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Natural Resource Damages Associated with Past Aesthetic and Ecosystem Injuries to Oklahoma's Illinois River System and Tenkiller Lake

Expert Report for State of Oklahoma, in Case No. 05-CV-0329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma)

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January 5, 2009

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Acronyms and Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CV	contingent valuation
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
GSS	General Social Survey
NOAA	National Oceanic and Atmospheric Administration
OMB	Office of Management and Budget
WTP	willingness-to-pay

Introduction

Historical data and analyses by Engel (2008a, 2008b, 2008c), Stevenson (2008a, 2008b, 2008c), Wells et al. (2008a, 2008b), and Cooke and Welch (2008a, 2008b) show that injuries to Oklahoma trust natural resources of the Illinois River system and Tenkiller Lake have occurred since at least 1970 as a result of the excess phosphorus from poultry waste and other sources. The evidence also indicates that these injuries will continue to occur for a considerable time in the future.

The report by Chapman et al. (2009) estimated the natural resource damages for a portion of those injuries, namely the combined injuries occurring between 2009 and 2058 (for the Illinois River system) and between 2009 and 2068 (for Tenkiller Lake). The report does not measure natural resource damages for injuries occurring before 2009.

A comprehensive accounting of damages would address injuries occurring in the past as well as the future. For example, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) authorizes trustees to recover damages for the period of time, starting in 1981, during which injury occurs, pending restoration to conditions that should have existed but for the release of contaminants (interim losses) [43 CFR 11.83(c)]. Damages for interim losses in this case clearly include damage estimates for both past and future injuries.

The present report evaluates damages for past natural resource injuries occurring between 1981 and 2008.

Conceptual Approach

There are two approaches to measuring damages for the total value losses resulting from the injuries to Oklahoma public trust resources in the Illinois River system and Tenkiller Lake occurring during the period 1981-2008: an original study that measures total value of losses, or a transfer of information existing now. For an original study, one would have needed to conduct a study similar to Chapman et al. (2009) in 1980. A transfer of existing information is known as a *benefits transfer* analysis. The first approach is not feasible, and so we adopt the benefits transfer approach.

Bergstrom and De Civita (1999, p. 79, emphasis added) offer the following definition of benefits transfer:

> Benefits transfer can be defined practically as the transfer of existing economic values estimated in one context to estimate economic values in a different context .... In the case of natural resource and environmental policies and projects, benefits transfer involves transferring value estimate from a "study site" to a "policy site" where sites can vary across geographic space and or time.

Benefits transfer is commonly used in economics and there is a well-developed scientific literature on the topic (Rosenberger and Loomis, 2003). Guidelines for economic analysis discuss how and when benefits transfer should be applied (U.S. EPA, 2000; U.S. OMB, 2003).

The benefit transfers approach is recognized as an appropriate assessment method in federal natural resource damage assessment regulations [U.S. Department of the Interior (DOI) 43, C.F.R. Part 11, 61 FR 20560, 73 FR 57259, the National Oceanic Atmospheric Administration (NOAA) 15 C.F.R. Part 990 61 FR 440] and benefit transfer studies have formed the basis of damage calculations in previous natural resource damage assessments and other court cases [e.g., *California v. B.P America, (S/V American Trader)*; *Alaska Pulp Corporation v. United States*]

In the present case, we adapt the estimate of average willingness-to-pay (WTP) per household in 2008 for reducing future injuries occurring after 2008, as reported in Chapman et al. (2009), in order to estimate the average WTP per household in 1980 for reducing injuries occurring between 1981 and 2008.

In evaluating the applicability of the estimate from Chapman et al. (2009) for a benefits transfer, we note that: the geographic location is the same; the same environmental resources are being evaluated with respect to the same types of injuries; and the population groups are similar. Below, we compare the characteristics of the population groups including incomes and attitudes towards spending on the environment to account for potential change in those variables.

