No. 105, ORIGINAL

In The

Supreme Court of the United States

STATE OF KANSAS,

Plaintiff,

v.

STATE OF COLORADO,

Defendant,

and

UNITED STATES OF AMERICA,

Defendant-Intervenor.

ARTHUR L. LITTLEWORTH, Special Master

FOURTH REPORT

October 2003

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SECTION I

INTRODUCTION

Both states rested their respective cases on January 17, 2003, thus completing the final segment of the trial. This Fourth Report includes those trial proceedings, together with all other issues that remained after the Court's Opinion on my Third Report. *Kansas v. Colorado*, 533 U.S. 1, 150 L.Ed.2d 72, 121 S.Ct. 2023 (2001).

The final segment of the trial began on June 24, 2002, and consisted of 56 trial days, 40 witness appearances, primarily by experts, and the introduction of approximately 279 exhibits. The transcript for this trial segment consists of 8697 pages. The primary issues were:

(a) Whether there were additional depletions to usable Stateline flows for the period 1997-99. Total depletions for the period of 1950-96 had been previously determined to be 428,005 acre-feet. Third Report at 119.

(b) Whether Colorado's Measurement Rules for the determination of groundwater pumping are sufficient, considering a 1999 USGS Report.

(c) Whether numerous changes proposed by both states to the H-I model should be made.

(d) Whether Colorado's Use Rules, as implemented, are sufficient to ensure compact compliance.

(e) How to utilize the H-I model in the future in order to determine compact compliance.

(f) Whether a River Master should be recommended in order to monitor and enforce future compact compliance.

In addition, there remained the issues of calculating damages for 1950-94 in accordance with the Court's Opinion of June 11, 2001, and determining monetary damages for the additional depletions of 7935 acre-feet that occurred in 1995-96 and were not included in my Third Report, and for any depletions occurring thereafter.

Following the Court's June 11, 2001, Opinion on my Third Report, the states recalculated and agreed upon the figure of $7,059,595 as the amount of "nominal damages" in the years 1950-98 resulting from compact violations for 1950-94. This amount has not been adjusted for inflation. Appendix, Exhibit 1. Nominal damages represent the actual dollar values of the various damage components at the time a loss occurred. The states disagreed, however, on the calculation of prejudgment interest. I decided that issue by Order dated December 2, 2002, which is included in the Appendix as Exhibit 2 for review by the Court.

With respect to the calculation of monetary damages for the 1995-96 depletions of 7935 acre-feet, the states stipulated to the figure of $236,664 in 2002 dollars, together with prejudgment interest at the rate of six percent per year, simple interest, beginning on January 1, 2003, and prorated to the day of payment. Appendix, Exhibit 3.

This Fourth Report, therefore, addresses all of the issues remaining in the case, whether raised during the final trial segment or by motion in connection therewith.

SECTION II

PROCEDURAL HISTORY

The Supreme Court issued its first Opinion in this case (514 U.S. 673, 131 L.Ed.2d 759, 115 S.Ct. 1733) on

May 15, 1995, confirming my First Report and the fundamental finding that postcompact well pumping in Colorado had violated Article IV-D of the Arkansas River Compact. Article IV-D provides that upstream development in Colorado shall not cause material depletions of usable Stateline flows into Kansas. On remand, additional trial proceedings were held to quantify the amount of the shortage, and to assess Colorado's then current compliance with its compact obligations. The states stipulated that depletions for the period 1950-85 were 328,505 acre-feet, and I later found that additional depletions for the period 1986-94 amounted to 91,565 acre-feet.

My Second Report, filed September 1997, sought approval of these shortage determinations, and included recognition of Colorado's compact compliance efforts, together with rulings on several legal issues affecting a remedy. Exceptions were taken only by Colorado, and only upon two of the legal issues then determined. Colorado excepted to my ruling, (1) that prejudgment interest is not barred because of the unliquidated nature of the Kansas claim; and (2) that the Eleventh Amendment of the United States Constitution does not bar an award of money damages from being based, in part, on losses incurred by Kansas water users. Both Kansas and the United States opposed the Colorado exceptions. Rather than deciding the legal issues at that time, the Court overruled the exceptions without prejudice to Colorado's right to renew them at the conclusion of the remedy phase of the trial. 522 U.S. 1073, 139 L.Ed.2d 750, 118 S.Ct. 849 (1998).

On May 11, 1998, the trial resumed to consider depletions for the 1995-96 period, and to determine certain modeling issues which affected the amount of depletions. At the conclusion of this trial segment, I issued an order on January 11, 1999, deciding the modeling and certain related issues, and ordering the states to rerun the H-I model in accordance with those decisions. This was done for the purpose of determining depletions to usable Stateline flow for the years 1995-96, and the results were presented in the form of Joint Exhibit 183. The states agreed that depletions for 1995-96 amounted to 7935 acre-feet, thus bringing the total depletions of usable Stateline flows from 1950 through 1996 to 428,005 acre-feet.

The remedy phase of the trial began on November 8, 1999, and was concluded on January 28, 2000. Almost all of the testimony related to money damages. Colorado had initially proposed repaying past depletions in water, but that proposal was virtually withdrawn. Having heard testimony on the proposal, I found that successful implementation of a water repayment program was too uncertain to be relied upon in a judgment, and that Kansas should be compensated for its past losses by monetary damages. Neither state filed exceptions to that recommendation.

Kansas analyzed its monetary damages in terms of four separate categories of costs or losses resulting from depletions of usable Stateline flows. These were: (1) additional costs incurred from pumping groundwater to replace depletions of surface water deliveries; (2) increased costs to pump groundwater in a larger regional area, both in the past and in the future, due to water level declines attributable to depletions of usable Stateline flows; (3) crop production losses on lands in the ditch service areas that were irrigated by surface water only, and did not have wells to replace depletions of Arkansas River flows; and (4) secondary or indirect economic losses to the Kansas economy resulting from the increased costs of pumping and crop production losses. Colorado followed the Kansas approach to damages (subject to its Eleventh Amendment objection), and organized its response using the same categories. The economists for both states predicated their testimony, in part, upon a Stipulation of much of the necessary basic data, including total irrigated acres, acres irrigated by wells, depletions to groundwater recharge, shortages in crop irrigation requirements, crops planted, prices, etc. However, these data had been accumulated only through 1994, and thus the damage testimony reported in my Third Report was limited to the period from 1950 through 1994. It did not include depletions of 7935 acre-feet for 1995-96. However, the states have now agreed that damages for these depletions amount to $236,664 in 2002 dollars. Appendix, Exh. 3.

My Third Report on the remedy phase of the trial was filed in August 2000. I found as a matter of law that the Eleventh Amendment does not preclude damages awarded to Kansas from being based, in part, upon losses incurred by its water users, and that the unliquidated nature of Kansas' claim for damages does not bar an award of prejudgment interest. I also made recommendations on the methodology and data to be used in calculating the various categories of Kansas' damages. Moreover, I recommended that damages should bear prejudgment interest from 1969 when I found that Colorado knew, or should have known, that postcompact wells were causing material depletions of usable Stateline flows. Prior to oral argument on the exceptions to the Third Report, the states advised the Supreme Court that damages calculated on the basis of the Third Report came to approximately 38 million dollars. The Supreme Court issued its Opinion on my Third Report on June 11, 2001. 533 U.S. 1, 150 L.Ed.2d

72, 121 S.Ct. 2023 (2001). The Court affirmed all of my findings and recommendations, with the exception of the date for the commencement of prejudgment interest. While initially there appear to have been three separate views on the Court concerning prejudgment interest (533 U.S. 1 at 15, fn. 5), the Court ultimately ruled that prejudgment interest should run from the date of the filing of the complaint, namely, from 1985.

Following the Supreme Court's June 11, 2001 Opinion, an effort was made to settle the remaining issues in the case through mediation. The states submitted a joint motion for a partial stay of proceedings in order to devote sufficient attention and resources to mediation. The states explained that they had retained Joseph P. Mazurek, former Attorney General of the State of Montana, as their mediator, and had committed the personal efforts of the respective Attorneys General to that effort. Accordingly, a stay was granted until December 31, 2001. Unfortunately, the mediation effort was not successful, as stated in a Joint Report submitted January 3, 2002. A copy of that report is attached as Exhibit 4 in the Appendix.

Also following the Supreme Court's Opinion, Kansas sought permission by letter to submit to Colorado and the United States, presumably for use in the next trial segment, an analysis by Kansas experts on the need for replacement water "to offset future depletions of usable stateline flows caused by the Colorado Winter Water Storage Program." Kansas stated that this analysis was directed toward assessing "the additional replacement water necessary for compliance by Colorado in the future with the Arkansas River Compact." Both Colorado and the United States opposed the request. I rejected the proposed evidence, holding that the Winter Water Storage Program had been fully considered in the liability phase of the trial; that Kansas had then failed to prove that the program adversely impacted Stateline flows; and that the case now concerns only the depletions from postcompact well pumping, and not the Winter Water Storage Program. A copy of this Order, dated July 25, 2001, is attached as Exhibit 5 in the Appendix for review by the Court.

During the course of the last trial segment, disagreements also surfaced over the calculation of prejudgment interest for the 1950-94 period. Kansas maintained that the Supreme Court's Opinion "left open" the question of whether prejudgment interest should begin to accrue on *all* damages existing as of 1985, or only upon the "additional damages" occurring after filing the suit in 1985. The difference between the states on this issue amounts to approximately 24 million dollars. Colorado contends that damages for the 1950-94 period, adjusted for inflation, and including prejudgment interest from 1985, amount to $28,998,366 in 2002 dollars. The corresponding Kansas calculation is $52,879,927. After the issue was briefed, I ruled in favor of Colorado by Order dated December 2, 2002, a copy of which is attached for the Court's review as Exhibit 2 in the Appendix.

Both states completed their evidence and rested their respective cases on January 17, 2003. Closing Briefs were filed on this final segment of the trial on March 24, 2003. My Fourth Report in draft form was submitted to the states on August 22, 2003, allowing comments to be received by September 30, 2003, and responses by October 8, 2003. After taking into account the submittals by both states, this Fourth Report was finalized.

SECTION III

1997-99 COMPACT COMPLIANCE

A. Use Rules.

One of the principal issues in this trial segment concerned the question of whether depletions to usable Stateline flows continued after the adoption of Colorado's administrative rules designed to regulate well pumping. These rules did not become fully effective until 1997.[1] Both states introduced evidence on compact compliance for the specific period of 1997-99.

Colorado's Administrative Regulations "Governing the Diversion and Use of Tributary Ground Water in the Arkansas River Basin" (Use Rules) were promulgated by Colorado's State Engineer in September of 1995, and became effective on June 1, 1996 after protest, trial, and approval by the Water Court. Colo. Exh. 1051, App. A; Kan. Exh. 1123. A copy of the Use Rules is included in the Appendix as Exhibit 6. These Rules were designed to protect surface water users in both Colorado and Kansas from upstream well pumping. Essentially all pumping is prohibited under the Rules unless replacement water is provided to protect senior surface water users in Colorado, and to provide appropriate Stateline flows for Kansas.

The direct protection for Kansas is found in Rule 3, which provides that all production of groundwater for irrigation use, from the valley-fill and surficial aquifers

[1] The Use Rules were adopted June 1, 1996, but for the remainder of 1996 only 60% of depletions were required to be replaced. Second Report at 61-66.

along the Arkansas River from Pueblo to the Stateline, "shall be totally discontinued" unless depletions to usable Stateline flows caused by such pumping are replaced pursuant to a plan approved by the Colorado State Engineer's Office. Kan. Exh. 1123, Rule 3.1; RT Vol. 222 at 82, 86. The only exceptions are the precompact wells which are allowed to pump 15,000 acre-feet annually in accordance with my First Report and the Court's ruling on the liability phase of the trial. Even these wells, however, are still subject to Rule 4, which requires that replacement water be provided in order to protect senior surface water rights in Colorado against depletions. Kan. Exh. 1123, Rule 3.3. The result is that precompact wells must also be included in an approved Replacement Plan.

Rule 4 responds to the protection of senior surface water rights in Colorado, although the Colorado State Engineer has testified that implementation of Rule 4 will also "protect the depletions to state line flow." RT Vol. 147 at 127. It has the "derivative effect" of benefitting Kansas. *Id.* at 130; RT 222 at 51-52; RT Vol. 224 at 124-25. If this should not be true, however, Rule 4.1 still provides that replacement water supplied to protect Colorado senior rights "shall not relieve a well user of an obligation to replace depletions to usable Stateline flows." Kan. Exh. 1123, Rule 4.1; RT Vol. 146 at 61.

The Use Rules establish certain "presumptive stream depletions" which are used in the augmentation plans to determine how much replacement water is required. Rule 4.2. For wells that provide a supplemental supply to flood and furrow surface water irrigation, 30 percent of the amount pumped is presumed to be a depletion to the stream. For wells that are the sole source of irrigation water, the presumed depletion is 50 percent. And for wells that are the sole source of supply using sprinkler irrigation systems, the presumptive stream depletion is 75 percent of the amount pumped. *Id*. Presumptive stream depletions are to be reviewed annually, and revised if necessary to prevent material injury to senior surface rights in Colorado, and depletions of usable Stateline flows. Rule 4.3. Colorado's State Engineer described the presumptive depletion percentages as "approximations" designed to provide a "simple and easy way" to determine stream depletions. Colo. Exh. 1390 at 11-12. But he recognized, and the Use Rules require, that actual compact compliance be determined by using the H-I model. Rule 3.4. The presumptive depletion percentages were developed on the basis of average data, and do not vary with wet and dry years. Hence, in some years the percentage factors may cause over-deliveries, and in other years under-deliveries. RT Vol. 216 at 114.

Implementation of the Rules begins with an estimate of pumping for the following year, prepared by the several associations which represent water users along the river. Using the presumptive stream depletions, the amounts of required replacement water are calculated, and an augmentation plan for replacement water is then prepared and submitted to the State Engineer for approval. Rule 6. The approved plans are implemented on a monthly basis, estimating the current depletions and providing the amounts of replacement water required. RT Vol. 215 at 123-24.

B. Sources of Replacement Water.

A major portion of the water available for replacement originates on the western slope of the Rockies, and is transported across the Continental Divide into the Arkansas River Basin through the Fryingpan-Arkansas Project (locally and sometimes herein referred to as "Fry-Ark" water). That is a federal project authorized by Congress in 1962. The water rights to the Project are held by the Southeastern Colorado Water Conservancy District, an agency created under Colorado law. RT Vol. 216 at 6, 8. The Conservancy District markets the water made available from the Project, and has the obligation to repay the Bureau of Reclamation for the costs of the Project. *Id.* at 8. The boundaries of the District include the Arkansas River downstream to the City of Lamar. Such transmountain water can be used only within the boundaries of the District, and therefore cannot be delivered into the Offset Account in John Martin Reservoir for delivery to Kansas. RT Vol. 216 at 46-47. On an annual basis, the District can import no more than 120,000 acre-feet, and the District generally takes "every drop" that is available. RT Vol. 216 at 18, 35. However, the drought in 2002 severely impacted transmountain supplies. While the District expected to import as much as 40,000 acre-feet in 2002, it received only about 8500 acre-feet. RT Vol. 216 at 19. Pueblo Reservoir is the main storage facility for the Fryingpan-Arkansas Project water, but storage capacity is also available in Turquoise Reservoir outside of Leadville, and in the Twin Lakes Reservoir. RT Vol. 216 at 25.

The Southeastern Conservancy District, acting through its Water Activity Enterprise, markets both "first use" Project water and the return flows from such use. RT Vol. 216 at 10, 14. Return flows are calculated, based on earlier studies, at 40 percent of the water applied to a first use. RT Vol. 216 at 14. Return flows represent water that is actually being introduced back into the river.

Besides releases of transmountain water from Pueblo Reservoir or other upstream reservoirs, replacement supplies come from several other sources. Water is purchased from the City of Colorado Springs and released from Lake Meredith, representing both transmountain sources and native water. Kan. Exh. 1093 at 18. Wastewater effluent is also purchased from Colorado Springs and delivered through Fountain Creek. Transmountain water stored in Pueblo Reservoir was also transferred to the Winter Water Storage Program account in Pueblo Reservoir for delivery into the river as a replacement supply for pumping. Kan. Exh. 1093 at 19. During this 1997-99 period of time, the most significant providers of replacement water upstream of John Martin Reservoir were the City of Colorado Springs and the Pueblo Board of Water Works. Kan. Exh. 1093 at 16.

In the reach of the river upstream from John Martin Reservoir, there were minor disagreements between the states over the credits claimed from some of the sources, but frequently the issue merely concerned whether the documentation provided by Colorado had been sufficient to verify the actual release of water. Admittedly, transfers of replacement water within reservoirs that include other waters and accounts, and calculating storage releases of replacement water as distinguished from other possible releases, are extremely detailed and complex. However, Colorado prepared a rebuttal report outlining all of the data that had been delivered to Kansas on these replacement water sources, and overall that showing appears to be satisfactory. Colo. Exh. 1408 at 28-33. Colorado indicates that it has always been prepared to provide additional documentation if requested, and that it continues to refine the documentation process for specific types of replacement operations in response to questions raised by Kansas. Colo. Exh. 1408 at 33; RT Vol. 246 at 52-53, 59-60, 67-68. In general, Kansas had "much fewer problems" with the replacement water sources provided through the upstream Replacement Plans. RT Vol. 224 at 105-06.

