Assessment of Kansas Damages and Nebraska Unjust Enrichment Resulting from Nebraska's Overuse of Republican River Water in 2005 and 2006

March 15, 2012

Dr. David Sunding
UC Berkeley and The Brattle Group

Contents

Tables

Figures

I. Background and Qualifications

My name is David Sunding and I am the Thomas J. Graff Professor of Natural Resource Economics at UC Berkeley, where I am also the Co-Director of the Berkeley Water Center. I teach graduate and undergraduate courses in natural resource economics, environmental economics, and the economics of water resources. I have published numerous peer-reviewed articles in the fields of environmental, agricultural and natural resource economics. I have received numerous awards for my research, including grants from the National Science Foundation, the US Department of Agriculture, the US Environmental Protection Agency, the State of California and private foundations. I have served on panels of the National Academy of Sciences and the USEPA's Science Advisory Board.

Prior to my current position at Berkeley, I served as a Senior Economist at President Clinton's Council of Economic Advisers, where I had responsibility at the Council for the areas of the environment, agriculture, energy and natural resources. During the 2010-2011 academic year, I was a Visiting Professor at the Woods Institute of the Environment at Stanford University.

I have been asked by the State of Nebraska to consider the magnitude of damages to Kansas allegedly resulting from Nebraska's overuse of water diverted from the Republican River in the years 2005 and 2006. I was also asked to consider Kansas' analysis of Nebraska's unjust enrichment from the same over use of water. This report contains my conclusions regarding Kansas' analysis.

II. Description of Kansas' Damage Analysis

Drs. Joel Hamilton and M. Henry Robison have submitted an economic analysis (hereafter, "Kansas Losses Report") purporting to measure damages to Kansas residents allegedly resulting from Nebraska's noncompliance with the terms of the Final Settlement Stipulation approved by the May 19, 2003 Supreme Court Decree in *Kansas v. Nebraska and Colorado*.[1] I say "allegedly" because Kansas does not attempt to define the extent to which Nebraska's actions were the proximate cause of its alleged damages. Rather, Kansas simply assumes all damages arise solely from Nebraska's actions. Their analysis used a mathematical model to simulate production decisions, behavior and output within the affected region of Kansas and considered how these behaviors were affected by a reduction in available surface water supply in 2005 and 2006. A yield model is first used to estimate agricultural productivity under the relevant water-availability scenarios. These estimates are then included in crop budget calculations to compute the value of lost economic output proceeding from Decree noncompliance. After direct losses are calculated by this method, the Kansas analysis then calculates indirect impacts resulting from the

[1] Hamilton, Joel and M. Henry Robison. "Economic Analysis of Kansas Losses from Overuse of Republican River Water by Nebraska in 2005 and 2006". November 18, 2011.

change in economic activity associated with the so-called "water shortage" allegedly occasioned by Nebraska's overuse of its Republican River Compact allocation. I will review each of these elements in turn.

Before beginning my analysis, however, I would like to clarify the term "water shortage" as used in my report. There are three concepts of "water shortage" that have been mentioned in this case. The first is the concept of "Water Short Year Administration" under the Compact. The second is a "water short" year as defined by KBID, which are all years in which KBID has less than 15" at its disposal (regardless of the actual demand within KBID in any given year).[2] Neither of these definitions applies to my report. There is no dispute that Water Short Year Administration was in effect in 2005-06. Further, neither of these concepts corresponds to the issue of Nebraska compliance with the Compact (i.e., Nebraska can be in compliance during a Water Short Year Administration scenario, and Nebraska can be in compliance when KBID experiences a "water short" year as defined by KBID.

The third concept of water shortage relates to the amount of water that KBID *would* have applied in 2005-06 as compared to what was actually applied in those years. This concept is the focus of my report and is the proper measure of actual damages resulting from Nebraska's noncompliance.

A. Yield Model

Kansas' damage analysis used a mathematic model to develop crop production functions for commodities produced in North Central Kansas.[3] The model is used to predict KBID agricultural productivity as a function of water availability. The crop production functions belong to a broader class of "water response" models that transform estimates of the quantity of available irrigation water into per-acre predictions of agricultural productivity. These predictions internalize a number of outside factors affecting productivity, such as the prices of farm inputs and outputs, and precipitation and other climatic factors.

Kansas' analysis used the yield model to estimate aggregate output in KBID under various irrigation scenarios. Kansas determined that 10.5 inches would have been applied to lands in KBID in 2005 and 2006. They term this the "Required Water." Irrigated yields were computed by assuming that KBID farmers received the Required Water. The yield model was also used to calculate what Kansas' report refers to as "actual yields", though these do *not* directly reflect observation of actual yields realized by farmers within KBID and are in reality another

[2] This is an historical value and is no longer valid based on testimony from Mr. Ross, the regional Division of Water Resources Commissioner. He made clear that 12"or less is all that is needed in KBID today. See Ross Deposition, pg. 18.
[3] Klocke, Norman L. "Development of Crop Production Functions for Irrigation in North Central Kansas". November 18, 2011.

prediction of the yield model. The report's "actual yields" are calculated by taking the decreased water volume delivered to Kansas after Nebraska's overuse and assuming farmers applied it uniformly across their irrigated land.

Normally, in a damage analysis one compares actual outcomes to simulated outcomes under the counterfactual assumption of no action causing damage.[4] Damages are then determined by measuring the difference in outcomes between the two cases. While data on yields in KBID were published for the years 2005 and 2006, Kansas' experts chose not to use those figures in their analysis, opting instead to use the outputs of the hypothetical yield model under assumed water-short conditions.[5]

Kansas' economists fail to note that yields reported in KBID in 2005 and 2006 are much higher than those that the yield model predicts, sometimes exceeding the yield model's predictions of crop productivity even under an assumption of full irrigation.[6] Despite this discrepancy, which should have prompted further investigation on Kansas' part given the model's poor fit to actual data, the difference between the model's water-short and theoretical maximum full-irrigation yield estimates is used to assess the economic impacts of Decree noncompliance.

B. Crop Budget Calculations

In order to estimate changes in economic output from decreased crop yield, Kansas makes use of crop cost and return budgets prepared by Kansas State University. Crop budgets are typically prepared with the goal of helping farmers make better management decisions.[7] They attempt to represent average costs for farm production of various commodities in a specific region. In Kansas' report, the crop budgets are modified to estimate changes in input costs and profit ("value-added") for each major crop grown in KBID.

The crop budget calculations require a large number of assumptions about what constitutes the average farm operation. Those assumptions which are invariant to the actions disputed in the case, such as crop prices, land/labor/irrigation costs, and irrigation technologies are derived from a variety of sources including KBID records, the academic literature, and data provided by federal agencies. These data are summarized in
Table 1. In some instances, invariant parameters were estimated using average data from 1994-2000 or 2010 based on the authors' judgment. According to the Kansas' analysis, years 2001-2009 were treated as anomalous because they were labeled as water-short.

---

[4] Allen, Mark, Robert Hall, and Victoria Lazear. "Reference Guide on Estimation of Economic Damages." In *Reference Manual on Scientific Evidence,* Third Edition. Federal Judicial Center, 2011. Pg. 432.
[5] Kansas Bostwick Irrigation District. "Annual Report 2006."
[6] Ibid.
[7] Kansas State University Research and Extension. "Crops: Projected Budgets."
<http://www.agmanager.info/crops/budgets/proj_budget/default.asp>

Some parameters used in Kansas' analysis are unobservable. For example, in order to calculate total output assuming Decree compliance (hereafter and in the Kansas analysis, the "Nebraska compliance scenario"), it is necessary to know how many acres would have been irrigated in the absence of Nebraska's overuse. To calculate this quantity, Kansas' economists estimated the average number of irrigated acres for the years 1994-2000. Parameters that required hypothetical estimation are summarized separately in Table 2.

The finalized crop budgets present Kansas' estimates of total spending on produced inputs and total value-added for each crop grown in KBID and the surrounding region, on a per-acre basis. These values make up the inputs to Kansas' final calculation of damages.

C. Damage Calculation

The Kansas analysis combines results from the crop budget calculations to measure total damages inside and outside KBID. Crop prices, crop yield, and total acreage are multiplied and weighted using the appropriate crop shares to determine total revenues. Total costs include the combined unit costs of labor, irrigation, fertilizer, energy; subtracting these from total revenues yields total profits, or value added. Kansas' analysis computes total value added for both Nebraska compliance and actual delivery scenarios and takes the difference between the two to determine lost profits. This difference comprises the on-farm direct portion of Kansas' stipulated damages.

The second part of the damage calculation is based on Kansas' estimation of indirect impacts of water shortage in KBID. Estimation of indirect impacts was performed using an input-output model known as IMPLAN. Kansas' experts take the total costs of agricultural production as inputs to the IMPLAN model to determine secondary spending impacts in the local economy. While the method is commonly employed by policy analysts, the use of IMPLAN to assess indirect impacts resulting from changes in water availability is fraught with problems making it improper to use in calculating monetary damages where a high degree of precision is required. Some of the major problems with IMPLAN include the generally poor quality of the embedded input purchase and consumer expenditure data, including information on "export" coefficients, for rural areas in the United States. More importantly, as will be explained further, indirect impacts are not a legitimate consideration in a proceeding of this type.

Table 1: Invariant Parameters

Parameter	Description	Source	Notes	Table[8]
Prevented Planting Payments	Crop insurance indemnity payments made to farmers unable to grow crops due to water shortage.	FOIA Request	All prevented planting payments in Jewell and Republic counties allocated in KBID above and below Lovewell based on non-irrigated land totals in each region.	8
Irrigation Efficiency	Percent of water at farm headgate that is used beneficially in crop production.	CROPSIM Simulation Model		13
Crop Prices	Regional market prices for KBID-grown crops in 2005 and 2006.	NASS		16
Irrigation Cost	Unit cost of applied irrigation water.	University of Arkansas Extension Publication	Irrigation repair and maintenance costs and system power costs are assumed to be proportional to system investment costs.	
Fertilizer Cost	Per acre cost of nitrogen fertilizer.	KSU Crop Budgets	Fertilizer costs are taken from the KSU crop budgets and calculated as a linear function of yield.	
Machinery Costs	Breakdown of crop budget custom hire costs into fuel and maintenance and repair expenses.	Beaton MS Thesis		17
Irrigation Technology Mix	Relative use of irrigation technology within KBID.	KBID	2010 KBID crop report used "because of concerns that the 2005-2006 water shortage could have skewed the 2006 percentages."	18

[8] Reference of numbered tables in Kansas Losses Report.

Table 2: Unobservable Parameters

Parameter	Description	Source	Notes	Table[9]
Total Irrigated Acres	Land that would have been irrigated absent Nebraska's overuse.	KBID	Estimate based on average percentage of irrigable lands actually irrigated from 1994-2000.	6
Irrigated Crop Mix	Irrigated crop mix that would have been grown absent Nebraska's overuse.	KBID	Kansas' report uses 2010 KBID crop mix as representative because in the 1994-2000 period crop mix was claimed to be "in flux."	7
Dryland Crop Mix	Dryland crop mix that would have been grown absent Nebraska's overuse.	NASS	Weighted average of NASS dryland crop production data for Jewell and Republic counties based on proportion of KBID acreage in each county. Excludes wheat.	9
Total Dryland Farmed Acres	Land that was farmed using dryland methods due to Nebraska's overuse.	KBID	Acres classified as irrigable less actually irrigated acreage. Assumes all land classified as irrigable was either farmed or received a prevented planting payment.	10
Crop Yields	Yields by crop assuming water-short and full irrigation levels.	Klocke Yield Model		14

[9] Reference of numbered tables in Kansas Losses Report.

III. Assessment of Kansas' Approach to Damages

With the steps in Kansas' analysis in mind, I now turn to an assessment of their approach. Kansas' economic analysis suffers from significant flaws that make it unreliable and inadequate as a basis for damages. The model of crop yields underlying Kansas' approach is a hypothetical representation of farm production decisions and does not correspond well with real-world data. The yield model is being used in this case for something other than its intended purpose. It is a model designed to help farmers make future production decisions to maximize an objective function specified by the researchers. It is not a model for predicting or explaining actual farmer behavior. Further, in applying the yield model to KBID, Kansas' economists make a series of unfounded assumptions that, taken together, lead to an overestimate of actual losses.

The shortcomings in Kansas' damage analysis are made evident by comparing their estimates of the value of water in KBID to observed market prices for water in the region. Such a comparison – which was not made by Kansas' economists – reveals that Kansas' estimates of the value of water are inflated, and therefore that their analysis overstates actual damages.

A. Fundamental Issues

There are a number of fundamental errors in Kansas' approach to estimating damages:

1. There is no dispute that crop yields are influenced by the amount of water applied. This water can come from natural precipitation or from irrigation. In a year with a large amount of precipitation occurring during the growing season, there is less need for irrigation and hence, the economic productivity of irrigation water is lower in this circumstance. When measuring the impact of reduced availability of irrigation water in a particular year, it is essential to take account of the amount of natural precipitation occurring in that year.

   Actual precipitation in KBID is easily observed from the historical record, yet Kansas' calculation of the net irrigation requirement that drives the yield model is determined by historical precipitation averages. An accurate damage calculation would incorporate the actual precipitation levels which were observed in 2005 and 2006, as they were significantly above the historic average, especially in 2005.[10]

   For example, the irrigation requirement for sorghum and alfalfa used in Kansas' model was based on average precipitation levels that would be exceeded in 50% of all years.[11] This erroneous assumption leads to an overestimate of the value of irrigation water for these crops

[10] Kansas Bostwick Irrigation District. "Annual Report 2006."

[11] USDA Natural Resources Conservation Service. National Engineering Handbook KS652.0408 state supplement, pg. 9. <ftp://ftp-fc.sc.egov.usda.gov/KS/Outgoing/Web_Files/Technical_Resources/ks_supplements/neh/ks652_ch4.pdf>

in the growing conditions specific to the years 2005 and 2006.

2. Kansas' methodology does not take into account the fact that the productivity of irrigation water varies over the growing season. Crop yields are often dependent on water application at specific times of the year. In KBID, the irrigation season ideally lasts from July 1 through September 1.[12] Treating all applied water as equally productive regardless of when irrigation took place inevitably simplifies a more accurate determination of crop yield response to water. This fact takes on further importance when precipitation in 2005 and 2006 is taken into account, as those years had above-average rainfall in July-September, the months comprising the height of the typical irrigation season.[13]

3. Kansas' analysis assumes uniform application of irrigation water across all irrigated acreage under water short and full delivery conditions. This assumption does not reflect farmers' production decisions and biases the results upwards. Economists typically distinguish between average and marginal value when considering the economic value of production inputs like water. Kansas' experts assume that all fields are equally productive and when faced with a shortage, it will be applied to all fields equally. For example, the Kansas report assumes all acres above Lovewell in 2005 received 6.1 inches of water under water-short conditions, and would have received 10.5 inches of water without Nebraska's overuse.[14]

   In reality, given the differences in soil quality, crop profitability and the productivity of water acknowledged by various Kansas deponents, it is more realistic to assume that Kansas farmers would curtail irrigation of the least productive fields first.[15] That is, the average value of water across all fields in KBID is larger than the marginal value of water on the least productive fields in the district, or those planted to the least profitable crops. Thus, basing damages on the average value of irrigation water leads to an overestimate of actual damages.

B. Yield Model

There are numerous problems with the crop-water relationships embedded in the yield model used to calculate Kansas' direct damages. In many cases the hypothetical yield estimates produced by the model are not close to real-world levels reported by KBID farmers, and are obtained from a variety of sources that frequently contradict one another. Each year, KBID surveys farmers in the district to determine actual crop yields. Comparing the yield model's hypothetical yield estimates with the values reported by KBID farmers as in Table 3 below

[12] Ross Deposition, pg. 30.
[13] Kansas Bostwick Irrigation District. "Annual Report 2006."
[14] Kansas Losses Report, Table 12.
[15] See, for example, the approach developed in Sunding, David et al., "Modeling the Impacts of Reducing Agricultural Water Supplies: Lessons from California's Bay-Delta Problem," in *Decentralization and Coordination of Water Resource Management*, Douglas Parker and Yacov Tsur, eds., New York: Springer, 1997.

indicates the magnitude of these issues.

Table 3: Yield Estimates Comparison

Year	Crop	"Actual Yield" Kansas Estimate	KBID Reported Yield	Difference
2005	Corn	155.6	187	-16.79%
	Milo	130.3	119.6	8.90%
	Soybeans	59.2	58	2.07%
	Alfalfa	5	7.6	-34.21%
2006	Corn	163.1	162.6	0.31%
	Milo	132.6	110.5	19.95%
	Soybeans	60.8	54.9	10.75%
	Alfalfa	5.15	6.3	-18.25%

Source: Kansas Losses Report, KBID Annual Reports

It is evident from the table that Kansas' yield estimates diverge significantly from those reported by farmers in KBID. For example, Kansas' prediction of the yields for soybeans in 2005 and 2006 are higher than any yields ever reported in KBID up to that point, while the yields for corn and alfalfa are significantly lower than average yields reported over the prior decade. No explanation is provided for why certain crops may be expected to be more productive in water-short years, while others would see significant yield declines.

Referring to the KBID survey of farmers, Kansas' experts state that "KBID management personnel indicated most of the larger farmers returned the survey," yet still chose to forego reported yields in favor of those produced by the yield model.[16] The results shown above indicate estimated yields diverged from KBID-reported yields by as much as 34%, with significant over- and under-estimates relative to the reported yields. These magnitudes are very significant, as the predicted changes in yield from failed water delivery that drive Kansas' estimated damages range from only 1 – 13%.

The discrepancies between KBID-reported yields and the predictions of Kansas' model can be traced back to the inputs to the yield model itself. The model's crop production functions rely on a number of parameters, including assumed maximum crop yields with full irrigation, regional yields produced by precipitation only, and the amount of irrigation required to produce maximum yield. The values for corn and soybeans are obtained from a separate simulation

[16] Kansas Losses Report, pg.4.

model referred to as CROPSIM, which is based on a combination of field research and mathematical descriptions of crop development.[17]

For sorghum and alfalfa, the parameters are obtained from a range of sources.[18] The net irrigation requirements for these crops are taken from the USDA Natural Resources Conservation Service's Kansas Irrigation Guide.[19] Assumed maximum yields for sorghum under dryland conditions and with full irrigation are taken from KSU Performance Test Data and NASS reports. The parameters for maximum alfalfa yield are likewise derived from consultation with a KSU agronomist and NASS data. Selected input parameters for the yield model are reproduced below in Table 4.

There are a number of fundamental problems with the parameters used in the yield model. First, the predicted maximum yields fall short of realized yields in KBID, and thus should be viewed with suspicion. The value for maximum corn yield is 182 bu/ac. However, the reported average KBID corn yield for 2005 was 187 bu/ac, a value in excess of the maximum possible yield permitted by the yield model. Since that time, corn yields in KBID have risen to as high as 220 bu/ac in 2009. This comparison reinforces the notion that Kansas' yield model does not fit the observed data in KBID since the yields reported by farmers surpass Kansas' assumed "maximum yield" by over 20%. This is a serious shortcoming of Kansas' yield model as setting a maximum yield under actual observed levels in KBID will consistently lead to the underestimation of corn yields in years with favorable growing conditions, such as 2005.

Table 4: Yield Model Inputs

Crop	Net Irrigation Requirement	Max. Unrestricted Crop Yield (Y_f)	Non-Irrigated Yield (Y_n)
	inches	bu/ac	bu/ac
Corn	10.1	182	98
Soybean	8.6	63	43
Sorghum	7.4	134	102
		ton/ac	ton/ac
Alfalfa	16	6.5	3.9

Source: Kansas Losses Report, Table 13

Further discrepancies arise when consulting the myriad sources used in choosing the model's parameters. For example, the net irrigation requirements for sorghum and alfalfa are derived from a USDA irrigation guide. That same guide also presents irrigation requirements for corn and soybeans, for which Kansas instead used the CROPSIM-generated parameters. However,

[17] Martin, Derrel, Darrell Watts, and James Gilley. "Model and Production Function for Irrigation Management". Journal of the Irrigation Drainage Division of the American Society of Civil Engineers, 110 (4):149-164, 1984.
[18] Klocke, pg. 5.
[19] USDA, pg. 9.

the values produced by CROPSIM and those from the guide are in some cases widely divergent. The USDA irrigation guide claims a net irrigation requirement of 6.4 inches for soybeans in Republic County, while the value produced in CROPSIM and used in Kansas' yield model is 8.6 inches. Given that the claimed shortage experienced in Kansas was 4.4 inches per acre, this discrepancy in irrigation requirements represents over half the total change in per acre irrigation claimed to result from Nebraska's overuse, and biases calculated damages upwards.

C. Crop Budgets

Kansas' crop budget calculations rely on a wide range of parameters, many of which are summarized in
Table 1 and Table 2. Some parameters were estimated by Kansas' experts by discarding more post-2006 data, including the most recent year for which there was no water shortage, in favor of that which pertains to the period 1994-2000. For example, fully-irrigated KBID acres and the proportions of planted acreage above and below Lovewell were estimated based on 1994-2000 data. Other assumptions used more recent data instead, such as Kansas' values for the irrigation technology mix, which relied on 2010 data. These assumptions are valid only insofar as they accurately describe the change in farmer behavior that would have resulted from increased surface water diversions in 2005 and 2006. However, as I will discuss, many of the assumptions appear arbitrary and the authors offer little justification for their choices.

