTOWN shows that PRICE decreases the farther the land is from a town

with at least 10,000 residents. For, example, a property 23 miles (straight line distance) from Idaho Falls will be priced $1,273 per acre less than property located near town.

Short-Term Water Acquisitions

In addition to permanent water acquisitions, the CAMP Committee is also considering a variety of shorter-term demand reduction strategies including annual leases, changes in crop mix, and dry year leases. Shorter-term acquisitions have the advantage of being adaptable according to changes in hydrologic effects and can be discontinued if the expected hydrologic benefits are not observed. In addition, short-term contracts are often more readily entered into by agricultural producers than permanent sales which suggest that short-term acquisitions will be a necessary component of a demand reduction program targeting significant water volumes. Disadvantages associated with a demand reduction program that relies upon short-term contracts include variability in funding requirements, uncertainty over future level of participation, management and monitoring costs, and potentially high costs associated with water acquisitions in dry years – when the program may be needed the most.

Historically, water right leases have occurred as part of the Idaho Water Bank and Rental Pool. However, the leases general involve surplus water supplies and do not result in crop idling. As a result, prices paid in the Idaho Water Bank and Rental Pool are not considered representative of water prices that would be observed under a demand reduction program. Consequently, there is limited information available to determine the potential prices for water right leases. To help overcome the lack of information, this section describes prices paid in several operating demand reduction and water exchange programs to inform the CAMP Committee about the range of water prices, transaction terms, and program structures.

Water Leasing Program – Case Studies

This section presents information on selected operating water leasing programs. This information will inform the CAMP committee of possible program structures and the likely range of prices that would be observed following implementation of a demand reduction program in the ESPA. This section provides a summary of five operating water leasing programs in Oregon, California, and Colorado. The programs differ according to goals, characteristics of the basin, competing water demands, and the level of participation in the program. The selected water leasing programs are located in the following regions:

- Upper Klamath River Basin, Oregon/California
- Deschutes River Basin, Oregon
- Southern California
- Southeast Colorado

Lease Price Determinants

The following factors are important determinants of lease prices and the level of activity in a program and warrant consideration when comparing existing demand reduction programs to potential activity in the ESPA.

- **Contract Terms:** The goals of the selected programs differ. In many cases, the contract terms have been structured to promote participation and achieve the goals of the program at the lowest total cost. For example, some environmental leasing programs are able to lease water only during the later part of the irrigation season when streamflows, and fish needs, are the greatest. This contract structure allows agricultural producers to irrigate and harvest a crop during the summer although at reduced crop yields. At the same time, the environmental buyer is able to lease water only when it is needed most thereby minimizing total expenditures. Other programs are administered primarily to provide water supply reliability in dry years and therefore have contract terms that can be executed as hydrologic conditions require.

- **Water Supply Methods:** The method through which agricultural producers are able to provide water for lease will also affect program participation and pricing. In some programs, agricultural producers must idle cropland in order to offer water for lease. Other programs allow agricultural producers to lease surface water supplies but continue to irrigate from groundwater sources (groundwater substitution).

- **Socioeconomic Conditions**: Regional economic conditions can influence the value of water by stressing available supplies and affecting the ease and cost with which new water supplies can be developed. High-growth areas tend to have increasing water demands for municipal and commercial uses and higher rates of agricultural land conversion. In areas where water supplies are constrained relative to new growth, these activities result in market prices for water rights that exceed the prices that can generally be supported by most agricultural uses.

- **Irrigated Agriculture**: The overall level of irrigation and the types of irrigated crops produced within a basin provide an indicator of the potential supply and costs of water acquisitions for instream purposes. For example, areas with a large proportion of permanent crops will have less flexible water demands, making it more difficult to lease water; whereas, areas with primarily forage and annual crops provide more opportunity for leasing and tend to exhibit lower prices. The higher the loss in income, the greater the expected lease price for associated water rights. In general, pasture and hay crops have been most commonly idled in order to supply water to leasing programs. In addition, regions with higher crop yields and crop prices tend to exhibit higher water lease prices where development demand is low. Consequently, it is common for water rights to be leased from higher elevation tributary sources where relative agricultural productivity tends to be lower.

- **Climate Conditions**: In general, areas with greater precipitation during the irrigation season have more dryland cropping options. Dryland crop opportunities minimize the reduction in agricultural income associated water right leasing thereby lowering water right prices.

- **Irrigated Farmland Values**: As described previously, the market value of farmland in a region can provide an important indicator of the value of water rights. In general, the difference between the price of irrigated land and non-irrigated land provides a useful benchmark for estimating the incremental value of water rights. Arid locations with limited dryland agricultural opportunities tend to exhibit the largest premium between irrigated and non-irrigated farmland. Similarly, these areas tend to exhibit higher prices for water rights sold separately from land. Consideration of irrigated farmland values in the selected water leasing programs can provide an indication of how water lease prices in the ESPA are likely to compare.

Klamath Basin Water Supply Enhancement

Program Description

The Klamath River Basin has one of the largest ongoing water leasing programs in the West. This section focuses on the Upper Klamath Basin where Reclamation has operated its water-leasing program. The Upper Klamath Basin contains approximately 8,000 square miles (5,158,340 acres) from upstream of the Iron Gate Reservoir in Siskiyou County, east to Clear Lake Reservoir in Modoc County and north to Klamath County and Crater Lake.[10] The Upper Basin has 471,700 acres of cropland and pasture.[11] According to Reclamation estimates, approximately 80 percent of this land is irrigated each year.

Reclamation created the Klamath Basin Water Bank, now called the Klamath Basin Water Supply Enhancement, in 2002 to balance help irrigation water use with instream and tribal water needs. In general, irrigators are compensated to voluntarily forgo their contractual entitlement to surface water supplies for one irrigation season in order to make more water available to support instream uses.[12] This section provides a general description of the leasing program.