Downstream of John Martin Reservoir, however, a principal source of replacement water comes from credits that result from the "dry-up" of lands historically irrigated by precompact surface water rights. In contrast to the amounts of replacement water provided to the river upstream of John Martin Reservoir, the dry-up amounts of replacement water claimed by Colorado generated numerous disputes among the experts.

C. Acquisition of Replacement Water Supplies.

Most of the farmers who have wells along the Arkansas River in Colorado are members of one of three associations. These associations have become the vehicles for preparing the Replacement Plans required by the Use Rules, and for acquiring replacement supplies of water. Kan. Exh. 1123, Rules 4, 6, 7. The Arkansas Groundwater Users Association ("AGUA") represents the farmers and other users in the upstream reach of the Arkansas River. It has a membership of about 268 farmers, including approximately 400 wells. RT Vol. 220 at 23, 37. Also in the upstream area, and as far east as John Martin Reservoir, the farmers and other users are also represented by the Colorado Water Protection and Development Association ("CWPDA"). That organization was formed in 1965 and included about 794 wells in its 2002 Replacement Plan, of which 680 were active. RT Vol. 220 at 120-121. Downstream of John Martin Reservoir and to the Stateline, most farmers belong to the Lower Arkansas Water Management Association ("LAWMA"), which was organized in 1973. Its year 2002 Replacement Plan included 441 irrigation wells along the main stem of the river, of which 364 were active, as well as 21 municipal and commercial wells. RT Vol. 221 at 87.

All of these associations are nonprofit corporations organized under Colorado law, subject to assessments. Their Boards of Directors range from 7 to 11 members. Each association employs a general manager, a small office staff, and has legal and engineering assistance readily available. The general manager of CWPDA testified that he was in almost daily contact with his legal and engineering consulting firms. RT Vol. 220 at 154. Each of these associations has acquired a wide variety of replacement sources of water, as owners or under leases or other contractual arrangements. The State of Colorado has assisted in financing replacement supplies, recently increasing its loan ceiling to 3.5 million dollars in addition to funds already loaned. Colo. Exh. 1267 at 7. LAWMA has been loaned 6.5 million dollars by the state to purchase shares in the Highland Ditch and other companies, entitling LAWMA to surface water to be used for replacement of well pumping. Similarly, AGUA was loaned money by the state to purchase about a third of the total shares in the Excelsior Ditch Company. Colo. Exh. 1267 at 7; RT Vol. 221 at 97, 151-52.

AGUA's Replacement Plan for 2002 serves to illustrate how these associations function. In the fall of 2001 AGUA solicited its members for their pumping projections for the 2002 irrigation season. RT Vol. 220 at 37-38. Until 2002, which was a very dry year, AGUA had been able to obtain sufficient replacement water to offset all of its members' pumping. RT Vol. 220 at 38. AGUA's replacement sources of water included shares purchased in the Excelsior Ditch Company, which provided water from certain "dry-up" lands; transmountain or other fully consumable water from the City of Pueblo; both first use and return flows of Fry-Ark project water; and return flows from the Cherokee Metropolitan District. Colo. Exh. 1384 at 16-20. Initially, AGUA indicated that in 2002 its members would be limited to 80% of their prior 5-year pumping average because of the shortage of available replacement water. But this projection turned out to be too generous. In February 2002, AGUA warned its membership that they might be cut to 50% of prior usage, and the cost of replacement water would be at least 50% higher than previous prices. Kan. Exh. 1134. A copy of this memo is included in the Appendix as Exhibit 7. The final pumping allocation in 2002 turned out to be 60% of prior use. RT Vol. 220 at 38-39. Farmers within AGUA are assessed equally for management, legal and engineering costs, and they must also pay an individual charge for the required replacement water attributable to each farmer's pumping. RT Vol. 220 at 43. A farmer must pay for the amount of water ordered, whether or not it is used. *Id*. at 45.[2]

[2] LAWMA is organized somewhat differently. LAWMA has a portfolio of replacement supplies, and each share of stock entitles the owner to a prorata amount of the total LAWMA supply. RT Vol. 221 at 155-56. A farmer's pumping is limited by his stock allocation. If he needs more water, he must obtain more shares, and there is an active trading market for shares of stock. RT Vol. 221 at 163-64. On average, one share of stock represents one acre-foot of replacement water. *Id*. at 161.

The AGUA 2002 Replacement Plan was prepared by its consulting engineers, a firm well experienced in water matters. Colo. Exh. 1384. After receiving the projected pumping estimates, the engineers used the presumptive depletion factors established by the Use Rules to determine a well head depletion for each well. RT Vol. 220 at 74-75. The presumed depletion for wells that are supplemental to surface water supplies was set at 30% of pumping; for wells that are the sole source of irrigation water, the presumed depletion factor was 50%; and for center pivot sprinkler systems, the presumed depletion was 75%. The engineers then utilized a groundwater accounting model developed by the Colorado State Engineer to determine the timing and location of such depletions. Kan. Exh. 1123, Rule 4.2; Rule 8; RT Vol. 222 at 30, 32-33. As a result, AGUA knew the specific location and amount of replacement water that had to be provided to the river each month. RT Vol. 220 at 87-89.

The AGUA 2002 Replacement Plan, which is about half an inch thick, contains a great deal of data on each of the 398 active wells: the owner's name, the state well ID, whether the well is active or inactive, the applicable depletion factor (i.e., 30%, 50%, or 75%), the location by quarter section, the state's well permit number, the case number for an adjudicated right, the appropriation date, and, finally, the amount of pumping requested multiplied by the presumed depletion factor to establish the estimated depletion for that well. Colo. Exh. 1384, App. A, C. The plan also uses the unit response functions, i.e., an input to the H-I model, to determine the "lag" effect, namely, the percentage of the depletions that will impact the river within the plan year, as opposed to those that will not be felt until the following year and will be replaced at that time. RT Vol. 215 at 121-22; RT Vol. 220 at 89. The plan, of course, is a projection. Actual amounts of pumping, actual replacement water required, and actual amounts of replacement water provided, are determined on a monthly basis during the irrigation season. RT Vol. 215 at 123-24; RT Vol. 220 at 87-89. Both AGUA and the State Engineer's Office monitor pumping on a monthly basis. If pumping from a well exceeds its estimate, and replacement water is not available, the well is "red tagged," that is, it is shut down by the state. RT Vol. 220 at 41.

A summary of AGUA's 2002 plan shows that the total quantity of replacement water projected to be required for that year amounted to 12,627 acre-feet, and that total anticipated replacement credits for the year actually amounted to 13,001 acre-feet, or an excess credit of 373 acre-feet. A copy of Table 11 in Colorado Exhibit 1384, showing this accounting, is included in the Appendix as Exhibit 8. The submitted plan, of course, is subject to what actually occurs, both in terms of actual pumping and replacement water provided. The Colorado Division of Water Resources prepared end of the year reports which summarized the true performance of all the Replacement Plans for 1997-99. For example, see Colorado Exhibit 1315 for the 1999-2000 plans. Kansas makes the point that such reports are not required by the Use Rules, but this is a practice which should continue, and such reports should be distributed to Kansas.

D. Administration of Replacement Plans.

Proposed Replacement Plans must be filed by March 1 for the irrigation year that begins on April 1, and extend through March 31 of the following year. There are presently 2130 irrigation wells in Colorado's database located within the valley fill and surficial aquifers of the Arkansas River between Pueblo and the Stateline. This is the area included within the H-I model area, and these are the wells that are subject to Rule 3 of the Use Rules. Of these 2130 wells, 858 have become inactive based on owners' affidavits, leaving 1272 considered as "active." Of the active wells, 1175 are included in Replacement Plans. The remaining wells have been tagged with Cease and Desist Orders and are monitored periodically to ensure that they are not in use, or have been included in Substitute Water Supply Plans. Colo. Exh. 1267 at 15.

During 1997-99, almost all of these active irrigation wells were included in the Replacement Plans submitted either by AGUA, CWPDA or LAWMA.[3] The AGUA, CWPDA and LAWMA Replacement Plans were all approved for the years 1997-99, subject to certain conditions that were tailored to each plan. The approval letters are found in Colorado Exhibit 1267, Appendix A. Copies were sent to Kansas. RT Vol. 222 at 62; RT Vol. 224 at 139. Each plan was required to show amounts of replacement water equal to projected depletions, even though the actual pumping might turn out to be less than estimated. RT Vol. 222 at 41. Where pumping was less than projected, some replacement sources like Fry-Ark return flows would

[3] The Use Rules also regulate pumping along the Arkansas River and its tributaries in areas outside of the H-I model domain. Replacement Plans are also required for wells in these areas. During 1997-99 the total number of Replacement Plans along the river ranged between 15 and 17.

nonetheless have been released to the river, and would result in excess credits. *Id*. at 42. Other replacement sources, such as water held in reservoir storage, would not have been released. *Id*. Replacement sources, like pumping, were estimated in the plans.

The procedures for determining depletions and required replacement water begin with pumping measurements, which are calculated monthly by the Colorado Division of Water Resources. The presumptive depletions under the Use Rules are then applied on a well-by-well basis, and the groundwater accounting model is used to lag the effects of such pumping back to the stream, both as to time and location. RT Vol. 222 at 29-32. Replacement supplies are generally provided to match the depletions when and where they occur. Beginning in 1996 the Division of Water Resources began holding monthly augmentation meetings to review actual pumping and amounts of replacement for the previous month, and to make estimates for the following month. Colo. Exh. 1267 at 3.

These meetings are attended by each of the well owner associations, and sometimes by Kansas representatives. RT Vol. 222 at 30-33. The data are sent to Kansas if its representatives should not attend. RT Vol. 222 at 33. A running account spreadsheet is kept on a monthly basis for each Replacement Plan. RT Vol. 224 at 59. An example of this monthly accounting is found in Kansas Exhibit 1140 for October 2001. The accounting keeps track of the river depletions by reach, the sources and amounts of replacement water by reaches, any excess replacement water credit that is to be carried over to the next month, the usability discount for Stateline deliveries, and a Stateline accounting. A "thick packet" of 50 or more pages of backup data to this summary spreadsheet is provided to all parties, including Kansas. RT Vol. 224 at 86-87. Excess replacement deliveries are carried over on a monthly basis only. RT Vol. 222 at 43, 45. There is no procedure for carrying over credits into a future year. *Id*. at 44-45. It had been the Kansas position until this trial segment that even winter depletions could not be offset by over-deliveries in the prior summer. *Id*. at 45.

The amounts of replacement credits actually available from lands that have been dried up depend upon water availability during the plan year; that is, the amount of flow in the river that would have been available in priority for diversion pursuant to the ditch company shares held in the Replacement Plan. Colo. Exh. 1267, App. A; Mar. 26, 1999 letter to LAWMA, Condition 13; RT Vol. 224 at 140-41. At the end of each plan year, the Colorado Division of Water Resources prepares a summary report for each of the Replacement Plans showing what, in fact, has occurred. For the 1997-99 plans, these reports are found in Colorado Exhibits 1313, 1314, and 1315.

During the trial, Kansas raised the question of whether the approval of a Replacement Plan indicated unqualified acceptance of the amount of replacement credits shown in the plan. Clearly, Colorado does not administer the plans in this fashion. RT Vol. 223 at 13, 19-20. Indeed, the approval letter of the 1999 LAWMA Plan, for example, states that: "The effectiveness of this replacement plan in replacing depletions to usable Stateline flow will be evaluated at the end of the plan year to determine if any additional replacements are required. . . ." And following a listing of the proposed replacement sources, the letter further states, "The actual yields from the replacement sources listed above will depend on the actual water availability during this plan year. . . ." Colo. Exh. 1267, App. A, Letter Mar. 26, 1999; RT Vol. 223 at 13, 19-20. Finally, Conditions 11, 12 and 13 provide that approval of the plan does not "guarantee" that the replacement water made available will protect senior surface water rights in Colorado or replace depletions to usable Stateline flows. If such replacement supplies are insufficient, the approval letter requires that additional supplies must be provided, or pumping curtailed. Colo. Exh. 1267, App. A, Letter Mar. 26, 1999. A copy of this letter, as an example of Colorado's procedure, is included in the Appendix as Exhibit 9.

E. Colorado's Results of its 1997-99 Replacement Plans.

Colorado's evidence showed that the amounts of replacement water provided as required by the presumptive depletion factors were in excess of the amounts necessary to offset Stateline depletions for each of the 1997, 1998 and 1999 years. Kansas disagreed with these data, although both states acknowledged that the final test of compact compliance lay with the results of the H-I model, and not necessarily with the Replacement Plan accountings. RT Vol. 222 at 53. It was the Kansas position that the presumptive depletion factors under the Use Rules did not accurately reflect consumptive use, and that the replacement water credits allowed by Colorado were too generous. RT Vol. 224 at 101-02.

Nevertheless, the Replacement Plans for 1997 estimated the so-called Rule 3 irrigation pumping within the H-I model area at 133,188 acre-feet. Colo. Exh. 1062 at 21. Actual pumping as determined by Colorado's Measurement Rules amounted to 112,025 acre-feet. Colo. Exh. 1267, Table 4-1 at 20; RT Vol. 222 at 40. Colorado claimed credit for the delivery of 26,542 acre-feet of replacement water to replace out-of-priority depletions to senior surface water rights in Colorado, and an additional 10,486 acre-feet to offset depletions to usable Stateline flows. Colo. Exh. 1267, Tables 4-4, 4-5 at 23-24; RT Vol. 222 at 52. Stateline depletions under the Use Rules were determined to be 10,462 acre-feet, i.e., slightly less than the amount of replacement water provided.

The 1998 Rule 3 plans projected pumping to be 142,876 acre-feet, but Colorado concluded that only 96,123 acre-feet were actually pumped. Colo. Exh. 1267 at 28-29. Replacement water for senior surface water rights in Colorado was shown as 30,097 acre-feet, and Stateline replacements at 10,888 acre-feet. *Id*. at 32-33. Again, the Colorado evidence shows that the 1998 replacement water slightly exceeded Stateline depletions of 10,855 acre-feet, as determined by the Use Rules. Colo. Exh. 1267 at 32-33; Colo. Exh. 1314, Table 4.

In 1999 the estimated Rule 3 pumping in the Replacement Plans totaled 145,604 acre-feet, while actual pumping for the plan year was measured at only 87,105 acre-feet. Colo. Exh. 1267 at 36; Kan. Exh. 1093, Table 6. In addition to replacement water for Colorado's senior surface water rights (25,342 acre-feet provided contrasted with 21,500 acre-feet required), Colorado's evidence shows Stateline delivery replacements of 4676 acre-feet, against Stateline depletions of 3797 acre-feet, as calculated under the Use Rules. Colo. Exh. 1315, Tables 2, 3, 4; RT Vol. 222 at 104.

Kansas, however, did not accept Colorado's accounting of replacement supplies. Many of the Kansas objections to the Replacement Plan accountings centered around the dry-up credits claimed by Colorado. Even Colorado acknowledged that the procedures to determine credits available from lands no longer receiving surface irrigation supplies had not been "as simple" as originally expected. RT Vol. 222 at 74. One of the problems was that the removal of surface water irrigation did not necessarily mean that all of the land was actually dried up. It might become irrigated by sole source wells. For example, a large tract of land was acquired by the Colorado Division of Wildlife, land that was previously irrigated by the X-Y Canal. While that canal system was entirely shut down, the Division of Wildlife still used wells to irrigate part of its property for wildlife habitat. RT Vol. 222 at 145, 152-53. The wells and associated land were then required to be included in LAWMA's Replacement Plan. Colorado's procedures to verify lands truly dried up now require mapping, engineering verification, and a final affidavit filed at the end of the irrigation season, but these procedures continue to develop. RT Vol. 222 at 74-75. Field inspections are made, sometimes in the company of Kansas representatives. RT Vol. 222 at 76-78; Colo. Exh. 1267 at 26; Colo. Exh. 1322, 1323. Kansas believes that these procedures would benefit from still further improvement, including "monumenting" the dried up fields. Kan. Exh. 1093 at 20, 25. This may well be true, and may be required when Colorado Water Court approval is sought to transfer the use of a water right for replacement purposes. Colo. Exh. 1468. If there are replacement water sources that do not require Water Court approval, sufficient procedures should be in place to allow Kansas and others to efficiently and clearly monitor results.