Estimating Past Damages

The objective is to estimate the economic value of the loss of services arising from injuries to Oklahoma public trust resources in the Illinois River system and Tenkiller Lake occurring during the period 1981-2008. This valuation is based on the estimate of average WTP of $184.55 per household in the Oklahoma study area, measured in 2008 dollars (Chapman et al., 2009). That single payment estimates the tradeoff an average household made in 2008 to avoid the combined loss of services from injuries in the Illinois River system and Tenkiller Lake occurring between 2009 and 2058 (for the Illinois River system) and between 2009 and 2068 (for Tenkiller Lake). This is being adapted to estimate the tradeoff that an average household would have made in 1980 to avoid a loss of services from injuries in the Illinois River system and Tenkiller Lake occurring between 1981 and 2008.

It is not possible to apportion the $184.55 from the contingent valuation (CV) study into separate values for the river and the lake, or into a separate value for the loss of services in any particular year. Each respondent to the CV survey made an overall assessment of whether the program for the accelerated reduction of injuries in the river and lake over these periods was worth at least the specified cost when deciding whether to vote for or

against the program. Different respondents could have evaluated the conditions in the river and the lake differently, as well as the plan and its implications for each resource. We do not know how each person aggregated the individual years' losses of services. In thinking about the program, some respondents may have discounted the future reductions in injuries as a result of the program, and others may not. Those who did discount future reductions in injuries may have applied different discount rates for this purpose. These are some of the variations that underlie the variation in voting responses and are implicit in the probabilistic formulation of a WTP distribution (see Chapman et al., 2009, Section 7.1).

In the CV survey, respondents valued a program to reduce injuries occurring in the river system through 2058 and in the lake through 2068. Chapman et al. (2009) used the tradeoff that respondents made to estimate a value for the change in the flows of services occurring during those periods of time. For simplicity, suppose respondents were assessing a change in services 55 years into the future, occurring between 2009 and 2063. (The year 2063 is selected here as the mid-point of the years for the recovery of the river and the lake.) The relevant question for the benefits transfer is: How might the choice about a plan in 2008 compare with the choice about a similar plan in 1980 looking forward in time at injuries beginning in 1981 and ending in 2008 (28 years)? The two choices could differ for several reasons. First, the time periods are different: 28 years versus 55 years. Second, the year-to-year injuries could be different between the two time periods. The analyses by Engel (2008a, 2008b, 2008c), Stevenson (2008a, 2008b, 2008c), Wells et al. (2008a, 2008b), and Cooke and Welch (2008a, 2008b), using standard indicators for injury, show that the annual injuries to the river system and the lake were growing after 1980 and will continue to grow until the spreading of poultry waste is stopped. Once that occurs, annual injuries will begin to decline. The injuries presented in the CV survey are those occurring after the spreading of poultry waste is stopped.

When comparing the indicators of injury in 1981-2008 against 2009-2063, the annual injuries to the river and lake are sometimes larger in the earlier period and sometimes smaller. Overall, the average annual injuries are approximately comparable between the two periods (J. Stevenson, G.D. Cooke, and E.B. Welch, personal communication, January 5, 2008).

Given that the average annual injuries between 1981 and 2008 are approximately the same as the average annual injuries between 2009 and 2063, the evaluation of injuries over the two periods then depends on the difference in the number of years and on the implicit discount rate used to aggregate injuries over the spans of time involved. As noted above, respondents to the CV survey may have acted as if they assessed the change in the injuries in terms of a discounted present value using their personal inter-temporal rate of time preference. And, if so, different respondents may have used different inter-temporal discount rates. Table 1 presents a sensitivity analysis for a variety of discount rates, including 0% (i.e., no discounting), 1%, 2%, 3%, 7%, 15%, and 25%. The table compares the present values of two streams of injuries: the present value as of 1980 of a stream consisting of one unit of annual injuries occurring between 1981 and 2008, and the

Table 1. Comparison of present values of past versus future injuries

Discount rate	Present value in 1980 of stream from 1981 to 2008 (A)	Present value in 2008 of stream from 2009 to 2063 (B)	Ratio (A/B)
0%	28.0	55.0	0.51
1%	24.32	42.15	0.58
2%	21.28	33.17	0.64
3%	18.76	26.77	0.70
7%	12.14	13.94	0.87
15%	6.53	6.66	0.98
25%	3.99	4.0	1.00

present value as of 2008 of a stream consisting of the same one unit of annual injuries occurring between 2009 and 2063.[1] With a discount rate of 2%, the present value of the injuries as of 1980 is 64% of the present value of the injuries as of 2008. Two percent is a modest discount rate and we employ it as a conservative estimate.