Within the Upper Klamath Basin, Reclamation provides water supplies for up to 278,000 acres of wetlands and cropland producing barley, irrigated pasture, hay, oats, potatoes and wheat. Offstream water uses in combination with drought conditions have resulted in low-flow conditions in the Klamath River, impacting Coho and Chinook populations. Tribal and Endangered Species Act (ESA) concerns prompted Reclamation to develop a plan to increase instream water flows.

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10 USGS. Upper Klamath Basin Ground-Water Study. Retrieved December 2006 from http://or.water.usgs.gov/projs_dir/or180/klamgw.html.

11 The Natural Resources Conservation Service. May 19, 2004. "Work Plan for Adaptive Management: Klamath River Basin Oregon and California."

12 General Accounting Office. March 2005. "Klamath River Basin." Report to Congress. GAO-05-283.

In 2002, Reclamation implemented the Klamath Basin Water Supply Enhancement and established water supply goals. The program required Reclamation to acquire 50,000 acre-feet of water in 2003, 75,000 acre-feet of water in 2004, and 100,000 acre-feet of water from 2005-2011 for instream use.[13] Reclamation began the project by working primarily with two irrigators to reduce water use. In 2003, the agency expanded the program and began soliciting bids from water users through public announcements early in the year. Reclamation offered $76.46 per acre-foot ($187.50/acre) for idled crop land and $75 per acre-foot for groundwater substitution. In 2004, Reclamation allowed payments for water leases to vary according to bid price. This process has continued in recent years with irrigators submitting bids to participate in the program either by forgoing water use ("dry land operation") or by irrigating with well water ("groundwater substitution").

Program Results

Figure 11 provides a summary of the annual volume of water leased under the program from 2003 through 2007. The program acquired the most water during its initial year . In 2007, Reclamation did not operate the program due to a sufficient water supply. In addition to leasing activity, Reclamation works to achieve flow targets through other methods such as using excess stored water from Lower Klamath Lake to augment flow or by contracting for direct groundwater pumping into surface canals.

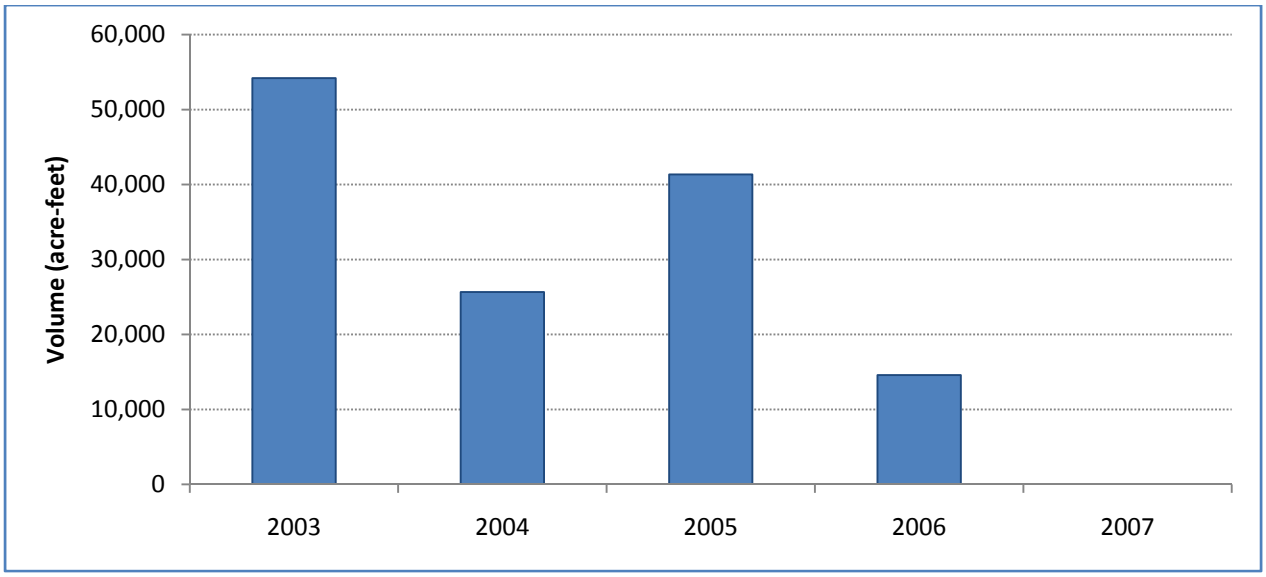

Figure 11: Volume of Water Leased in the Klamath River Basin

Source: U.S. Bureau of Reclamation. 2006 and 2007. "Klamath Basin Project."

[13] USGS. May 3, 2005. "Assessment of the Klamath Project Pilot Water Bank: A Review from a Hydrologic Perspective."

As shown by Figure 12, lease prices during the initial year of the program varied significantly according to the method of supply. However, the average price per acre of groundwater substitution increased in subsequent years to be comparable to prices paid for water supplied through crop idling as expected under a reverse auction format. In 2006, the price was approximately $78 per acre-foot ($174 per acre) on average for dryland farming and $71 per acre-foot ($165 per acre) on average for groundwater substitution. The following sections review the prices and accepted bids under the program.