Determining the credits available from dried up lands also requires an analysis of the amount of surface water that would have been available to that land under Colorado's priority system, the actual flows in the river, and the consumptive use of that water. It is only the consumptive use of water that is "saved" and thus becomes available as a replacement supply. RT Vol. 221 at 131. Colorado has continued to develop a methodology for determining the consumptive use credit for each of the direct flow replacement sources. RT Vol. 223 at 36; RT Vol. 222 at 65-66. Initially, Colorado used the 1996 data from the H-I model approved in my Second Report, but these values have now been refined. RT Vol. 223 at 21-22. One revised consumptive use analysis submitted by LAWMA was found to be "wanting" and was not used by Colorado. RT Vol. 223 at 18. Colorado acknowledged that appropriate consumptive use factors will be ultimately determined by the Colorado Water Court. RT Vol. 222 at 66; RT Vol. 223 at 37.

F. Kansas' H-I Model Results for 1997-99.

Both states used the H-I model to address the question of whether the replacement supplies provided by Colorado during the 1997-99 period were sufficient to offset the depletions to usable Stateline flows. The states were in agreement on much of the data required for the model update, including the amount of well pumping in each of the three years.[4] RT Vol. 234 at 26, 28-29; Kan. Exh. 1093, Table 6. The data prepared by Colorado on

[4] Approximately 119,000 acre-feet for 1997; about 97,000 for 1998; and 87,000 acre-feet for 1999. These totals compare with long-term average pumping of approximately 145,000 acre-feet per year. Kan. Exh. 1093 at 14; Colo. Exh. 1408, Table 6.

precipitation, tributary inflows, and transmountain and project deliveries to canals were also accepted by Kansas for use in the model analysis. Kan. Exh. 1093 at 47.

Kansas, however, disagreed with Colorado's 1998 acreage study, and used a total of 261,030 irrigated acres in its model analysis, while Colorado used only 252,802 acres. Kan. Exh. 1093, Table 1. Both of these totals reflected a decrease in irrigated land from the 1995-96 total of 267,985 acres. Kan. Exh. 1093 at 8. The states had agreed upon those 1995-96 figures. There was also disagreement over the amount of replacement credits that should be allowed during the 1997-99 period. Specific figures can be found in Table 7 of Kansas Exhibit 1093, but in its H-I model analysis, Kansas rejected about 8000 acre-feet of the replacement credits claimed by Colorado. Kan. Exh. 1093, Table 7. Later during the trial, Kansas acknowledged that about 2700 acre-feet of the rejected credits should have been allowed, but the model results do not reflect that change. RT Vol. 234 at 54-57.

Kansas also modified input to the H-I model in the calculation of potential evapotranspiration ("PET"). In all prior uses of the H-I model, the PET had been determined using the Modified Blaney-Criddle formula. Kan. Exh. 1093 at 12. However, because of recent professional developments, Kansas concluded that the standardized form of the ASCE Penman-Monteith equation should be used instead of Blaney-Criddle, and Kansas made this change. *Id*. The effect of using Penman-Monteith is to increase Stateline depletions. This became a major issue in the case, and it is discussed in Section VI.

Kansas also reclassified acreages in farms having lands with supplemental well water available, and the lands that did not receive well water. The purpose was to provide a uniform distribution in the model of the combined supply of well water and surface water on these lands. Kan. Exh. 1093 at 11. The effect was to increase the acreage modeled as receiving groundwater from 95,000 to 110,000 acres, and to increase depletions. Kan. Exh. 1093 at 11; RT Vol. 233 at 140; RT Vol. 237 at 140-42; RT Vol. 242 at 24-26. As discussed in Section V, I rejected that model change.

Kansas makes the point, which is not insignificant, that the 1997-99 period was "wet," and should not be used to judge more normal hydrologic periods. RT Vol. 234 at 27; RT Vol. 246 at 27, 31. River inflow at Pueblo during 1997-99 was about 40% above average, and precipitation was approximately 30% above average. Kan. Exh. 1093 at 6; Colo. Exh. 1408, Table 1. John Martin Reservoir spilled in 9 months out of 36, and indeed, Colorado lost credit for 11,607 acre-feet of water that had been stored in John Martin Reservoir for the benefit of Kansas. RT Vol. 234 at 131-32; Kan. Exh. 1093, Table 9. Total Stateline flows (as distinguished from usable flows) averaged 182,084 acre-feet over the 1986-94 period, but increased to 365,342 acre-feet over 1995-99. Colo. Exh. 1408, Table 2. Kansas argues that because of the increased river flows, Colorado's pumping was down by some 40% of the long-term average, and it could be expected that Stateline depletions would be less. Kan. Exh. 1093 at 6; Colo. Exh. 1408, Table 2. Consequently, Kansas urges that the H-I model results for 1997-99 "should not be used as an indicator of the adequacy of the Use Rules in preventing usable depletions over the long term." Kan. Exh. 1093 at 6. Kansas' expert testified that the 1997-99 results were more a result of hydrology than the effectiveness of the Use Rules. RT Vol.

237 at 43-44. It should be noted, however, that the years following 1999 were not wet. In fact, 2002 was probably the driest year in recorded history. RT Vol. 215 at 92-95. During this period, pumping has been equally low, curtailed not because water was not needed, but because replacement water was simply not available. RT Vol. 215 at 92-94; RT Vol. 246 at 120-21. A longer period of time will be required in order to evaluate fully the effectiveness of the Use Rules, but they may have performed as intended; that is, either to provide sufficient replacement water when it is available in order to offset depletions, or to limit pumping when sufficient replacement water cannot be obtained.

It is Kansas' position, however, that the current Use Rules, as implemented, are not adequate to achieve compact compliance. They cite three primary reasons. RT Vol. 241 at 119-25. The first reason relates to the presumptive depletion factors, which were developed using the 1950-85 version of the H-I model. *Id*. at 120. The later versions of the model would produce higher depletion factors, according to Kansas' long-time expert, Dale Book. *Id*. at 120-21. Additionally, Mr. Book believes that less water will be pumped in the future, and will be used more efficiently than older versions of the model assumed. *Id*. at 121-22. Kansas' second objection concerns the usability discount which does not require full replacement for depletions downstream of the Buffalo headgate which is about 20 miles from the Stateline. *Id*. at 123-25. The third reason concerns the credits allowed for direct flow sources, primarily for the X-Y and Sisson-Stubbs Canals. *Id*. at 125.

In the final analysis, however, compact compliance is not to be judged on the basis of the Use Rules, but on the results of the H-I model. It has long been the Kansas position that the H-I model is reliable on an annual basis, and compact compliance should be judged on annual model results. The Kansas H-I model results are shown, by month, for 1997-99 in Table 14 of Kansas Exhibit 1093. A copy of that Table is included in the Appendix as Exhibit 10. Accretions shown in that Table represent Stateline flows in excess of depletions for the month. Accretions which meet the criteria to be considered "usable" are also shown separately from total excess flows. For reasons that only engineers can appreciate, a positive number in the Table reflects a depletion, while a negative number with a minus sign shows an accretion, i.e., an excess delivery. It should also be remembered that the timing of accretions, as well as depletions, are in part artifacts of the modeling process, and the results are not likely to be exactly replicated in actual operations. First Report at 262-63.

Viewing those Kansas model results, usable Stateline flows exceeded depletions in 1997 by 2673 acre-feet, and in 1999 by 2556 acre-feet. Only in 1998 does Kansas show a shortage of 2410 acre-feet. Over the whole three-year period the Kansas model does not indicate a shortage, but rather shows that usable accretions exceed depletions by 2819 acre-feet. RT Vol. 241 at 47-48, 129-31; Colo. Exh. 1411, Table 7c. Yet Kansas concludes from these monthly calculations that Colorado is still short by 6650 acre-feet over the whole 1997-99 period. Its analysis requires that accretions be allowed to offset depletions only within a "season," i.e., accretions during the summer irrigation season cannot be used to offset depletions in the winter. Kan. Exh. 1093 at 48. For example, in the summer of 1997 usable Stateline flows increased by about 7500 acre-feet while depletions in the following winter were about 4700 acre-feet. RT Vol. 241 at 49-50. Yet the Kansas model analysis gives Colorado no credit for the summer increase as an offset against the winter decrease. It was the Kansas position that such seasonal accounting was in accord with past practice. However, the Kansas Chief Engineer finally acknowledged that extra water in the summer was more valuable to Kansas than in the winter, and he agreed that accretions in the summer should be allowed to offset depletions in the following winter. RT Vol. 241 at 52-53; see also RT Vol. 241 at 129.

G. Colorado's H-I Model Results for 1997-99.

In preparation for this trial segment, Colorado developed a version of the H-I model referred to as its "Test Model." Colo. Exh. 1353 at 1-2. This new version included some 17 changes to the prior model code, and was calibrated over 1970-94, a shorter and more recent period than had been previously used to calibrate the H-I model. Colo. Exh. 1411 at 1; RT Vol. 260 at 84-85. These changes were made to the version of the model that had been used earlier to calculate depletions for 1995-96. That version was often referred to as the "approved model" since it had been the subject of my Second Report. Dewayne Schroeder, Colorado's long-time employee and modeling expert, then extended the Test Model from 1994 through 1999 to reflect the operation of Colorado's Replacement Plans, its 1998 acreage study, and other data input. Colo. Exh. 1353 at 2. This model was called Colorado's "Updated Model," and was the model used by Colorado to determine compact compliance for the 1997-99 period. Colo. Exh. 1353 at 15-20; Colo. Exh. 1411.

The first model results prepared by Mr. Schroeder showed that usable accretions to Stateline flows exceeded depletions over the 1997-99 period by 37,596 acre-feet. Colo. Exh. 1358, Table 7; Colo. Closing Br. at 98-99. Revisions made "in response to comments by the Kansas experts" reduced these excess deliveries to 19,523 acre-feet.[5] Colo. Exh. 1411, Table 7a; RT Vol. 260 at 9-13, 20; Colo. Closing Br. at 99. All of the Colorado modeling results rejected the notion of a "seasonal" accounting, i.e., that accretions could offset depletions only within the same irrigation season. It is true that the past accounting had been done on a seasonal basis pursuant to a compromise agreement between the states, but this procedure related to model offsets before the time when actual replacement water was being added to the river. Colo. Exh. 1353 at 21-22; RT Vol. 237 at 21, 25-26. Kansas did not indicate that this early agreement still controlled, and I find that it should not. RT Vol. 241 at 52-53, 129, 133.

The Colorado Test Model was designed not only to assess compact compliance for the years 1997-99, but also to test the effectiveness of the Use Rules into the future. Both states introduced modeling evidence on "prospective compliance," i.e., using different versions of the H-I model to forecast whether the Colorado Use Rules would provide sufficient replacement water in the future to assure compact compliance. These modeling efforts are discussed in Section IX. It is not necessary, however, to analyze the modeling changes made by both states in order to evaluate compliance for 1997-99. For this purpose, the Kansas

[5] Schroeder produced another model run, calibrated over 1950-94, instead of 1970-94, that showed excess deliveries of 12,523 acre-feet. Colo. Exh. 1411, Table 7b.

results can be used, and it is unnecessary to rely upon the excess deliveries shown by the Colorado Updated Model.

H. Conclusions.

In its Opening Post-Trial Brief, Kansas indicates that depletions for the 1997-99 period amount to 6650 acre-feet, determining net depletions and accretions on a seasonal basis. Kan. Op. Br. at 55. However, based on its own testimony that summer season accretions should offset winter depletions, Kansas submits a reduced claim of 1809 acre-feet, with a credit of 1441 acre-feet to be applied against any depletions occurring after December 1999. Kan. Op. Br. at 56. Whichever claim is examined, Kansas' use of the H-I model to achieve these results depends upon accepting the model results as being reliable on a seasonal basis. It has always been the Kansas position that the H-I model was reasonably reliable on an annual, and even on a seasonal or monthly basis. RT Vol. 243 at 118-21. And with equal consistency, this view has always been opposed by Colorado.[6] RT Vol. 215 at 135; RT Vol. 231 at 40-41; Colo. Exh. 1412 at 1-2, 6-8, 11. However, I cannot agree with Kansas' position on the model's accuracy. In using the H-I model results, I find that some measure of annual averaging is necessary in order to produce reasonably reliable compliance figures. There is an abundance of evidence in the record to support this conclusion, just as there is also much expert testimony to support the Kansas view. However, a benchmark in determining the H-I model's

[6] Schroeder testified for Colorado that he did not consider even his own H-I model analysis of depletions and accretions to be accurate on a monthly, seasonal or annual basis. Colo. Exh. 1353 at 19-20, 23.

accuracy is found in its ability to predict stream diversions. RT Vol. 236 at 104. The model's recent performance in this regard must make one wary of accepting single-year outcomes, recognizing that the effect of under-predicting diversions is to increase Stateline depletions. The model predicted only 77.6% of observed diversions in 1995; 80.4% in 1996; 87.4% in 1997; 96.5% in 1998, and 91.6% in 1999. Colo. Exh. 1412, Table 1 at 34. Over the whole 1950-99 period, we see that total diversions have been over-predicted by as much as 22.2% in 1960, and under-predicted by as much as 22.4% in 1995. *Id.*; Kan. Exh. 1113. Accordingly, looking at the 1997-99 period as a whole, and taking into account the replacement water provided and the model accretions, I find that Colorado is not in violation of the Arkansas River Compact during the 1997-99 years.

I also conclude that the Use Rules, as implemented during 1997-99, were sufficient to assure compact compliance. However, these were wet years, and it remains to be seen whether they will perform satisfactorily over a longer period of time including average and dry years. The Use Rules themselves cannot be faulted since they prohibit all postcompact pumping unless adequate replacement water is provided at the Stateline. If the 30%, 50% and 75% presumptive depletion factors should not prove to be adequate, the Use Rules provide that they may be changed, or that additional replacement water be provided. In the final analysis, therefore, it is the implementation of the Use Rules that becomes determinative of compact compliance.

SECTION IV

MEASUREMENT OF COLORADO'S WELL PUMPING

When Kansas sought to file this suit at the end of 1985, the action was targeted principally at the many new wells that had been drilled in Colorado after the 1949 compact became effective. Yet there was little good data on the number of wells then in operation, where they were located, or how much water they pumped. In the early years there had been no state regulation of Colorado wells. They could be constructed without state permission, and pumped without reports to anyone. In the liability phase of this trial, when pumping figures were essential, both states sought to estimate pumping from electric power records, although these data were neither complete nor consistent. In addition, many wells were not powered by electricity, but used either natural gas or diesel engines. It is not surprising, therefore, that the pumping estimates of the states varied considerably. For the period 1950-85, Kansas estimated that pumping along the Arkansas River averaged 161,394 acre-feet per year, while the Colorado average was 145,200. First Report, Vol. 2 at 202-03. In the trial segment on depletions for the period 1986-94, Kansas initially estimated average pumping at 151,114 acre-feet per year, compared to Colorado's average of 137,665 acre-feet. However, Kansas agreed as a compromise to use the Colorado pumping data in its model analysis for that period, but specifically withheld approval of the Colorado methodology for the future. Second Report at 12.

In March of 1994, the Colorado State Engineer adopted rules and regulations governing the "Measurement of Tributary Groundwater Diversions Located in the

Arkansas River Basin." ("Measurement Rules.") These rules became effective July 15, 1994, after approval by the District Court Water Division 2 in Case No. 94CW12. Colo. Exh. 1018, p. 14, App. B. By July of 1996, over 2000 wells within the H-I model domain were in compliance with the Measurement Rules.

A. Current Measurement Rules.

In 1996 the Colorado State Engineer proposed, and the Water Court approved, certain amendments to the Measurement Rules which became effective on June 1, 1996. Colo. Exh. 1019 at 12; Colo. Exh. 1051 at 4-6. The current form of the amended Measurement Rules is found in Kansas Exhibit 1122, and included in the Appendix as Exhibit 11. Also in 1996, the Colorado State Legislature enacted SB 96-124 requiring power companies to transmit directly to the State Engineer the records of energy used to pump groundwater. Colo. Exh. 1051 at 3. The Measurement Rules apply to all wells located in the Arkansas River Basin, not only to irrigation wells. All such wells must be equipped with either a totalizing flow meter, or be rated to determine a power coefficient. Rule 3. The power conversion coefficient, or PCC, is the number of kilowatt hours required to pump one acre-foot of water. Colo. Exh. 1331 at 9. The PCC method of calculating pumping depends first upon the amount of electricity used by a well, and those data are supplied directly to the State Engineer by the power utilities. Second, a pump test must be made on each well to determine the appropriate power coefficient. Rule 3.2. A re-rating of power coefficients is required whenever a change is made in the well, or at least every four years. Rule 3.5. The budgets and assessments of the three major well associations along the river all provide for regular PCC testing.

Kansas has always maintained, however, that the PCC method of determining pumping is not sufficiently accurate, and that the Measurement Rules should be amended to require the installation of totalizing flow meters on all wells. At the present time, about 25% of the pumping is measured through such meters. Kan. Exh. 1093 at 14; RT Vol. 215 at 154-55. Kansas points out that meters are required along the Arkansas River in Kansas, and that meters have been installed on more than 15,000 wells in the whole State of Kansas. RT Vol. 162 at 97; RT Vol. 240 at 102. Totalizing flow meters have also been required in the Pecos River Basin in New Mexico and in the Upper Republican Natural Resource District in Nebraska. RT Vol. 162 at 75, 115-16; RT Vol. 163 at 47. The PCC methodology, however, provides the Colorado State Engineer with assured monthly pumping data, and it is also less expensive to farmers. RT Vol. 168 at 37-38; RT Vol. 216 at 82-84; Second Report at 53-54. The real issue at hand is simply whether the PCC method is sufficiently accurate to provide pumping data for the H-I model.