Accordingly, based on the benefits transfer, had Oklahoma households made an evaluation in 1980 of the future loss of services from injuries in the Illinois River system and Tenkiller Lake occurring during the period 1981-2008, they would have valued it at about $118.11 per household in 2008 dollars (64% of $184.55).

Two other factors need to be considered. The first is the difference in real incomes between 1980 and 2008. Since we intend to express the value of the 1980 natural resource damages in 2008 dollars and we are conducting a benefit transfer from an estimate presented in 2008 dollars, what matters for an economic adjustment of WTP is the change in real income (i.e., income after adjusting for inflation) per household in Oklahoma between 1980 and 2008, measured in 2008 dollars.

Table 2 shows the median real household income in Oklahoma between 1980 and 2007, the most recent year for which information is available from the US Census Bureau. The nominal (1979) dollars reported by the Census Bureau are converted in 2008 dollars using the Consumer Price Index (Bureau of Labor Statistics, 2009). Real median household income in Oklahoma has changed very little over this period – in fact, it is now somewhat lower than it was in 1980. Therefore, the WTP estimate from 2008 should be adjusted upwards to account for the slightly higher real income in 1980. However, since the change was so small, to be conservative we make no adjustment for this increase in real household income.

1. The formulas used for the calculations in the table are given in the appendix.

Table 2. Oklahoma median real household income, 1980 to 2007 (2007$)

1980	1990	2000	2007
$40,819	$38,880	$41,309	$40,371

Sources: 1979 data (U.S. Census Bureau, 1983); 1990 data (U.S. Census Bureau, 1993); 2000 data (U.S. Census Bureau, 2003); 2007 data (U.S. Census Bureau, 2005-2007).

Another factor to consider is changes in attitudes towards spending money on the environment between 1980 and 2008. To gauge whether attitudes toward spending money on the environment have changed over this period, we use indicators from the General Social Survey (GSS), administered by the National Opinion Research Center, Chicago, Illinois, which is a data-collection program designed to monitor trends in social change within the United States. Since the 1970s, the GSS has included two versions of a question on environmental attitudes. One question asked about how much money is being spent on "Protecting and Improving the Environment." The other version asked about money being spent on "the Environment." In both cases, the response categories were "too little," "about right," "too much," and "don't know" or "no answer." Figures 1 and 2 show how the responses to these questions varied between the late 1970s and now for region 7, which includes Oklahoma. While there has been some fluctuation in the responses, overall the responses are about the same now as they were in 1980. There is no evidence of a material change in attitudes towards spending money on the environment that warrants an adjustment to the estimate of value obtained for Oklahoma public trust resources in 2008 when it is adapted to 1980.

Accordingly, based on evaluation of potential adjustments, the best estimate of the total value placed, in 1980, on the injuries to Oklahoma public trust resources in the Illinois River system and Tenkiller Lake during the period 1981-2008 is $118.11 per household, in 2008 dollars.