One of the most significant decisions made by Kansas' experts in determining the crop budget parameters was the exclusion of 2001-2009 from the calculations. Kansas' experts stated their belief that those years were not representative of 2005 or 2006 conditions due to ongoing water shortages. However, KBID crop data reveals that many of the "water-short" years had higher irrigated acreage totals and higher crop yields than those that were not water short. In deposition, Dr. Hamilton revealed that Kansas did not examine the magnitude of the water shortages in the excluded years, did not know why those years were labeled as water short, and furthermore had no basis for assuming 2005 or 2006 would not have been labeled as "water short" but-for Nebraska's overuse.[20]

In many cases, the choices of Kansas' economists bias damages significantly upwards. For example, in using data from 1994-2000 Kansas' experts assume that 89% of irrigable land would have been irrigated in 2005 and 2006.[21] However, the long-term average of irrigable land actually irrigated in KBID is much lower, at 74%.[22] As confirmed by Dr. Hamilton in his deposition, if he had used the long-term average figure for irrigated land acreage, he would have arrived at a significantly lower damage figure.[23]

[20] Hamilton Deposition, pg. 71-72.
[21] Kansas Losses Report, pg. 2.
[22] Kansas Bostwick Irrigation District, "Annual Report 2006."
[23] Hamilton Deposition, pg. 74-75.

Kansas' choice of a representative time period is further complicated by its lack of consistency. For other parts of the analysis, Kansas chooses to use data from 2010 instead of 1994-2000. As shown in
Table 1 and Table 2, assumed values for both irrigated crop mix and irrigation technology breakdown under a full water scenario were selected in this way. The authors state that this choice was made because crop mix was "in flux" in the period from 1994-2000, with the relative crop share of corn falling and that of soybeans rising.[24] However, even in 2010 there is no sign similar trends have come to a halt. Indeed, in examining regional trends, the decline in corn and rise in soybean acreage appears to be stronger than ever. It is thus unclear why Kansas deems the crop mix in 2010 to be the best representation of what would have been farmed in 2005 and 2006.

In addition to the use of questionable time periods for baseline data, numerous other parameters are chosen without any justification. For example, the Kansas analysis assumes that half of all farmers receiving prevented planting payments grew a dryland forage grass crop.[25] A Kansas state cane hay budget was used to determine costs and returns for those crops. No basis for either of these assumptions is offered, despite their significant impact on damages. Under Kansas' assumptions, the spending on produced inputs for fields with a cane hay crop is double that of those which are fallowed, and value added is 42% higher. Kansas' calculations estimate that in 2005 and 2006, prevented planting added over $750,000 to the Kansas economy. This figure is a significant relative to the total direct damages that Kansas claims, and the report fails to produce any justification for the assumptions that lead to it.

Overall, the magnitude of Kansas' calculated damages is dependent not only on the accuracy of the yield model, but also many assumptions in the crop budget calculations which are made without any support. In testimony, Dr. Hamilton cited "professional judgment" as the basis for many of these assumptions, without making attempts to confirm the assumptions with facts on the ground.[26]

Indeed, although Kansas economists had the opportunity to interview a number of KBID farmers and staff, issues as fundamental to the analysis as corn yields and precipitation impacts were not discussed or verified with anyone having actual knowledge of the KBID system.[27] Neither the superintendent of KBID or the regional commissioner for the Division of Water Resources, both of whom were deposed as part of this proceeding, were ever given a version of their report to review for accuracy. The decision to rely exclusively on simulated outcomes and unverified assumptions is inappropriate when calculating damages. When compared to the available

[24] Kansas Losses Report, pg. 2.
[25] Ibid, pg. 10.
[26] Hamilton Deposition, pg. 101.
[27] Ibid, pg. 64.

market data presented in the next section, the conclusions offered by Kansas' experts relative to Kansas' damages are shown to be wildly inflated.

IV. Analysis of Actual Behavior of Kansas Irrigators

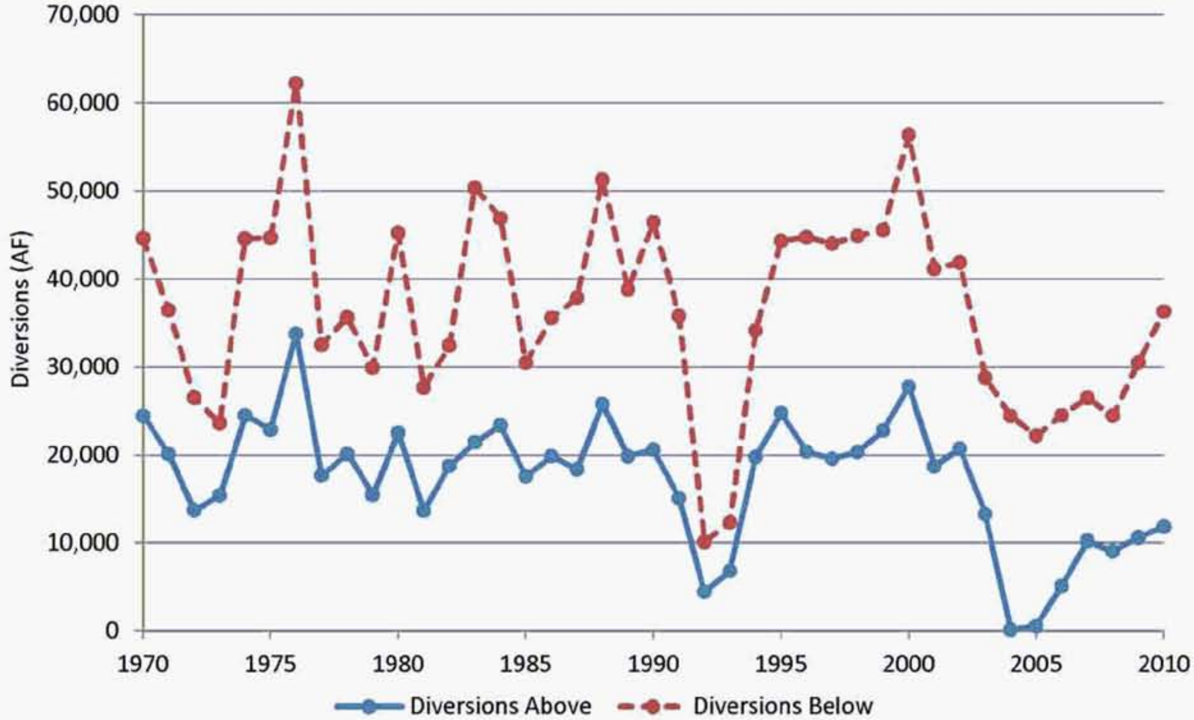
A. Market Data

When possible, it is preferable to calculate damages based on actual behavior and data as opposed to simulated outcomes of hypothetical impact models.[28] The analysis in the previous section illustrates why – hypothetical impact models can produce results that are at odds with reality, particularly when they are not checked against actual data. Consistent with this general principle broadly accepted by economists, it is useful to examine the available information on the behavior of farmers in KBID before, during and after the damage period of 2005 and 2006 to see what lessons can be drawn for assessing damages from water shortages. Relevant historical data for KBID are compiled by the Bureau of Reclamation, and some information is available at a fairly refined level, with separate data for the area above and below Lovewell Reservoir, for example. Annual data on irrigated acres, quantities of diversions and delivery (loss) are available for KBID as a whole, and for the areas above and below Lovewell, from 1958-2010.[29]

Water diversions are not distributed equally within KBID. The area above Lovewell Reservoir receives substantially less water and the deliveries are more variable than the area below, which has over twice the irrigated acreage. While it is clear that water diversions in 2005 and 2006 were historically low, in neither area were water diversions in 2005 and 2006 at the absolute lowest of the period between 1970 and 2010. Figure 1 shows water diversions in acre-feet (AF) above and below Lovewell Reservoir between 1970 and 2010. This observation is significant since it implies that whatever occurred in 2005 and 2006, diversions to KBID farmers in these years were within historical ranges. Thus, historical relationships between, say, diversions and irrigated acres can be used to assess the acreage that would have been planted in KBID if Nebraska had not overused water in those years. Examination of these historic relationships shows that, at least in the relevant period of 2005-2006, there was little direct correlation between the amount of Republican River water available to KBID and the crop yield within KBID.

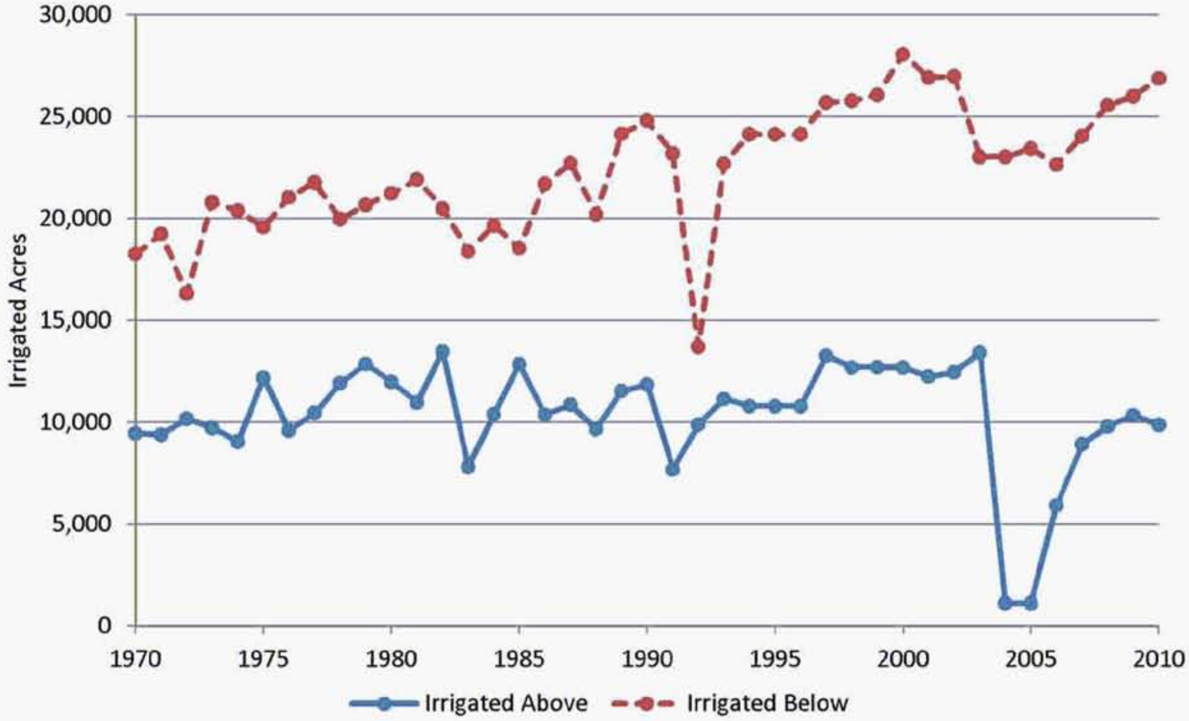
[28] Allen, 2011. Pg. 432.
[29] Kansas Bostwick Irrigation District. "Annual Report 2010."

Figure 1: Diversions Above and Below Lovewell



A similar picture emerges when plotting the number of acres irrigated above and below Lovewell. Figure 2 shows irrigated acres above and below Lovewell between 1970 and 2010. Notice that irrigated acres below Lovewell are greater than average in both 2005 and 2006.

Figure 2: Irrigated Acres Above and Below Lovewell

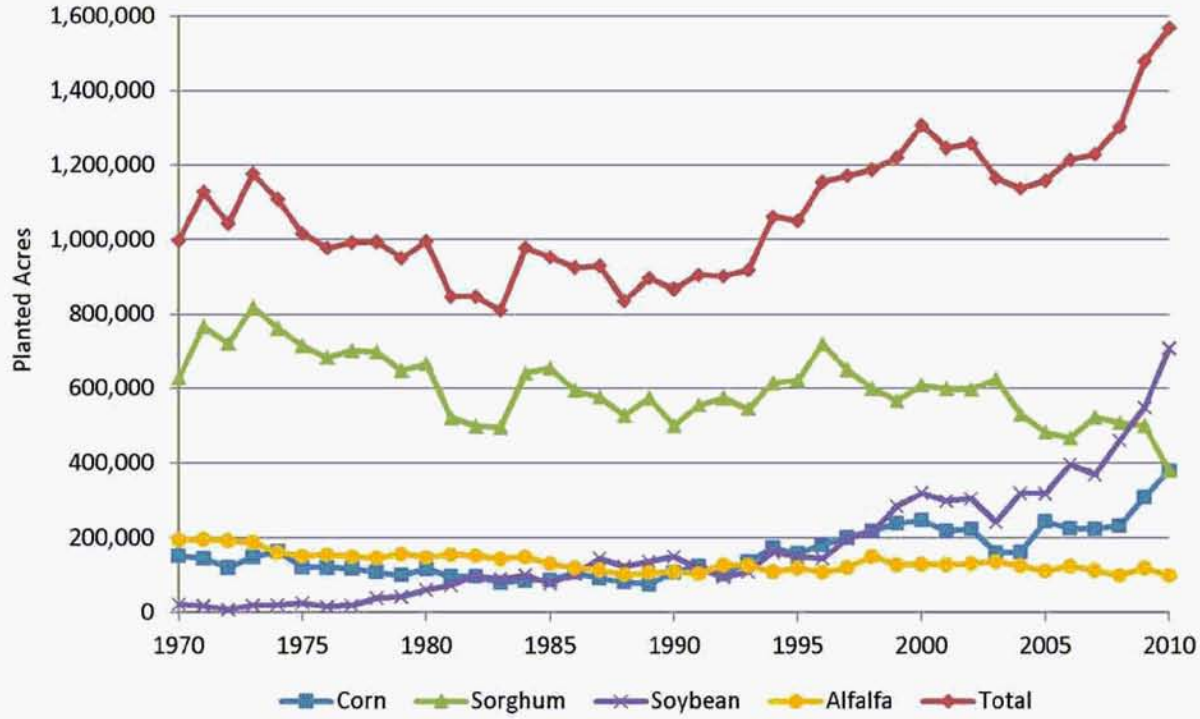


Data are available at the level of KBID for precipitation and corn yields. Corn is the crop that is the most widely grown in KBID and had the greatest value to farmers in 2005-2006.[30] As the precipitation data are available on a quarterly basis and the decisive month of precipitation for corn production in July, I use the July-September annual precipitation totals from 1970-2010. I use annual data on corn yields for the same time period.[31]

[30] Kansas Bostwick Bulletin, April-May-June 2007.
[31] Kansas Bostwick Irrigation District. "Annual Report 2010."

The National Agricultural Statistics Service (NASS) maintains regional crop statistics data for north-central Kansas (the region in which KBID is located).[32] I use regional data on planted acres and irrigated corn yield between 1970 and 2010. Planted acres are estimated as the annual sum of all acres planted in north-central Kansas for the crops considered in the Kansas' analysis. Corn yield is calculated to be the annual total yield of corn for grain in the region. Figure 3 shows the total planted acres in north-central Kansas.

Figure 3: Total Acres Planted in North Central Kansas



[32] National Agricultural Statistics Service, Quick Stats 2.0. <http://quickstats.nass.usda.gov/>

Figure 4 shows KBID and north-central Kansas corn yields (bushels per acre) between 1970 and 2010. Despite the decrease in water diversions to KBID, and despite the predictions of Kansas' yield model, corn yields actually reached a historical high in KBID in 2005. Additionally, for the past 17 years, and in every year since 2001, KBID corn yields exceeded those in the rest of the region.

Figure 4: KBID and North Central Kansas Irrigated Corn Yield

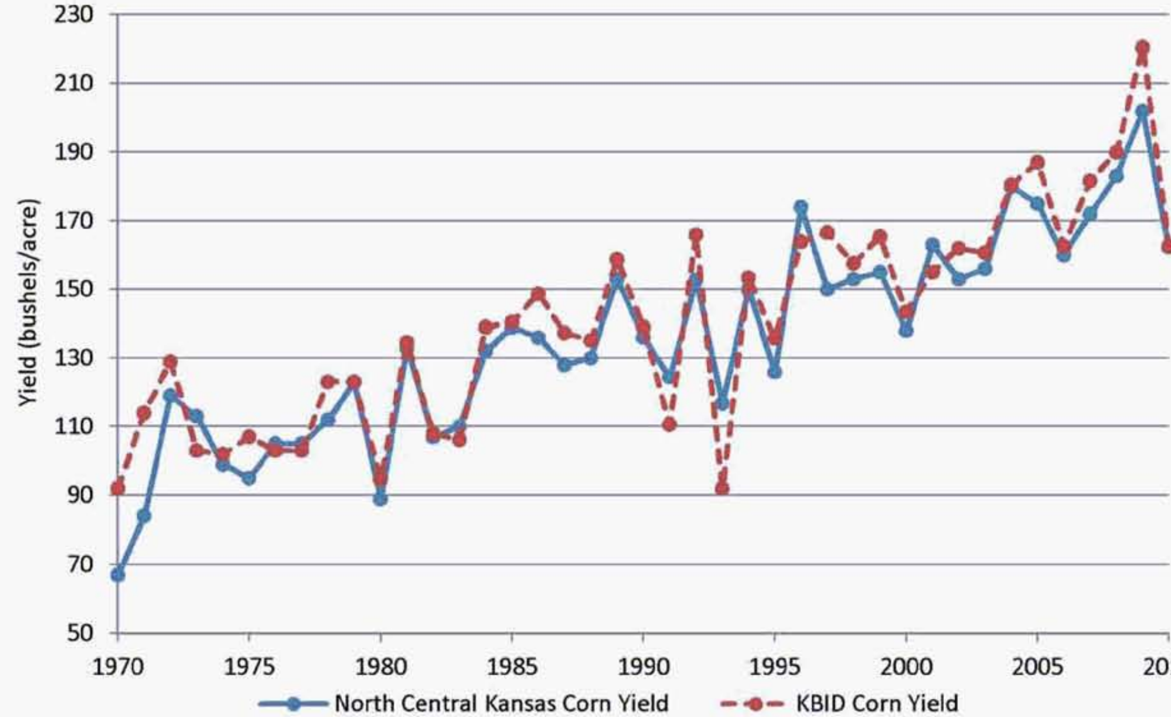
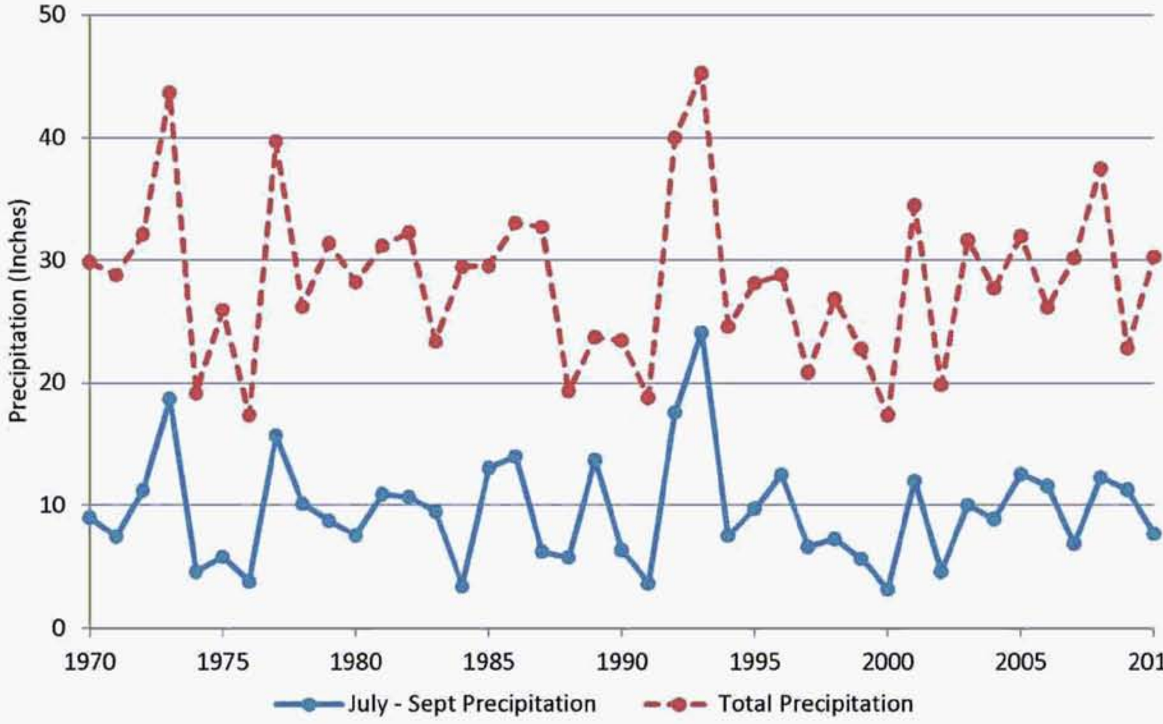


Figure 5 shows total yearly precipitation and precipitation between July and September in KBID between 1970 and 2010. The relatively high total precipitation in 2005 and 2006 as well as the high July-September precipitation in 2005, may explain in part the large yields in KBID in those years.