B. USGS Study.

In order to deal with ongoing Kansas concerns about the accuracy of the PCC method, Mr. Simpson, the Colorado State Engineer, asked the United States Geological Survey to study the issue. RT Vol. 215 at 99-108. Specifically, Mr. Simpson asked the USGS "to independently evaluate the PCC method, as it is used in Colorado, for the Arkansas River Basin and how it is used within the H-I Model." RT Vol. 168 at 45. The objective of the study, as stated in the USGS proposal, was to "determine whether ground-water pumpage estimates for the study area using the PCC method, as applied by the State of Colorado, are statistically different from ground-water pumpage determined using TFMs [totalizing flow meters], and if so, determine the percent difference." Colo. Exh. 1062, App. F at 2.

The USGS report, which is Colorado Exhibit 1331, compares the two measurement approaches for the year 1998. Initially, 1300 irrigation wells were identified in the model area, but this number was reduced to 800 under the criteria that a well had to be active, electrical, and had reported recent pumping. Colo. Exh. 1331 at 6. A computer program was then used to "randomly select" one primary and four alternative sites for each potential well in the study. *Id*. After further evaluation, 103 wells were finally included in the study. *Id*.; RT Vol. 216 at 69-70. A new PCC test was performed in 1998 on each of the study wells, which were also equipped with totalizing flow meters. The results were compared from two to four times during the year. RT Vol. 215 at 101-02; RT Vol. 216 at 76.

The study concluded that about 80% of the difference in pumpage between the TFM and PCC approach was less than 10%, and that the overall mean difference in pumpage was only 0.01%. Colo. Exh. 1331 at 38. This indicates, reported the USGS, that there was "no significant difference on average between pumpage as measured by TFMs and pumpage as computed by the PCC approach." *Id*. It should be noted, however, that the Kansas expert, Steven P. Larson, testified that this was not an arithmetical calculation reflecting the actual difference in pumping measurements, but rather was the result of a statistical model. Kan. Exh. 1096 at 3. The USGS study also concluded that there is a 95% probability that the difference in aggregated pumpage between the TFM and the PCC approach, for any given year, for 1000 wells, would be between -1.71% and -0.11%. Colo. Exh. 1331 at 39.

Through cross-examination and the testimony of Mr. Larson, Kansas established the fact that the USGS study did not fully achieve its original objective. Colo. Exh. 1331 at 33-34; RT Vol. 242 at 143-44, 153-54. The study compares new PCC coefficients and meter measurements only within a single year. It does not address the issue of whether PCC measurements can be relied upon, as the measurement rules provide, for as long as four years. RT Vol. 215 at 164, 173; RT Vol. 242 at 143-44, 150. Mr. Simpson agreed that further study is needed. RT Vol. 216 at 58. The PCC rating can be affected over time by the efficiency of the pump, and by changes in water levels. If water levels drop, more power is required to pump the same amount of water, and conversely, less power if water levels rise. Colorado did introduce a limited study comparing pumping results from the new USGS 1998 PCC measurements with those previously used by Colorado in 1997. Colo. Exh. 1332. The study found that the 1998 results were only 1.6% higher than the 1997 estimates. *Id.*, Fig. 1. This limited evidence also showed that both the 1997 and 1998 PCC methods calculated pumping that was slightly higher than the totalizing flow meter results on the same wells. *Id.*, Fig. 2.

Kansas, however, challenged the USGS study results, even within the same year. It argued strenuously that the 103 wells finally used were not representative of all the wells in the model domain. RT Vol. 215 at 169-70; RT Vol. 216 at 67-75. Mr. Larson testified that the well selection was not random. RT Vol. 242 at 158. From USGS depositions, he said Kansas had learned that 800 potential sites were not used when 60 well sites were selected for 1998; rather, that a second list of 480 sites provided by Colorado was used. RT Vol. 242 at 157. Kansas also objected to many of the wells that were excluded, but in particular to the elimination of complex wells operating under a variance. *Id*. at 163-64. A complex well, defined in Rule 2, discharges at more than one point. At times, the farmer might pump the well straight into an irrigation ditch, and at other times into a gated pipe. Or he might always pump into a pipeline, but discharge at varying distances from the well. RT Vol. 215 at 139-40. The rules require that two PCC measurements be made for complex wells, one under the maximum head, and one under the minimum head, with a registered engineer determining what PCC value should be used. Rule 3.6. However, under the variance procedure, only one measurement may be used, but this must be at the discharge point closest to the well. This is the point of least friction, producing the lowest PCC rating, which in turn tends to slightly overstate pumping. RT Vol. 215 at 142, 151, 153, 158; RT Vol. 216 at 127, 132; RT Vol. 243 at 47-48. Approximately 25% of the total pumping comes from complex wells operating under a variance, but the evidence does not show that the PCC method employed on these wells operates to the detriment of Kansas. RT Vol. 217 at 16.

The USGS report specifically states that the test wells were randomly selected through a computer process, and it is difficult to believe that a USGS study would invalidate its results through a biased selection process of the test wells. Kansas, however, points to the deposition testimony of one of the authors of the USGS study. At the very end of that deposition, the witness was asked if he had made a determination as to whether the wells finally selected were representative of the total population of wells in the valley. Kan. Exh. 1098 at 144; RT Vol. 216 at 72, 74. The witness replied that he had not made such a determination. *Id*. However, that single question and answer were never pursued, and the witness' response is not the same as saying that the wells finally selected were not representative, nor that the random selection process used did not produce a representative selection.

Throughout this trial, the amounts of pumping have been determined by both states using principally the PCC methodology. Pumping data in the H-I model are aggregated by ditch, not on a well-by-well basis. The evidence is clear that use of the PCC methodology is adequate for purposes of the H-I model when the pump has been recently tested. The real issue with respect to the Measurement Rules is whether the PCC rating should be retested more often than once every four years. On that issue, Colorado is now engaged in Phase 2 of the USGS study. Four years of data through the end of the 2002 irrigation season have been collected, and the USGS will analyze that data and submit a second report, expected to be published toward the end of 2003. RT Vol. 216 at 65-66. The purpose of the Phase 2 study is to determine the multi-year variability of the PCC methodology, and the Colorado State Engineer has testified that the Measurement Rules will be amended if the USGS concludes that the four-year period is too long. RT Vol. 216 at 74, 77.

There was also evidence, although contested by Kansas, that the amount of pumping may no longer be the most important data input to the H-I model. Mr. Simpson was pressed persistently on this point during cross-examination, but held to his view that the amount of irrigated land and the distribution of groundwater on that land are more important in determining Stateline depletions than the amounts of pumping. RT Vol. 215 at 133-34; RT Vol. 216 at 120-121; RT Vol. 217 at 19-20. The amount of irrigated land and the distribution of groundwater became major issues in this trial segment, and are discussed in Section V. It should be noted, with regard to the amount of pumping, that Kansas accepted the Colorado pumping data for 1997-99, essentially as determined by the Measurement Rules, namely, 119,434 acre-feet for 1997; 96,749 for 1998; and 87,105 for 1999. RT Vol. 234 at 26, 28-29; Kan. Exh. 1093, Table 6; RT Vol. 244 at 97-98.

C. Conclusions.

The Colorado data system to identify and locate wells, and to determine the amounts of pumping and the use of such groundwater, continues to be steadily refined and improved. I believe that Colorado is acting in good faith to develop reasonably accurate data as necessary for compact compliance. Moreover, the weight of the evidence supports the conclusion that the Colorado system for determining pumping for use in the H-I model, taking into account the commitment to the results of Phase 2 of the USGS Study, is adequate. The value of monthly power records supplied to the State Engineer directly by the utilities, and the ability to estimate pumping on a monthly basis, can hardly be overestimated. Those data are essential to the administration of the Replacement Plans on a monthly basis. Accordingly, I conclude that it is not necessary in this case to require the installation of totalizing flow meters on all of the wells within the H-I model domain.

SECTION V

COLORADO'S 1998 IRRIGATED ACREAGE STUDY

In determining Stateline depletions, the H-I model is sensitive not only to the amount of well pumping, but also to the number and location of wells, to the number of wells which are active, and to the assumed distribution and use of pumped groundwater. Yet in the past, because of the lack of reliable data in regard to the use of groundwater, the H-I model has been required to use certain simplifying modeling assumptions. RT Vol. 218 at 77; RT Vol. 217 at 44. To remedy this, Colorado in 1998 undertook a comprehensive study of the irrigated acreage within the model area, with the aim of improving model results. RT Vol. 218 at 77-78, 91.

A. The GIS System.

The Colorado study began with maps prepared earlier by George Moravec. These maps were based upon 1985 aerial photos of the farms within the model area. Colo. Exh. 1268 at 4. The Moravec farm field boundaries were then digitized into field "polygons" to establish a Geographical Information System ("GIS"). Colo. Exh. 1408 at 9. Additional aerial photographs for later years were also used. *Id*. The digitizing process essentially takes the field boundaries from the aerial photos and puts them into a computer-readable form. RT Vol. 217 at 36. A computer polygon represents a farm field. RT Vol. 217 at 52. Originally there were approximately 7100 polygons, but after reviewing data provided by Kansas, the total number was increased to 7578. Colo. Exh. 1408, Table 3 at 78. Transforming the aerial photographs into the GIS computer system allows the inclusion and storage of relevant data associated with a specific field, including well identification numbers, well locations, and recent pumping amounts. RT Vol. 217 at 51-53, 55-56, 119; Colo. Exh. 1275. The GIS system also produces a map of each farm unit. Samples are found in Colorado Exhibit 1274A, B, C, D, E; RT Vol. 217 at 110. By the time of trial, both states were using the same GIS database and were in agreement on the polygon boundaries and the total farm acreage within the model study area. RT Vol. 241 at 138-39; Colo. Exh. 1408 at 10-11. The states were also in agreement upon the assignment of fields to the different canal systems, and as to those fields irrigated by groundwater only. RT Vol. 241 at 139-40. Mr. Book, the Kansas expert, agreed that with the modifications made by Colorado that "we now have a very accurate set of information on the fields irrigated in the Arkansas River Valley in Colorado." *Id*. at 140.

B. Satellite Imagery.

Colorado used satellite imagery to classify the field polygons in the GIS system as either irrigated or nonirrigated. Use of satellite imagery is now being "commonly used" as a method to replace aerial photos. RT Vol. 217 at 42-43, 53, 68. The satellite process allows land to be classified without having to visit the parcel several times a year. A satellite signal is transmitted to the earth and the reflected values detect greenness, brightness, wetness, and other features that allow the land to be classified in various ways. RT Vol. 217 at 42-43. In this study, Colorado purchased August 1998 satellite imagery from the Bureau of Reclamation, and then contracted with a private specialty company, Logicon Space Imagery Incorporated, to evaluate the reflected signals and to make the classifications of either irrigated or nonirrigated land. RT Vol. 217 at 58-61. The resolution of the satellite imagery used was 30 meters by 30 meters, or approximately 1/4 of an acre. RT Vol. 217 at 46. These units are called "pixels." *Id*. The process also requires some "groundtruthing." RT Vol. 217 at 48, 61-63. Sample fields are inspected to see whether the visual evidence of irrigated fields corresponds with the signature from the electronic data, and to make adjustments if necessary. *Id*. Aerial photos were also used to assist in classifying the land and determining field boundaries. RT Vol. 217 at 55, 69-70. Three maps showing the August satellite imagery over the whole length of the river are found in Colorado Exhibits 1271, A, B and C.

The automated classification system had difficulties with pasture lands that might have been irrigated early in the season but did not have enough water for the full season; with alfalfa fields recently cut; and with crops that had already been harvested. Kan. Exh. 1093 at 8; RT Vol. 233 at 85. Colorado sought to address these problems by obtaining additional satellite imagery for May, 1998. Mr. Bill Tyner, who was in charge of the study, also testified that he had "learned quite a bit" from this initial use of satellite imagery and from the year 2000-01 field work, and that he expected to make improvements in the future. RT Vol. 244 at 128. He said that he would be using three sets of images, perhaps even four, ranging over the spring, summer and fall. *Id*. at 129-30. He also expected to use higher resolution imagery, probably 5 or 15 meter units instead of 30 meters. *Id*. at 130.

C. Survey and Verification Program.

As part of the 1998 irrigated acreage study, Colorado also included a survey and verification program. Survey forms were sent to the owners and operators of all wells included in the Replacement Plans. RT Vol. 217 at 44-45. These included 725 farm units. *Id*. at 80-81, 83-87, 91. A sample survey form appears in Colorado Exhibit 1268 at 25. Colorado sought information on the wells, their locations, ownership of ditch shares, total irrigated acres, acres irrigated by surface water only, acres irrigated by wells only, and acres irrigated by both wells and surface water. RT Vol. 217 at 44-45. Farmers were advised that failure to return the completed survey would jeopardize their ability to be included in the 1999-2000 Replacement Plans. Ultimately, data were collected for all of the 725 farms with wells in Replacement Plans. Colo. Exh. 1268 at 27. Colorado then began to verify the survey information by sending local water commissioners into the field to interview the farm owners and operators. RT Vol. 217 at 81-92; Colo. Exh. 1268 at 5-7. The initial verification effort included a random selection of 10% of the total well population; 20% of farms with sole-source wells; and 10% of the farms with multiple wells. Colo. Exh. 1268 at 27. When the first irrigated acreage report was completed and provided to Kansas, the field verification work had been completed on 258 farm units. *Id*. That first report included the results of the GIS system, the satellite imagery, the survey information, and the verification work. Colo. Exh. 1268.

D. Kansas' Independent Investigation.

The initial results of the Colorado study were provided to Kansas. Mr. Book compared the results of the Tyner mapping and satellite imaging process with the input previously used in the H-I model. That prior mapping was based on 1980 aerial photos with some updates and 1989 field work, all of which had been done by Kansas. RT Vol. 233 at 67-69. This earlier mapping was then converted into GIS coverage so that it could be compared with the Colorado results. *Id*. at 68. Kansas experts noticed that some of the fields that had been mapped on the basis of 1980 photography had not been included in the 1985 Moravec mapping, and hence were not in the 1998 Colorado study. About 20,000 acres were involved. RT Vol. 233 at 68-69. Secondly, Kansas found that about 8000 acres, classified as not being irrigated, had been found to be irrigated in the earlier 1980 aerial photos and 1989 field work. *Id*. Kansas' experts then undertook their own three-week field investigation in the summer of 2000, using a GPS system to locate the fields in question. RT Vol. 233 at 68-69, 86-87; Kan. Exh. 1093 at 6-8; Colo. Exh. 1408 at 9. As a result of its field work, Kansas concluded that 528 fields, totaling 10,099 acres, should be added to the Colorado GIS field polygons of 7125. Colo. Exh. 1408 at 11, Table 3. Colorado accepted most of these field additions, and after further field work of its own, increased the number of GIS polygons to 7578. Colo. Exh. 1408, Table 3. A significant number of the new fields were small and irrigated only by surface water when those supplies were abundant. Colo. Exh. 1408 at 14-15. Colorado acknowledged that there are "inherent inaccuracies" in the automated classification process using satellite imagery, and that in 1998 there were also limitations on the groundtruthing undertaken by Colorado. Nonetheless, Colorado stated that the land classifications based on satellite imagery had proved very useful, and that the process worked well for most crops and for larger fields. *Id*. at 15. Colorado expects that the field investigations will provide refinements for future use of the satellite imagery process. *Id*.

Kansas experts also identified 362 fields, totaling 11,395 acres, that were in fact irrigated but had been classified by Colorado as nonirrigated. In addition, Kansas concluded that 186 fields, totaling 5123 acres, were not irrigated, but had been classified as irrigated by Colorado. Colo. Exh. 1408 at 13. Colorado's subsequent staff investigation produced agreement with the Kansas recommendations for about 81% of the fields. *Id*.

Following the results of its initial study, Colorado continued its field investigations and included a second satellite imagery done in May. By the time of this trial segment, Colorado had verified an additional 168 farms, bringing it to a total of 426 verifications out of 725 farm units. Colo. Exh. 1269 at 7. The results of this additional work are found in Colorado Exhibit 1269. The farms verified represent 67,000 acres of 84,500 acres that received well water in 1998. Colo. Exh. 1269 at 7. Colorado represents that it intends to complete its verification process by March 2003, and then would begin a five-year cycle where the state would re-verify 20% of the farm units each year. RT Vol. 258 at 5-7; RT Vol. 269 at 15, 61, 66.