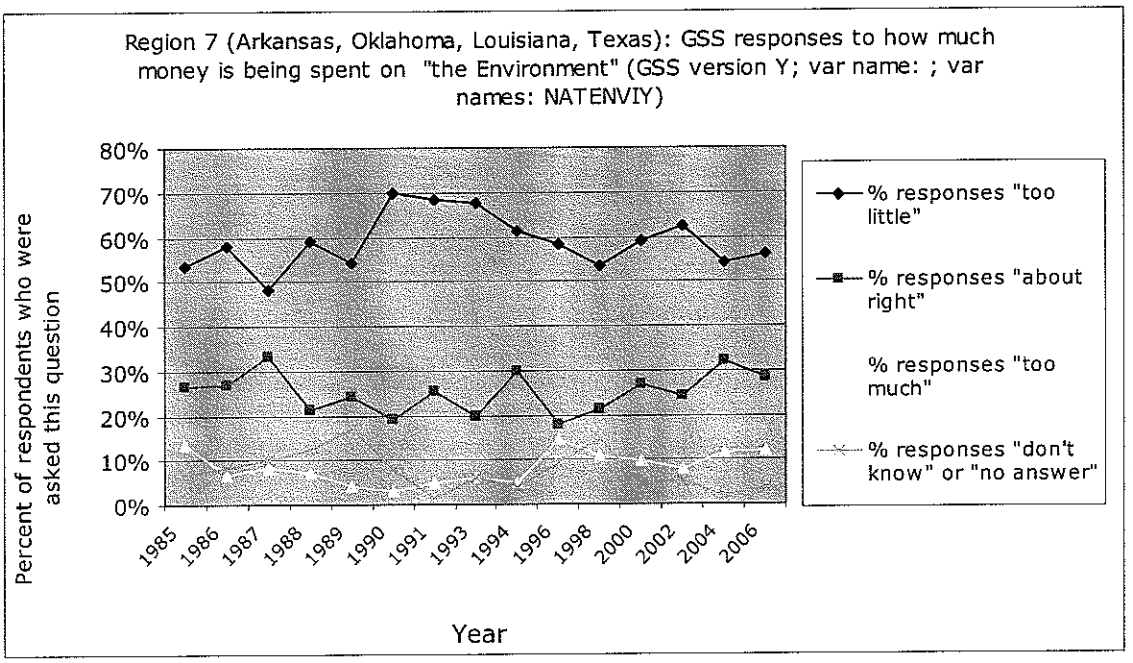

Figure 1. General social survey – spending on "the environment."

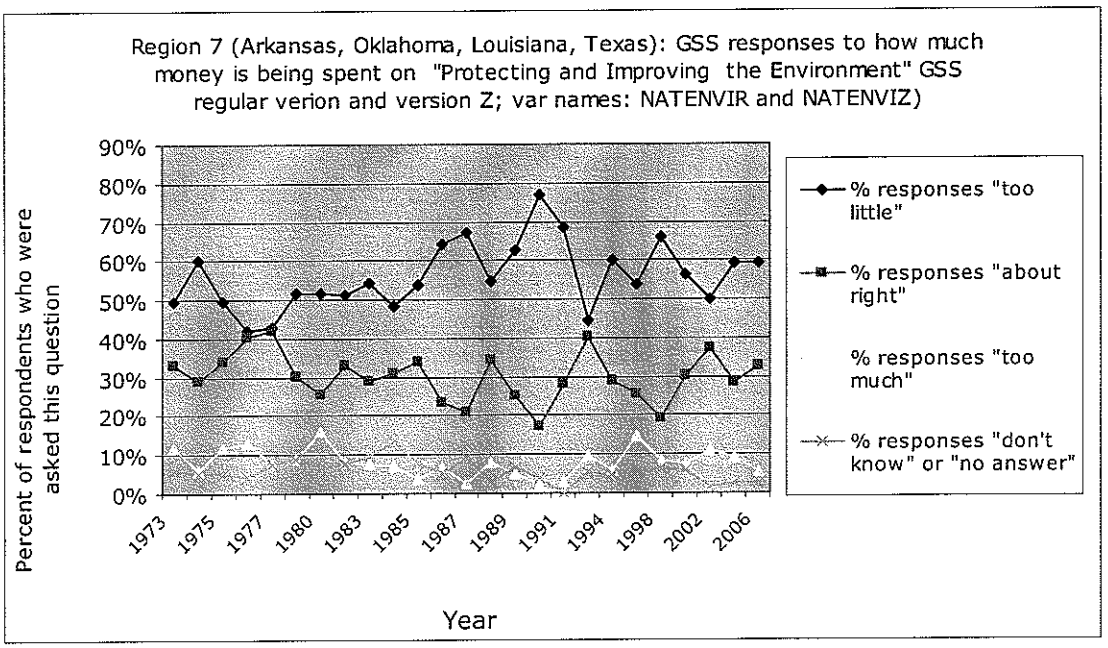

Figure 2. General social survey – spending on "protecting and improving the environment."