Figure 5: KBID Precipitation



The foregoing series of figures demonstrates that, at least in the relevant period of 2005-2006, there was little correlation between the amount of Republican River water available to KBID and the crop yield within KBID. As a practical matter, the available data indicate that irrigation water from the Republican River had little marginal value as compared to the same volume of water, say, in the more arid regions of western Kansas and Nebraska. More fundamentally, and as articulated further below, it is apparent that any shortage of irrigation water experienced as a result of Nebraska's overuse was of far less significance to KBID irrigators than Kansas' experts assert.

B. Analysis of Market Data

Whereas Kansas' approach relies heavily on untested assumptions and modeled scenarios, a more realistic approach utilizes actual market data to better define the true value of water in North-Central Kansas. Market data also provide a way to test the validity of the predictions of the Kansas' yield model framework. These data also suggest an alternative approach to damages that is both more straightforward and more accurate than Kansas' complicated and artificial method.

1. Land Rents

If there were a competitive water market in KBID, it would be relatively straightforward to calculate the economic value of irrigation water. However, no such market exists. However, there is a competitive, well-functioning market for land in the KBID region. Thus, it is possible to infer the value of irrigation water by examining the difference in the market price of irrigated and non-irrigated farmland.

This line of reasoning is fundamental to what economists refer to as hedonic analysis, which is one of the most important techniques of environmental and resource economics.[33] Hedonic analysis is frequently used to measure willingness to pay for various characteristics of land such as access to transportation infrastructure, local weather conditions, and soil quality. Differences in the price of land between, say, good and poor soils allows the economist to infer farmers' willingness to pay to farm on good soil as opposed to poor soil. In a competitive market, this willingness to pay should be equal to incremental profit. In this way, comparing Kansas' claims regarding the marginal value of irrigation water to market data on land price differentials is a good way to assess their validity.[34]

Kansas State University publishes market rental rates for cropland in Kansas, including the north-central region where KBID is located.[35] The difference between rental rates for irrigated and non-irrigated cropland was $34 per acre in 2005 and $33 per acre in 2006. The average difference in land rents for these two years was $33.50 per acre. To express these values in units of water, it is necessary to divide the price difference by the amount of irrigation water used per acre. Based on the recent average delivery of 12 inches per acre in KBID, the implicit price of irrigation water in the region is thus an average of $33.50 per acre-foot.[36]

---

[33] Freeman, A. Myrick. "The Measurement of Environmental and Resource Values." 2nd Edition, RFF Press. February 2003.
[34] I note that Kansas' analysis contains no such comparison.
[35] Dhuyvetter, K. and T. Kastens, "Kansas Land Prices and Cash Rental Rates," Kansas State University, Farm Management Guide MF-1100, September 2008.
[36] This is the average net irrigation requirement in KBID according to the regional Division of Water Resources Commissioner. He made clear that 12"or less is all that is needed in KBID today. See Ross Deposition, pg. 18.

This value is consistent with observed per acre-foot prices offered by KBID in recent years. For example, in 2011 KBID offered to sell farmers an additional 6" of water at $33 per acre-foot if needed.[37] However, no farmers ended up opting to purchase additional water at that price.[38] The relatively low marginal value of water is also reflected in KBID's decision to sell irrigation water for drought assistance in 2005. In that year, the district chose to forgo diversions of 1,200 acre-feet of water in exchange for a $12,000 payment.[39]

Comparing the observed market price of irrigation water to Kansas' analysis shows that their theoretical estimates of the value of water are overstated by upwards of 200%. Kansas' damage model predicts a water value of $53.98 per acre-foot in KBID in 2005 and $63.90 per acre-foot in 2006. I am not aware of any empirical evidence that water has ever traded for a price near this level in KBID. For areas outside of KBID, the Kansas model predicts a water value of $77.98 per acre-foot in 2005 and $88.85 per acre-foot in 2006. Again, there is absolutely no evidence that water has ever traded at those values within KBID. These values are roughly double what farmers actually pay for access to water in the North-Central region of Kansas, and thus should be viewed with skepticism.

It is important to note that rental rates are determined prior to knowing the magnitude of water supplies or the amount of precipitation in a particular year. Rather, rental rates for irrigated land are based on the expected value of water. In a year like 2005 where timely and adequate crop water was provided by rainfall, the ex post value of irrigation water will be lower than the expected value, and Kansas' implied value of irrigation water is even more overstated.

2. Irrigated Acres

Other aspects of Kansas' analysis can be evaluated by examining market data. In this section, I consider the relationship between KBID irrigated acres and diversions, modeling the area above and below Lovewell separately. I specify a relationship between irrigated acres and water diversions and control for any fixed effects by adding a variable for the total number of acres planted in north-central Kansas. This variable should capture any general trends in crop production, such as a government subsidy program or a spike in input prices.

I use ordinary least squares to estimate a model of the natural log of irrigated acres above Lovewell as a linear function of the natural log of diversions above Lovewell, and the natural log of planted acres in the north-central Kansas region for the years 1970-2010.[40]

---

[37] Nelson Deposition, Exhibit 9.
[38] Nelson Deposition, pg. 94.
[39] Correspondence with Tom Riley, March 8, 2012.
[40] For further detail and model output, see Appendix 1.

In the area above Lovewell Reservoir, diversions explain most of the variation in irrigated acreage, whereas regional planting behavior is statistically significant in the area below. Because I specify a log-log model, so that the estimated coefficients on the variables can be interpreted as elasticities. The results reveal that a one percent increase in the average annual diversions would result in a 0.47% increase in the number of irrigated acres in the area above Lovewell, and only a 0.12% increase in irrigated acres in the area below.

The Kansas analysis contains a claim about the impact of KBID diversions on irrigated acreage. In particular, the analysis states that if Nebraska had complied with the Decree in 2005 and 2006, irrigated acres above Lovewell would have been 12,962 in 2005 and 12,946 in 2006. Below Lovewell, their analysis claims that irrigated acreage would have been 25,448 in 2005 and 25,417 in 2006.[41]

Using the econometric analysis described in this section, it is possible to evaluate these claims using the historic relationship between diversions and acreage in KBID. Using Spronk Water Engineers' estimate of the reduction in KBID diversions above and below Lovewell for 2005 and 2006, the statistical model forecasts that irrigated acreage above Lovewell would have been 10,635 in 2005 and 11,085 in 2006.[42] Below Lovewell, the corresponding quantities are 23,756 and 24,555 in 2005 and 2006. Thus, Kansas' claims regarding reductions in irrigated acreage in KBID, particularly for the area above Lovewell, appear to be overstated.

3. Yield

Kansas' analysis makes a series of claims about the loss in yield resulting from water shortage in KBID. Because corn yield data are only available at the KBID level I specify a model where corn yield is a function of total diversions in KBID, a regional variable, corn yield in north-central Kansas (that controls for any general effects such as technological change or weather conditions), and an interaction term with the north-central Kansas corn yield and the KBID diversions. The interaction term controls for any effects that vary in the north-central region with KBID diversions, isolating the effect of changes in corn yields in north central Kansas that are due to KBID diversions from those that vary generally in the region.[43]

The estimated effect of KBID diversions on corn yield is positive and significant at the 5% level, indicating that increased water use increases farm-level productivity for this crop. A negative interaction term with regional yield suggests that the marginal productivity of irrigation is highest when weather conditions (including precipitation) are the least favorable. These results

[41] Kansas Losses Report, Table 10.
[42] Book, Dale E. and Angela Schenk. "Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska in 2005 and 2006," Spronk Water Engineers, Inc, November 2011. Page 23.
[43] For further detail and model output, see Appendix 1.

are generally consistent with standard findings in irrigation economics, and also with the broad assertions of Kansas' economists.

Where this statistical analysis diverges from Kansas' approach is in the size of the yield effect. I use the above regression results to predict the reduction in KBID corn yields due to Nebraska's overuse of water. The table below shows the predicted reduction in yields using Spronk Water Engineers' water shortage estimates (20,934 acre feet in 2005 and 18,079 acre feet in 2006).[44] Yield reductions based on the actual relationship between yield and water use are much smaller than those predicted by Kansas optimization model.
Table 5 indicates that yield loss in 2006 was roughly 6 bushels per acre, and was minimal in 2005 (the year of record corn yields in KBID).

Table 5: Estimated Reduction in KBID Corn Yields due to Water Shortage

	Diversion Level	Yield Prediction (bushels/acre)	
		2005	*2006*
Corn Yield	Actual	150.19	118.47
	Actual + Shortfall	150.28	124.56
Predicted Reduction in Corn Yield		**0.09**	**6.09**

Another factor contributing to the small estimated yield effect in 2005 and 2006 is the fact that summer precipitation was high in 2005 and roughly average in 2006. Because natural precipitation is a substitute for irrigation water, more rainfall during the growing season implies that the productivity of irrigation is lower.

C. Assessment of Kansas Damages Based on Land Market Data

As noted above, a more realistic assessment of Kansas' actual damages would rely less on theoretical model inputs and untested assumptions. A better approach is to review actual market data to infer the value of water to farmers in North-Central Kansas. The difference in cash rents between irrigated and non-irrigated land provides a valid basis for estimating the direct loss from any perceived water shortage. An implicit market price of $33.50 per acre-foot is observed for irrigation water in North-Central Kansas. To obtain an estimate of direct loss, this observed market price is simply multiplied by the number of acre-feet lost at the farm level in Kansas as a result of Nebraska's overuse.

[44] Book, pg. 25.

1. Inside KBID

Spronk Water Engineers' estimate that in 2005 an additional 20,934 acre-feet of water would have been delivered to farms in KBID.[45] In 2006, this figure is 18,079 acre-feet, for a two-year total of 39,013 acre-feet. Multiplying this volume of water lost by farmers' observed willingness to pay for water ($33.50), I arrive at a damage total of, at most, $701,289 for 2005 and $605,647 for 2006. Of course, this estimate represents the outer boundary of any actual damage assessment and takes Spronk Water Engineers' analysis at face value. It is also based on the expected value of irrigation water in Kansas, whereas the ex post value in 2005 was considerably lower given favorable precipitation.

The damage figure above is also predicated on expectations with respect to farm-level water use. As described above, I set these expectations equal to the water entitlement in KBID, which is also close to water use per acre over a period of several decades. As described above, 2005 and 2006 were years in which even non-irrigated yields were well above average, and in fact at record levels in 2006. It is likely that the direct losses of $701,289 and $605,647 for these years are an overestimate of the lost profits resulting from water shortage in 2005 and 2006.

2. Outside KBID

In addition to these losses experienced by KBID farmers, there is some dispute about losses resulting from reductions in return flows caused by Nebraska's overuse of water. Kansas' economic experts addressed this issue by prorating their damage calculation to account for water shortages outside of KBID. Adopting the same procedure, I can also calculate losses from reduced return flows.

Kansas has asserted that losses outside of KBID totaled 1,727 acre-feet in 2005 and 2,105 acre-feet in 2006.[46] Using the same value of irrigation water, I conclude that return flow losses are, at most, $57,855 in 2005 and $70,518 in 2006. Totaling the losses in and outside of KBID, I conclude that Kansas' direct losses from Nebraska's overuse of water are, at most, $759,144 in 2005 and $676,165 in 2006.

The above damage estimates assume that the Spronk Water Engineers' analysis of the total volume of undelivered water is accurate. Should further analysis reveal that those numbers over-estimate the actual reduction in water supply faced by Kansas, the calculated losses would need to be revised downward accordingly. Such a calculation has been developed by Mr. Tom Riley of the Flatwater Group, Inc. and is presented in Appendix D. I conclude from his work that the timing and volume of required water would be reduced substantially from the volume presented in the Spronk Water Engineers' analysis.

[45] Book, pg. 25.
[46] Kansas Losses Report, Table 34.

V. Nebraska Unjust Enrichment

Many of the issues identified in Section III are equally applicable to Kansas' calculation of Nebraska's benefits from overuse, which uses a similar methodology. Common issues include failing to account for observed historical precipitation patterns affecting irrigated and dryland crop yields, relying on regional yield and acreage averages that aren't verified locally, and assuming water shortages faced by Nebraska's farmers would be evenly distributed across all produced crops. As described previously, the failure to accurately reflect farmers' crop irrigation decisions severely handicaps Kansas' approach.

The analysis in this section is intended to address the economic value of irrigation water in the Republican River Basin in Nebraska. I am not offering an opinion on what Nebraska would have had to do to comply with the Compact in 2005 and 2006. In determining an average value for water in the region based on an analysis of available survey and market data, it is possible to compare the results of Kansas' analysis to the observed value for access to irrigation water paid by farmers in the region.

A. Crop Budgets

The crop budget calculations used in determining Nebraska's benefits again rely on unconfirmed assumptions. Crop budgets from the University of Nebraska were not made in 2005, and Kansas chose to use those from 2004 instead. Out of multiple available budgets constructed for different irrigation technologies and crop rotations, a single version was selected for each crop as representative of all acreage in the region. This approach fails to account for the whole range of actual farming practices employed in Nebraska. In addition, the selections are not explained in detail despite the fact that these choices have significant impacts on the results of the analysis. While Kansas' experts provide a short description of their choice for the corn budget used, they merely state that other representative budgets were chosen "in a similar fashion."[47]

One indication of the unreliability of the crop budgets used is the difference between the crop budget estimates used in calculating Kansas Losses and those used in calculating Nebraska Benefits. For example, the 2006 dryland milo budget for Kansas in Jewell and Republic counties shows total value-added of $216.44 per acre, while the dryland milo budget for the neighboring Lower Republican region of Nebraska depicts a value added of $124.27 per acre.[48] Despite these regions being adjacent to one another, according to the crop budgets dryland milo crops on the Kansas side of the border are predicted to return profits 74% higher than those on the Nebraska side. While there may be some regional variation that would lead to slight differences in expected returns, the substantial predicted difference in profit between crop plantings in regions

[47] Hamilton, Joel and M. Henry Robinson. "Economic Analysis of Nebraska Benefits from Overuse of Republican River Water by Nebraska in 2005 and 2006". November 18, 2011. Page 4.
[48] Kansas Losses Report, Table 25; Nebraska Benefits Report, Table 13.

directly neighboring one another reveals the lack of dependability in Kansas' assumptions.

B. Surveyed Value of Water

The Nebraska Farm Real Estate Survey conducted by researchers at the University of Nebraska performs an annual survey of agricultural land markets in Nebraska.[49] The survey is based on approximately 130 panel reporters with some year to year variation. Panel reporters include agricultural real estate appraisers, professional farm managers, agricultural lenders and others who can offer expert valuations of agricultural land. A recent analysis of this data combined with data on annual water right to irrigate suggests that the capitalized value of annual water right per acre in Nebraska agricultural land markets was approximately $600 to $800 in 2011 U.S. dollars for 2005 and 200650. Assuming a five percent discount rate then this implies an annual value of $30 to $40 in 2011 U.S. dollars; assuming an average inflation of 2.5% this is approximately $25.87 to $34.49 in 2005 U.S. dollars. Assuming the average water right in Nebraska corresponds to 10 acre-inches per acre, then this implies that in 2005 an acre-foot of water was valued between $31.04 and $41.39. Importantly, these represent the range of average values of irrigation as opposed to marginal valuations of irrigation. The latter is the most relevant to the assessment of Nebraska's benefits because if Nebraska would have reduced irrigation in 2005 and 2006 then they would have reduced irrigation to land where water was least valued. Therefore, valuations of Nebraska's benefits from additional irrigation water which are based on average values, rather than marginal values, will be overestimates.

C. Market Data Analysis

The drawback to the crop budget analysis and the survey of experts is that these analyses are not derived from data on observed market behavior. In the case of crop budgets, the analysis is largely determined by assumptions about farmer production behavior; as a consequence, the quality of valuations depends on the quality of the assumptions underlying the crop budget model. In the case of the expert survey, valuations are based on the subjectivity of the experts. The quality of their valuations depends on the quality of the assumptions underlying their models of agricultural land markets, and their ability to adequately integrate available information. It is also the case that the expert survey valuations report average values, not marginal values.

A more robust approach to measuring the economic value of irrigation water in Nebraska relies on observed market behavior using data on premiums paid for irrigated land. A recent analysis

[49] Johnson, Bruce, Sara Van Newkirk, and Tyler Rosener. "Nebraska Farm Real Estate Market Highlights 2010-2011." Department of Agricultural Economics, University of Nebraska-Lincoln, 2011.
[50] Thompson, Chris and Bruce Johnson. Slide 14: Value of Water Rights over Time. Presentation: "The Value of Water in Agriculture Land Markets: The Nebraska Case". Accessed March 1, 2012 at http://agecon.unl.edu/c/document_library/get_file?uuid=f553ab3a-ad76-48c6-9620-a5bbf3411853&groupId=2369805&.pdf

of land sale transactions in Nebraska investigated the implied value of irrigation by comparing the prices paid for irrigated land to those paid for dryland acreage.[51] By collecting the values of over 2,100 land sale transactions conducted between 2000 and 2008, the authors are able to use a hedonic price model to determine the relative contribution of irrigation access to the total price paid for agricultural land in the region. Valuations derived from this econometric approach can be considered marginal values since they consider how price changes in response to one additional acre-foot of water per acre. This type of hedonic analysis is the same as that described previously in calculating Kansas land rents, and is commonly used by economists.

The results of the analysis were robust, and found that the contribution of irrigation to sale prices was directly related to the varying regional dependency of crops on irrigation water. Western areas of Nebraska experience less precipitation, and are therefore more dependent on irrigation water. As expected, the hedonic analysis revealed higher relative prices for irrigation in those regions. Since the land sale transactions include lands which may require irrigation for cultivation, regional differences also reflect variation in average soil quality. The results of the analysis are shown in Table 6 below. All predicted marginal irrigation prices were statistically significant at the 1% level.

Table 6: Marginal Prices of Nebraska Irrigation in the Republican River Basin

Region	Marginal Price of Irrigation ($/acre)	Mean Irrigated Sale Price ($/acre)	Contribution of Irrigation to Sale Prices
Lower Republican	$413	$1,190	35%
Middle Republican	$508	$865	58%
Upper Republican	$795	$1,054	75%

Source: Shultz, 2010

The above prices are capitalized values as opposed to annual values, and thus reflect the total value of anticipated net income from access to irrigation water in perpetuity. Farmers who choose to pay a higher price for irrigated land anticipate greater net incomes in the future from access to irrigation water. In order to determine the expected net income gain on an annual basis, this capital value must be converted into an annual value.

This calculation must also take into account the time value of money, as income received at the present in worth more than that received in the future. The use of an appropriate discount rate accounts for present land purchase prices that are made in expectation of future returns. The expected income from each future year is thus discounted to reflect the present value of annual

[51] Shultz, Steven and Nick Schmitz. "The Implicit Value of Irrigation Through Parcel Level Hedonic Price Modeling." Prepared for Agricultural and Applied Economics Association Joint Annual Meeting, July 2010.

gains from irrigation. The expression below depicts this relationship, where *A* represents each year's expected net income, *r* is the discount rate, and *t* is the time in years, representing each year from now into the future:

$$PV = \sum_{t=1}^{\infty} \frac{A_t}{(1 + r_t)^t}$$

Assuming a constant interest rate and constant annual net income from irrigation water, the above formula can be reduced to the following:

$$PV = \frac{A}{r}$$

Using the present value paid by farmers for access to irrigation water and an assumed discount rate, I solve for *A*, the expected annual irrigation value revealed by Nebraska land sale prices. Using the discount rate of 4.372% proposed by Kansas' experts, the implied annual values for irrigation water in the Republican Basin of Nebraska are depicted in Table 7 below.[52]

Table 7: Annual Value of Nebraska Irrigation in the Republican River Basin

Region	Marginal Price of Irrigation ($/acre)	Expected Annual Irrigation Returns ($/acre)
Lower Republican	$413	$18.06
Middle Republican	$508	$22.21
Upper Republican	$795	$34.76

The above table reveals that based on actual land sale transactions occurring between 2000 and 2008, farmers in the Republican River Basin of Nebraska valued access to irrigation water at $18.06 - $34.76 per acre. Assuming an average of one acre-foot of water is delivered to irrigated lands annually, these values would reflect the implied value of one acre-foot of water to Nebraska's farmers. I note that these values inferred from Nebraska land market transactions are also consistent with the values of irrigation water in neighboring KBID as described in the previous section of my report.

[52] Nebraska Benefits Report, pg. 15.

VI. Assessment of Kansas' Approach to Secondary Damages

Nearly half of Kansas' claimed damages resulting from Nebraska's overuse of water stem from so-called "indirect" secondary effects. These refer to damages which are not incident on the farmers themselves, but rather on businesses and individuals in the region, who suffered as a result of the farmers' loss of income and corresponding reduction in spending.

Kansas has not reliably estimated secondary effects and therefore no damages should be awarded based on them. Kansas has presented no evidence of actual secondary impacts. Kansas' economists did not make any attempt to collect data showing that incomes or business activity in Kansas suffered as a result of Nebraska's overuse of water. Instead, their analysis relies entirely on a hypothetical model of trade flows and economic activity that has not been checked against any real-world data.