E. Revised Results of Colorado's 1998 Irrigated Acreage Study.

Irrigated acreage in Colorado has been continually declining. The average acreage figure used in the H-I model for the 1950-85 period was 313,867 acres; for 1986-94 the model figure had declined to 288,774 acres; and for 1995-96 it was 267,985. Second Report at 12; Kan. Exhs. 759, 786; RT Vol. 150 at 12; Kan. Exh. 1093, Table 1. For the years 1997 through 1999, Colorado's 1998 study showed total irrigated acreage to be just over 259,000 acres. Colo. Exh. 1442. These were data based upon the field verifications completed at the time of trial, namely, 426 out of 725 farm units. Colo. Exh. 1269 at 7. The comparable Kansas data for 1998 were just over 261,000 acres. Kan. Exh. 1093, Table 1.

Colorado's irrigated acreage study also calculated the amount of land irrigated by surface water only, the number of acres irrigated by groundwater only, and the number of acres receiving both surface water and groundwater. This latter category is referred to as "supplemental acreage" or "mixed" acreage, and the wells pumping the water for these lands are referred to as "supplemental wells." The Colorado figures are shown in Colorado Exhibit 1442; RT Vol. 244 at 80-83; RT Vol. 269 at 12. Surface water only lands ranged from 162,000 to 166,000 acres over the 1997-99 period. The comparable Kansas figure is 186,773 acres. Kan. Exh. 1093, Table 3. For lands irrigated with groundwater only, the Colorado results average about 15,000 acres, while the Kansas average is about 18,000 acres. Colo. Exh. 1442, Table 5; Kan. Exh. 1093, Table 3.

However, the most significant reduction from the data used in past versions of the H-I model, and the most important difference between the states, concern the supplemental or mixed acreage figures. Colorado shows a range from 72,814 to 78,773 acres for 1997-99. The Kansas figures are between 91,566 and 92,083. *Id*. Supplemental acreage is a key to Stateline depletions. As the amount of supplemental acreage is increased in the model, so are depletions. RT Vol. 233 at 140-142. The supplemental acreage used in the 1995-96 version of the H-I model was 147,293 acres, and both states recognize that this figure was too high. Colo. Exh. 1268 at 21. But the states are some 15,000 acres apart on what the reduction should be. The appropriate supplemental acreage figure will depend upon completion of the Colorado irrigated acreage study and its continued updating.

F. Well Data.

Currently there are approximately 2100 irrigation wells in Colorado's database for the model area. Colo. Exh. 1267 at 8-9, 15; Kan. Exh. 1093, Table 2. During the 1997-99 period, almost half of these wells were classified with the state as "inactive." Colo. Exh. 1267 at 15; Kan. Exh. 1093 at 10. This does not mean simply that the wells were not pumped, but rather that a filing had been made with the state whereby they may not be pumped. Colorado maintains an inspection program to prevent such unauthorized pumping. Kan. Exh. 1093 at 10; RT Vol. 242 at 36. All wells which are not classified in any year as being "inactive" must be included in a Replacement Plan. *Id*. Mr. Tyner testified that since the Use Rules had been adopted in 1996, typically just over half of the wells have been active. RT Vol. 218 at 77. He does not foresee a "large number" of inactive wells becoming active again in the future. RT Vol. 245 at 51. The LAWMA Replacement Plan, for example, requires that any farmer attempting to add a new well to the plan must bring his own source of replacement water. *Id*. In 1999 there were 1199 active irrigation wells included in Replacement Plans. Colo. Exh. 1267 at 10. During 1997-99, pumping by sole source wells ranged between 32,999 and 42,581 acre-feet. Kan. Exh. 1093, Table 6. Supplemental well pumping varied between 54,106 and 76,853 acre-feet. *Id*.

In the past, and in the absence of reliable data, "simplifying engineering assumptions" have been used to allocate surface and groundwater supplies in the H-I model. RT Vol. 218 at 77-78. Surface water supplies are distributed uniformly to all lands within a ditch system that have access to such supplies. RT Vol. 233 at 122, 124-25; RT Vol. 245 at 8. This uniform distribution includes lands that may also receive well water. RT Vol. 233 at 132. With respect to groundwater, the basic procedure used by Kansas has been to assume, with some adjustments, that if a well were located within a section, the entire section would be considered as being irrigated by the well. RT Vol. 233 at 122-24; Colo. Exh. 1268 at 9. Colorado, on the other hand, based its earlier model estimates of land irrigated by both surface and groundwater on the Water Court's decreed and permitted acreage. Colo. Exh. 1268 at 9. And it was not until the 1995-96 version of the H-I model that data for sole source wells were separately broken out. RT Vol. 233 at 120. Prior modeling assumptions of the amounts of acreage irrigated by supplemental groundwater were substantially greater than the amounts shown by the Colorado irrigated acreage study. (See Kansas letter of December 6, 2002: the amounts were 156,000 acres for 1991-94; 147,000 for 1995-96; compared to 91,000 for 1997-99.)

Under the GIS system, Colorado has been mapping the groundwater acreage and determining the exact number of acres associated with each well. RT Vol. 245 at 52. The Colorado program will determine which wells are sole source, and which wells are supplemental. *Id*. at 54. At the time Mr. Tyner testified, he still lacked verification for 140 of the original 725 farm units, but he expected to finish in the 2002-2003 winter. *Id*. at 55. Later evidence indicates that the work will be complete in March, 2003. Kansas acknowledges that such mapping and documentation is needed, and "would provide the basis to identify the acreage on farm units using ground water each year." Kan. Exh. 1093 at 10.

G. Supplemental Acreage.

Irrigation water is distributed in the H-I model on an acreage basis, depending upon how the land is classified, namely, as (1) surface water only; (2) groundwater only ("sole source" land); or (3) supplemental land which receives both surface and groundwater. RT Vol. 233 at 120, 132. Because the H-I model does not recognize individual farm boundaries, supplemental acreage is reflected in the model as a percentage of land within a ditch service area. Colo. Exh. 1353, Table 2; Kan. Exh. 1093, Table 4; RT Vol. 233 at 139. In assessing potential depletions for 1997-99, Colorado used the results of its 1998 irrigated acreage study as direct input to the H-I model. RT Vol. 233 at 133. Kansas, however, "reclassified" the supplemental acreage to obtain what was said to be a more "reasonable distribution of water supply within farm units." Kan. Exh. 1093 at 11. The effect of the reclassification was to increase the acreage receiving groundwater from 95,000 to 110,000 acres. Kan. Exh. 1093 at 11; RT Vol. 233 at 146. In turn, the impact of this change was to increase Stateline depletions as shown by the H-I model. RT Vol. 233 at 140; RT Vol. 237 at 140-42; RT Vol. 242 at 24-26.

Mr. Book's rationale for this reclassification was that the model has always distributed surface water uniformly over the whole canal system. RT Vol. 233 at 143; RT Vol. 242 at 23. Pumped water, he testified, is then distributed "on top of that." RT Vol. 242 at 25; RT Vol. 233 at 132. In some situations, he said, the total supply could be greater than crop demand, producing "excess supply" which increases runoff and reduces Stateline depletions. RT Vol. 242 at 25; RT Vol. 233 at 137-38. To remedy this perceived problem, Mr. Book recommended that the surface water only lands be considered as supplemental acreage. RT Vol. 233 at 130-40, 142-44, 146-47. In essence, if a farm unit had a well, all of the land within the farm would be considered as supplemental acreage, and both surface and groundwater would be distributed uniformly over the whole farm by the model. RT Vol. 233 at 145; Kan. Exh. 1093 at 11. Mr. Book acknowledged, however, that farmers' testimony showed that they did not use their surface and well water supplies in this way. RT Vol. 242 at 23-24. It appears that Mr. Book's groundwater recommendation is an effort to compensate for problems with the model's "surface water allocation," and does not replicate actual conditions. RT Vol. 242 at 24.

The Kansas reclassification of groundwater applied only to the H-I model use for the 1997-99 period. RT Vol. 233 at 140. When Kansas recalibrated the model using the period 1950-94, it classified supplemental acreage quite differently. In the recalibration procedure, Kansas assigned groundwater on the basis of decreed and permitted acreage, including acreage associated with inactive wells. RT Vol. 233 at 131, 152; RT Vol. 242 at 30; Kan. Exh. 1093, Table 4. Mr. Book testified that it was best to include all of the inactive wells when looking back historically, although there was no evidence as to how many of the wells currently declared to be inactive had been pumped earlier. RT Vol. 233 at 152. Nor did Mr. Book adjust for the fact that substantially fewer wells existed in the 1950s and 1960s.

RT Vol. 242 at 29. Both states in the past have relied upon decreed and permitted acreage, but better data were not then available. Since the Use Rules were enacted, almost half of the wells have been inactive, and over a period of time including both wet and dry years. RT Vol. 218 at 77. In the wet years when surface supplies are abundant, there is less need for supplemental pumping. And in the dry years, when farmers historically have relied more heavily on well pumping, the availability of replacement supplies now acts to constrain such pumping. Yet Kansas has used its 1950-94 recalibrated model to predict compact compliance in the future. RT Vol. 233 at 127-29; Kan. Exh. 1093, Table 4. That is, future depletions are based not on actual supplemental acreage data, but rather on the decreed and permitted acreage associated with all irrigation wells in the model area, including inactive wells. Such model input is clearly contrary to the evidence.

H. Conclusions.

The H-I model is designed, insofar as feasible, to replicate actual conditions and on that basis to calculate depletions of usable Stateline flows. RT Vol. 239 at 109-11. Colorado's irrigated acreage study and program provide reliable data on how groundwater is actually applied, and should be used in place of prior modeling assumptions. The supplemental acreage data for 1997-99, as it may be modified upon completion of the verification program, should be used as model input for those years. As the H-I model is used in the future to measure Colorado's compliance with its compact obligations, input to the model for surface water only acreage, for sole source acreage, for supplemental acreage and how groundwater is actually applied, shall be based upon the data developed from Colorado's several programs; provided that nothing herein shall prejudice the right of Kansas to object to or contest such data. Indeed, work by Kansas' experts in the past has brought about substantial improvements to these Colorado data, and continued input by Kansas should be encouraged.

SECTION VI

CROP CONSUMPTIVE USE IN THE H-I MODEL

An important function of the H-I model is to estimate the consumptive use of water applied to irrigate the various crops grown along the Arkansas River Valley. As part of this function, the model utilizes an estimate of the potential evapotranspiration (PET) which establishes an upper limit on crop consumptive use. RT Vol. 248 at 145-46, 149; RT Vol. 249 at 13. It should be kept in mind that the PET is not necessarily the same as actual evapotranspiration (ET). Actual consumptive use values calculated by the H-I model may be less than the PET under water short conditions. The PET factor comes into play under conditions of a full water supply. RT Vol. 266 at 19, 23. To the extent that the PET increases, the model may simulate greater crop consumption of water, with less water being returned to the river to contribute to the supply at the Stateline. Conversely, lower estimates of PET generally mean that more water is shown to reach Kansas. In all previous versions of the H-I model the estimates of PET have been based on the modified Blaney-Criddle equation developed a number of years ago by the U.S. Soil Conservation Service. Jt. Exh. 152. This is a widely used temperature-based method of estimating seasonal crop water use, requiring only average monthly air temperatures and an estimate of the percentage of annual daylight hours. When the H-I model was developed, the Blaney-Criddle method was the best available. However, more accurate methods of calculating crop water use have now been developed, although they require more weather data than the modified Blaney-Criddle formula. These other methods are called "reference" type equations, and are based upon daily maximum and minimum temperatures, wind, solar radiation, and relative humidity.

In this last trial segment, Kansas proposed a change in the model input for PET, substituting a reference type equation known as the ASCE standardized Penman-Monteith equation for the Blaney-Criddle formula. This became a major trial issue. Neither state recommended the continued use of the Blaney-Criddle method. RT Vol. 247 at 84-85; RT Vol. 252 at 99-100; Kan. Exh. 1094. However, experts for Colorado advocated a different reference equation, namely, the 1982 Kimberly Penman method. RT Vol. 247 at 78, 90, 97; Colo. Exh. 1409 at 2. They also testified that certain adjustments would be required for wind, aridity, management and salinity in order not to overestimate evapotranspiration (ET). Crop "consumptive use" of water and ET are often used interchangeably. RT Vol. 235 at 147.

Credible studies show that the Blaney-Criddle method underestimates PET in arid locations by as much as 16 percent. Kan. Exh. 1109, Table 7.13 at 226; Kan. Exh. 1094 at 3; Colo. Exh. 1409 at 8. The ASCE Manual 70 states that the Blaney-Criddle method "typically underestimated reference ET in the arid climates." Kan. Exh. 1109 at 235, Table 7.18. Yet, the Colorado adjustments made to the proposed 1982 Kimberly Penman equation would leave PET at about the same levels as under Blaney-Criddle. RT Vol. 266 at 131; Colo. Exh. 1409, Table 13. Underestimating PET has the effect in the model of reducing Stateline depletions. Conversely, the Penman-Monteith equation, recommended by Kansas, increases PET values by about 10 percent, and actual ET by 3 percent. RT Vol. 241 at 105-06. This change would cause model depletions to increase, although the states disagree over how much. Kan. Opening Br. at 10; Colo. Reply Br. at 12. Mr. Sullivan indicated for Kansas that the difference would be about 2031 acre-feet per year. RT Vol. 262 at 24. Colorado thought the change to Penman-Monteith would cause a greater increase in depletions, but I do not find a specific figure from their experts. The issue should not be, however, which state might gain an advantage through any PET change but rather which model input is likely to produce more accurate results.

A. Penman-Monteith Method.

ASCE Manual 70 entitled "Evapotranspiration and Irrigation Water Requirements" compares the results of studies on numerous methods used to calculate crop ET.[7] Kan. Exh. 1109. The Penman-Monteith, 1982 Kimberly Penman, and Blaney-Criddle methods, among others, are compared with precision lysimeter data.[8] Kan. Exh. 1109,

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[7] "ASCE" is the American Society of Civil Engineers. One of the three editors is R. G. Allen, a principal Kansas expert witness on this subject.

[8] A lysimeter is a container in which a crop is grown and the applied water is carefully measured. The amount of water actually consumed by the crop, i.e., the ET, is then calculated either by subtracting the amount of water that drains from the container, or through

(Continued on following page)

Table 7.13, at 226. Penman-Monteith results for arid locations were 1 percent under the lysimeter measurements; the1982 Kimberly Penman results were 3 percent over; and Blaney-Criddle results were 16 percent under. The National Engineering Handbook, published in 1993 by the U.S. Department of Agriculture and the Soil Conservation Service, recommends using the Penman-Monteith method, when appropriate data are available, because it is the "most accurate." Kan. Exh. 1107 at 2-41; Kan. Exh. 1182, App. A at 22; RT Vol. 267 at 9. In tests performed at Bushland, Texas, a research center about 200 miles from the Arkansas River Valley, the standardized Penman-Monteith equation again outperformed the 1982 Kimberly Penman method, as well as Blaney-Criddle. Kan. Exh. 1168. That study reported that the Penman-Monteith equation predicted alfalfa ET well, while the 1982 Kimberly Penman produced "biased estimates in all years, tending to over-predict ET at low ET rates and under-predict at high ET rates." Kan. Exh. 1168 at 270-71. The Bushland studies were specifically aimed at determining ET in a "windy, semi-arid environment." Kan. Exh. 1168 at 266. Bushland is known as a "very windy location," and "its aerial conditions are not very different from Arkansas Valley." RT Vol. 266 at 156. The Penman-Monteith method has now been adopted by the Food and Agriculture Organization of the United Nations as its "sole method for calculating reference crop evapotranspiration." RT Vol. 266 at 139. See FAO-56, "Guidelines for Computing Crop Water Requirements." Kan. Exh. 1183. Both the Penman-Monteith

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other water level or weight change techniques. RT Vol. 247 at 41-42. The lysimeter can also be sited in a field plot.

and the 1982 Kimberly Penman methods require the same data, namely, daily air temperature, and measurements of wind speed, solar radiation, and humidity. RT Vol. 247 at 89-91; RT Vol. 266 at 143. These data were not available along the Arkansas River in Colorado until 1993.

B. CoAgMet Climatic Data.

Climate stations operated by the Colorado Agricultural Meteorological Network, "CoAgMet," were established along the Arkansas River in the early 1990s at Vineland, Avondale and Rocky Ford. Kan. Exh. 1094 at 4. These stations represented a joint effort by Colorado State University and the USDA Agricultural Research Service Water Management Unit. Kan. Exh. 1178. The system is now under the control of Colorado State Climate Center. RT Vol. 251 at 116; RT Vol. 253 at 15. Electronic data necessary for use in either of the recommended reference equations are available from 1993. Kan. Exh. 1094 at 4. These three stations are all located upstream of John Martin Reservoir, although since 2001 two new stations have been operating downstream at Lamar and Holly. RT Vol. 266 at 134-35; Kan. Exh. 1182 at 3. The collection of data from 1993 from the three upstream sites has not been as good as might be expected. Some data are missing, other data are questionable. Dr. Ley testified that he was "disenchanted" with the maintenance of the electronic sensors at these sites. RT Vol. 251 at 87. Nonetheless, experts for both states worked independently with the records, making "integrity assessments" to develop "clean" data that turned out to be essentially the same. RT Vol. 247 at 113-14; RT Vol. 252 at 8-23, 32-36, 161; Kan. Exh. 1210 at 1, Figures 1-8. If data from all of these stations should become an important factor in the operation of the

H-I model, I am confident that we can expect more complete and accurate weather measurements in the future. RT Vol. 252 at 107.