Estimate of Past Damages Associated with Aesthetics and Ecosystem Injuries

The sample surveyed for the 2008 CV study was drawn from the population of 63 Oklahoma counties (Chapman et al., 2009, Section 5.2.1). According to the 1980 census, there were 1,069,571 households in those same counties (U.S. Census Bureau, 1983). Multiplying this number of households by $118.11 yields an estimate of the natural resource damages, as of 1980, for injuries to public trust resources in the Illinois River system and Tenkiller Lake occurring between 1981 and 2008 amounting to $126,327,031 in 2008 dollars.

Associated with the estimate of $184.55 per household in Chapman et al. (2009), there is a 95% confidence interval of $165.72 to $203.38. If this confidence interval is scaled to the natural resource damage estimate for 1980 of $126,327,031, it amounts to $113,439,556 to $139,218,784 in 2008 dollars. To the degree there are additional sources of variation associated with the benefits transfer, this confidence interval could be larger.

This estimate of natural resource damages in 1980 does not cover categories of damages beyond damages for aesthetic and ecosystem injuries during the years 1981 to 2008, such as those resulting from injuries to groundwater or human health.

Compound Interest

While measured in 2008 dollars, the figure of $126,327,031 is the amount of compensation owed, *as of 1980*, for natural resource damages for injuries occurring between 1981 and 2008 in the Illinois River system and Tenkiller Lake. Therefore, compounding to allow for interest accrued between 1980 and now is a factor that needs to be considered, if the court allows. In the event that the court does allow this, if the natural resource damages for these injuries were paid in December 2008, for example, compound interest would have accrued on the $126,327,031 between January 1, 1981 and December 31, 2008.

Both the DOI regulations for conducting natural resource damage assessment [43 C.F.R. Part 11.84 (e)] and Oklahoma Statute Title 12 Section 727 (I)[2] cite the use of U.S. Treasury instruments interest rates to calculate post judgment interest in certain circumstances. The Office of Management and Budget (OMB) annually publishes real Treasury interest rates in Appendix C to circular A-94. (OMB, 1992)

2. Title 12 Section 727 (I) is not specific regarding the use of a real or a nominal interest rate, or the use of a particular Treasury bill maturity.

of OMB Circular A-94. Table 3 presents average real Treasury interest rates for 3, 5, 7, 10, and 30-year instruments for the period 1981 through 2008. The overall average real Treasury interest rate for instruments with these maturity dates was 3.83%. Applying the 3.83% interest rate to the principal of $ 126,327,031 yields interest in the amount of $235,529,322. The total amount for the period 1981 through 2008, including interest, comes to $361,856,352.

Table 3. Average real Treasury interest rates

Length of investment	Average real interest rate (1981-2008)
3-year	3.26 %
5-year	3.61 %
7-year	3.84 %
10-year	4.06 %
30-year	4.39 %
Overall average 1981-2008	3.83%

Source: U.S. OMB, 2008.

To evaluate the effect of alternative real interest rates, in Table 4, we present calculations using alternative interest rates to calculate the total damages plus interest that would accrue on the $126,327,031 between December 1980 and December 31, 2008.

Table 4. Comparison of present values for future injuries

Real interest rate	Principal (A)	Interest (28 years) (B)	Past damages (sum of principal and interest)
1%	$126,327,031	$40,587,734	$166,914,765
2%	$126,327,031	$93,611,388	$219,938,419
3%	$126,327,031	$162,700,079	$289,027,110
3.83%	**$126,327,031**	**$235,529,322**	**$361,856,352**
4%	$126,327,031	$252,490,256	$378,817,287

The estimate of past natural resource damages developed in this report does not account for any injuries after 2008. Therefore, it does not overlap with the damages estimated in Chapman et al. (2009), and is an independent component of damages. For a more complete accounting of the damages associated with aesthetics and ecosystem injuries to public trust resources in the Illinois River system and Tenkiller Lake, an estimate of natural resource damages in 1980, adjusted for compound interest as in Table 4, should be added to the estimate of natural resource damages in Chapman et al. (2009).