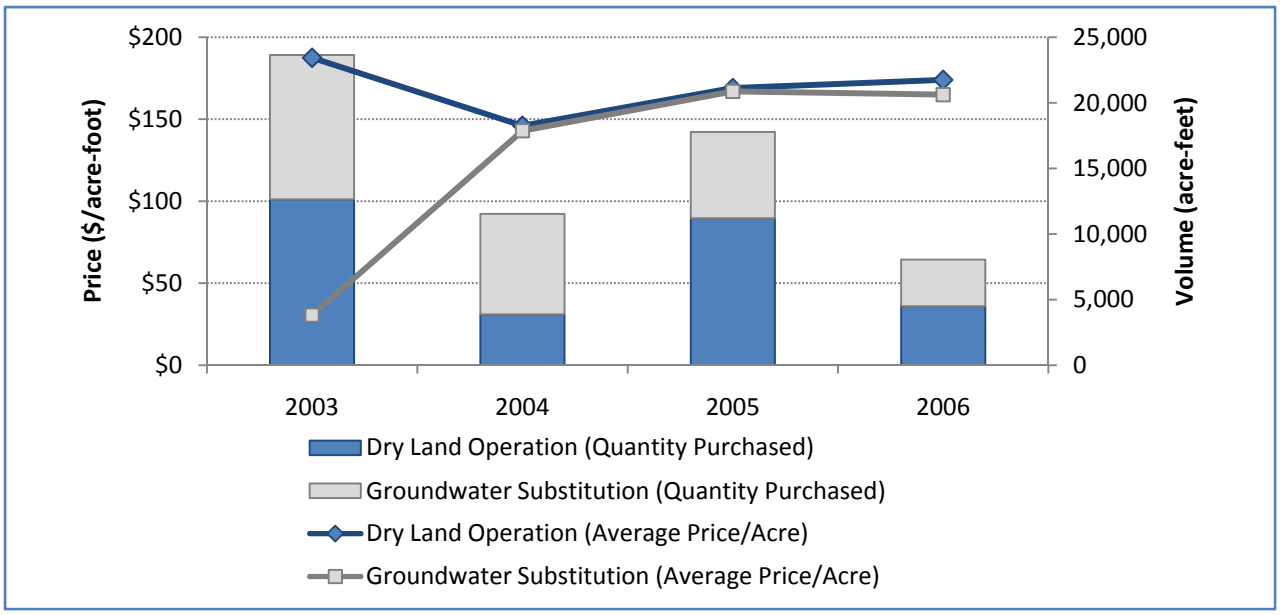

Figure 12: Klamath Water Enhancement Program Results

Source: U.S. Bureau of Reclamation. 2006 and 2007. "Klamath Basin Project."

Crop Idling/Dryland Farming

For crop idling/dryland farming, contracts were awarded under the following conditions:

- Either the land remains idle during the irrigation season or is farmed using dryland farming.
- The land must have been irrigated in the past three years.

The applications are scored according to the volume of consumptive use, which varies by crop and soil type. Preference is given to large volume bids with low bid prices. The majority of the crop idling contracts involve hay crops and pasture, as Figure 3 shows. Other annual crops made up 24 percent of the crop idling while mint comprised just one percent of the total.

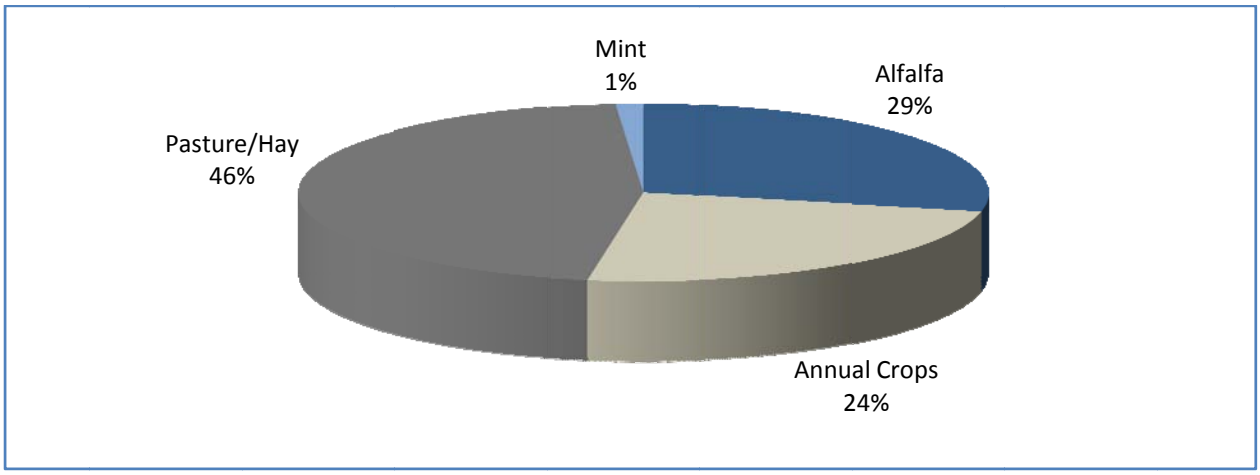

Figure 13: Klamath Basin Water Supply Enhancement Project Crops Idled

Excluding 2003 when the prices were fixed at $76.46 per acre-foot ($187.50 per acre), the prices paid by Reclamation have increased from $59.54 per acre-foot ($146 per acre) in 2004 to $70.95 per acre-foot ($174 per acre) in 2006. Bids ranged from $20.39 per acre-foot ($50 per acre) to $142.73 per acre-foot ($350 per acre) for dryland farming in 2006. Reclamation did not accept bids for dryland operations in 2007.

Groundwater Substitution

Groundwater substitution is another method used to supply water to the leasing program. Applications for groundwater substitution are scored according to the estimated irrigation requirement, which varies according to crop and soil type. As with crop idling contracts, bid award preference is given to large bid volumes with low bid prices. The majority of the groundwater substitution contracts (54 percent) are associated with alfalfa hay production. The remaining crops participating in the program include annual crops, pasture/hay, horseradish, and mint, as shown by Figure 14.