C. Colorado's Reference Equation Adjustments.

Both the Penman-Monteith and the 1982 Kimberly Penman are reference type equations in which ET is established for a "reference" crop. In this case, the reference crop is alfalfa, and its ET was determined from studies done at Kimberly, Idaho, a research station of the U.S. Department of Agriculture. RT Vol. 247 at 24. To establish consumptive use for specific crops at different locations, local weather data are inserted into the reference equation to derive a local ET for the reference crop. This is essentially a climatic index. A coefficient for each individual crop is then applied against that index to calculate the PET of the actual crops being grown. Crop coefficients are different for each month in order to adjust the reference equation to fit the growth processes of the various crops. RT Vol. 248 at 67-69.

Mr. Eugene Franzoy is a Kansas expert who has testified on several previous occasions on crop water use.[9] He applied the Penman-Monteith equation, using the CoAgMet clean weather data, and specific crop coefficients for wheat, corn, sorghum, vegetables and other crops grown in the Arkansas River Valley. With these data, he developed the consumptive use values used by Kansas in the H-I model. Kan. Exh. 1094. Initially, Mr. Franzoy used

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[9] His qualifications appear in Kansas Exhibit 785.

crop coefficients developed at Kimberly for use in the 1982 Kimberly Penman equation. RT Vol. 247 at 99-100; Kan. Exh. 1182 at 4. These were later converted by a routine process to be suitable for use in the Penman-Monteith equation along the Arkansas River. Kan. Exh. 1182 at 4-5; Kan. Exh. 1210; RT Vol. 248 at 76-77. Mr. Franzoy's results were close to those calculated by the Colorado experts, except for certain adjustments which they made. RT Vol. 248 at 73-74, 77-79, 82.

Colorado's experts followed the same general approach used by Kansas, although using the 1982 Kimberly Penman equation instead of Penman-Monteith. Their results, however, were substantially different, not so much because of their choice of the reference equation, but because of the adjustments made to that equation and to the CoAgMet weather data. Colorado's experts made adjustments for wind, aridity, management and salinity. Without these adjustments to the Kimberly Penman method, and presumably to the Penman-Monteith equation also, they testified that evapotranspiration would be overestimated.

D. Wind Limit.

The first of the Colorado experts to testify in this issue was Dr. Robert W. Hill, a full Professor in the Department of Biological and Irrigation Engineering at Utah State University.[10] He has been an irrigation specialist at the University since 1985, providing technical assistance and training to farmers on irrigation, and advising state and

[10] His resume is Colorado Exhibit 1422, which includes a lengthy list of relevant publications, and overseas consulting experience.

federal agencies in all areas of irrigation and water resource management. He has done numerous studies of crop water use and yields, including a study of the consumptive use of irrigated crops in Utah. RT Vol. 247 at 14-15, 125-30.

In reviewing the CoAgMet weather data, Dr. Hill applied a wind limit of 132 miles per day to the measurements which were used to calculate ET. RT Vol. 247 at 136, 138. This limit, also referred to as a "wind run" or "wind travel," is defined as the average wind speed in miles per hour multiplied by 24 hours. *Id*. at 72-73. Thus, an average wind speed of 5 miles per hour, over 24 hours, would result in a wind limit of 120 miles per day. *Id*. at 73. The effect of Dr. Hill's recommended limit was said to remove the impact of high winds on evapotranspiration. *Id*. at 132, 137. He testified that a limit was necessary in any Penman type equation "in high wind environments." RT Vol. 250 at 143. Yet the true impact of his limit was to exclude not only high wind effects but all wind effects over an average speed of 5.5 miles per hour. RT Vol. 248 at 90, 100-01. While Dr. Hill acknowledged that the 132 limit was a "judgment" call, it was necessary in his opinion to prevent either of the Penman type equations from overestimating ET. RT Vol. 250 at 136-37.

Dr. Hill in previous work had imposed a wind limit of 100 miles per day, but in that instance he was applying the 1972 version of the Kimberly Penman equation before it had been improved in 1982 to include a better wind function. RT Vol. 248 at 95-96, 98; RT Vol. 250 at 134-35. In this case, Dr. Hill said he "relaxed" the previously used limit of 100 to 132 because he was also adjusting for irrigation management and salinity, and he thought that otherwise there might be "some overlap." RT Vol. 248 at 102-03.

Contrary testimony was offered by Kansas' expert, Dr. Richard Allen. In his opinion a wind limit in the Arkansas River Valley was not only not necessary, but was not appropriate. Dr. Allen is presently a Professor of Civil Engineering and Biological and Agricultural Engineering at the University of Idaho. He has published some 40 articles in refereed journals, and 79 non-refereed articles. He is a contributing author or co-editor of numerous ASCE manuals, and United Nations Food and Agriculture Organization (FAO) publications, on evapotranspiration. He is one of the three editors of ASCE Manual 70 on Evapotranspiration and Irrigation Water Requirements. Currently Dr. Allen is the Chair of the Technical Committee on Evapotranspiration which is working on revising Manual 70.[11]

Dr. Allen pointed out that both the 1982 Kimberly Penman and the Penman-Monteith equations include calibrated wind functions and therefore do not require a limit. Kan. Exh. 1182 at 6, App. B at 30. Dr. James Wright, who developed the 1982 Kimberly Penman equation, did not recommend imposing a wind limit, and did not use a wind limit in developing the crop coefficients, or in calibrating the crop coefficients to the lysimeter data used for the 1982 Kimberly Penman or Penman-Monteith equations. RT Vol. 267 at 6; RT Vol. 248 at 86-87; RT Vol. 270

[11] Dr. Allen's resume is Kansas Exhibit 1181, and his extensive qualifications appear at RT Vol. 266 at 106-28. His research, consulting and teaching experience include many projects around the world.

at 62-63. Dr. Hill could not cite any article that recommended applying a wind limit for the 1982 Kimberly Penman equation. RT Vol. 248 at 110. Neither the ASCE Manual 70, nor the United Nations Food and Agriculture Organization in FAO-56, recommends using a wind limit with either of the reference crop evapotranspiration equations. Kan. Exh. 1182 at 6, Kan. Exh. 1183; Kan. Exh. 1109; RT Vol. 248 at 85-86; RT Vol. 268 at 24-25.

The 1982 Kimberly Penman equation used by Colorado was developed at Kimberly, Idaho based on climatic data measured at that location. It does not appear that wind conditions at Kimberly are appreciably different from those along the Arkansas River in Colorado. Dr. Hill testified that the average wind travel at Avondale is 134 miles per day, at Vineland it is 124, and at Rocky Ford it is 120 miles per day. RT Vol. 247 at 74; RT Vol. 248 at 88. At Kimberly the average wind travel is 124 miles per day. RT Vol. 248 at 88-89. At all of these stations wind speeds range on average between 5.0 and 5.6 miles per hour.

Dr. Allen demonstrated that if the 132 mile-per-day wind limit recommended by Dr. Hill were applied to the same data used to develop the 1982 Kimberly Penman equation, that ET would be under-predicted by the equation. Kan. Exh. 1182, App. B at 29. Application of the wind limit caused the Penman Monteith equation to estimate 8.5 percent lower than without a wind limit, and caused the 1982 Kimberly Penman to underestimate by 10.6 percent. *Id*.

It appears from the weight of the evidence that no wind limit should be applied to the measurements made at the CoAgMet weather stations. Evapotranspiration data from these stations are distributed daily to Colorado farmers for their use in actual irrigation, and such ET calculations, using the 1982 Kimberly Penman equation, do not include any wind limit Kan. Exh. 1178; RT Vol. 252 at 104, 117-18.

E. Aridity Adjustment.

Colorado's other expert with respect to the assessment of weather data and siting of the CoAgMet weather stations was Dr. Thomas W. Ley.[12] Dr. Ley is an irrigation engineer who is currently employed by the Colorado Division of Water Resources as lead hydrographer in the Division 2 office in Pueblo, Colorado. He has been with the Division of Water Resources since February 1999, although he was also born and raised in Pueblo, Colorado. RT Vol. 251 at 36. Dr. Ley was previously employed as an extension irrigation engineer at Washington State University from 1983 to 1997. In that position, he designed and implemented the Washington Public Agricultural Weather System, consisting of 69 electronic weather stations that provide irrigation scheduling information. *Id*. at 51. In this case, Dr. Ley assisted in the preparation of Colorado Exhibit 1409, "Crop Water Use Estimates for the Arkansas River Basin in Southeastern Colorado," but his primary responsibilities related to Appendices B and C of that report concerning weather data. *Id*. at 80.

Dr. Ley evaluated not only the data collected from the CoAgMet weather stations, but also assessed their siting environments for use in reference equations. He testified

[12] His resume and qualifications are found in Colorado Exhibit 1432.

that a weather station from which data are to be used for reference ET estimation should be collected in what he called a "reference environment." RT Vol. 251 at 100. The weather station itself, he said, should be located over an actively transpiring green crop, preferably short clipped grass, and be centrally located in a large irrigated area. *Id*. The station should be in a wide open area without influence from trees or buildings. *Id*. And the weather data should be collected in an environment which is "similar" to that in which the reference equation and crop coefficients were developed. *Id*. at 105.

After a series of site visits to the CoAgMet stations, Dr. Ley concluded that there were "some significant departures" from what he would recommend if the data were going to be used for reference ET calculations. RT Vol. 251 at 95-96. He found that two of the weather stations were situated over non-irrigated, unclipped weeds; that dirt farm roads bordered on at least one side of the stations; and that the weather stations were located in areas irrigated by various crops that were harvested and sometimes fallowed so that a full cover of vegetation was not always present. Colo. Exh. 1409, App. B. Because of the siting environments, he concluded that conditions measured at the CoAgMet stations would be drier than under reference conditions. He gave each station an "aridity rating." A rating of "0" percent represented a completely irrigated condition, while a value of "100" percent represented a completely arid situation. Colo. Exh. 1409, App. B at 2. For Vineland, the aridity rating was 35 percent; for Avondale it was 39 percent; and for Rocky Ford it was 19-20 percent. Colo. Exh. 1409, App. B at 5, 16, 27. Without an aridity adjustment, he testified that PET would be overestimated. RT Vol. 252 at 42. His adjustments included subtracting a constant one degree Fahrenheit from the daily maximum and minimum air temperatures measured at Vineland, and subtracting one and one-half degrees at Avondale, together with certain dew-point changes. RT Vol. 252 at 43-45. His aridity adjustments were designed to achieve measurements that would have been made if the stations had been located under reference conditions, namely, the conditions at Kimberly, Idaho. RT Vol. 252 at 52.

The ultimate results of his aridity adjustments were to decrease PET values at Avondale by 5 percent, at Vineland by 3.7 percent, and at Rocky Ford by 0.75 percent, and thus to decrease depletions at the Stateline. Kan. Exh. 1179; RT Vol. 252 at 163-64.

At the heart of Dr. Ley's opinion was his belief that conditions at and surrounding the CoAgMet stations were not the same as the reference conditions at Kimberly, thus resulting in drier measurements. However, Kansas produced substantial evidence to the contrary. Dr. Allen, whose office is located at Kimberly, identified a series of photos of the Kimberly research station, including satellite photographs of the surrounding area. Although Dr. Allen is a Professor at the University of Idaho, his office is at the research and extension center in Kimberly. The photos show conditions at Kimberly not only at the present time, but also during the years when Dr. Wright developed his 1982 Kimberly Penman equation. The conditions appear to be very similar to those at the CoAgMet stations along the Arkansas River.

The weather station site at Kimberly is a small grassed plot surrounded by agricultural research fields. These research fields show many bare soil conditions due to harvesting and crop rotation. Three sides of the weather station are bordered by dirt and asphalt roads. On the far side of one of the roads is the large research station, including about two acres of asphalt and buildings. Kan. Exhs. 1173, 1174, 1175, 1176, 1182, 1184; RT Vol. 267 at 49-62. Satellite images of a two-mile circle around the several weather stations show that the irrigated areas around Avondale, Vineland and Rocky Ford were at least equal to, if not greater than, the irrigated fields surrounding the Kimberly station. Kan. Exh. 1177. The Kimberly Station is located about five miles east of Twin Falls, Idaho, on the high plains area along the Snake River. The elevation is about 4000 feet, similar to that of the Arkansas River Valley. RT Vol. 267 at 70-71. Dr. Allen testified that the Kimberly weather station was located in an environment "similar" to that of the CoAgMet stations, and that no adjustments should be made to the CoAgMet data. Id. at 48, 70-72, 115-16. It is significant that Dr. Wright made no adjustments to the Kimberly weather data for aridity. RT Vol. 252 at 117-18; RT Vol. 253 at 58; Kan. Exh. 1109 at 161, Table 6.19.

Dr. Ley, however, was not moved by the departures at Kimberly from ideal reference conditions. RT Vol. 267 at 13. He testified that he understood that Dr. Wright in his work at Kimberly had excluded those times when reference conditions were not met. RT Vol. 252 at 134; RT Vol. 253 at 30, 45. There was no evidence to support this premise. RT Vol. 253 at 34. Indeed, an article by Dr. Wright describing his procedures made no mention of any such exclusions, and instead stated that "Daily reference ET was then computed for the entire period [1968-78] from daily weather data." Kan. Exh. 1172 at 58. Crop coefficients were determined for every day of the growing season. RT Vol. 253 at 41.

In trying to distinguish Kimberly from the CoAgMet stations, Dr. Ley also placed singular reliance on the fact that the Kimberly sensors overlay clipped grass, as opposed to those at the CoAgMet stations. RT Vol. 253 at 53, 55. In ascribing overriding importance to this factor, to the near exclusion of the nearby and distant irrigated environment, he disregarded the weighting factors found in the literature, and those that he himself had used in calculating his aridity ratings. Colo. Exh. 1409, App. B at 2; RT Vol. 252 at 125-26; Kan. Exh. 1109. An analysis by Dr. Allen of the CoAgMet stations demonstrated that more than 90 percent of the impact in the weather sensors came from within a one-mile radius upwind. RT Vol. 267 at 69. Taking into account wind conditions in the Arkansas River Valley, and even assuming bare soil under the weather sensors, Dr. Allen concluded that the average impact on the sensors would be in the range of only 2-3 percent. *Id.* at 68.

Dr. Allen also compared the humidity data from the CoAgMet stations with the data from Kimberly. This evidence showed that the CoAgMet stations were actually more humid, i.e., less dry, than Kimberly. RT Vol. 267 at 38-39. Humidity data for the growing season (March-October) at Kimberly showed that the "daily maximum relative humidity" over the period 1985-98 was less than 80% during 27% of all days. Kan. Exh. 1182, App. C, Table C-1; RT Vol. 267 at 38-39. During 1969-71 when the 1982 Kimberly Penman equation was developed, daily maximum relative humidity was less than 80% during 33% of the days. Kan. Exh. 1182, App. C, Table C-1; RT Vol. 267 at 29. Comparing the CoAgMet stations, daily maximum relative humidity at Vineland was less than 80% during 14% of the days; 14% at Avondale 17% of the days; and at Rocky Ford during 19% of the days. RT Vol. 267 at 38-39. Dr. Allen concluded, properly I find, that the CoAgMet measurements should not be adjusted to remove the impact of "dryness of air." RT Vol. 267 at 41. The CoAgMet values of crop ET are distributed daily for use in irrigation scheduling in Colorado, and these data are not adjusted for aridity. RT Vol. 252 at 104, 117-18; Kan. Exh. 1178.

While certainly Dr. Ley was conscientious in his efforts to fully assess the CoAgMet data, I find that the evidence on the whole does not support his recommended aridity adjustments.

F. Irrigation Management Adjustment.

Dr. Hill also reduced the ET values he calculated using the 1982 Kimberly Penman method by applying an irrigation management adjustment factor. Alfalfa ET was reduced by 6%; corn, sorghum and grains by 5%; and vegetables were reduced by 3%. Colo. Exh. 1409 at 33-34; Table 12 at 43. The downward adjustment was intended to reflect the difference between reference equation conditions, and the results that might be expected in farm fields. RT Vol. 250 at 17. Such differences included irrigation scheduling, uniformity of irrigation, and "perhaps" frost, hail, insects and disease. RT Vol. 249 at 134. These reductions were a "judgment" decision, although he relied heavily on a 1979-81 Utah study for alfalfa ET. RT Vol. 249 at 135, 138, 150; RT Vol. 250 at 82; Colo. Exh. 1409, App. A, Fig. 2.

The results of the Utah study are found in Dr. Hill's Report. Colo. Exh. 1409, App. A, Fig. 2.[13] Dr. Hill looked at three Utah fields in Figure 2 and found that their average ET was 8% less than the ET calculated by the 1982 Kimberly Penman equation with a 100-mile per day wind limit. RT Vol. 250 at 16-17. He concluded, therefore, that if the equation were overestimating in Utah by 8%, it would be "reasonable to expect that it might overestimate by 6 percent in the Arkansas River Valley." RT Vol. 250 at 81-82.