As an analogy, consider the recent Deepwater Horizon oil spill in the Gulf of Mexico. British Petroleum established a compensation fund for the benefit of fisherman, restaurant owners, hotels and the like that were damaged as a result of the oil spill. To make a successful claim, each of these entities had to present evidence of actual impacts to sales, visitation, trips, etc. Kansas has not presented any similar evidence in this case.

In this section, I will discuss the modeling framework used by Kansas' economists and demonstrate why it is inadequate as a basis for a damage award. I will also discuss Kansas' failure to quantify cross-border trade flows from Nebraska into Kansas that would mitigate Kansas' actual damages from Nebraska's overuse of water.

A. IMPLAN

The IMPLAN model used by Kansas' experts to measure indirect impacts is commonly used to develop impact estimates to inform public policy; it is improper to use such a model to calculate monetary damages. IMPLAN estimates have a significant margin of error for many reasons, yet the researcher using the model is unaware of the error bounds of any of the estimates IMPLAN produces. It is impossible to formally test a hypothesis with IMPLAN, meaning that the results cannot be verified through hypothesis testing, and are difficult to refute on statistical grounds. IMPLAN also rests on very strong and unrealistic assumptions about the behavior of farmers, laborers, or other market participants.

Because of its relative ease of use, virtually anyone can produce impact estimates in IMPLAN without formal training. The most common consequence of the misuse of IMPLAN is inflated impacts. This implies an inherent riskiness in the use of IMPLAN to substantiate the award of monetary damages.

Since IMPLAN is an input-output model rather than a statistical model, there is no variation in outcome given a fixed set of inputs and no readily available margin of error attached to the estimates it generates. This does not mean, however, that assumptions built into the IMPLAN model and thereby the results that it generates are not subject to statistical variation. The data sources underlying the production functions in IMPLAN are derived from surveys, many of them several years old. All survey-based estimates are subject to sampling error. For example, the basis of IMPLAN's production functions is the BEA's Benchmark Input-Output Accounts, released every five years.[53] The primary data source for the Benchmark I-O is the Economic Census put out by the U.S Bureau of the Census. The Economic Census consists of data such as receipts, inventories and payrolls that are essential to the I-O tables. These data are collected at the establishment level, using various sampling rules to reduce respondent burden.[54] Without any measure of error (such as confidence intervals or standard errors) to qualify the results of such analysis, these results should not be accepted as fact or treated as causal effects in a legal proceeding, where the standards for quantitative research are and should be much higher than in a policy setting.

IMPLAN is a system of accounting that relies on a static picture of the economy. The multipliers do not necessarily imply causation, but rather are outcome ratios representing the average economic structure of a region at a fixed time and given fixed prices. As a result, any conventional IMPLAN analysis requires the assumption that the production relationships built into the model hold for any marginal change and that substitution or offsetting effects in the market for factors does not take place. This is simply not a realistic view of the economy, at least not by the standards for rigor required in litigation.

For the purposes of analysis I attempt to replicate Kansas' 2005 estimate for Kansas losses in KBID above Lovewell. My method of calculating losses differs from Kansas' in a number of ways. The plaintiff uses 2006 IMPLAN data whereas I use 2009 data. The sectoring scheme and magnitude of the multipliers, regional purchase coefficients and other key parameters have changed (though not necessarily by much) since the 2006 data were released. In an unconventional approach, the plaintiff chooses to manually perform all of the calculations that take place within the IMPLAN model, such as taking producer margins, applying regional purchase coefficients, and applying value added multipliers to the input spending portion of output. I opt instead for the more standard approach of running Kansas output (spending on inputs plus value added) changes through IMPLAN using the industry change activity type for the 2009 equivalents of the input sectors defined by the plaintiff. This yields impacts in terms of employment, labor income, output and value added, which we can compare directly with the

---

[53] Day, Frances (MIG), "IMPLAN Data Source Outline", 22 February 2011. <http://implan.com/V4/index.php?option=com_content&view=article&id=689%3Aimplan-data-source-outline&catid=253%3AKB33&Itemid=1.>

[54] Horowitz, Karen J. and Planting, Mark A., "Concepts and Methods of the United States Input-Output Accounts," Bureau of Economic Analysis, U.S. Department of Commerce, September 2006 (Updated April 2009).

plaintiff's results. It also allows us to examine which industries are included in the secondary impacts.

Since IMPLAN models changes in final demand (or output), I converted the spending on produced inputs in Table 45 of Kansas' expert report to changes in output in each of the input spending categories. This exercise required allocating initial value added across the spending categories. I chose to do this proportionately. The inputs for my replication effort are shown in the right-most column in Table 8.

Table 8: IMPLAN Inputs for 2005 Kansas Loss Estimate

SPENDING ON PRODUCED INPUTS	Change in Value Added and Produced Input Purchases *Original* [1]	*Mapped* [2]	% of Mapped [3]	Allocated Value Added [4] = [3] * *Initial Value Added*	Final Demand/Output [5] = [2] + [4]
Seed	$265,382	$265,382	24.0%	$151,688	$417,070
Herbicide	$56,680	$56,680	5.1%	$32,397	$89,077
Insecticide/Fungicide	$183	$183	0.0%	$105	$288
Fertilizer and Lime	$283,167	$283,167	25.6%	$161,853	$445,020
Crop Insurance	($63,676)	($63,676)	-5.8%	($36,396)	($100,072)
Drying	$83,181	$83,181	7.5%	$47,545	$130,726
Machinery Fuel and Oil	$20,695	$20,695	1.9%	$11,829	$32,524
Machinery Repairs and Maint	$32,445	$32,445	2.9%	$18,545	$50,990
Irrigation Fuel and Oil (Diesel)	$258,530	$68,872	6.2%	$39,366	$108,238
Irrigation Electricity		$58,972	5.3%	$33,707	$92,679
Irrigation Natural Gas		$130,685	11.8%	$74,697	$205,382
Irrigation Repairs and Maint	$19,256	$19,256	1.7%	$11,006	$30,262
Water District Assessment	$150,745	$150,745	13.6%	$86,163	$236,908
TOTAL	**$1,106,588**	**$1,106,587**	**100.0%**	**$632,505**	**$1,739,092**
Initial Value Added	*$632,505*	*$632,505*			

Sources: Table 45, Kansas Losses report.

Table 9 below shows a comparison of our results using this conventional method with those estimated by the plaintiff.

Table 9: Comparison of Estimates of Kansas Losses in KBID Above Lovewell in 2005

Value Added	Kansas' Estimate	Our Estimate
Direct Effect	$632,505	$618,403
Indirect Effect	$413,426	$280,468
Induced Effect	$288,030	$244,605
TOTAL EFFECT	**$1,333,961**	**$1,143,476**

Sources: Table 46, Kansas Losses report.

My estimate of Kansas Losses using the plaintiff's assumptions is close to what is presented in the plaintiff's report, with the exception of the indirect effect (or the sum of secondary direct and secondary indirect in the plaintiff's report). This discrepancy is possibly due to double-counting on the part of Kansas' experts. Based on my review of this information, I conclude that Kansas' experts have treated the multipliers incorrectly on two counts. First, they treat the Direct Value Added Multiplier (called the "Secondary Direct" multiplier in the plaintiff's report) as if it is a first round indirect multiplier. The Direct Value Added Multiplier is actually the multiplier for the direct value added associated with $1 million in output. Kansas' experts do not need to use this multiplier because they already know what portion of direct output belongs to direct value added.

Second, Kansas' experts treat the Indirect Value Added Multiplier (called the "Secondary Indirect" multiplier in the report) as if it is a second round indirect multiplier. In fact, the Indirect Value Added Multiplier captures the effect of the first round of spending on inputs as well as all other rounds of business to business spending to the suppliers of the suppliers. Even if the "Secondary Direct" multiplier that the plaintiff uses is an indirect multiplier, by IMPLAN's definition, it would capture the impacts from *all* rounds of indirect spending, meaning a secondary indirect multiplier is unnecessary.

For the purposes of comparison, I have included the 2006 multipliers from the plaintiff's report and the 2009 multipliers taken from IMPLAN in Table 10 and Table 11. Note that since the IMPLAN software transitioned from a 509 sector to a 440 sector sectoring scheme in 2007, some of the 2006 industries are aggregated in 2009 and will have aggregated multipliers relative to 2006 (e.g. the 2006 sector for nitrogenous fertilizer manufacturing was combined with other fertilizer sectors to create the more general fertilizer manufacturing sector in 2009). Apart from such cases, the multipliers do not seem to have changed drastically, which is evidence that their definition has remained constant over the years.

Table 10: 2006 IMPLAN Multipliers

Sector Code	IMPLAN Sector Description	"Secondary Direct"	"Secondary Indirect"	"Secondary Induced"
2	Grain farming	0.481351	0.163382	0.127898
18	Agriculture and forestry support services	0.752309	0.058507	0.402618
30	Power generation and supply	0.812892	0.053966	0.110385
31	Natural gas distribution	0.289406	0.219393	0.101084
142	Petroleum Refineries	0.148899	0.260072	0.083500
156	Nitrogenous fertilizer manufacturing	0.220055	0.232961	0.087965
159	Pesticide and other agricultural chemical man	0.273290	0.231794	0.084086
390	Wholesale trade	0.674194	0.129944	0.203702
427	Insurance carriers	0.373945	0.288848	0.180116
485	Commercial machinery repair and maintenance	0.471712	0.140274	0.169735
499	Other state and local government enterprises	0.375244	0.239360	0.163403

Sources: Table 46 from the Kansas Losses report.

Table 11: 2009 IMPLAN Multipliers

Sector Code	IMPLAN Sector Description	Direct	Indirect	Induced
2	Grain Farming	0.428237	0.151771	0.153617
19	Support activities for agriculture and forestry	0.795485	0.033263	0.411434
31	Electric power generation, transmission, and distribution	0.704137	0.086005	0.108181
32	Natural gas distribution	0.287228	0.11107	0.056669
115	Petroleum refineries	0.279764	0.092187	0.041858
130	Fertilizer manufacturing	0.109661	0.192595	0.070019
131	Pesticide and other agricultural chemical manufacturing	0.261045	0.158443	0.072922
319	Wholesale trade businesses	0.655469	0.157171	0.201105
357	Insurance carriers	0.659486	0.237226	0.168445
417	Commercial/ industrial machinery/equip repair/maint	0.671170	0.098957	0.252947
432	Other state and local government enterprises	0.253855	0.259515	0.161743

To illustrate a point made earlier, the top 20 sectors in terms of indirect and induced value added loss are presented in Table 12 and Table 13. If we bear in mind that IMPLAN is a system of accounting when examining these results, then we may find that it makes sense that on average, a $1.7 million decrease in output shared amongst the input sectors specified earlier produces $12,172 in value added loss for food services and drinking places through a fall in induced spending. It is not proper, however, to treat IMPLAN as a model with predictive power and assert that a $1.7 million final demand decrease across those input sectors did in fact result in the loss of $12,172 in value added for food services and drinking place. Kansas is asking for the latter interpretation.

Table 12: Top 20 Sectors in Terms of Indirect Value Added Loss

IMPLAN Sector Code	IMPLAN Sector Description	Indirect Value Added	% of Total Indirect Value Added
319	Wholesale trade businesses	$33,516	12.0%
360	Real estate establishments	$32,868	11.7%
335	Transport by truck	$21,477	7.7%
354	Monetary authorities and depository credit intermediation activities	$20,583	7.3%
32	Natural gas distribution	$19,397	6.9%
31	Electric power generation, transmission, and distribution	$13,963	5.0%
381	Management of companies and enterprises	$11,269	4.0%
369	Architectural, engineering, and related services	$10,065	3.6%
39	Maintenance and repair construction of nonresidential structures	$6,993	2.5%
115	Petroleum refineries	$6,553	2.3%
351	Telecommunications	$6,237	2.2%
333	Transport by rail	$5,825	2.1%
19	Support activities for agriculture and forestry	$5,522	2.0%
20	Extraction of oil and natural gas	$5,492	2.0%
432	Other state and local government enterprises	$4,962	1.8%
388	Services to buildings and dwellings	$4,883	1.7%
368	Accounting, tax preparation, bookkeeping, and payroll services	$4,018	1.4%
366	Lessors of nonfinancial intangible assets	$3,849	1.4%
367	Legal services	$3,481	1.2%
355	Nondepository credit intermediation and related activities	$3,393	1.2%

Table 13: Top 20 Sectors in Terms of Induced Value Added Loss

IMPLAN Sector Code	IMPLAN Sector Description	Induced Value Added	% of Total Induced Value Added
361	Imputed rental activity for owner-occupied dwellings	$42,601	17.4%
394	Offices of physicians, dentists, and other health practitioners	$16,818	6.9%
319	Wholesale trade businesses	$12,786	5.2%
360	Real estate establishments	$12,298	5.0%
413	Food services and drinking places	$12,172	5.0%
357	Insurance carriers	$10,304	4.2%
397	Private hospitals	$9,875	4.0%
354	Monetary authorities and depository credit intermediation activities	$8,421	3.4%
324	Retail Stores - Food and beverage	$6,445	2.6%
351	Telecommunications	$6,405	2.6%
329	Retail Stores - General merchandise	$6,108	2.5%
398	Nursing and residential care facilities	$5,386	2.2%
320	Retail Stores - Motor vehicle and parts	$5,062	2.1%
31	Electric power generation, transmission, and distribution	$4,663	1.9%
355	Nondepository credit intermediation and related activities	$3,502	1.4%
396	Medical and diagnostic labs and outpatient and other ambulatory care services	$3,374	1.4%
323	Retail Stores - Building material and garden supply	$3,279	1.3%
358	Insurance agencies, brokerages, and related activities	$3,059	1.3%
331	Retail Nonstores - Direct and electronic sales	$2,988	1.2%
325	Retail Stores - Health and personal care	$2,833	1.2%

Finally, on page 21 of the Kansas Losses report, Kansas' experts note that "a payment equal to the on-farm direct plus the secondary direct and indirect losses…will induce its own secondary consumer-spending impacts." Apparently, after disputing the secondary benefits of payments from Nebraska in the Arbitration phase of this dispute, Kansas has now conceded their existence.

B. Cross-Border Flows

One significant shortcoming of the plaintiff's analysis is that it fails to take into account cross-border trade flows. In particular, the additional economic activity in Nebraska associated with overuse of water will stimulate the economy in Kansas. This cross-border effect should be subtracted from any assessment of Kansas damages, yet Kansas' economists made no attempt to do so. This omission is especially surprising since of the Kansas economists has authored an academic paper warning other analysts not do ignore cross-border trade flows when assessing secondary impacts. [55]

In order to quantify this cross-border spillover effect, I construct multi-regional input-output (MRIO) models in IMPLAN to quantify the impact that demand changes in the relevant Nebraska counties have on the Kansas economy. Taking the plaintiff's calculation of on-farm direct benefits as given, I model the following inputs in IMPLAN using the industry change activity type for the grain farming sector. IMPLAN inputs are generated by taking the total unjust enrichment figure advanced by Kansas and allocating it proportionally across counties based on Kansas' assumed shutdown irrigation acreage. Total unjust revenues are the sum of spending on inputs and value added, and therefore can be treated as changes in output.

Table 14: Nebraska Benefits and Spillover into Kansas

Value Added	2005		2006	
	Nebraska	**Kansas**	**Nebraska**	**Kansas**
Direct Effect	$12,973,032	$0	$18,660,205	$0
Indirect Effect	$1,438,962	$617,089	$2,092,807	$885,849
Induced Effect	$1,693,757	$221,226	$2,433,078	$317,566
TOTAL EFFECT	**$16,105,751**	**$838,315**	**$23,186,090**	**$1,203,415**

As shown in Table 14, my method of modeling the impacts in IMPLAN produces a value added benefits estimate for Nebraska that is much lower than that produced by the plaintiff. Even assuming that this lower bound estimate on benefits to Nebraska is correct, the associated

[55] Hamilton, Joel, M. Henry Robison, Norman Whittlesey, and John Ellis. "Interregional Spillovers in Regional Impact Assessment: New Mexico, Texas, and the Supreme Court." *Growth and Change,* 25:1, pg. 75-89. 1994.

spillover effect into Kansas through indirect and induced spending is over $2 million in value added. That is, Nebraska's benefit from overuse of water would produce indirect benefits in Kansas that are large in relation to Kansas' damage estimated by plaintiffs' experts. This effect should have been considered by Kansas' economists.

VII. References

Allen, Mark, Robert Hall, and Victoria Lazear. "Reference Guide on Estimation of Economic Damages." In *Reference Manual on Scientific Evidence,* Third Edition. Federal Judicial Center, 2011.

Book, Dale E. and Angela Schenk. "Engineering Analysis of Losses to Kansas Water Users Resulting from Overuse of Republican River Supply in Nebraska in 2005 and 2006," Spronk Water Engineers, Inc, November 2011.

Day, Frances (MIG), "IMPLAN Data Source Outline", 22 February 2011. <http://implan.com/V4/index.php?option=com_content&view=article&id=689%3Aimplan-data-source-outline&catid=253%3AKB33&Itemid=1.>

Dhuyvetter, K. and T. Kastens, "Kansas Land Prices and Cash Rental Rates," Kansas State University, Farm Management Guide MF-1100, September 2008.

Freeman, A. Myrick. "The Measurement of Environmental and Resource Values." 2nd Edition, RFF Press. February 2003.

Hamilton, Joel and M. Henry Robison. "Economic Analysis of Kansas Losses from Overuse of Republican River Water by Nebraska in 2005 and 2006". November 18, 2011.

Hamilton, Joel and M. Henry Robison. "Economic Analysis of Nebraska Benefits from Overuse of Republican River Water by Nebraska in 2005 and 2006". November 18, 2011.

Hamilton, Joel, M. Henry Robison, Norman Whittlesey, and John Ellis. "Interregional Spillovers in Regional Impact Assessment: New Mexico, Texas, and the Supreme Court." *Growth and Change,* 25:1, pg. 75-89. 1994.

Horowitz, Karen J. and Planting, Mark A., "Concepts and Methods of the United States Input-Output Accounts," Bureau of Economic Analysis, U.S. Department of Commerce, September 2006 (Updated April 2009).

Johnson, Bruce, Sara Van Newkirk, and Tyler Rosener. "Nebraska Farm Real Estate Market Highlights 2010-2011." Department of Agricultural Economics, University of Nebraska-Lincoln. June 2011.

Klocke, Norman L. "Development of Crop Production Functions for Irrigation in North Central Kansas". November 18, 2011.

Kansas Bostwick Irrigation District. Annual Reports.

Kansas State University Research and Extension. "Crops: Projected Budgets." <http://www.agmanager.info/crops/budgets/proj_budget/default.asp>

Lazarus, William F., Platas, Diego E. and George W. Morse, “IMPLAN’s Weakest Link: Production Functions or Regional Purchase Coefficients?”, *Journal of Regional Analysis & Policy,* 32:1, 2002.

Martin, Derrel, Darrell Watts, and James Gilley. “Model and Production Function for Irrigation Management”. Journal of the Irrigation Drainage Division of the American Society of Civil Engineers, 110 (4):149-164, 1984.

MIG Inc., “Version 3.0 User’s Guide”, Minnesota IMPLAN Group, 30 March 2010.

National Agricultural Statistics Service, Quick Stats 2.0. <http://quickstats.nass.usda.gov/>

Shultz, Steven and Nick Schmitz. “The Implicit Value of Irrigation Through Parcel Level Hedonic Price Modeling.” Prepared for Agricultural and Applied Economics Association Joint Annual Meeting, July 2010.

Sunding, David et al., “Modeling the Impacts of Reducing Agricultural Water Supplies: Lessons from California’s Bay-Delta Problem,” in *Decentralization and Coordination of Water Resource Management*, Douglas Parker and Yacov Tsur, eds., New York: Springer, 1997.

Swenson, Dave, “Input-Outrageous: The Economic Impacts of Modern Biofuels Production,” Department of Economics, Iowa State University, June 2006.

USDA Natural Resources Conservation Service. National Engineering Handbook KS652.0408 state supplement. <ftp://ftp-fc.sc.egov.usda.gov/KS/Outgoing/Web_Files/Technical_ Resources/ks_supplements/neh/ ks652_ch4.pdf>

Appendix A. Irrigated Acreage Model

I use the Bayes Information Criterion (BIC) to select between a log-log, log-linear or linear specification for the irrigated acreage model. The criterion strongly preferred the log-log specification for both the above and below Lovewell regressions (hereafter I use a natural log). An equation describing the irrigated area above Lovewell can be written as:

$$\ln(I_t) = \alpha + \beta \ln(D_t) + \phi \ln(P_t) + \varepsilon_t$$

Where I_t is the number of irrigated acres above Lovewell in year t, D_t is the acre feet of diversions above Lovewell in year t, P_t is the total number of acres planted in north-central Kansas in year t, and ε_t is the error term. The above equation can be appropriately adjusted for the area below Lovewell. Table 1 lists the estimation results for the area above Lovewell. Table 2 lists the estimation results for the area below Lovewell.