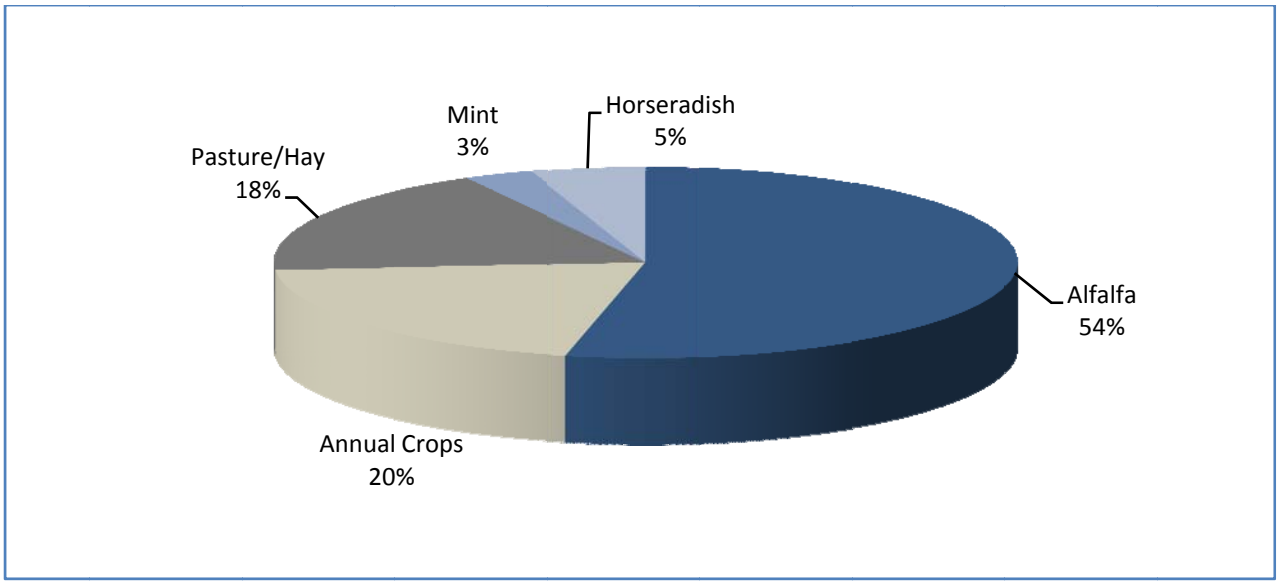

Figure 14: Groundwater Substitution by Crop

Reclamation paid an average of $165 per acre in 2006 and received bids ranging from $75 to $250 per acre for groundwater substitution. The price for a full season groundwater substitution contract was approximately $70 per acre-foot in 2006. Reclamation did not accept bids for its groundwater substitution operations in 2007.

Deschutes Groundwater Mitigation Bank

Program Description

The Deschutes River Basin is located north of the Klamath Basin in Central Oregon and has one of the most developed water banking programs in the West. The Deschutes River Basin encompasses 172,517 acres (270 square miles). The State of Oregon authorized a water banking program in response to legislation that requires mitigation of the effects of new groundwater use. The bank provides new water users a place to purchase or lease water rights for mitigation. It also provides water right owners an opportunity to lease, donate or sell all or a portion of their water rights. A primary objective of the bank is to increase instream flow in the Middle Deschutes River (City of Bend to Lake Billy Chinook) through water right leases and purchases. This section describes the leasing activities associated with the water bank.

In 2002, the Oregon Water Resources Department (OWRD) authorized the Deschutes Groundwater Mitigation Bank, Oregon's first water bank. In 2007, the bank acquired 27,710 acre-feet through leases. Two primary factors— the establishment of mitigation rules and population growth— have promoted development of the bank.

Mitigation Rules

OWRD adopted water mitigation requirements for new groundwater pumping in 2002 to address the effects of groundwater pumping on surface water flows. The basin's mitigation rules require groundwater-permit applicants to fulfill mitigation obligations prior to issuance of a permit. The applicant's mitigation obligations are based on the consumptive use requested. In general, two methods are available to fulfill the mitigation requirements. First, they can implement a mitigation project that may consist of the following:

- Allocation of conserved water for instream use;
- The transfer of an existing eligible surface water right to instream use;
- A permit to use water for artificial recharge of groundwater;
- A secondary permit to use stored water from an existing reservoir provided the secondary permit is for instream use; or
- Other projects approved by OWRD that result in legally protected mitigation water.[14]

The other option for new groundwater users is to purchase or lease water from an approved water bank. Currently, there are two approved water banks operating in the Deschutes Basin. The most active bank is the Deschutes Water Exchange (DWE). The DWE includes a groundwater mitigation bank and a water reserve program. The mitigation bank allows applicants for new groundwater permits to purchase temporary groundwater mitigation credits. The water reserves facilitate the redistribution of water among bank participants. The DWE implements mitigation projects as well as instream leases and acquisitions in order to establish mitigation credits.

The bank primarily obtains the water for exchange through the following mechanisms:

- Standard lease involving one water right, typically one to five years with an opt-out provision.
- Pooled landowner lease involving more than one water right; one or five years.

Population growth in the basin has led to some demand for the mitigation credits. However, relatively few new uses have purchased temporary mitigation credits from the bank as there is concern over the ability of temporary credits to satisfy long-term needs. Nearly 200,000 people currently reside in the basin's three counties. Combined, the population in the region is expected to nearly double to 272,902 in 2025 and grow to 331,734 by 2040. Moreover, the region is attracting new commercial development such as resort communities and golf courses. This growth has contributed to an increased demand for groundwater pumping and the need for mitigation credits.