In analyzing these three Utah fields, however, there is some question about the accuracy of the ET field results. Consumptive use was determined not through lysimeter measurements, but rather using neutron meters to measure changes in soil moisture content. RT Vol. 250 at 58. The difference in soil moisture between two dates was calculated as the measure of ET. RT Vol. 267 at 82. Of course, it was necessary under this procedure to account for applied water, either from irrigation or rainfall. The three fields were irrigated by sprinklers, not by furrows as in Kimberly. RT Vol. 250 at 59. The sprinkler water was measured by rain gauges, and Dr. Allen testified, with literature support, that such measurements likely underestimated the irrigation, and thereby the ET. RT Vol. 267 at 83-85. Use of rain gauges to measure sprinkler irrigation is a generally recognized problem, causing underestimation of applied water from 6 to 8 percent. *Id*.

[13] The same Figure 2 is also included in a Bureau of Reclamation study that compared the behavior of 10 selected equations in estimating alfalfa ET. Colo. Exh. 1423 at 3-20.

Dr. Hill also acknowledged that it was difficult in the Utah study to determine how much water might have been lost to deep percolation past the root zone, as opposed to the water actually consumed by the crop. RT Vol. 250 at 59, 69-70. The neutron probe measurements could have included deep percolation. *Id.* at 65. The probes measured an area about 18 inches in diameter, and those results were then projected over the rest of the field. *Id.* at 62-63. Dr. Hill did not know whether the three fields had received a full water supply, which is a requirement of the reference equation. RT Vol. 250 at 36-37. Finally, part of the reduction in field ET was due, as Dr. Hill acknowledged, to the "windrow effect." RT Vol. 249 at 138. This referred to a situation where farmers left cut hay on the ground for 8-10 days, thereby affecting the regrowth of the plants underneath. *Id.* There was no evidence that this practice was prevalent in the Arkansas River Valley.

Dr. Hill's only observation of farms in the Arkansas Valley came from a two-day driving trip with Dr. Ley. This visit included not only some Colorado farms, but also farms in Kansas as far downstream as Garden City, a distance of 150 miles in all. RT Vol. 247 at 80-81; RT Vol. 249 at 148-49. Dr. Hill testified that some farms were in "good" condition, while others were not, although he made no quantitative division. RT Vol. 269 at 164. In any event, on the basis of this brief and incomplete tour, he concluded that the Colorado fields were "obviously not in lysimeter condition," and by implication that a management adjustment was required. *Id.* His adjustment included all fields, including those in good condition, apparently on the premise that reference calculations always overestimate ET on the farms. But the Bureau of Reclamation report, that includes the Utah study on which Dr. Hill relied, also includes a number of other studies where the Kimberly Penman equation underestimates the field calculated ET. Colo. Exh. 1423, Figures 3-2 through 3-10. In this case, Dr. Hill had no field measurements of ET in Colorado. Nor did he know whether the fields he saw had a full water supply. PET comes into play only at times of full water supply. RT Vol. 267 at 82. Dr. Hill did understand that PET in the H-I model is not necessarily the same as the ET in a field. RT Vol. 269 at 166. The H-I model includes a factor based upon calculated soil water content, and if the moisture content drops below a certain level, then the model makes the adjustment of actual ET below the PET. *Id*.

As support for his 6% reduction in PET, Dr. Hill also pointed to a study by Dr. Allen in the Imperial Irrigation District in California. In that study Dr. Allen compared ET calculated by a reference equation known as CIMIS Penman [different from the Kimberly Penman] with consumptive use calculated from a water balance analysis. RT Vol. 250 at 91-92. The study is reported in Colo. Exh. 1427, and provided a district-wide ET, including some 400,000 acres. RT Vol. 267 at 75. The Imperial Irrigation District presents a unique situation. Its whole supply comes by canal from the Colorado River, and is carefully measured. Once used for irrigation, all tailwater runoff and groundwater resulting from leaching are collected in a drainage system, measured, and discharged into the Salton Sea or the New and Alamo Rivers. RT Vol. 267 at 74. The difference between the incoming supply, and the discharges into the Salton Sea and the two rivers, represents the consumptive use of the various crops which turned out to be less than the PET calculated from the reference equation. Dr. Allen then utilized aerial photos, a visual grid system of greenness, density, and bare fields, and following certain FAO-56 prescribed procedures, adjusted the reference equation to reduce ET by 6%, that is, close to the water balance results. RT Vol. 267 at 81. It is common knowledge that the Imperial Irrigation District is below sea level, and Dr. Allen testified to extreme summer heat there, between 105 and 110 degrees, and "cracking" clay soils, that provide a poor basis to justify an equivalent adjustment in the Arkansas River Valley. RT Vol. 267 at 79.

Dr. Hill has developed a commercial model for crop growth and irrigation scheduling which is applicable to commercial fields as well as experimental plots. Kan. Exh. 1163. The model has been used for a wide range of crops, including alfalfa, grown in the Arkansas Valley, in Idaho, Utah, and in many countries around the world. *Id*. at 3. The model uses the Kimberly Penman equation among others, without any adjustment for irrigation management. RT Vol. 250 at 112-13.

At the heart of Dr. Hill's adjustments is his opinion that the 1982 Kimberly Penman equation overestimates ET. On the last day of trial he presented a table showing that alfalfa ET was overestimated by 11%. Colo. Exh. 1474. This result was based on Dr. Wright's data from Lysimeter 2 for the years 1972-75. RT Vol. 270 at 30. It is clear, however, that Dr. Wright did not use these data in developing the 1982 Kimberly Penman equation and the crop coefficients associated therewith. RT Vol. 270 at 32-33. Dr. Wright used only data from Lysimeter 1 during the years 1969-71. RT Vol. 270 at 26, 30-34. The data from Lysimeter 2 were rejected by Dr. Wright for a number of reasons: half of the top soil had been removed during leveling operations; more of the highly calcareous subsoil had been mixed into the surface layer; concerns about the strain of alfalfa; periods when not enough water was supplied; and the fact that the irrigated cover was 6.9% less than Lysimeter 1. RT Vol. 270 at 27, 31, 34, 41-42. The data upon which Dr. Wright did rely do not support Dr. Hill's opinion. In fact, the 1969-71 data from Lysimeter 1 used by Dr. Wright show that alfalfa ET was slightly underestimated. Colo. Exh. 1474.

Dr. Allen testified that the management adjustment by Dr. Hill was poorly supported and cannot be checked against any known information. I am in agreement. While the experts speak in terms of "equations," the mathematical certainty that one might be led to expect from this terminology is not real. Clearly, under some conditions, adjustments are made to reflect local conditions, and these adjustments are not without subjective input. RT Vol. 267 at 16, 18, 24-27. However, in this case, a good deal more needs to be known about farm conditions in Colorado before an irrigation management adjustment should be considered.

G. Salinity Adjustment.

Lastly, Dr. Hill adjusted the PET for the effects of salinity in the Arkansas River water. There is no question about the fact that the Arkansas River, especially downstream of John Martin Reservoir, contains a high degree of salts. It is also an accepted principle that salinity can reduce crop yield through reduced consumptive use of water by the crop.

Dr. Hill's analysis was based first upon salinity measurements made by Mr. Miles, and published in a 1977 report. Colo. Exh. 89, Table 1. The Miles Report included a "volume weighted" salinity figure for each of the canals, and also a figure for maximum salinity (TDS). Colo. Exh. 1409, Table 3; RT Vol. 249 at 27-29. The Miles data appear to have been collected over the period 1963-73. RT Vol. 249 at 87. More recent studies have been done, but Dr. Hill used only the Miles data in his calculations. *Id*. at 88-89. From these Miles data, Dr. Hill calculated what he termed a "time weighted" salinity value for each canal. RT Vol. 249 at 29. Using output from the H-I model, his salinity values were then adjusted by effective precipitation and a leaching fraction, that is, the percentage of applied water that passed through the root zone. RT Vol. 247 at 166-67; RT Vol. 249 at 25-26, 76. This process yielded the amount of salinity in the soil. It is the total amount of dissolved (unprecipitated) salts in the soil that affects crop yield. RT Vol. 249 at 65-66. Dr. Hill then relied upon published studies to calculate reductions in crop yield, based upon the soil salinity. RT Vol. 248 at 9-10; Colo. Exh. 1409 at 19, Table 11 at 42. And finally, he used other published studies to move from a reduction in crop yield to a reduction in ET. Colo. Exh. 1409, Fig. A1. There are no standard publications showing a direct relationship between salinity and ET. RT Vol. 267 at 102. He concluded that PET should be adjusted based upon salinity effects, particularly below John Martin Reservoir. RT Vol. 248 at 145.

There are problems, however, with the foundation of Dr. Hill's analysis, that is, with the salinity values he used for Arkansas River water. He did not use the volume weighted averages developed by Mr. Miles. Instead, he increased those values by using two-thirds of Miles' maximum values and only one-third of his volume weighted values, in order to develop a "time weighted" value. RT Vol. 249 at 29, 35, 69. For example, for the

Bessemer Canal, Miles' data showed a volume weighted average TDS, in parts per million, of 300, and a maximum value of 770. Colo. Exh. 1409, Table 3 at 22. Dr. Hill's time weighted average for the Bessemer was calculated to be 615. *Id*. This approach approximately doubled Miles' volume weighted averages for all canals. RT Vol. 267 at 98. The effect of Dr. Hill's modifications was to assume that all of the canals were diverting river water at maximum salinity two-thirds of the time. RT Vol. 249 at 29-31.

Dr. Hill's approach was not in accord with procedures outlined in the National Engineering Handbook, which call for using a volume weighted average in determining soil salinity, and was strongly criticized by Kansas' expert. Colo. Exh. 1401 at 2-115, 2-116; RT Vol. 267 at 92-94, 116. Salinity impacts on crop yield derive from the total amount of dissolved salt in the soil, which is related not only to the concentration in the applied water, but to the amount of irrigation water. Maximum irrigation water salinity is a measurement at a point in time, and does not relate to the total amount of salts applied to a field. Moreover, maximum salinity is likely to occur during low flow conditions in the river when the amount of water and salt delivered to a field is small. RT Vol. 267 at 94. Dr. Hill acknowledged that salinity problems are generally going to occur at low flow conditions, and that high water supply generally means lower salinity. RT Vol. 249 at 16, 18-19.

Dr. Hill modified the Miles flow weighted data because of certain statements found in the text of the Miles Report. The report states, "the volume weighted average TDS level does not accurately reflect the salinity problems," and later, "Unfortunately, many of the canals are diverting much more saline water most of the time. This water often approaches the maximum level shown in Table

1." RT Vol. 249 at 29. On the basis of these statements, Dr. Hill used his judgment to calculate his "time weighted" average based upon two-thirds of the maximum figures reported. Actually, there is no time averaging in his formula, and the reported maximums apparently could have occurred at any time during a decade. A recent study involving six canals upstream of John Martin showed wide seasonal variation in TDS, ranging from 548 ppm to 1190 ppm. Colo. Exh. 1431 at 91; RT Vol. 247 at 176. It should also be noted that Mr. Miles' comments related to "many of the canals," but Dr. Hill's PET adjustment applies to all canals. Miles also stated that canals holding junior rights may be able to divert only in times of higher flows when water quality is better. RT Vol. 249 at 32-33. Generally, the higher the river flows are, the better the quality will be. RT Vol. 248 at 148-49; RT Vol. 249 at 16. Typically, salinity is a concern at times of low flow. RT Vol. 248 at 149; RT Vol. 249 at 18-19.

There is another problem associated with Dr. Hill's analysis. All of the experts recognized that Arkansas River water carries large amounts of calcium and sulfate in solution, and that these ions will precipitate in the soil to form calcium sulfate, better known as gypsum. RT Vol. 267 at 114; RT Vol. 249 at 117, 121, 123-25. The presence of gypsum moderates, and perhaps even eliminates, the effects of salinity. RT Vol. 267 at 115-16. The threshold tolerances of crops for salinity increase where gypsum is in the soil. It can cause a "sizeable adjustment," perhaps as much as 1600 ppm of TDS. RT Vol. 249 at 111-14; Colo. Exh. 1429. Dr. Hill acknowledged the presence of gypsum, but did not take that into account in his calculations. RT Vol. 249 at 114, 117, 124-25. The Miles Report, however, on which Dr. Hill relies, states that "large amounts of less soluble salts [are] precipitated east of La Junta [upstream of John Martin Reservoir]," and that "nearly all of the salt entering the system . . . is precipitated . . . between La Junta and the Stateline." RT Vol. 249 at 85, 104-05. If salts are precipitated out, the Miles Report states that they have no further relevance in regard to salinity problems. RT Vol. 249 at 84, 105.

Salts in the soil can also be controlled, or removed, by leaching, that is, by applying sufficient water to take the salts below the plant root zone. RT Vol. 249 at 71-72. The Miles Report states that even in dry years the senior ditches have water for leaching that "more than compensates for the higher salinity of the water." RT Vol. 249 at 32. Dr. Hill, using the H-I model, applied the same leaching fraction to all crops. RT Vol. 267 at 98. Kansas' expert, however, testified that farmers would operate differently. They would apply less water to salt-tolerant crops in order to preserve more water for leaching on the salt-sensitive crops like vegetables. *Id*. Earlier farmer testimony showed that some farmers used their well water in dry years for vegetable crops. Dr. Hill did not appear to take the quality of well water into account in his analysis. Dr. Hill's analysis showed essentially no reduction in crop yields due to salinity upstream of John Martin Reservoir. Colo. Exh. 1409, Table 11. Downstream, however, he showed yield losses up to 14% for alfalfa, 27% for corn grain, and for vegetables as high as 55%. *Id*. Kansas experts provided solid data to the contrary, showing no differences in crop yields for all of the major crops grown in the Arkansas River Valley between those farms located upstream of John Martin Reservoir and those situated downstream that irrigated with more saline water. Kan. Exh. 1210; RT Vol. 266 at 29, 32-33.

Finally, it does not appear that an adjustment to PET in the H-I model is the proper way to account for any salinity impacts that should be recognized. The PET in the model establishes an upper limit on crop consumptive use. RT Vol. 248 at 149. It comes into play only under conditions of a full water supply, while, as Dr. Hill recognized, salinity problems are typically associated with low flow conditions. RT Vol. 248 at 145-46; RT Vol. 249 at 18-19; RT Vol. 248 at 149. In times of low water supply, the amount of water available for consumptive use in the H-I model is controlled not by PET but by a factor known as the maximum farm efficiency. RT Vol. 266 at 23. This factor is supposed to allow enough water for leaching and tailwater runoff, as well as for ET. RT Vol. 235 at 145, 149-50. If the model does not simulate enough water for the proper leaching of salts, Kansas' expert testified that the maximum farm efficiency percentage should be reduced accordingly. Kan. Exh. 1210 at 6; RT Vol. 235 at 145-50.

Based on all of the evidence, I find that the PET should not be adjusted for salinity effects as recommended by Dr. Hill.

H. Conclusions.

The PET values for the various canals computed by both the Kansas and Colorado experts are similar, except for the adjustments made by Colorado. RT Vol. 247 at 100, 101; RT Vol. 248 at 78-79, 82. I conclude that the Colorado adjustments are not sufficiently supported, and the PET values to be used are those found in Kansas Exhibit 1164, last column. Colorado's final recommended values are found in Colorado Exhibit 1409, Table 13. For the canals below John Martin Reservoir, these Colorado values represent a PET that is approximately 4.5% less than what has been used previously in the H-I model, as determined using the Blaney-Criddle formula, yet there was uncontroverted evidence that the Blaney-Criddle formula already tends to underestimate ET. This is not to say that the Kansas values, as calculated with the Penman-Monteith equation and crop coefficients, can never be changed. As more information is developed on conditions in the Arkansas River Valley, adjustments made in accordance with recognized professional procedures may be appropriate.

During this trial segment, climatic data from electronic weather stations suitable to calculate reference PET using the Penman-Monteith equation were effectively available at only two upstream stations, i.e., Rocky Ford and Avondale-Vineland combined. The ratios between these upstream Penman-Monteith values and the Blaney Criddle values were then used by the Kansas experts, with certain adjustments, to calculate values downstream. However, we now have in operation two new electronic weather stations at Lamar and Holly, and data from those stations should be used to develop appropriate adjustment ratios in those locations. Kansas experts adjusted the Blaney-Criddle PET values not only for the 1993-99 period but also for 1950-92 so that the PET values used in the calibration process would be consistent with the PET values used in the current and future compliance runs of the H-I model. Colorado appears to agree that the model should be recalibrated after inputting revised PET estimates. Colo. Exh. 1408 at 25. This is the procedure that should be followed.

SECTION VII

COLORADO'S CHANGES TO THE H-I MODEL

Dewayne Schroeder, Colorado's modeling expert throughout this long trial,[14] made a number of changes to the version of the H-I model that was approved for purposes of calculating 1995-96 depletions. Some of these changes, for example the amount of supplemental acreage and the credits recognized for dry-up, are discussed elsewhere in this Report. This Section deals with his remaining changes.