Table 1: Regression Results for Above Lovewell Model

Source	SS	df	MS	
				Number of obs = 41
				F(2, 38) = 76.09
Model	8.7160	2	4.3580	Prob > F = 0.0000
Residual	2.1764	38	0.0573	R-squared = 0.8002
Total	10.8924	40	0.2723	Adj R-squared = 0.7897
				Root MSE = 0.23932

Variable	Coefficient	Standard Error	t-value	P>|t|	[95% Conf. Interval]	
ln Diversions Above	0.471	0.038	12.25	0.000	0.393	0.549
ln NC Region Planted Acres	0.160	0.243	0.66	0.561	-0.333	0.652
Constant	2.460	3.458	0.71	0.481	-4.541	9.461

Table 2: Regression Results for Below Lovewell Model

Source	SS	df	MS	
				Number of obs = 41
				F(2, 38) = 14.16
Model	0.3712	2	0.1856	Prob > F = 0.0000
Residual	0.4979	38	0.0131	R-squared = 0.4271
Total	0.8691	40	0.0217	Adj R-squared = 0.3969
				Root MSE = 0.11447

Variable	Coefficient	Standard Error	t-value	P>|t|	[95% Conf. Interval]	
ln Diversions Above	0.124	0.050	2.50	0.017	0.024	0.225
ln NC Region Planted Acres	0.535	0.115	4.67	0.000	0.303	0.767
Constant	1.281	1.668	0.77	0.447	-2.095	4.656

Appendix B. Yield Model

The yield model is specified as follows:

$$C_t = \alpha + \beta \mathbf{D_t} + \gamma \mathbf{NC_{t+}} \phi_t \mathbf{NC_t} * \mathbf{D_t} + \varepsilon_t$$

Where C_t is the KBID corn yield in year t, $\mathbf{D_t}$ is the amount of diversions to KBID, $\mathbf{NC_t}$ is the north-central region corn yield, and ε_t is the error (where t is 1970-2010).[1] Regional corn yield proxies for weather and other conditions affecting corn yields in the relevant portion of Kansas.

The Durbin-Watson statistic is less than one (0.564) for this model, so I use the Prais-Winsten transformation to correct for autocorrelation. The transformed Durbin-Watson statistic is 2.56. imation results for this model.

Table 3 lists the estimation results for this model.

Table 3: Regression Results for KBID Corn Yield Model

Source	**SS**	**df**	**MS**			
					Number of obs = 41	
					F(3, 37) = 26.61	
Model	16062.17	3	5354.06		Prob > F = 0.0000	
Residual	7445.34	37	201.22		R-squared = 0.6833	
Total	23507.51	40	587.68		Adj R-squared = 0.6576	
					Root MSE = 14.185	
Variable	**Coefficient**	**Standard Error**	**t-value**	**P>|t|**	**[95% Conf. Interval]**	
KBID Total Diversions	0.001564	0.000696	2.25	0.031	0.000155	0.002974
NC Region Corn Yield	1.450547	0.234552	6.18	0.000	0.975300	1.925794
Interaction of NC Corn Yield and KBID Diversions	-0.000013	0.000007	-1.90	0.065	-0.000026	-0.000001
Constant	-26.835090	28.635200	-0.94	0.355	-84.855520	31.185340

[1] Although the BIC was high for this model I did not use a log specification because of collinearity among the variables in the log form.

QUALIFICATIONS AND COMPENSATION

I have prepared this expert report on behalf of the State of Nebraska. A true and accurate copy of my curriculum vitae is attached hereto as Appendix A. The opinions contained in this report are made to a reasonable degree of scientific certainty. In preparing this report, I utilized theories and methodologies that are accepted within the scientific community and which have been subject to peer reviewed analysis and publication. I was compensated $450 per hour for my work.

David Sunding, Ph.D.

CURRICULUM VITAE

DAVID L. SUNDING

November 2011

Thomas J. Graff Professor in the College of Natural Resources
207 Giannini Hall, MC3310
University of California
Berkeley, CA 94720

Phone: 510-642-8229
Mobile: 415-299-2653
e-mail: sunding@berkeley.edu

EMPLOYMENT

Professor, Department of Agricultural and Resource Economics, UC Berkeley, 2002 – Present.

Associate Professor, Department of Agricultural and Resource Economics, University of California at Berkeley, 2000 – 2002.

Cooperative Extension Specialist, Department of Agricultral and Resource Economics, University of California at Berkeley, 1997 – Present.

Senior Economist, Council of Economic Advisers, The White House, Washington, DC, 1996–1997.

Assistant Adjunct Professor, Department of Agricultural and Resource Economics, University of California at Berkeley, 1992–1996.

Assistant Professor, Department of Economics and School of Law, Boston College, 1989–1992.

VISITING APPOINTMENTS

Visiting Professor, Woods Institute of the Environment, Stanford University, 2010 - 2011.

EDUCATION

Ph.D., University of California at Berkeley, 1989.
M.A., University of California at Los Angeles, 1986.
B.A., Claremont McKenna College, 1983.

COURSES TAUGHT

Risk, Technology and the Environment (Graduate)
Environmental and Resource Economics (Graduate)
Economics of Water Resources (Undergraduate)
Natural Resource Economics (Undergraduate)
Economics of Public Law (Boalt Hall School of Law)
Environmental Policy (Undergraduate)
Public Finance (Graduate)
Microeconomic Theory (Graduate and Undergraduate)
Law and Economics (Boston College School of Law)

HONORS AND AWARDS

National Science Foundation. "Reinventing America's Urban Water Infrastructure." With Stanford University, Colorado School of Mines and New Mexico State University. $37,000,000. 2011 – 2021.

Giannini Foundation. "Agricultural Labor Markets and Water Supplies." $10,000. 2010 – 2011.

Giannini Foundation. "Habitat Conservation in a Working Landscape." $10,000. 2009 – 2010.

Academic Affiliate, Natural Heritage Institute, 2009 – Present.

Thomas J. Graff Chair in the College of Natural Resources, UC Berkeley, 2009 – Present.

Giannini Foundation. "Economics of Groundwater Storage in Southern California." $24,000. 2008-2009.

Invited Participant, Rosenberg International Forum in Water Policy, Valencia, Spain, 2008.

Energy Biosciences Institute. “Development of Biofuel Productivity Potentials for Economic Analysis Under Changing Climate, Land Use, and Societal Demands.” $154,000. 2007-2009.

U.S. Bureau of Reclamation, “Independent Review of Fisheries Restoration Programs.” $380,000. 2007-2008.

U.S. Department of Energy, “Joint Modeling of the Water and Energy Sectors.” $200,000. 2006-2009.

Invited Participant, Rosenberg International Forum in Water Policy, Banff, Canada, 2006.

Giannini Foundation. “Multimarket Impacts of Water Transfers in Areas of Origin.” $18,000. 2005 – 2006.

Giannini Foundation. “Land Use Regulation and Housing Market Dynamics.” $20,000. 2004-2005.

United States – Israel Binational Agricultural Research and Development Fund. “Dynamic Intraseasonal Irrigation Management Under Water Scarcity, Water Quality, Irrigation Technology and Environmental Constraints.” $200,000. 2003-2004.

Giannini Foundation. “Economics of Water Conservation in Agriculture.” $20,000. 2003-2004.

U.S. Environmental Protection Agency. STAR Grant. “Mechanisms for Risk Trading.” $206,000. 2002-2003.

Food Systems Research Group. “Optimal Commodity Promotion in Markets with Imperfect Competition and Differentiated Products.” $40,000. 2002-2003.

Outstanding Journal Article Award, AAEA, 2001.

Giannini Foundation. “Economic Benefits of Joint Management of Surface and Ground Water Storage Facilities.” $17,000. 2001–2002.

Best Published Research Award Finalist, WAEA, 1998.

California Department of Food and Agriculture. “Economic Impacts of Pesticide Regulation.” $1,150,000. 1994–2002.

California Department of Water Resources and U.S. Department of the Interior (CALFED Program). “Economic Valuation of Increased Water Supply Reliability and Trading Opportunities by Westside Agriculture.” $80,000. 1998–2000.

California Department of Food and Agriculture. “Economic Importance of Compound 1080 in California Agriculture.” $60,000. 1998–1999.

U.S. Department of Interior, Bureau of Reclamation. “Financial Incentives to Encourage Agricultural Water Conservation.” $1,500,000. 1994–2000.

U.S. Environmental Protection Agency. “Economic Incentives to Reduce Nonpoint Source Loads in Nevada’s Truckee River Basin.” $98,500. 1995–1997.

UNIVERSITY SERVICE

Vice Chair, Department of Agricultural and Resource Economics, 2010-2012.

Member, Academic Senate Committee on Faculty Welfare, 2010-2012.

Co-Director and Founder, Berkeley Water Center, 2005 – 2010.

Member, UC Division of Agricultural and Natural Resources Strategic Planning Committee, 2008.

Reviewer, California Policy Research Center, UC Office of the President, 2007.

Member, Forestry Search Committee, Ecosystem Sciences Division, Department of Environmental Science, Policy and Management, 2005-2006.

Member, Giannini Hall Seismic Retrofit Design Committee, 2005 – 2006.

Member, Academic Senate Committee on Amrican Cultures Requirements, 2004-2005.

Member, CNR Executive Committee, 2003-2005.

Member, CNR Committee on Directions, Opportunities and Initiatives, 2003.

Co-Director, Center for Sustainable Resource Development, College of Natural Resources, UC Berkeley, 1997 – 2004.

Faculty, Beahrs Environmental Leadership Program, 2001-2005.

Member, CNR Dean Search Committee, 2001-2002.

Chair, Specialist Search Committee, Department of Agricultural and Resource Economics, 2001-2002.

Member, CNR Advisory Board Development Committee, 2001-2002.

Member, Faculty Search Committee (International Trade), Department of Agricultural and Resource Economics, 1999-2000.

Member, CNR Dean Search Committee, 1999–2000.

Member, Workgroup Review Committee, University of California Division of Agriculture and Natural Resources, 1999–2002.

UC Berkeley Representative, Academic Assembly Council, University of California Division of Agriculture and Natural Resources, 1999–2001.

Departmental Affirmative Action Representative, 1999–2000.

Member, Faculty Search Committee (Environmental Health), Department of Agricultural and Resource Economics, 1998–2000.

PROFESSIONAL SERVICE

Research Thrust Leader, Urban Water Systems, National Science Foundation Engineering Research Center, 2011 – 2021.

National Science Foundation Workshop on Engineering and Economics, 2011.

Affiliate, Natural Heritage Institute, 2009 – Present.

Advisory Board, Water Policy Institute, 2008 – Present.

Advisory Board, American Groundwater Trust, 2008 – Present.

Board of Trustees, Bay Area Council Economic Institute, 2008 – Present.

Reviewer, Delta Risk Management Study (DRMS), California Department of Water Resources, 2007-2008.

Member, Economic Advisory Committee on North of Delta Offstream Storage, California Department of Water Resources, 2006-2007.

Member, Panel on Illegal Competitive Advantage Economic Benefit, Science Advisory Board, U.S. Environmental Protection Agency, 2004-2005.

Mentor, American Economic Association Pipeline Project for Minority Graduate Students, 2004 – 2005.

President, International Water Resource Economics Consortium, 2003-2009.

Member, Science Advisory Board, National Center for Housing and the Environment. 2003 – 2005.

Member, Expert Panel on Cost Allocation, CalFed Bay-Delta Program, 2001-2002.

Member, National Academy of Sciences Panel on Water Conservation and Reuse, 2001-2002.

Member, Technical Advisory Committee on Water Use Efficiency, CalFed Bay-Delta Program, 1997–1998.

Referee: *Agricultural Economics, American Journal of Agricultural Economics, California Agriculture, Contemporary Economic Policy, Environmental and Resource Economics, Journal of Agricultural and Resource Economics, Journal of Business and Economic Strategy, Journal of Environmental Economics and Management, Journal of Political Economy, Journal of Public Economics, Journal of Regulatory Economics, Journal of Law and Economics, Land Economics, Natural Resources Modeling, Resource and Energy Economics, Review of Economics and Statistics, Social Choice and Welfare, Water Resources Research.*

PUBLICATIONS

Peer-Reviewed Publications

"Hedonic Analysis with Locally Weighted Regression: Measrueing the Shadow Value of Housing Regulation in Southern California." With Aaron Swoboda. *Regional Science and Urban Economics* 40(2010): 550-573.

"On The Spatial Nature of the Groundwater Pumping Externality." With Nicholas Brozovic and David Zilberman. *Resource and Energy Economics* 32(2010): 154-164.

"Sustainable Management of Water Resources under Hydrologic Uncertainty." With Newsha Ajami and George Hornberger. *Water Resources Research* 44(2008): W11406, doi:10.1029/2007WR006736.

"Estimating Business and Residential Water Supply Interruption Losses from Catastrophic Events." With Nicholas Brozovic and David Zilberman. *Water Resources Research* 43(2007): 418-428.

Management of Saline Wastewater Discharges in the San Joaquin Valley. Report to the Central Valley Regional Water Quality Control Board. With Yoram Rubin, Gretchen

Miller, Pascual Benito, Ulrich Meyer, Michael Kavanaugh, Todd Anderson, Mark Berkman, David Zilberman, and Steve Hamilton. September 2007.

"Consideration of Economics Under the California Porter-Cologne Act." With David Zilberman. *Hastings West-Northwest Journal of Environmental Law & Policy* (2007): 73-116.

"Water Markets and Trading." With Howard Chong. *Annual Review of Environment and Resources* 31(2006): 239-264.

"Panel Estimation of an Agricultural Water Demand Function." With Karina Schoengold and Georgina Moreno. *Water Resources Research* 42(2006): 411-421.

"Fat Taxes and Thin Subsidies: Prices, Diet and Health Outcomes." With Sean Cash and David Zilberman. *Acta Agriculturae Scand. C* 2(2006): 167-174.

"Economic Impacts." *The Endangered Species Act at Thirty*. M. Scott, D. Goble and F. Davis, eds. Washington, DC: Island Press, 2006.

"The Economics of Environmental Regulation of Housing Development." *Housing and Society* 32(2005): 23-38.

"Joint Estimation of Technology Adoption and Land Allocation with Implications for the Design of Conservation Policy." With Georgina Moreno. *American Journal of Agricutural Economics* 87(2005): 1009-1019.

"Factor Price Risk and the Adoption of Conservation Technology." With Georgina Moreno. *Frontiers in Water Resource Economics*. D. Berga and R. Goetz, eds. New York: Springer-Verlag, 2005.

"Optimal Management of Groundwater over Space and Time." With Nicholas Brozovic and David Zilberman. *Frontiers in Water Resource Economics*. D. Berga and R. Goetz, eds. New York: Springer-Verlag, 2005.

"Response to 'Environmental Regulation and the Housing Market: A Review of the Literature' by Katherine Kiel." *Cityscapes* 8(2005): 277-282.

"The Economics of Climate Change in Agriculture." With Xuemei Liu, David Roland-Holst and David Zilberman. *Mitigation and Adaptation Strategies for Global Change* 9(2004): 365-382.

"Wetlands Regulation … An Opening for Meaningful Reform?" *Regulation* 26(2003): 30-35.

"Government Regulation of Product Quality in Markets with Differentiated Products: Looking to Economic Theory." *American Journal of Agricultural Economics* 85(2003): 720-724.

"The Economics of Environmental Regulation by Licensing: Observations on Recent Changes to the Federal Wetland Permitting Program." With David Zilberman. *Natural Resources Journal* 42(Winter 2002): 59-90.

> * Cited in the U.S. Supreme Court's plurality and dissenting opinions in the consolidated cases of *Rapanos v. United States* and *Carabell v. United States*.

"Trading Patterns in an Agricultural Water Market." With Nicholas Brozovic and Janis Carey. *Water Resources Update* (2002): 3-16.

"Public Goods and the Value of Product Quality Regulations: The Case of Food Safety." With Stephen Hamilton and David Zilberman. *Journal of Public Economics* 87(2003): 799-817.

"Regulating Pollution with Endogenous Monitoring." With Katrin Millock and David Zilberman. *Journal of Environmental Economics and Management* 44(2002): 221-241.

"Transactions Costs and Trading Behavior in an Immature Water Market." With Janis Carey and David Zilberman. *Environment and Development Economics* 7(2002): 733-750.

"Measuring the Costs of Reallocating Water from Agriculture: A Multi-Model Approach." With David Zilberman, Richard Howitt, Ariel Dinar and Neal MacDougall. *Natural Resource Modeling* 15(Summer 2002): 201-225.

"Voluntary Development Restrictions and the Cost of Habitat Preservation." With Sabrina Lovell. *Real Estate Economics* 29(March 2001): 191–206.

"Emerging Markets in Water: A Comparative Institutional Analysis of the Central Valley and Colorado-Big Thompson Projects." With Janis Carey. *Natural Resources Journal* 41(2001): 283–328.

"Risk Management and the Environment." With Mark Metcalfe and David Zilberman. In Richard Just and Rulon Pope (eds.). *A Comprehensive Assessment of the Role of Risk in U.S. Agriculture*. Norwell, MA: Kluwer Academic Publishers, 2002.

"A Comparison of Policies to Reduce Pesticide Poisoning Combining Economic and Toxicological Data." With Joshua Zivin. In: Joe Moffitt (ed.). *Advances in the Economics of Environmental Resources: Volume 4*. Greenwich: JAI Press, 2001.

"The Impact of Climate Change on Agriculture: A Global Perspective." With David Zilberman and Xuemei Liu. In: Charles Moss, Gordon Rausser, Andrew Schmitz, Tim Taylor and David Zilberman (eds.), *Agricultural Globalization, Trade, and the Environment*. New York: Kluwer, 2001.

"The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector." With David Zilberman. In: Bruce Gardner and Gordon Rausser (eds.), *Handbook of Agricultural and Resource Economics*. Amsterdam: North Holland, 2001, 207-261.

"Insect Population Dynamics, Pesticide Use and Farmworker Health." With Joshua Zivin. *American Journal of Agricultural Economics* 82(August 2000): 527–540.

* Winner of the AAEA Outstanding Journal Article Award.

"Product Liability, Entry Incentives and Market Structure." With Stephen Hamilton. *International Review of Law and Economics* 20(September 2000): 269–283.

"Climate Change Policy and the Agricultural Sector." With David Zilberman. In: R. Lal, J.M. Kimble, R.F. Follett and B.A. Stewart (eds.), *Assessment Methods for Soil Carbon*. Boca Raton, FL: CRC Press, 2000, 629–643.

"Methyl Iodide as an Alternative to Methyl Bromide." With Brent Hueth, Bruce McWilliams and David Zilberman. *Review of Agricultural Economics* (Spring/Summer 2000): 43–54.

"Using Water Markets to Improve Environmental Quality: Two Innovative Programs in Nevada." With Sabrina Ise Lovell and Katrin Millock. *Journal of Soil and Water Conservation* 55(First Quarter 2000): 19–26.

"The Price of Water…Market-Based Strategies are Needed to Cope wth Scarcity." *California Agriculture* 54(March-April 2000): 56–63.

"Designing Environmental Regulations with Empirical Microparameter Distributions: The Case of Seawater Intrusion." With Gareth Green. *Resource and Energy Economics* 22(January 2000): 63–78.

"The Economics of Inter-District Water Transfers in California." In *Proceedings of the American Society of Civil Engineers*. New York: ASCE, 1999.

"Returns to Public Investment in Agriculture with Imperfect Downstream Competition." With Stephen Hamilton. *American Journal of Agricultural Economics* 80(November 1998): 830–838.

"Reallocating Water from Agriculture to the Environment under a Voluntary Purchase Program." With Sabrina Ise. *Review of Agricultural Economics* 20(Summer 1998): 214–226.

"Allocating Product Liability in a Multimarket Setting." With David Zilberman. *International Review of Law and Economics* 18(March 1998): 1–11.

"Resolving Trans-Boundary Water Disputes: Economists' Influence on Policy Choices in the United States." In: Richard Just and Sinaia Netanyahu (eds.), *Conflict and Cooperation on Trans-Boundary Water Resources*. Norwell: Kluwer, 1998.

"Economics and Pesticide Regulation." With Erik Lichtenberg, Douglas Parker and David Zilberman. *Choices* (Fourth Quarter 1997): 26–29.

"The Effect of Farm Supply Shifts on Concentration and Market Power in the Food Processing Sector." With Stephen Hamilton. *American Journal of Agricultural Economics* 79(May 1997): 524–531.

"Land Allocation, Soil Quality and the Demand for Irrigation Technology." With Gareth Green. *Journal of Agricultural and Resource Economics* 22(November 1997): 367–375.

"Water Marketing in the '90s: Entering the Electronic Age." With Janis Carey, David Zilberman and Douglas Parker. *Choices* (Third Quarter 1997): 15–19.

"Modeling the Impacts of Reducing Agricultural Water Supplies: Lessons from California's Bay/Delta Problem." With David Zilberman, Neal MacDougall, Richard Howitt and Ariel Dinar. In: Doug Parker and Yacov Tsur (eds.), *Decentralization and Coordination of Water Resource Management*. New York: Kluwer, 1997.