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[14] OAR 690-521-0300

Program Results

In 2007, the bank leased 27,710 acre-feet for a total of $641,066 ($23 per acre-foot). Some of the water was donated. District landowner payment is based on $7/AF for the leased water, as applied to previous years, according to the DWE. For individual rights, the fixed price varies up to $40 per acre. The volume leased to the DWE is large relative to most other water leasing programs. At the same time, the price paid is among the lowest as much of the water is surplus as a result of the development of irrigated land for residential and commercial purposes. Both the quantity of water leased and the number of participants have increased over time, as shown by Figure ___. Overall, in 2007 the program resulted in 86 cfs of water rights reallocated to instream use to streams throughout the basin.

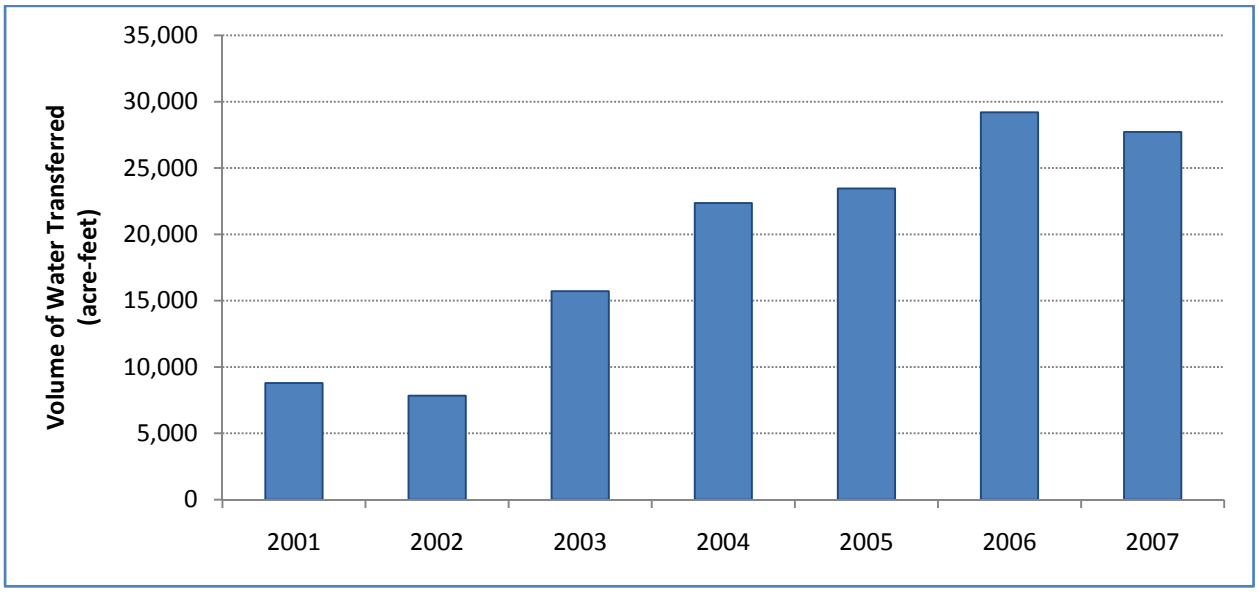

Figure 15: Deschutes Water Exchange Water Leasing Activity, 2002-2007

Source: Deschutes River Conservancy Newton Consultants Inc. May 2006. Water Summit Draft. "Growth, Urbanization and Land Use Change: Deschutes Water Alliance Issue Paper—Water Summit Draft." Prepared for the Deschutes Water Alliance.

The DWE typically leases its water from irrigation district patrons. The price varies according to the length of the lease and the source of the water. Most water leases are for a single season. On average, the DWE has paid $7 per acre-foot for annual water right leases.[15] Irrigators in the Crooked River's districts receive $7 per acre-foot while irrigators in the Deschutes River districts are paid $14 per acre-foot.

Water prices paid by the DRC are often less than the cost of water delivery to the district patrons. Each district has an assessment fee placed upon water users for water delivery. Assessment fees range from $6 to $24 per acre-foot, more than the average lease of $7 per acre foot. Despite the low lease prices,

[15] Deschutes River Conservancy Newton Consultants Inc. May 2006. Water Summit Draft. "Growth, Urbanization and Land Use Change: Deschutes Water Alliance Issue Paper—Water Summit Draft." Prepared for the Deschutes Water Alliance.

irrigation district patrons continue to provide water to the bank for two reasons. First, much of the leased water is associated with land that is no longer actively farmed. Second, participation in the program protects the water rights from regulatory nonuse concerns.

The DRC is beginning to permanently acquire water rights for instream and mitigation purposes. In general, the price for permanent water right acquisitions is expected to remain relatively low as irrigation districts are participants in the program and have actively controlled the volume of water supplied permanently to the bank. In addition, the active conversion of irrigated farmland to urban uses is providing a steady source of water rights to supply the new growth. Water prices in the Deschutes Basin are relatively low due to the limited crop choices and modest yields provided by climate and soil conditions. In addition, the conversion of irrigated land to residential and rural-residential development is providing a steady supply of water rights that more than offset the increased demand for urban uses.

Palo Verde Irrigation District/Metropolitan Water District Water Transfer Plan

Program Description

In 2004, the Palo Verde Irrigation District (PVID) and Metropolitan Water District (MWD) agreed to a 35-year contract calling for PVID farmers to voluntarily fallow their land in exchange for annual compensation from the MWD. Each year, depending on MWD's water needs, MWD may call upon the participating PVID farmers to fallow their irrigated acres. This forgone farming activity results in increased surface water flow into the Colorado River. The MWD diverts the increased Colorado River flows for municipal use on the South Coast. The MWD's goal in initiating this agreement was to add between 30,700 acre-feet and 116,000 acre-feet of flexible and affordable water supply to its water resource portfolio.