Evaluation of this Benefits Transfer

The benefits transfer method used in this report is recognized as a standard tool in economic valuation. The U.S. Environmental Protection Agency (EPA) in its peer-reviewed "Guidelines for Preparing Economic Analyses" describes the well-accepted steps involved in benefits transfer (U.S. EPA, 2000). The EPA guidelines list five steps to consider when conducting a benefits transfer. Below, we evaluate the benefits transfer presented in this report against each of the five steps.[3]

Describe the policy case

The term "policy case" refers to the condition upon which the transferred values are to be applied. In our study, the "policy case" involves the same geographic region, the same natural resources, and the same types of injuries as included in Chapman et al. (2009). The main difference between the "policy case" and Chapman et al. (2009) is the time span of injuries evaluated. We adjust for this difference in time spans in the application. We also considered two potential differences in the population characteristics of Oklahomans between 1980 and 2008. First, we evaluate potential impacts of changes in real income between 1980 and 2008. Second, we evaluate potential changes in attitude toward spending on environmental issues. No additional adjustments were needed for changes in either income or attitudes.

Identify existing, relevant studies

Unlike nearly all other benefits transfers, in this study there is an existing study (Chapman et al., 2009) that addresses the same types of natural resource injuries, to a very similar population, in the same geographic region. This was the only relevant study.

Review available studies for quality and applicability

The identified study, Chapman et al. (2009), was designed and executed to meet the highest scientific standards, including the NOAA Panel's guidelines, and therefore, based on quality and applicability, is an appropriate study for use in this benefits transfer.

Transfer the benefit estimates

The "policy case" and the study case in this transfer are nearly identical, therefore it was determined that a point estimate transfer was appropriate. The need to adjust the point estimate for difference in income, attitudes toward the environment, and injury levels was evaluated. Potential adjustments for income would have increased the value transferred,

3. These steps are the same as those presented in the U.S. Fish and Wildlife Service (Undated) *Handbook for Conducting Natural Resource Damage Assessments: The Role of Economics* (p.75) and DOI's regulations for conducting natural resource damage assessments [43 C.F.R. Part 11.83]. When this benefits transfer is evaluated against these additional sources, it meets all of the applicable guidance.

and to be conservative, no additional adjustments for these factors were made. Available information indicated that adjustments for changes in attitudes were not warranted. Adjustments were made for the difference in the duration of injuries between the study and policy cases.

Address uncertainty

Uncertainty was addressed in a number of ways. First, all of the fundamental assumptions in the transfer were made explicit. Second, the uncertainty associated with the original point estimate from Chapman et al. (2009) was reported as the confidence interval on the transferred point estimate. Third, uncertainty on the underlying discount rate applied by individuals to the "policy case" and study case was addressed by repeating the calculations with a number of alternative discount rates. Finally, alternative calculations for accrued past interest were presented using alternative interest rates.

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al. (In the United States District Court for the Northern District of Oklahoma) (September 22; this version includes the first errata, dated in August 2008).

Appendix. Present Value Formula

Formula for the present value in 2008 of a stream of annual flows of 1 unit occurring each year between 2009 and 2063, discounted using an annual discount rate of 100r%. When r ≠ 0:

(1) $$PV_{2008} = \frac{(1+r)^{55}-1}{r(1+r)^{55}} \quad .$$

When r = 0:

(2) $$PV_{2008} = 55 \, .$$

Formula for the present value in 1980 of a stream of annual flows of 1 unit occurring each year between 1981 and 2008, discounted using an annual discount rate of 100r%. When r ≠ 0:

(3) $$PV_{1980} = \frac{(1+r)^{28}-1}{r(1+r)^{28}} \, .$$

When r = 0:

(4) $$PV_{1980} = 28 \, .$$

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