"The Changing Nature of Agricultural Markets: Implications for Privatization of Technology, Information Transfer and Land Grant Research and Extension." With David Zilberman and Madhu Khanna. In: Stephen Wolf (ed.), *Privatization of Information and Agricultural Industrialization*. Boca Raton: CRC Press, 1997.

"Changes in Irrigation Technology and the Impact of Reducing Agricultural Water Supplies." With Ariel Dinar and David Zilberman. In: Darwin Hall (ed.), *Advances in the Economics of Environmental Resources: Volume 1*. Greenwich: JAI Press, 1996.

"Measuring the Marginal Cost of Nonuniform Environmental Regulations." *American Journal of Agricultural Economics* 78(November 1996): 1098–1107.

"Explaining Irrigation Technology Choices: A Microparameter Approach." With Gareth Green, David Zilberman and Douglas Parker. *American Journal of Agricultural Economics* 78(November 1996): 1064–1072.

"How Does Water Price Affect Irrigation Technology Adoption?" With Gareth Green, David Zilberman, Douglas Parker, Cliff Trotter and Steve Collup. *California Agriculture* 50(March-April 1996): 36–40.

"Strategic Participation and the Median Voter Result." *Economic Design* 1(April 1996): 355–363.

"Social Choice by Majority Rule with Rational Participation." *Social Choice and Welfare* 12(December 1995): 3–12.

"Water Markets and the Cost of Improving Water Quality in the San Francisco Bay/Delta Estuary." With David Zilberman and Neal MacDougall. *Hastings West-Northwest Journal of Environmental Law & Policy* 2(Spring 1995): 159–165.

"Flexible Technology and the Cost of Improving Groundwater Quality." With David Zilberman, Gordon Rausser and Alan Marco. *Natural Resource Modeling* 9(April 1995): 177–192.

"Water for California Agriculture: Lessons from the Drought and New Water Market Reform." With David Zilberman, Richard Howitt, Ariel Dinar and Neal MacDougall. *Choices* (Fourth Quarter 1994): 25–28.

"Methyl Bromide Regulation…All Crops Should Not Be Treated Equally." With Cherisa Yarkin, David Zilberman and Jerry Siebert. *California Agriculture* 48(May-June 1994): 10–15.

"Cancelling Methyl Bromide for Postharvest Use to Trigger Mixed Economic Results." With Cherisa Yarkin, David Zilberman and Jerry Siebert. *California Agriculture* 48(May-June 1994): 16–21.

"Who Makes Pesticide Use Decisions? Implications for Policymakers." With David Zilberman, Michael Dobler, Mark Campbell and Andrew Manale. In: Walter Armbruster (ed.), *Pesticide Use and Product Quality*. Glenbrook: Farm Foundation, 1994.

"Managing Groundwater Quality under Uncertainty." With David Zilberman and Gordon Rausser. In: Michelle Marra (ed.), *Quantifying Long-Run Agricultural Risks*. Orono: University of Maine, 1993.

"Natural Resource Cartels." With David Teece and Elaine Mosakowski. In: Allen Kneese and James Sweeney (eds.), *Handbook of Natural Resource and Energy Economics*, Volume III. Amsterdam: Elsevier, 1993.

"Joan Robinson as a Development Economist." With Irma Adelman. In: George Feiwel (ed.), *Joan Robinson and Modern Economic Theory*. London: Basil Blackwell, 1988.

"Economic Policy and Income Distribution in China." With Irma Adelman. *Journal of Comparative Economics* 11(September 1987): 444–461. Reprinted in Bruce Reynolds (ed.*), China's Economic Development: How Far, How Fast?* New York: Academic Press, 1989. Reprinted in Joseph C. H. Chai (ed.), The Economic Development of Modern China. London: Edward Elgar, 1999.

Technical Reports, Book Chapters and Other Publications

Economic Impacts of Water Supply Disruptions Caused by Seismic Events in the Bay-Delta Estuary. September 2010.

"Improving Groundwater Management to Cope with Reduced Surface Water Imports: The Case of Los Angeles County." With Steve Hamilton and Newsha Ajami. In A. Findikakis, ed., *Groundwater Management Practices*, Leiden: CRC Press, 2010.

Economic Impacts of Residential Water Shortages in California. With Steve Hamilton. April 2010.

"The Economics of Federal Land Use Controls." *Rebuilding the Ark: Strategies for Reforming the Endangered Species Act*. Jonathan Adler, ed., Washington, DC: AEI-Brookings Joint Center for Regulation, 2009.

Economic Impacts of Flow Requirements for Delta-Dependent Species. With Newsha Ajami, David Mitchell, Steve Hatchett and David Zilberman. December 2008.

The Economics of Stormwater Regulation. June 2008.

Strategies to Reduce the Economic Impacts of Drought-Induced Water Shortage in the San Francisco Bay Area. April 2007.

A Guide to Consideration of Economics Under the California Porter-Cologne Act. With David Zilberman. March 2005.

"Water Allocation and Water Market Activity in California." With Richard Howitt. *California Agriculture: Dimensions and Trends*. Jerome Siebert, ed. Giannini Foundation, 2004.

Fiscal Costs and Economic Impacts of Recovering the Coho Salmon in California. With Alix Peterson Zwane. California Department of Fish and Game. October 2003.

Economic Impacts of Critical Habitat Designation for the Coastal California Gnatcatcher. July 2003.

The Economic Impacts of Critical Habitat Designation: Framework and Application to the Case of California Vernal Pools. With Aaron Swoboda and David Zilberman. January 2003.

Non-Federal and Non-Regulatory Approaches to Wetland Conservation: A Post-SWANCC Evaluation of Conservation Alternatives. National Center for Housing and the Environment. December 2002.

Economic Impacts of Earthquake-Induced Water Supply Shortages in the San Francisco Bay Area. With Nicholas Brozovic and David Zilberman. Bay Area Economic Forum. October 2002.

Economic Impacts of Organophosphate Use in California Agriculture, Parts 1 and 2. With Mark Metcalfe, Bruce McWilliams, Brent Hueth, Robert Van Steenwyk and David Zilberman. California Department of Food and Agriculture. February 2002.

Water Pricing and Water Use Efficiency. U.S. Department of the Interior, Bureau of Reclamation. January 2001.

Economic Impacts of Critical Habitat Designation for the California Red-Legged Frog. Home Builders Association of Northern California. With David Zilberman. January 2001.

A Proposal for Management of the Confined Aquifer in the Western San Joaquin Valley. With David Purkey. July 2000.

Analysis of the Army Corps of Engineers' NWP 26 Replacement Permit Proposal. Foundation for Economic and Environmental Progress. With David Zilberman. February 2000.

Economic Valuation of Increased Water Supply Reliability and Trading Opportunities in Westside Agriculture. With Georgina Moreno, Daniel Osgood and David Zilberman. CalFed Bay-Delta Program. December 1999.

Costs of Implementing the Food Quality Protection Act of 1996 on California Agriculture. With Bruce McWilliams, Yuria Tanimichi and David Zilberman. September 1999.

Economic Impact of Restricting Use of Compound 1080 in California's Intermountain Region. With Brent Hueth and Michelle McGregor. California Department of Pesticide Regulation. April 1999.

Downstream Economic Impacts of Reducing Federal Water Subsidies: The Case of Alfalfa and Dairy. With Gergina Moreno. Natural Resources Defense Councl. August 1998.

Economic Importance of Organophosphates in California Agriculture. With Brent Hueth, Grazyna Michalska, and David Zilberman. California Department of Food and Agriculture. August 1998.

An Environmentally Optimal Alternative for the San Francisco Bay-Delta. With John Cain, David Fullerton, David Purkey and Greg Thomas. Natural Heritage Institute. July 1998.

Water Trading and Environmental Quality in the Western United States. With David Zilberman. U.S. Environmental; Protection Agency. April 1998.

Impact of Endangered Species Legislation on California Agriculture. With David Zilberman, Jerome B. Siebert, Joshua Zivin, Sabrina Isé and Brent Hueth. California Resources Agency. January 1998.

Economics Impacts on California Agriculture of Banning Methyl Bromide Use. With Bruce McWilliams, Brent Hueth, Lori Lynch, David Zilberman and Jerome Siebert. California Department of Food and Agriculture. January 1998.

Economic Incentives for ImprovingWater Quality in Nevada's Truckee River Basin. With Sabrina Ise and Katrin Millock. U.S. Environmental Protection Agency. October 1996.

Managing Seawater Intrusion in Monterey County through Agricultural Water Conservation. With Gareth Green and Larry Dale. Monterey County Water Resources Agency. May 1995.

Conclusions and Recommendations on a Framework for Comparative Cost Effectiveness Assessment of CVP Yield Augmentation Alternatives. With Greg Thomas. U.S. Department of the Interior, Bureau of Reclamation. December 1994.

Economic Impacts of USFWS' Water Rights Acquisition Program for Lahontan Valley Wetlands. U.S. Department of the Interior, Fish and Wildlife Service. June 1994.

Market Implementation of Bay/Delta Water Quality Standards. U.S. Environmental Protection Agency. March 1994.

Economic Impacts of Mevinphos Cancellation in California. California Department of Pesticide Regulation. March 1994.

Economic Impacts of Federal Worker Protection Standards. With Cheryl Brown, Valerie Brown and Bob Chavez. California Department of Food and Agriculture. October 1993.

Water Quality Regulation in the San Francisco Bay and Delta. With David Zilberman, Richard Howitt, Neal MacDougall and Linda Fernandez. U.S. Environmental Protection Agency. May 1993.

The Economic Consequences of Enforcing the Delaney Clause. With Alan Marco. U.S. Environmental Protection Agency. March 1993.

Economic Impacts of Cancelling Methyl Bromide in California. With Cherisa Yarkin, David Zilberman, Jerome Siebert and Alan Marco. California Department of Food and Agriculture. February 1993.

Economic Impact of the Silverleaf Whitefly. With Jerome Siebert, David Zilberman and Michael Roberts. California Department of Food and Agriculture. January 1993.

PAPERS UNDER REVIEW

"Hydrologic Uncertainty and the Economic Value of Improved Water Supply Forecasts." With Newsha Ajami, George Hornberger, David Yates and David Purkey. *Water Resources Research*, revise and resubmit.

"Economic Impacts of Critical Habitat Designation: Evidence from the Market for Vacant Land." With Maximillian Auffhammer and Maya Oren. *Journal of Law and Economics*, revise and resubmit.

"Prices vs. Limits." With Nicholas Brozovic and David Zilberman.

"The Economics of Urban Water Supply Reliability." With Steven Buck and Steve Hamilton.

"Approximately Optimal Speculation and the Value of Groundwater Storage." With Jonathan Terhorst.

"Land Markets and the Value of Irrigation." With Steve Buck and Maximillian Auffhammer.

"The Economics of a Waste Disposal Network." With Steve Hamilton, David Zilberman and Thomas Sproul.

"Conserving Habitat through Regulation of Housing Development." With Jonathan Terhorst.

"Input Price Risk and Adoption of Conservation Technology." With Karina Schoengold.

WORKING PAPERS

"The Incidence of Environmental Regulation." With Steve Hamilton.

"Endangered Species Act Regulation and Agricultural Employment in California's San Joaquin Valley." With Maximillian Auffhammer and Kate Foreman.

"The Central Role of Groundwater in Achieving Urban Water Sustainability." With Newsha Ajami, Steve Buck and Steve Hamilton.

"Environmental Regulation by Licensing." With Aaron Swoboda and David Zilberman.

"Investment with Uncertain Environmental Permits." With Steve Hamilton.

"An Optimal Deposit-Refund Scheme for Lubricating Oil." With Steve Hamilton.

"Managing a Coastal Aquifer under Multiple Uncertainty." With David Zilberman.

"Salinity and Land Allocation in Delta Agriculture." With Vaughn Quoss.

INVITED PRESENTATIONS

"Novel Approaches to Infrastructure Finance," California Foundation for the Environment and the Economy, Palos Verdes, CA, October 2011.

"The Economics of Bay-Delta Restoration," California Foundation for the Environment and the Economy, Sonoma, CA, Sonoma 2011.

"The Economics of Water Reuse," From Used to Useful, Riyadh, Saudi Arabia, April 2011.

"The Economics of Isolated Conveyance in the Delta," California Water Policy Conference, Santa Barbra, April 2011.

"Managing a Groundwater Storage Bank." American Groundwater Trust, New York, NY, March 2011.

"The Economics of Future Water Supplies." California Water Association. Monterey, CA. November 2010.

"Vulnerability of Water Infrastructure to Seismic Events." Southern California Water Committee. September 2010.

"Economics of Water Allocation." American Bar Association. Orlando, FL. May 2010.

“Expanding the Role of the Private Sector in Water: Opportunities and Challenges.” General Electric. Los Angeles, CA. May 2010.

“Adapting to Unreliable Water Supplies.” University of the Pacific McGeorge School of Law, Sacramento, CA, February 2010.

“The Economics of Water Exports from the Delta,” American Society of Agronomy, Tulare, CA, January 2010.

“Long Term Contracts, Storage Incentives and Conjunctive Use: The Case of the Central and West Coast Basins in Los Angeles County.” International Water Resource Economics Consortium Meetings. Berkeley, CA. November 2009.

“Economic Barriers to Recycled Water.” General Electric Corporation Leadership Summit, Crotonville, NY. November 2009.

“Habitat Protection in a Dynamic Landscape.” California HCP/NCCP Conference. Vacaville, CA. November 2009.

“New Approaches to Financing Water Infrastructure.” Water Policy Institute – Berkeley Water Center Conference on Water and Economics. Washington, DC. October 2009.

“The Economics of Federal Land Use Regulation.” AEI-Brookings Joint Center on Regulation. Washington, DC. September 2009.

“Water Policy in the United States.” New York Bar Association. New York, NY. June 2009.

“The Role of the Private Sector in Water Resource Management.” American Law Institute – American Bar Association. Denver, CO. March 2009.

“Economic Analysis of Water Resources.” American Bar Association Annual Water Law Conference. San Diego, CA. February 2009.

“Benefits of Drought-Resistant Seed Varieties.” Conference on Biotechnology and Water Use. Gates Foundation and Giannini Foundation. Berkeley, CA. January 2009.

“U.S. Agriculture in Transiton.” Northwest Food Processing Association. Portland, OR. January 2009.

“Economic Perspectives on Water Resources.” Water Policy Institute. Washington, DC. October 2008.

"Climate Change and Groundwater Resources." Groundwater Resource Association. Sacramento, CA. August 2008.

"Climate Change, Energy Prices and California's Water Resources." BWC Conference on Biofuels and California Agriculture. Parlier, CA. May 2008.

"Sustainability and the Role of Private Investment in the Water Sector." American Groundwater Trust. New York, NY. April 2008.

"Recent Development in Designating Critical Habitat." Endangered Species Law. American Law Institute-American Bar Association. San Diego, CA. June 2008.

"Assessing Risks to California's Water Systems." Discover Cal. Redwood City, CA. November 2007.

"New Settings for HCPs and New Approaches to ESA Compliance." CLE International. San Francisco, CA. November 2007.

"Policies to Control Point Source Discharges of Salts in the San Joaquin Valley." Regional Water Quality Control Board. Modesto, CA. October 2007.

"Federal Land Use Controls." Pacific Rivers Council. San Francisco, CA. October 2007.

"The Economic Implications of Conjunctve Use and Groundwater Banking." Theis Conference, National Groundwater Association. Park City, UT. September 2007.

"Evaluating Investments in Groundwater: Hard Science or Black Art?" Groundwater Resource Association. San Francisco, CA. June 2007.

"Delta Futures and California's Water Economy." Public Policy Institute of California. San Francisco, CA. February 2007.

"California's Water Infrastructure Needs." Bay Area Economic Forum. San Francisco, CA. February 2007.

"Management of a Coastal Aquifer under Multiple Uncertainty." Association of Environmental and Resource Economists. Chicago, IL. January 2007.

"Growth, Environment & Efficiency: California's Water Future." UC Berkeley Homecoming. Berkeley, CA. October 2006.

"Water Supply and the Bay Area Economy." League of Women Voters Know Your Bay Area Day. San Francisco, CA. September 2006.

"Economics of Water Quality Regulation." International Agricultural Economics Association Pre-Conference Workshop on Water Resources. Brisbane, Australia. August 2006.

"Measuring the Groundwater Pumping Externality." American Agricultural Economics Association. Long Beach, CA. July 2006.

"Costs and Benefits of Wetland Regulation." American Law Institute – American Bar Association Wetlands Conference. Washington, DC. June 2006.

"Economics of Water Resource Management in California." University-Industry Consortium. Oakland, CA. May 2006.

"Regulating Water Quality in California." University of California Water Resources Center Continuing Conference. Davis, CA. May 2006.

"Natural Disasters and the Resilience of the Urban Economy." Symposium on Real Estate, Catastrophic Risk and Public Policy. Berkeley, CA. March 2006.

"Economics and the Endangered Species Act: The Role of Critical Habitat." Annual Conference on the Endangered Species Act and Habitat Conservation Planning. San Francisco, CA. December 2005.

"Economics of Groundwater Management." Groundwater Resources Association. Pasadena, CA. September 2005.

"The Economics of Waer Quality Regulation." Central Valley Clean Water Association. Sacramento, CA. May 2005.

"Economics of Technology Adoption and Diffusion." Conference on Sustainable Energy Futures. Berkeley, CA. April 2005.

"Consideration of Economics Under Porter-Cologne." Urban Water Institute. Newport Beach, CA. April 2005.

"Tools for a New Era of Sustainable Water Management." Barcelona, Spain. March 2005.

"Bad Neighbors: The Economics of Conflict Over New Housing." Conference on Urban Policy. Berkeley, CA. January 2005.

"Economic Analysis of Water Quality Regulations: When is It Worth the Trouble?" Industrial Environmental Association. San Diego, CA. November, 2004.

"Measuring the Cost of Conservation by Permitting." Association of Environmental and Resource Economists. Denver, CO. August 2004.

"Panel Estimation of Agricultural Water Demand Based on an Episode of Rate Reform." American Agricultural Economics Association. Denver, CO. August 2004.

"Local Public Goods and Ethnic Diversity." American Agricultural Economics Association. Denver, CO. August 2004.

"Prices vs. Quantities Revisited." American Agricultural Economics Association. Denver, CO. August 2004.

"Managing Groundwater with Localized Externalities." American Agricultural Economics Association. Denver, CO. August 2004.

"Fat Taxes and Thin Subsidies." American Agricultural Economics Association. Denver, CO. August 2004.

"Environmental Regulation and California Agriculture: Focus on ESA and the Clean Water Act." Western Growers' Association. Sacramento, CA. June 2004.

"Endangered Species Regulation and California Agriculture." Giannini Foundation Conference on the Future of California Agriculture. Sacramento, CA. May 2004.

"Environmental Regulation and Housing Affordability." U.S. Department of Housing and Urban Development Conference on Regulatory Barriers to Housing Affordability. Washington, DC. April 2004.

"Economic Analysis of Evironmental Regulation." Clean Water Act Summit Meeting. Irvine, CA. March 2004.

"Economic Impacts of Endangered Species Regulation: A Project-Level Perspective Focusing on the Housing Industry." Conference on the Endangered Species Act at 30. Santa Barbara, CA. November 2003.

"Whither Reclamation Reform? Looking to the Next 100 Years of Reclamation Law." Berkeley Conference on Water Policy Reform. San Francisco, CA. September 2003.

"Simultaneous Estimation of Technology Choice and Land Allocation." American Agricultural Economics Association. Montreal, Canada. July 2003.

"Advertising in Markets with Product Differentiation and Imperfect Competition." Food Systems Research Group, University of Wisconsin. June 2003.

"Wetlands Protection Beyond Section 404." American Law Institute – American Bar Association Wetlands Conference. Washington, DC. May 2003.

"Prioritizing Habitat Conservation." Conference on the Endangered Species Act. Land Use Research Foundation of Hawaii and the Hawaii State Bar Association Section on Real Property and Finance. May 2003.

"Government Regulation of Product Quality in Markets with Differentiated Products: Looking to Economic Theory." Allied Social Science Association. Washington, DC. January 2003.

"Non-Regulatory and Non-Federal Approaches to Wetland Protection." National Association of Home Builders. Las Vegas, NV. January 2003.

"Agricultural Water Use and the Role of Prices." Joint Meeting of the U.S. and Iranian Academies of Sciences. Tunis, Tunisia. December 2002.

"Economic Megatrends and Water Use in the United States." National Academy of Sciences. Washington, DC. September 2002.

"Pesticide Regulation and Changes in Human Health." World Congress of Environmental Economics. Monterey, CA. June 2002.

"Mechanisms for Risk Trading." World Congress of Environmental Economics. Monterey, CA. June 2002.

"Economic Damage from Water Supply Disruptions Following an Earthquake in the San Francisco Bay Area." Bay Area Water Users' Association. Foster City, CA. June 2002.

"Economic Perspectives on Federal Wetland Regulation." American Law Institute – American Bar Association. Washington, DC. May 2002.

"Reconciling Competing Interests in the West Side." CSRD Conference on the Future of the West Side. Parlier, CA. March 2002.

"Protecting Public Interests on Private Land." Center for Sustainable Resource Development, UC Berkeley. February 2002.