The program provides MWD with the option to call upon PVID's participating farmers to forgo water use for a one year period. The deal calls for PVID farmers to fallow between 7% and 28% of their land in exchange for annual payments from MWD. When the program commenced in January 2005, farmers received a one-time payment of $3,170 per encumbered acre. MWD may call upon the participating PVID farmers to fallow their acres depending on the MWD's water needs for the year. Under the agreement, MWD pays $602 per non-irrigated acre during the first year in the program. The price escalates for the first 10 years by 2.5 percent and by the CPI for the remaining 25 years (subject to a minimum adjustment of 2.5 percent and a maximum adjustment of 5 percent). The MWD may call for up to 111,000 acre/feet per year, depending on its water needs.

The development and implementation of the program required extension negotiation and study. Farmers were concerned about the length of the agreement and that leaving 20% of their land fallow would result in environmental degradations, job loss, and weakening of the farming culture in the valley. Ultimately, the organizations reached agreements on the amount of land left fallow, levels of farmer compensation for fallowed land, the duration of the agreement, control over productive land, and how often the MWD may call for peak water levels (111,000 acre-feet per year). In addition to negotiating the agreement, the MWD

was required to complete an environmental review of water transfers from Palo Verde to ensure that the plan satisfied state of California environmental guidelines.

Program Results

The annual volume of water PVID water users have provided has varied depending on MWD's water needs. In 2004, PVID water users provided 62,000 acre-feet. In 2008, MWD called for the full volume of 111,000 acre-feet, which required PVID water users to leave 29 percent of the valley fallow. The request was in response to a 30-percent decrease in State Water Project supplies because of a threatened fish. Meanwhile, the prices paid have been steadily increasing per the terms of the contract. MWD paid approximately $146 per acre-foot in 2008.[16] Metropolitan's annual Operations and Maintenance budget allocates $17.9 million to finance the PVID/MWD program.

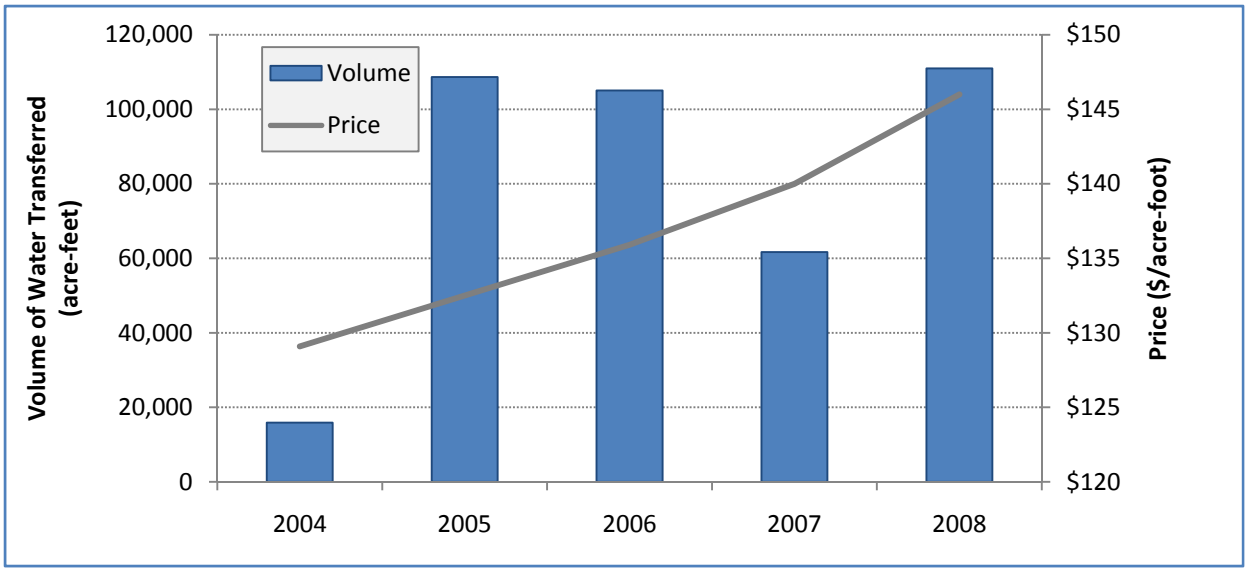

Figure 16: PVID/MWD Program Activity Summary

Super Ditch Company's Lease Rotation Program

Program Description

In May 2008, the Lower Arkansas Valley Super Ditch Company (SDC) was formed by farmers and ranchers in six irrigation companies in southeast Colorado. Modeled after the PVID/MWD program, the SDC will market water to the growing municipalities along Colorado's Front Range. SDC will employ a rotational fallowing arrangement in which their members will forgo irrigation on a rotational basis. The

[16] Not including the upfront payment made to irrigators participating in the program.

water supply generated through crop idling will be leased on an annual basis to urban water providers including Colorado Springs.

A goal of the water leasing program is to reduce and/or eliminate the negative aspects to traditional "buy and dry" water purchasing by municipalities. Under the program, farmers would forgo irrigation on a portion of their land each year thereby securing a stable source of revenue while continuing to farm the remaining portion of their property.

SDC is controlled and owned by irrigators, and is managed by a Board of Directors elected by participating irrigators. Participation in the Company is completely voluntary. The Company is responsible for leasing water, obtaining water court approval, and permitting. The Company members will shift fallowed acres from one farm to the next annually to spread forgone farming activity equally over the member's farms and ranches. The company determines which lands would be fallowed each year based on supply, lease demand, and hydrologic conditions.