"Cost-Shifting and Environmental Quality." POWER Annual Conference. Los Angeles, CA. December 2001.

"Factor Price Risk and the Diffusion of Conservation Technology." California Conference on Environmental and Resource Economics. UC Santa Barbara. November 2001.

"Valuation of Water Supply Reliability." American Agricultural Economics Association. Chicago, IL. August 2001.

"Allocating Water by Markets." American Society of Horticultural Sciences. Sacramento, CA. July 2001.

"The Farm Bill and Resource Conservation: Success Stories." CSRD Conference on Agriculture and the Environment. Washington, DC. June 2001.

"Does Factor Price Risk Encourage Conservation?" International Water Resource Economics Consortium. Girona, Spain. June 2001.

"Optimal Control of Groundwater Over Space and Time." International Water Resource Economics Consortium. Girona, Spain. June 2001.

"Trading Behavior in an Informal Market." International Water Resource Economics Consortium. Girona, Spain. June 2001.

"Economics of Pesticide Cancellation: The Food Quality Protection Act of 1986." University of California Agricultural Economics and Management Workgroup. UC Davis. May 2001.

"Economic Aspects of Biological Control." University of California Conference on Urban Pest Management. UC Riverside. October 2000.

"Price Volatility and Resource Conservation." American Agricultural Economics Association. Tampa, FL. July 2000.

"Economics of Water Trading in California." UC Berkeley Water Working Group. Berkeley, CA. March 2000.

"Reforming Public Lands Policy." Painting the White House Green: Economics and Environmental Policy-Making in the Clinton Administration. Laramie, WY. September 1999.

"Transaction Costs and Trading Behavior in a Permit Market." American Agricultural Economics Association. Nashville, TN. August 1999.

"Facilitating Water Transfers with the *WaterLink* System." American Society of Civil Engineers. Seattle, WA. August 1999.

"Valuing Agricultural Water Supply Reliability." International Water Resource Economics Consortium. Waikoloa, HI. July 1999.

"Economics of Inter-District Water Transfers." Western Economics Association. San Diego, CA. June 1999.

"The Value of Water Supply Reliability in Westside Agriculture." CalFed Economics Workgroup. Sacramento, CA. June 1999.

"Economic Impacts of Pesticide Regulation." Center for Sustainable Resource Development Conference on Pest Management. UC Berkeley. May 1999.

"Water Marketing within Irrigated Agriculture." American Agricultural Economics Association. Salt Lake City, UT. August 1998.

"Welfare Impacts of Climate Change: Focus on Pest Problems and Water Resources." American Agricultural Economics Association. Salt Lake City, UT. August 1998.

"Water Trading and the Costs of Bay/Delta Protection." Water Education Foundation. San Diego, CA. July 1998.

"Federal Public Land Policy: Litmus Test Issues." Berkeley Commons Club. Berkeley, CA. June 1998.

"Recent Developments in American Agricultural Policy." Commonwealth Club. San Francisco, CA. October 1997.

"Performance of a Voluntary Water Purchase Program." Western Regional Water Economics Conference. Lihue, HI. October 1997.

"Water Marketing for the Environment: The Clinton Administration's Perspective." Conference on Regional Water Markets. Berkeley, CA. July 1997.

"Returns to Public Investment in Agriculture with Imperfect Downstream Competition." American Agricultural Economics Association. Toronto, Canada. July 1997.

"Markets for Crop Germplasm." Invited Paper, American Agricultural Economics Association. Toronto, Canada. July 1997.

"Land Allocation, Soil Quality and Irrigation Technology Choice." Western Agricultural Economics Association. Reno, NV. July 1997.

"Product Liability and Entry Incentives." Western Agricultural Economics Association. Reno, NV. July 1997.

"Agricultural Policy in the Post-1996 Farm Act World." Signature Lecture, USDA Economic Research Service. Washington, DC. May 1997.

"Federal Water Policy in the United States." International Conference on Coordination and Decentralization in Water Resources Management. Annapolis, MD. April 1997.

"Non-Uniform Regulation of Groundwater Quality." American Agricultural Economics Association. San Antonio, TX. July 1996.

"The Effect of Farm Supply Shifts on Concentration and Market Power in the Food Processing Industry." American Agricultural Economics Association. San Antonio, TX. July 1996.

"Differential Property Tax Assessment, Land Allocation and Land Values at the Urban Fringe." American Agricultural Economics Association. San Antonio, TX. July 1996.

"Efficient Strategies for Acquiring Agricultural Water Rights." Invited Paper, Australian Agricultural and Resource Economics Society. Melbourne, Australia. February 1996.

"Strategies for Agricultural Water Conservation." U.S. Bureau of Reclamation Water Users Conference. Concord, CA. January 1996.

"Voting on Environmental Health Risks." American Agricultural Economics Association. Indianapolis, IN. August 1995.

"Explaining Irrigation Technology Choice: A Microparameter Approach." American Agricultural Economics Association. Indianapolis, IN. August 1995.

"The Economics of United States Environmental Laws." Symposium at Far Eastern State University. Vladivostok, Russia. March-April 1995.

"The Endangered Species Act: Impact on California Agriculture and Policy Options." University of California Executive Seminar on Agricultural Issues. Sacramento, CA. December 1994.

"Economics of Tort Liability Rules for Pesticide Damage." Second Occasional California Conference on Environmental and Resource Economics. Santa Barbara, CA. October 1994.

"Water Law as a Regulating Mechanism." International Conference on Coordination and Decentralization in Water Resources Management. Rehovot, Israel. September 1994.

"Contaminant Dynamics and the Cost of Groundwater Quality Regulations." Conference on Pesticide Economics and Policy in Memory of Carolyn Harper. Amherst, MA. April 1994.

"Water Markets and Water Quality." University of California Conference on Regional Water Constraints. Berkeley, CA. October 1993.

"Irreversibility, Contaminant Dynamics and the Cost of Groundwater Quality Regulations." American Agricultural Economics Association. Orlando, FL. August 1993.

"Methodological Issues in Pesticide Regulation." First Occasional California Conference on Environmental and Resource Economics. Santa Barbara, CA. May 1993.

"Economic Impacts of the Central Valley Project Improvement Act." First Occasional California Conference on Environmental and Resource Economics. Santa Barbara, CA. May 1993.

"Majority Rule with Rational Abstention is Globally Transitive." Sixth World Congress of the Econometric Society. Barcelona, Spain. August 1990.

GOVERNMENT BRIEFINGS

"Employment Impacts of Cponstructing an Isolated Conveyance Facility," California State Senate Town Meeting. Fresno, CA. November 2011.

"System Integration and California Water Management." California Assembly and Senate Members and Staff. Sacramento, CA. August 2006.

"The Endangered Species Act at 30: Lessons for Reform." Organized with U.S. Senate Committee on Energy and Natural Resources. Washington, DC. December 2004.

"Non-Federal and Non-Regulatory Approaches to Wetland Conservation." House Transportation and Infrastructure Committee Staff. Washington, DC. February 2003.

"Removing Barriers to Water Marketing." California Senate Committee on Agriculture and Water and the California Foundation for Environment and Economy. Berkeley, CA. January 2003.

"Agricultural Water Pricing and Water Use Efficiency." U.S. Bureau of Reclamation. Sacramento, CA. May 2002.

"Assessing Recent Changes to the Wetlands Permitting Process." Congressional Real Estate Caucus. Washington, DC. September 2000.

"Water Markets in California." California Assembly and Senate Staff. Sacramento, CA. May 2000.

"Economic Analysis of Proposed Changes in Wetlands Permitting Policies." U.S. House of Representatives and Senate Staff. Washington, DC. March 2000.

"Groundwater Implications of Water Trading." California Assembly Water Parks and Wildlife Committee and Senate Agriculture and Water Committee. Sacramento, CA. November 1999.

"Economic Aspects of the 1996 Food Quality Protection Act." Office of Policy, U.S. Environmental Protection Agency. Washington, DC. October 1998.

"Innovative Approaches to Water Conservation: The Westside Case." Joint U.S. Bureau of Reclamation and the California Department of Water Resources Water Conservation Information Committee. San Diego, CA. August 1998.

"Climate Variability and U.S. Agriculture: Mitigating the Impacts." U.S. Environmental Protection Agency. Washington, DC. May 1998.

"New Approaches to Agricultural Water Conservation." Congressional Water Caucus. Washington, DC. February 1996.

LEGISLATIVE AND ADMINISTRATIVE TESTIMONY

"The Economic Implications of EPA's After the Fact Veto of a Discharge Permit." Subcommittee on Water and Energy, Committee on Transportation & Infrastructure, U.S. House of Representatives. June 2011.

"Cost Benefit Analysis as a Tool for Regulating Once Through Cooling." State of California Water Resources Control Board. May 2010.

"Economic Impacts of the Proposed Construction General Permit for Stormwater Discharges." State of California Water Resources Control Board. June 2008.

"Climate Change, Energy Prices and Commodity Markets: Implications for America's Water Resource Systems." Subcommittee on Energy and Environment, Committee on Science and Technology, U.S. House of Representatives, May 2008.

"Consideration of Economic Impacts of TMDL for PCBs in th San Francisco Bay." San Francisco Regional Water Quality Control Board. February 2008.

"Economic Impacts of Sediment Quality Objectives for Enclosed Bays and Estuaries." State of California Water Resources Contro Board. February 2008.

"Economic Aspects of the Proposed TMDL for PCBs in the San Francisco Bay." San Francisco Regional Water Quality Control Board. September 2007.

"Economic Impacts of Drought-Induced Water Shortage in the San Francisco Bay Area." San Francisco Public Utilities Commission. June 2007.

"Economic Considerations Relating to the Designation of Critical Habitat." Committee on Resources, U.S. House of Representatives, April 2004.

"Fiscal and Socioeconomic Impacts of of Implementing the California Coho Salmon Recovery Plan." California Fish and Game Commission, February 2004.

"Economic Impacts of Critical Habitat Designation." Subcommittee on Fisheries, Wildlife and Water, Committee on Environment and Public Works, U.S. Senate, April 2003.

"Performance of the Federal Wetlands Permitting Program." Subcommittee on Water and Wetlands, Committee on Transportation and Infrastructure, U.S. House of Representatives. September 2001.

"Economic Observations on Water Infrastructure Investment in California." Subcommittee on Water and Power, Committee on Transportation and Infrastructure, U.S. House of Representatives. July 2001.

"Economic Impacts of Reduced Water Supplies on Westside Agriculture." Bay-Delta Advisory Committee. June 1998.

"Economic Impacts of the Central Valley Project Improvement Act." Subcommittee on Water and Power, Committee on Transportation and Infrastructure, U.S. House of Representatives. April 1998.

"Forest Service Losses on Below-Cost Timber Sales." Committee on Energy and Natural Resources, U.S. Senate. February 1997.

"Benefits and Costs of Enhanced Flood Protection in the American River Valley." Committee on Transportation and Infrastructure, U.S. House of Representatives. February 1996.

"Economic Impacts of Banning Methyl Bromide Use in California Agriculture." Committee on Appropriations, California Senate. February 1996.

"Economic Impacts on Leeward Agriculture of Eliminating Waiahole Ditch Diversions." Hawaii Water Commission. January 1996.

"Least-Cost Implementation of Bay/Delta Water Quality Standards." State of California Water Resources Control Board. July 1994.

"The Potential for Agricultural Water Conservation." State of California Water Resources Control Board. June 1992.

"Economic Impacts of the Central Valley Project Improvement Act." Committee on Energy and Natural Resources, U.S. Senate. April 1992.

CONFERENCES ORGANIZED

Finding the Right Balance: Tradeoffs in the Water-Energy Nexus. Water Policy Institute – Berkeley Water Center. Washington, DC. February 2011.

International Water Resource Economics Consortium. Berkeley, CA. November 2009.

"Water and Economics." Water Policy Institute – Berkeley Water Center. Washington, DC. October 2009.

"Mixing Water and Oil: Biofuels and their Implications for California's Natural Resources." Parlier, CA. May 2008.

"Assessing Investments in Clean Water and Hygiene in Developing Countries." Sponsored by the Bill & Melinda Gates Foundation. Berkeley, CA. November 2006.

"The Endangered Species Act at 30: Lessons for Reform." Washington, DC. December 2004.

"A Decade of Water Policy Reform: The Central Valley Project Improvement Act in 2003." San Francisco, CA. September 2003.

"The Future of the San Joaquin Valley." Parlier, CA. March 2002.

"Pest Management Strategies and Policies." Berkeley, CA. May 2001.

SEMINARS

University of Arizona, Boston College, Boston University, UC Berkeley, UC Davis, UC Irvine, UCLA, UC Riverside, UC Santa Barbara, University of Colorado, Harvard University, Hebrew University, Kansas State University, University of Maryland, Massachusetts Institute of Technology, University of Massachussetts, Montana State University, Ohio State University, University of Pennsylvania, Purdue University, Stanford University, U.S. Department of Agriculture, U.S. Department of the Interior, U.S. Environmental Protection Agency, U.S. Department of Housing and Urban Development, University of Wisconsin, University of Wyoming.

GRADUATE STUDENTS SUPERVISED

Deepak Rajagopal
UCLA

Brian Gross
University of British Columbia

Prof. Karina Schoengold
University of Nebraska at Lincoln

Prof. Aaron Swoboda
University of Pittsburgh

Prof. Nicholas Brozovic
University of Illinois

Prof. Sean Cash
University of Alberta

Prof. Georgina Moreno
Scripps College

Prof Daniel Osgood
University of Arizona

Prof. Janis Carey
Colorado School of Mines

Prof. Joshua Zivin
Columbia University

Prof. Katrin Millock
EUREQua, CNRS and Université Paris I

Dr. Sabrina Ise
U.S. Environmental Protection Agency

Prof. Steven Hamilton
Kansas State University

Prof. Gareth Green
Washington State University

PROFESSIONAL ASSOCIATIONS

American Economic Association
American Law and Economics Association
Association of Environmental and Resource Economists
Econometric Society

Responsive Report to the Kansas Analysis of Nebraska's Overuse in 2005 and 2006

March 15, 2012

Thomas E. Riley, P.E.

The Flatwater Group, Inc.

PROFESSIONAL CIVIL ENGINEER
THOMAS E. RILEY
E-7137
STATE OF NEBRASKA

Contents

Tables

Figures

I. Introduction

This report examines two reports Kansas experts have prepared in this case. The first is titled "Engineering Analysis of Losses to Kansas Water Users from Nebraska's Overuse of Republican River Water in 2005 and 2006" [1] and presents Kansas' hypothetical view of how Kansas (specifically Kansas Bostwick Irrigation District [KBID] and users downstream) would have used what Kansas terms the "Required Water." [2] I refer to this as the "Use Report". The second is titled "Analysis of Measures that Would Have Been Required for Nebraska to Achieve Water-Short Year Compliance with Republican River Compact in 2006" [3] and presents Kansas' hypothetical view of what would have been necessary for Nebraska to achieve Compact compliance under what is called "Water Short Year Administration." I refer to this as the "Compliance Report." The former makes one assumption about the timing and volume of water that would have been available for use while the latter makes a contrary assumption that cannot be resolved. Logic suggests that these two reports should treat issues of timing and volume identically, however, they do not. I cannot reconcile this conflict.

In addition, although every deponent questioned to date has indicated that precipitation plays a critical role in crop production and crop water requirements, the analysis contained in the Use Report fails to consider the effect of actual precipitation received in 2005 and 2006 [4] on the likelihood that KBID would have called for any of the additional water that Kansas assumes would be available in Harlan County Reservoir (HCR). Even assuming all the "Required Water" were available in HCR, it seems unlikely that KBID would have called for its complete release based on actual precipitation events in those years.

As stated in Dr. Hamilton's deposition testimony (and confirmed by Dr. Robison), any calculation of potential damages would be affected by overstating the water available to KBID. In addition, Dr. Sunding has indicated his results would be affected by the accuracy of the Use Reports' analysis for the volume of Required Water.

[1] Spronk Water Engineers (Dale Book), "Engineering Analysis of Losses to Kansas Water Users from Nebraska's Overuse of Republican River Water in 2005 and 2006" (Nov. 18, 2011).
[2] Hamilton Deposition Transcript at 45, ln15-18.
[3] Spronk Water Engineers (Dale Book), "Analysis of Measures that Would Have Been Required for Nebraska to Achieve Water-Short Year Compliance with Republican River Compact in 2006" (Nov. 18, 2011).
[4] Hamilton Deposition Transcript at 84, ln 8-13 and at 85, ln 2-11.

II. Timing and Volume of Water Presumed to be Available (including Return Flows)

I have reviewed the analysis conducted in the Use Report. The analysis presented suggests a different timing and volume of water that would have been delivered to KBID than what is determined in the Compliance Report. The results of the Use Report were provided to the Kansas economists for the purpose of computing economic losses (KS000359). My review follows.

1. The Use Report is entirely founded on the premise that the Kansas calculation of overuse of water (78,680 acre-ft) would have been available for regulation through HCR for 2005 and 2006 during the irrigation season (defined as May through September). But, that premise is not correct.
2. Nebraska's overuse of its allocation in 2005 and 2006 would not equate to water available in HCR to be routed to KBID because much of that water would arrive outside the irrigation season. To show this, I examined the timing of this water by reviewing the Kansas analysis of compliance, as presented in the Compliance Report that states what "would have been necessary" for Nebraska to achieve compliance.[5]
3. The Compliance Report uses a reduced Groundwater Computed Beneficial Consumptive Use (GW CBCU) to determine Nebraska's requirement for reducing groundwater pumping impacts to streamflow (Table 3, "Summary of Reduced Groundwater Computed Beneficial Consumptive Use in Nebraska, 2005-2006"). Table 3 presents a calculation of change in Nebraska pumping impacts as an annual number. The GW CBCU value in that table comes from another Kansas report "Pumping Reduction Impacts for 2005-2006" which I refer to as the "Perkins Analysis."[6]
4. The Perkins Analysis calculates the reduction in groundwater pumping impact to streamflow using the RRCA groundwater model. The results of that calculation are presented for 2005 and 2006 in Table 2 of the Perkins Analysis. Table 2 only presents the annual effects of Perkins' net reduction in pumping for the two years. The Use Report assumes all of Nebraska's overuse would be available in HCR and able to be routed to KBID during the irrigation season. The Compliance Report and Perkins Analysis show otherwise.

[5] While the Compliance Report demonstrates one way that Nebraska could have been in compliance, I do not hold that method out as Nebraska's position. Nebraska's position and those methods and procedures are discussed fully in "Nebraska Responsive Expert Report Concerning Nebraska's Future Compliance" (March 15, 2012) submitted concurrently with this document.

[6] Perkins and Larson, "Pumping Reduction Impacts for 2005-2005" (Nov. 18, 2011).

5. Table 2 of the Perkins Analysis only shows the annual "net difference of Nebraska pumping impacts and Platte River import credits" (KS000674). I asked Nebraska's modelers to provide me the monthly values of the net difference using Perkins' data because the Perkins Analysis does not explicitly state monthly values. Those monthly net differences are provided in Table 1[7] of my report.
6. To demonstrate the fallacy in the Use Reports' analysis and the contradiction that follows, I looked at the timing of reduced impacts and their geographic location. For brevity, I examined just two accounting points: "Harlan – Guide Rock" which is located below HCR, and "Frenchman," located upstream of HCR (see Figure 1). A simple observation of the monthly values for the Harlan – Guide Rock accounting point illustrates that in 2005, under the scenario developed by Kansas, 2,488 acre-ft of additional baseflow would have passed that point after the irrigation season. In 2006, 1,696 acre-ft of additional baseflow would have passed that same accounting point after the irrigation season.
7. A similar observation can be made at the Frenchman accounting point. For October through December the total additional baseflow passing the Frenchman accounting point for 2005 and 2006 was 3,282 and 3,421 acre-ft, respectively. The additional baseflow passing these two accounting points total over 10,000 acre-ft and would not have been available to route through HCR during the irrigation season as presented in the Use Report.
8. For 2005 and 2006, the total quantity of additional baseflow passing all accounting points upstream of Guide Rock for the months of October through December, was 19,017 acre-ft. I interpret the Perkins Analysis to say that this increase in baseflow would have occurred in months outside of the irrigation season. However, the Use Report inexplicably "routes" all of this water to KBID directly from HCR and only during the irrigation season.
9. It follows, that since not all of the water would have been available to Kansas in the irrigation season, the Return Flow timing and amounts presented in the Use Report are overstated.

III. The Effects of Precipitation

As shown above, not all the so-called "Required Water" was available to be routed through HCR during the irrigation season. The Use Report assumes a distribution of irrigation water throughout an irrigation season defined as May through September. There are two problems with this assumption. First, the duration of the KBID irrigation

[7] Refer to file "NE_impacts_bgn2005_RapResp10_2AVU_noTriBsn_MONTHLY.xls", Tab "Tbl2 Monthly Impact Differences" contained in the backup information

season is generally 2 to 3 months.[8] Second, a closer review of Kansas' assumed distribution indicates that the majority of water (97%) was applied in the three months of June, July, and August.[9] Yet, no effort is made to examine rainfall amounts during that time and the effect they might have on whether KBID actually would have called for irrigation water from HCR.