The initial technical engineering feasibility and hydrological studies, economic analyses, and legal investigations to develop the concept of the lease rotational program were incurred by the Lower Arkansas Valley Water Conservancy District (LAVWCD). The LAVWCD invested over $750,000 in developing the program. In addition, the LAVWCD also obtained grant funding through the state Interbasin Compact Committee and the Colorado Water Conservation Board. After the program is up and running, municipalities would pay water rights owners for the right to use a portion of their water for a predetermined amount of time. Organizers indicate that SDC could lease up to 45,000 acre-feet of water each year, generating $10 million to $15 million annually for farmers and other water-rights owners.

Potential administrative issues remain regarding operation of the program such as variation in yield and water value among ditches, farm water delivery issues, and land fallowing rules. SDC will also need to develop contract terms with municipalities addressing municipal delivery schedules, water supply reliability, price, payment terms, and length of leases.

Crop Mix Change

In addition to leases and purchases of water rights, the CAMP Committee is also considering the opportunities associated with paying agricultural producers to change to crops that require and consume less water. The goal of this type of contract is to develop an opportunity to improve the water budget in the ESPA while at the same time keeping irrigated land in production and reducing the potential economic and social effects associated with acquisitions that result in land fallowing. An operating program that pays farmers to change crops in order to reduce water use was not identified during research for this study. However, a program that includes crop mix changes as a potential element is described in the case study at the end of this section.

The consumptive water use of commonly planted crops in the ESPA region varies considerably as shown by Figure 17. As a result, large-scale changes in crop mix have the potential to reduce the amount of water that is withdrawn from the ESPA for irrigation purposes. Alfalfa consumes approximately 3 acre-feet per acre compared to spring grain and beans which consume approximately half as much water. Introducing more grain crops in the normal crop rotations of groundwater users in the ESPA, could reduce consumptive use by more than 50,000 acre-feet each year if 10 percent of the alfalfa and silage corn acreage were planted to barley.[17]

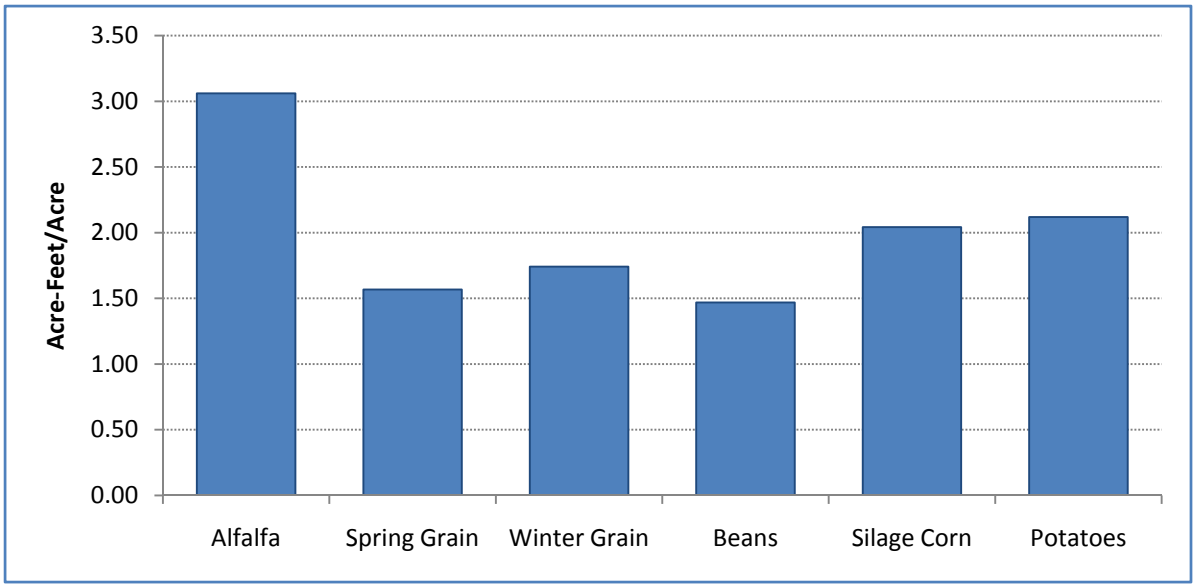

Figure 17: Evapotranspiration (AF/acre) by Crop in the ESPA Region

Estimated Costs of Crop Mix Program

There are no payments from operating programs available to use as a guide for the payments that would potentially be required to promote a large-scale change in the ESPA crop mix. However, it is expected that payments to participating producers would need to at least offset the potential reduction in net income that would be earned over a rotation period. Annual crop production budgets published by the University of Idaho Cooperative Extension were applied to develop an estimate of the direct per acre-foot costs of the program. The cost per acre-foot of water "saved" through the program would be expected to vary according to the relative prices of alfalfa and grain crops. Currently, crop prices for grain and alfalfa are high relative to historic market conditions. As a result, crop prices were varied in order to consider how these factors may result in changes in required payments.

Agricultural producers in the ESPA follow a variety of crop rotations to maximize productivity and minimize disease problems among other factors. In order to estimate the costs of the program, this

[17] B. Contor, February 2008. "Changes in Crop Mix." Presentation to the CAMP Committee.

analysis assumed a simple starting crop rotation consisting of four years in alfalfa followed by one year in grain. Participating producers would be paid to change the rotation to three years in alfalfa following by two years in grain. Table 6 shows the assumed yield for each crop and the estimated price at which revenues exactly cover production costs (breakeven price). At current prices, agricultural producers are earning estimated net revenues of $302 per acre for alfalfa, $223 per acre for spring wheat, and $286 per acre for winter wheat.

Table 6: Estimated Yield, Breakeven Price, and Net Revenue by Select Crop

Crop	Units	Yield	Breakeven Price	Current Price	Net Revenue ($/acre)
Alfalfa	Tons	7	$97.80	$141.00	$302.00
Spring Wheat	Bushels	115	$4.96	$6.90	$223.00
Winter Wheat	Bushels	125	$4.71	$7.00	$286.00

Sources: University of Idaho Cooperative Extension, Crop Production Budgets. USDA National Agricultural Statistics Service.

The currently high prices for grain crops may make the program more attractive to agricultural producers and less costly to implement.[18] However, changes in the market conditions for grain crops relative to alfalfa has the potential to cause program costs to increase in order to maintain enrollment. Table 7 provides the estimated change in annual net returns for the two crop rotations with varying grain prices. As shown, the net returns between the two rotations are similar at current grain prices. As a result, the estimated payments required to keep agricultural producers financially "whole" is less than $5 per acre ($299.17 minus $295.94) which is equivalent to an annual cost of $12.24 per acre-foot "saved." Reductions in grain prices dramatically increase the potential program costs, however. If, for example, grain prices fall to $6 per bushel, the difference in net returns between the two rotations increases to approximately $30 per acre per year. This is equivalent to a cost of $107 per acre-foot "saved."

Table 7: Estimated Payments at Various Grain Prices

Alfalfa Price ($/ton)	Grain Price ($/bu)	Net Returns w/o Program ($/acre/yr)	Net Returns w/ Program ($/acre/yr)	Water Savings (AF/acre/yr)	Program Cost ($/AF/yr)
$141.00	$7.00	$299.17	$295.94	0.26	$12.24
$141.00	$6.50	$286.67	$270.94	0.26	$59.62
$141.00	$6.00	$274.17	$245.94	0.26	$107.00
$141.00	$5.50	$261.67	$220.94	0.26	$154.38
$141.00	$5.00	$249.17	$195.94	0.26	$201.76

18 This analysis does not consider how federal commodity price support programs would affect operation of a program to pay agricultural producers to produce more grain crops.

Implementation Challenges

There is little guidance available from review of existing demand reductions to characterize the potential implementation challenges. However, monitoring and verification are important components of any demand reduction program to ensure contract performance. Implementation of a program to pay agricultural producers to switch to less water –intensive crops would require a long-term commitment on the part of the participants to ensure that the changes in crops differ from those that would have existed as a result of normal farming practices and changes in crop market conditions. Acceptance of the program by agricultural producers may be affected by crop contracts and markets.

Parker Water and Sanitation District, Rural-Urban Water Model Study

Program Description

Parker Water & Sanitation District (Parker Water) and Colorado State University initiated a project in 2007 to improve rural and urban water supply management through research in cropping system. The goal of the Rural-Urban Water Model Study was to develop and investigate cropping system options for meeting growing urban water needs while at the same time sustaining viable economic returns to the agricultural and rural communities. While the project is considering rotational crop fallowing, it is also researching opportunities for deficit and partial season irrigation and planting of alternative crops that require less water. Parker Water purchased irrigated land along with water rights to support the project and has committed more than $1 million for research in support of the project.

Changes in crop mix are being studied to determine the effects on farm profitability and regional economic activity as well as the volume of water that would be made available through the changes in farming practices.

Program Results

No program "results" yet but we are checking on the status of research and analysis in support of crop mix changes.

Summary

The water values provided in the study provide estimates of the potential direct costs associated with implementation of a demand reduction program that pursues a variety of strategies including short-term and permanent acquisitions as well as payments to change to crops that consume less water. It is anticipated that payments for participation in a demand reduction will be established through willing seller – willing buyer negotiations or based upon a fixed offer price. Consequently, actual values may differ from those presented in this analysis.

Permanent Acquisitions

A hedonic pricing model was used to estimate the value that water rights contribute to agricultural land prices in the ESPA region. The model relied upon 333 individual agricultural land sales in the ESPA from January 2003 through June 2008 encompassing more than 200,000 total acres and nearly 140,000 irrigated acres. Results of the model indicate that water values vary by location within the ESPA and are also affected by the depth to groundwater for land irrigated from wells. The estimates provided by the model indicate that average water values range from $1,260 to $2,240 per acre depending upon location. The estimates provided by the hedonic pricing model are entirely dependent upon the dataset and model specification. Application of different data and changes in model specification are likely to result in different estimates.

Short-Term Acquisitions

Operating water leasing programs in other regions were reviewed in order to inform the CAMP Committee of different program structures and water pricing. As described the costs of the programs vary according to the lease terms and the methods available to supply water to the program among other factors. In most of the programs, hay and pasture crops have primarily been idled to supply water to the programs. Due to the large amount of irrigated hay and pasture in the ESPA region, the prices paid for water in other active leasing programs are considered to be a relevant measure of the prices that will likely be required to lease water under a demand reduction program in the ESPA. Differences in lease terms, water supply and demand conditions, and agricultural productivity are expected to result in prices that are higher or lower than those observed in the other water leasing programs however. The highest lease prices occur in areas with increasing municipal demand. Annual lease prices in regions without significant urban demands have generally been between $100 and $200 per acre for programs enrolling agricultural land that is actively irrigated.

Crop Mix Change

Reducing the amount of land planted to crops that consume a relatively high amount of water has the potential to contribute to a change in the overall ESPA water budget. Research for this study did not reveal any operating programs that pay agricultural producers to plant crops that require less water. A simple analysis of crop budget suggests that required payments would be greatly affected by the relative price of lower water using crops such as grain. A reduction in grain prices would result in an increase in the payments required to induce a higher proportion of grain planting than that which would occur in the absence of the program. A number of monitoring and verification challenges could increase the indirect costs of administering the program.