To provide a sense of the importance of this shortcoming, I looked at the actual recorded rainfall for the 1994-2000 time period.[10] The Use Report indicates that these are "normal" years. Over that time period the actual average rainfall for the months of June through August was 8.00 inches. The actual precipitation for 2005 in that same time period was 16.00[11] inches or twice the amount recorded during "normal" years. The 1956-2011 long-term average for those same months is 11.09 inches. I can only conclude, as confirmed by Kansas' witnesses and those closest to KBID's operations, that it is unlikely KBID would have called for all the water in HCR in 2005, even if a full supply were available.[12]

IV. Conclusions

The Use Report presents Kansas' retrospective calculation of Nebraska's overuse as 78,960 acre-ft for 2005 and 2006 and assumes that this water would have been available in HCR and subsequently routed to KBID lands during the irrigation season. The Use Report goes to great lengths to distribute that water over a hypothetical five month irrigation season to determine the location and timing of return flows. However, the analysis is fundamentally flawed and creates a contradiction when contrasted against the timing and volume of water that necessarily would have been available under the Compliance Report analysis. Information underlying the Compliance Report shows that a portion of the water routed to the KBID lands through HCR in the Use Report could not possibly have been available during the time period or in the amounts suggested.

[8] Book Deposition, Exhibit 18.
[9] Kansas Backup Worksheet KBID Return Flows _ 2011-11-05.xlsx "Monthly Delivery Distribution" tab
[10] Spreadsheet of historical precipitation at Lovewell Reservoir provided via email from Bill Peck (Bureau of Reclamation) to David Kracman (The Flatwater Group) on February 8, 2012. The spreadsheet is called Lov-prec 2012-02-08.xls and is included with the backup material for this report.
[11] Interestingly, Book Deposition, Exhibit 17 indicates an even higher three month total of 17.04 inches.
[12] See Nelson Deposition Transcript at 54, ln 25 – 55, ln 16;, Ross Deposition Transcript at 83, ln 23-25; Book Deposition Transcript at 75, ln 3-19.

With that, it follows that the calculations of return flows in the Use Report would also be in error by a proportional amount. Finally, to the extent additional water might have been available in HCR, there is no reason to believe KBID would have called for the release of all that water given the fact that precipitation was nearly 200% of normal in June through August in 2005.

TABLE 1. MONTHLY IMPACT DIFFERENCES

State	Year	Month	Arikaree	Beaver	Buffalo	Driftwood	Frenchman	NorthFork	AbvSwanson	Sw-Harlan	Harlan-GR	GR-Hardy	Medicine	PrairieDog	RedWillow	Rock	Sappa	SouthFork	HughButler	Bonny	KeithSeb	Enders	Harlan	H_Strunk	Swanson	Mainstem	Total
NE+MD	2005	Jan	0	0	0	0	-8	0	-1	7	-5	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	2	-7
NE+MD	2005	Feb	0	0	0	0	-12	0	-1	7	-8	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	-2	-17
NE+MD	2005	Mar	0	0	0	0	-27	0	-2	11	-17	0	-5	0	0	0	0	-1	-4	0	0	0	0	0	0	-9	-46
NE+MD	2005	Apr	0	0	0	0	-49	0	-4	23	-31	0	-9	0	0	0	0	-1	0	0	0	0	0	0	0	-12	-72
NE+MD	2005	May	0	0	-1	0	-83	0	-7	54	-52	1	-16	0	-1	0	0	-2	-4	0	0	-4	4	0	0	-3	-110
NE+MD	2005	Jun	7	0	1	1	321	0	223	-104	321	-6	49	0	2	0	0	33	12	0	0	12	0	4	12	354	816
NE+MD	2005	Jul	0	0	6	3	869	0	-16	-860	1,012	-14	216	0	7	0	0	9	32	0	0	40	36	8	36	122	1,384
NE+MD	2005	Aug	0	0	11	6	903	0	-20	-886	1,528	10	378	0	13	0	0	8	32	0	0	48	28	4	36	632	2,098
NE+MD	2005	Sept	0	0	14	7	649	0	-23	-628	1,504	100	431	0	15	0	0	8	24	0	0	40	28	4	24	953	2,198
NE+MD	2005	Oct	21	0	15	7	895	0	695	-874	1,269	476	402	0	14	0	0	34	4	0	0	16	8	0	4	1,565	2,987
NE+MD	2005	Nov	27	0	14	6	1,214	0	1,276	-968	750	464	307	0	13	0	0	14	4	0	0	16	0	0	0	1,523	3,145
NE+MD	2005	Dec	18	0	14	6	1,173	0	617	192	469	324	232	0	12	0	0	8	4	0	0	16	0	0	4	1,602	3,089
NE+MD	2006	Jan	11	0	14	6	702	0	297	1,273	295	195	198	0	11	0	0	90	4	0	0	12	0	0	4	2,059	3,111
NE+MD	2006	Feb	7	0	12	5	391	0	154	1,502	184	107	156	0	10	0	0	122	4	0	0	12	0	0	4	1,947	2,670
NE+MD	2006	Mar	5	0	13	5	262	0	113	1,342	145	72	151	0	10	0	0	52	4	0	0	12	0	0	4	1,671	2,189
NE+MD	2006	Apr	3	0	12	4	132	0	64	710	89	39	122	0	10	0	0	22	4	0	0	12	0	0	4	902	1,227
NE+MD	2006	May	1	0	11	4	51	0	36	311	47	21	109	0	12	0	0	12	4	0	0	8	0	0	4	415	630
NE+MD	2006	Jun	0	0	11	5	253	0	-17	-20	256	-4	155	0	14	0	0	5	4	0	0	24	8	0	16	215	710
NE+MD	2006	Jul	0	0	14	7	211	0	-18	-198	671	-40	286	0	13	0	0	4	4	0	0	40	12	0	28	414	1,033
NE+MD	2006	Aug	0	0	17	9	248	0	-20	-280	1,066	2	432	0	24	0	0	3	8	0	0	48	24	0	32	817	1,662
NE+MD	2006	Sept	0	0	18	11	424	0	-41	-250	1,143	150	487	0	29	0	0	23	8	0	0	40	12	0	20	1,001	2,073
NE+MD	2006	Oct	13	0	19	11	887	0	498	162	853	280	450	0	31	0	0	42	8	0	0	28	-4	0	4	1,792	3,280
NE+MD	2006	Nov	20	0	18	10	1,196	0	1,547	837	508	239	324	0	29	0	0	17	8	0	0	24	0	0	8	3,131	4,705
NE+MD	2006	Dec	14	0	18	9	1,338	0	757	712	335	174	258	0	31	0	0	10	8	0	0	24	-4	0	4	1,979	3,688
NE+MD	2005	Annual	72	0	75	36	5,843	1	2,738	-4,105	6,741	1,354	1,981	0	74	0	0	112	104	0	0	184	112	20	124	6,728	15,467
NE+MD	2006	Annual	74	0	175	85	6,095	2	3,370	6,150	3,592	1,232	3,126	0	223	1	0	401	68	0	0	284	48	0	152	16,343	27,057

Note: For a description of the methods used to extract these monthly results from the modeling dataset provided by the State of Kansas, refer to the word document "Documentation_of_Monthly_Accounting_Procedure.docx" enclosed as part of the support materials for this report.

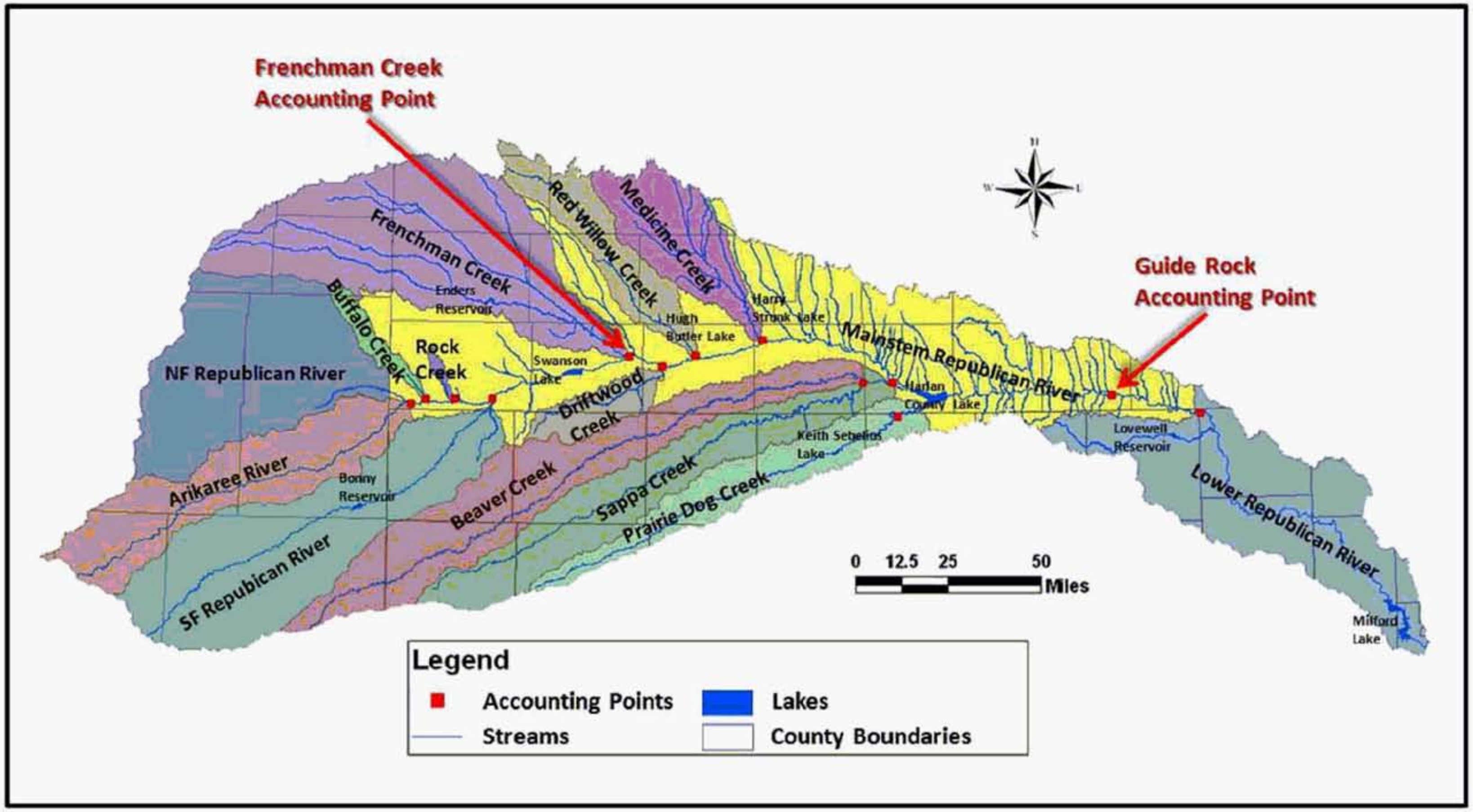


Figure 1: Accounting Points in the Republican River Basin

Appendix A—Qualifications and Compensation

I have prepared this expert report on behalf of the State of Nebraska. A true and accurate copy of my curriculum vitae follows in this appendix. The opinions contained in this report are made to a reasonable degree of scientific certainty. I was compensated $170 per hour for my work.

Thomas E. Riley

Thomas E. Riley, P.E.

THE FLATWATER GROUP INC.

THOMAS E. RILEY, P.E.
Water Resources/Environmental Engineer

SUMMARY OF PROFESSIONAL QUALIFICATIONS...

- President and operating partner of successful Midwest environmental consulting firm.
- Exhibited success in project direction, supervision, and management, as well as proposal development and client cultivation.
- Skilled in hydraulic and hydrologic modeling, computer aided drafting and design, project cost-estimating, and instrument-oriented surveying.
- Directed multiple inter-disciplinary projects, including efforts related to water resources engineering, hazardous and solid waste investigations, groundwater restoration, and environmental compliance.
- Illustrated problem-solving abilities and strong facilitation skills for developing solutions for multi-objective groups.

ACADEMIC PROFILE...

PhD: University of Nebraska, Lincoln: Biological System Engineering; in progress
M.S.; University of Nebraska, Lincoln; Civil Engineering; 1988
B.S.; University of Nebraska, Lincoln; Civil Engineering; 1986

CERTIFICATION and AFFILIATIONS...

Registered Professional Engineer in Nebraska (E-7137), Iowa, Missouri, Kansas & South Dakota
Wetlands Seminar for the Creation of Wetlands for Wastewater Treatment, Enhancement, and Mitigation
40-hour OSHA hazardous waste health and safety training
American Society of Civil Engineers

PROFESSIONAL EXPERIENCE...

Hydrology **-** Conducts or participates in all phases of hydrologic investigation, including watershed response modeling, stream flow and flood hydrology, and statistical evaluation of hydrologic data. Participates in inter-disciplinary efforts in Wetland Hydrology and restoration. Coordinates data collection and database management, liaison with government agencies (local, state, and federal), application of current hydrologic techniques and software, permit applications, client recommendations, and report writing. Experienced with HEC-1, HEC-HMS, TR-55, HECWRC, and TR-20. Responsible for the development of monitoring program for stream flow monitoring and sampling. Developed and taught university graduate course in hydrology as ad hoc instructor for the University of Nebraska.

Hydraulics **-** Developed and directed a river model study evaluating roadfill embankments located on floodplains and their effects on flood backwater. Has performed many hydraulic evaluations of bridges, culverts, and floodplains. Experienced user of HEC-2, HEC-RAS, FHWA's HY-7 (WSPRO) program, FESWMS-2DH two-dimensional modeling program, UNET one-dimensional unsteady flow program, and HY-8 Culvert Analysis program. Project director for many wetland restoration projects and lake rehabilitation designs requiring hydraulic design. Manages urban stream bank rehabilitation projects that include two-stage channel design, bioengineering and riparian improvement techniques. Analyzed modeling data to receive a no-rise certification for stream bank projects by ensuring that design components did not increase the height of flood elevations on existing properties.

Project Management - Mr. Riley manages inter-disciplinary multi-office projects in both the environmental and water resources areas. Responsibilities include management of support staff, contract negotiation, proposal preparation, personnel assignment and oversight, coordination of field efforts, subcontractor management, report preparation, QA/QC, client correspondence, agency liaison, and presentations.

Habitat Restoration and Evaluation – Mr. Riley participates in various projects addressing water resources planning and engineering, habitat restoration evaluation and design, watershed and river basin analysis (surface and ground water), stream stability, and geomorphic analysis. Mr. Riley has recently concentrated on solutions for stream degradation and habitat loss for the Salt Creek Tiger Beetle near Lincoln, Nebraska. He also directed the design of Missouri River backwater habitat for the pallid sturgeon. His focus has been ephemeral and perennial streams developing long term interventions for restoration and the development of improved habitat. In particular, he has focused on restoration using his experience, hydrologic/hydraulic modeling, and GIS applications to minimize the anthropogenic effects on hydrologic/geomorphic processes and their effects on aquatic habitat.

Water Supply Management – Mr. Riley assists clients in evaluation of water supply and management issues through the use of multi-objective decision making processes. He uses complex surface and groundwater modeling along with other data to prepare evaluations and solutions for supply issues. He continues to work with DNR in finding solutions to water shortages in the Republican River Basin and with other entities across the region in this time of stressed water supply.

Litigation Support - Provided project management and technical support to the State of Nebraska's Attorney General for the Republican River Compact litigation heard before the Supreme Court. Expert in evaluating and presenting technical information for water dispute resolution.

Hazardous Waste Management - Managed comprehensive CERCLA PA investigations for USACE Civil Works recreational facilities at four mainstem dams on Missouri River. Included coordination of multi-location/disciplinary teams throughout 5 states. The project consisted of the research and reconnaissance of over 400 sites. Senior Engineer for feasibility studies for RI/FS at 12 Operable Units at Ellsworth AFB, SD. Used Presumptive remedy approach to accelerate cleanup and save Air Force resources. Project Manager for PA/SI for Hickam AFB, Hawaii. Project involved extensive community relations and tight schedule and budget. Project Manger for FS phase for Lake City Army Ammunition Plant. Act as facilitator for Army and regulator interactions. Project Engineer for "Fast Track" design of 58 oil/water separators at Fort Campbell, KY. Project Engineer for treatability studies of contaminated wastewater and completed Remedial Design for treatment of contaminated wastewater.

Solid Waste Management - University Instructor for graduate course in Solid Waste Management. Project Engineer for the preparation of a Closure/Post Closure Plan for 120-acre landfill at Minot Air Force Base. Managed projects for the preparation of RCRA Closure Plans, including development of sampling plans and cleanup efforts. For USACE-Nashville, managed development of engineering drawings, calculations, design analysis report, and cost estimate for upgrade of 58 oil/water separators. Led field program to characterize existing conditions at each site and performed sampling of influent and effluent at selected sites. Fast track design project worth over $2 million completed in less than three months.

Surveying and Database Management - Works with current state-of-the-art surveying and data collection equipment. Performed numerous surveys for hydraulics evaluations, topographic analysis, wetland restoration, and dam site evaluation. Developed software for integrating electronic survey data with CADD. Routinely operates database management software by developing custom applications for office users. Laboratory instructor for beginning survey class at the University of Nebraska.

SELECTED PUBLICATIONS...

Coke, Gordon & Riley, Thomas. November/December 2011. "Restoring Eastern Nebraska's Saline Wetlands." Land and Water.

Riley, Tom et al. May/June 1998. "Creative Funding Results in Lake Restoration Success Story." Land and Water.

Riley, T.E., Todd, R. Petersen, D. November 1997. "Road to ROD." The Military Engineer.

Riley, T.E. 1996. Solid and Hazardous Waste Engineering. Undergraduate/Graduate environmental engineering course taught at the University of Nebraska-Lincoln.

Riley, T.E., et al. 1996. A Statistically Biased and Sequential Approach to Data Collection for a Hawaii Wartime Fuel System. Presented at SUPERFUND '96, Washington, D.C.

Todd, R.D., Riley, T.E., et al. 1996. Integrating Presumptive Remedies into the CERCLA Process: A Case Study of the Accelerated RI/FS at Ellsworth Air Force Base, SD. Presented at SUPERFUND '96, Washington, D.C.

Riley, T.E. 1996. Solid and Hazardous Waste Engineering. Undergraduate/Graduate solid waste management taught at the University of Nebraska-Lincoln.

Riley, T.E. 1993. Hydrology. Undergraduate/Graduate water resources course taught at the University of Nebraska-Lincoln.

Dahab, M.F., Becker, H.L., Riley, T.E. July 1991. Treatment of a Wood Products Superfund Wastewater: A Case Study. Canada Journal of Civil Engineering.

Riley, T.E. April 1990. Introductory training workshop for AutoCad users. Inter-office training seminar.

Riley, T.E. 1988. A Hydrologic Evaluation of Twenty-four Small Watersheds in Nebraska. Masters Thesis, University of Nebraska-Lincoln.

Riley, T.E. 1987. Hydrologic and Hydraulic Design of Culverts. Unpublished report for the Nebraska Department of Roads.

EMPLOYMENT HISTORY...

Senior Engineer/Principal, The Flatwater Group, Incorporated; Lincoln, Nebraska; 2000-present

Serves as a firm President and active as project director/manager. Civil engineer with extensive experience in both environmental and water resources engineering. He manages various projects addressing water resources planning and engineering, CERCLA preliminary assessment and site inspections, solid and hazardous waste management, remediation and feasibility studies, database management, and project report writing. Mr. Riley is a project director/manager for inter-disciplinary projects ranging from litigation support; environmental restoration; site inspections; preparation of CERCLA feasibility studies, proposed plans, records of decision, and engineering evaluations/cost assessments; hydrologic analyses; and hydraulic structure evaluation and design.

Senior Engineer/Project Manager, EA Engineering, Science, and Technology, Incorporated; Lincoln, Nebraska; 1988-2000

Served as a civil engineer with extensive experience in both environmental and water resources engineering. He managed various projects addressing water resources planning and engineering, CERCLA preliminary assessment and site inspections, solid and hazardous waste management, remediation and feasibility studies, database management, CADD/GIS, computer graphics and design applications, cost estimation, and project report writing. Mr. Riley was project manager for inter-disciplinary projects ranging from preliminary assessments and site inspections; preparation of CERCLA feasibility studies, proposed plans, records of decision, and engineering evaluations/cost assessments; hydrologic analyses; and hydraulic structure evaluation and design. Project Director for Lake Restoration projects for the Midwest.

Ad-Hoc Instructor, University of Nebraska-Lincoln Civil Engineering Department; Lincoln, Nebraska; 1993-Present

Research Assistant/Graduate Student, University of Nebraska-Lincoln Civil Engineering Department; Lincoln, Nebraska; 1985-1988

--- END REPORT ---

PROFESSIONAL CIVIL ENGINEER
THOMAS E.
RILEY
E-7137
STATE OF NEBRASKA

Assessment of Kansas Damages and Nebraska Unjust Enrichment Resulting from Nebraska's Overuse of Republican River Water in 2005 and 2006

Bates # NE0500700

David L. Sunding, Ph.D.

March 15, 2012

Disk 1 of 1