A. Interception by the Amity Canal of Fort Lyon Return Flows.

The Amity Canal diverts many miles upstream of its principal service area, and the canal runs along the north side of the Arkansas River immediately down-gradient of the very large area irrigated by the Fort Lyon Canal Company. Amity's own principal service area is located downstream to the east of Fort Lyon, and also on the north side of the river. There are three major drains which discharge tailwater from Fort Lyon irrigation into the Amity Canal, such water becoming part of its supply. RT Vol. 157 at 173-74; RT Vol. 158 at 28-29. The Amity Canal has records of these drain flows, except for four years. For

[14] Counsel for Colorado noted that this trial segment would be Mr. Schroeder's last appearance after dedicating 15 years of his life to this case, through some periods of great personal adversity. Certainly no expert has tried harder to improve the operation of the H-I model. His work has not always been successful, even by his own admission. And I have not always been in agreement. But his efforts have always been forthright, genuine and aimed at being constructive.

the period 1974-99, the recorded flows averaged 7493 acre-feet annually. Kan. Exh. 1093, Table 11; RT Vol. 260 at 66. For reasons that were not explained, the H-I model does not include this water as part of Amity's supply. Mr. Schroeder proposed to remedy this, and Kansas agrees that some modification to the H-I model is appropriate, but disagrees with the amount of intercepted flows proposed by Mr. Schroeder.

Initially, Mr. Schroeder thought that the amount of the intercepted return flows were around 49,000 acre-feet annually, but after reviewing a Kansas report, he reduced that figure. RT Vol. 226 at 87; RT 260 at 41. His revised model first shows average return flows intercepted by the Amity Canal of 41,184 acre-feet for the 1950-94 period. Kan. Exh. 1147. Later still, he made a dramatic reduction to 11,791 acre-feet, although the average period was different, namely, 1970-94. Colo. Exh. 1411, Fig. 2; RT Vol. 260 at 50. This revised amount was based on his conclusion that return flows from 40% of the Fort Lyon area were not tributary to the three drains, and therefore were not measured. RT Vol. 260 at 42, 57. Based on that assumption, Schroeder increased the measured drain flows by 67%. RT Vol. 260 at 53-57, 59. He testified that the Amity Canal receives flows from a number of small drains that are not measured, as well as from groundwater. RT Vol. 260 at 62, 69-72, 75. Mr. Straw made a field investigation of the area, and found more than 40 points at which Fort Lyon return flows enter the Amity Canal. RT Vol. 246 at 100. He was also of the firm opinion that the three measured drains did not capture the full extent of surface water flowing into the Amity Canal. *Id*. at 101. With respect to any groundwater contribution, however, there was evidence that groundwater levels at several points along the

Amity Canal were below the canal, and consequently groundwater could not seep directly into the canal.[15] RT Vol. 260 at 64, 68, 73, 74. Mr. Schroeder testified that he made another adjustment to account for groundwater flows that might go directly to the river, as well as for drain flows that Amity might release to the river during periods of high rainfall. RT Vol. 260 at 62, 66, 70, 72. During his model calibration process, he finally reduced the total amount of intercept flows by 25 percent. RT Vol. 260 at 60-62.

Mr. Schroeder's efforts were, in part, an attempt to remedy the fact that the H-I model historically over-predicts expected river flows at the Lamar gage. RT Vol. 246 at 90. A possible explanation may be that Fort Lyon return flows are actually consumed by the Amity Canal crops rather than flowing to the river. RT Vol. 246 at 90. While this explanation may have some merit, it is clear that far too much uncertainty surrounds the various amounts of intercepted return flows presented by Mr. Schroeder for any of his figures to be ordered as a model change.

In its revised version of the H-I model, Kansas simulated the Fort Lyon return flows intercepted by the Amity Canal at an average of 8517 acre-feet annually for the period 1974-99. RT Vol. 236 at 40; Kan. Exh. 1093, Table 11. This average results from model predictions, determined as a percentage of return flows "that are intercepted in such a way that [they] matched the historical

[15] Nonetheless, the Kansas revised H-I model did simulate some underground return flows. RT Vol. 236 at 47.

amounts [7493 acre-feet].” RT Vol. 236 at 40-42, 47. The Kansas average covers the irrigation season only. Flows during the non-irrigation season are simulated to return to the river. *Id*. at 48-49. The Kansas change was said to “reasonably replicate[s] what the historical records show.” *Id*. at 50. However, such records may not reflect the full amount of intercepted flows. *Id*. at 50. Counsel for Colorado stated that whether the amount “is as high as Mr. Schroeder estimated is another question,” but clearly he said that Kansas acknowledges that the flows are higher than shown by the Amity Canal records, and the proper amount “can be refined through further investigation.” Colo. Reply Br. at 34. Kansas agrees that measurements and monitoring need to be improved so that the model simulation of intercepted return flows is consistent with what is “actually occurring in the real world.” RT Vol. 236 at 50. It is to be hoped that this will be done.

However, based on the limited evidence now before the Court, I find that the H-I model should be changed in accord with the recommendations of the Kansas experts. Perhaps future studies and measurements will dictate a different result, but at present the Kansas evidence is the most reliable.

B. X-Y Graham Alternate Points of Diversion.

The X-Y Canal water rights and the Graham Ditch rights are separate. At some point in time, at least by 1949, the diversion point of the Graham right was moved to the X-Y Canal, and the Graham water rights were diverted through a common canal. The Graham water was carried in the X-Y Canal for about two miles before being discharged into the old Graham Ditch. Colo. Exh.. 1411 at

13; Colo. Exh. 1416 at 2-3. Both of these water rights are relatively junior, but the X-Y right is senior to the Graham right. Colo. Exh. 1411 at 14. The X-Y right is for 69 cfs; the Graham right for 61 cfs. Colo. Exh. 1416 at 2. The capacity of the X-Y canal (66 cfs) was not sufficient to deliver the full amount of both these rights. Colo. Exh. 1411, Table 3. About 1961 most of two water rights and associated lands were combined under single ownership, and these rights are treated in the H-I model as a single water user. Colo. Exh. 1416 at 1, 3. In 1977 the Colorado Water Court approved existing wells as alternate points of diversion for 59.43 cfs of 61 cfs of the Graham Ditch water right. Colo. Exh. 1353 at 9; Colo. Exh. 1416 at 3. These wells would be allowed to pump, without providing replacement water, the amounts of water that could have been diverted under the Graham diversion right, taking into account its priority and the stream flow available. As Colorado succinctly puts it, the issue is "how much of the pumping by the Graham wells should be considered as in-priority pumping under the Graham Ditch water right." Colo. Reply Br. at 38.

Mr. Schroeder implemented an extremely complex change to the H-I model regarding the Graham water right. He stated that the change was made "to account for the fact that the water right decreed to the Graham Ditch had been changed to wells in 1977." Colo. Exh. 1411 at 12-13. It is not apparent why a model change is necessary to account for a decree that merely establishes wells as an alternate point of diversion. However, Mr. Schroeder states that "when well pumping is limited to the pre-Compact pumping allowance in the Compact run, the model does not represent the increased demand to divert surface water . . . that would occur if the wells were not operated."

Colo. Exh. 1353 at 9. If that is true, it seems that the solution would be simpler than what Mr. Schroeder did.

Mr. Schroeder modified the model code by which the diversion demand for the X-Y Graham Canal had been previously determined. He subtracted from that previous demand an estimate of Graham pumping, apparently 40% of the pumping estimate for 1986 to 1995. RT Vol. 236 at 52-53; Colo. Exh. 1411 at 16. The change was only implemented in the model beginning in 1977. Colo. Exh. 1411 at 15-16. Those changes cause the model to demand more surface water in the compact run than it does in the historical run of the model. RT Vol. 236 at 53-54. The final result is to increase consumptive use for the X-Y Canal users in the compact run, in effect increasing its precompact entitlement. *Id*. at 54. For the model calibration period of 1950-94, observed diversions for the X-Y Graham Canal average 7718 acre-feet annually. The revised Kansas version of the H-I model predicts an average of 8390 in the compact run, while the Colorado Test Model predicts an average of 12,440 acre-feet. Kan. Exh. 1117. While the records are spotty and incomplete, a report prepared for LAWMA (which has acquired essentially all of the X-Y right and the X-Y Graham Article II account) shows average diversions for the Graham Ditch of 1383.9 acre-feet for 1895-1932 and 1946-63. Colo. Exh. 1416, Table 2. The LAWMA report also shows that the Graham wells have been pumping between 7000 and 10,000 acre-feet in recent years. *Id*. Table 9.

The Schroeder changes to the model code appear to increase historic use, and should not be made. However, I also do not agree with the conclusion of the Kansas expert, if I understand it correctly. Mr. Sullivan indicated that there was nothing different about the "XY-Graham wells" from all other postcompact pumping. RT Vol. 236 at 65. At least as to the *Graham* wells there are court decrees establishing the wells as alternate points of diversion. It may well be true that the seniority of the X-Y right, the capacity constraints of the X-Y Canal, and the very junior priority of the Graham Ditch water right, all converge to dictate that the Graham lands received little surface water. However, to the extent that the Graham surface rights would be in priority, the X-Y Canal would have had capacity for Graham water, and there would be no enlarged use of the combined X-Y Graham water rights, the model should recognize the amount of pumped water that would have been diverted. Colorado states that there may be a "simpler method" to account for in-priority pumping by the Graham wells than was attempted by Mr. Schroeder. Colo. Response, October 8, 2003.

Kansas argues that this issue is *res judicata*, that no more than 15,000 acre-feet of precompact pumping can be allowed. Kan. Opening Br. at 42. However, I do not believe that prior decisions in this case were meant to preclude pumping to the extent that authorized surface diversions are replaced.

C. Buffalo Canal Seepage.

In July and September of 2001, Mr. Straw made two field trips along the Buffalo Canal to see if return flows were being intercepted from Amity lands. Colo. Exhs. 1419, 1420. On the first inspection he estimated flows from Buffalo Creek, Deadman Draw, Horse Draw and Simpson Draw, totaling approximately 15 cfs. Colo. Exh. 1419. Flows during the second trip were measured, totaling about 28 cfs. The H-I model, as it has been used through the determination of 1995-96 depletions, does not represent these intercept flows. RT Vol. 246 at 98; RT Vol. 260 at 103. These intercepted return flows compare with headgate diversions into the Buffalo Canal of 67 cfs. Colo. Exh. 1420. Responding to those intercept data, Mr. Schroeder reduced the seepage factor in the H-I model for the Buffalo Canal from 9% to 1%. RT Vol. 260 at 96; RT Vol. 264 at 118. His purpose was to simulate the interception of return flows from the Amity lands, and he figured that reducing the seepage rate was "akin to putting more water in the canal." RT Vol. 260 at 96.

While this information was known, the data were not included in Mr. Schroeder's rebuttal report [Colo. Exh. 1411] and did not surface until his rebuttal testimony. RT Vol. 260 at 95. This is unfortunate, because it appears that a model adjustment may be in order, but Kansas experts indicated that Mr. Schroeder's approach was not the best way to address the problem. By reducing the canal seepage rate, the additional water in the canal becomes a function of the headgate diversions, not necessarily equating to the Amity flows. The greater the Buffalo diversions, the greater the Amity intercepted flows simulated in the model. RT Vol. 260 at 99. Moreover, the 1% loss from seepage is not reasonable. RT Vol. 264 at 118.

Mr. Schroeder's proposed model change increases the Buffalo water supply by an average of approximately 1500 acre-feet annually, which in turn reduces Stateline depletions. RT Vol. 264 at 121-22; RT Vol. 260 at 104. Mr. Book suggested that it would be necessary, before any model change is made, to look at the whole Buffalo Canal operation – with quantitative measurements of intercepted Amity return flows, amounts of water actually delivered to farmers, and amounts of water turned back into the river through wasteway gates. RT Vol. 264 at 119. I am in agreement, and find that no change in the Buffalo Canal seepage rate should be made on the basis of present information.

D. Ungaged Tributary Inflows.

This was another effort by Mr. Schroeder to improve the model data on ungaged tributary inflows. He made the daily ungaged flows for certain reaches proportional to the gaged flows for the Huerfano and Apishapa Rivers. RT Vol. 260 at 37. Kansas acknowledges that perhaps this approach "has some merit," but again it came late in the trial, not being included in Schroeder's rebuttal report or even in his direct testimony. I concur with Kansas that any model change should be explicitly presented to the other state and to the Special Master. This is a matter for the future, not to be approved here.

E. Rerouted Return Flows, and Fort Lyon Leakage Allowance.

Mr. Schroeder proposed rerouting a portion of Reach 7 return flows to Reach 8. This model change made such Reach 7 flows unavailable for diversion by the Fort Lyon Canal. Colo. Exh. 1353 at 8; Kan. Exh. 1093 at 35. Kansas was in agreement with this change, and it should be made. Kan. Opening Br. at 45.

Mr. Schroeder also recommended initially a 30 cfs bypass of streamflow at the Fort Lyon Canal headgate because of leakage around, through, and under the diversion structure. Colo. Exh. 1353 at 10. During rebuttal testimony, however, he stated that the change did not operate in the Colorado test model as intended, and he withdrew the proposal. Kansas is in agreement that no such bypass should be considered "at this time." Kan. Opening Br. at 46.

F. Holbrook Returns, Rocky Ford Transfer, and Lamar Canal.

After Kansas experts pointed out that Mr. Schroeder had allowed the Amity Canal to intercept too much Fort Lyon return flow and certain other matters, Schroeder made several other model changes which Colorado characterized as "minor." Colo. Reply Br. at 56. These were part of the calibration process of the Colorado Revised Test Model, and were intended to address his model's over-prediction of consumption below John Martin Reservoir, and the Kansas Revised Model's over-prediction of streamflows at Lamar. Kansas states that it is "open" to considering at least one of the changes, but Kansas did not respond technically because the changes were raised first on rebuttal, and some were undocumented except in the computer code itself. The changes do not appear to be substantial, e.g., accounting for exchanges that occurred after the transfer of shares in the Rocky Ford Canal to municipal use, and using actual recorded Lamar power plant discharges into the Lamar Canal rather than predicting such diversions, and should be matters that experts can agree upon. Nonetheless, the evidence is probably insufficient to order them at this time.

G. Calculation of Model Demand.

In the H-I model, the demands for water, i.e., surface water diversions, are predicted by a subroutine known as GET. RT Vol. 227 at 51. The diversions thus predicted are then passed to another subroutine termed LAND, and distributed among consumptive crop use, canal seepage, losses, etc. *Id*. In prior versions of the model, the same acreage figure was used for the most part in both of these subroutines, that is, to predict diversions as well as to determine consumptive use. RT Vol. 227 at 52-53. For the 1986-94 version of the H-I model the acreage figures used in connection with both of these subroutines are found in Colorado Exhibit 1353, Table 1, Col. 1. RT Vol. 227 at 52. For the 1995-96 version of the model, the acreage figure was 309,654. Colo. Exh. 1353, Table 1. Mr. Schroeder changed this methodology, using a different acreage figure to determine demand from that which was used for consumptive use. RT Vol. 227 at 51-53. The reason for the change was to recognize new lands that had been found in Colorado's 1998 acreage study to be irrigated by wells only, i.e., the "sole source" acreage. Colo. Exh. 1353, Table 1. Previously these lands had been included in the model's demand for surface water diversions. Colo. Exh. 1353, Table 1; RT Vol. 225 at 118-19, 121-23; RT Vol. 227 at 51-52.

For the GET subroutine to determine surface water demand, Mr. Schroeder included the total amount of acreage that "could" receive surface water irrigation, i.e., 295,336 acres. Colo. Exh. 1411, Table 1. This figure did not include the "sole source" lands, i.e., lands irrigated by wells only. *Id*. Kansas described this as a "significant change," one that increased the amount of surface water on the acreage used to calculate consumptive use, thereby causing extra water to "pile up" in the canal service area and leading to reduced impacts from well pumping. Kan. Opening Br. at 45. Colorado, on the other hand, treats the change simply as a "refinement to the calculation of demands in the model," that recognizes that the demand for surface water may be different from the total acreage irrigated. Colo. Reply Br. at 55.

Colorado states that Kansas seems to misunderstand the nature of Mr. Schroeder's change. Perhaps that is so, although the record is not clear. Kansas says that Schroeder used 298,835 acres to determine demand, but 28,165 acres less to calculate consumptive use. Kan. Opening Br. at 44. Kansas provides no citation to the record to support this statement, and I have not found testimony to this effect. While Kansas cross-examined Mr. Schroeder on his change, Kansas did not offer any expert testimony of its own. The figure of 28,165 comes from Colo. Exh. 1353, Table 1, and reflects the amount of land that was found not to be irrigated in Colorado's 1998 acreage study, but I have seen no evidence as to how this acreage was treated in the LAND subroutine. Mr. Schroeder's testimony on the subject did not mention nonirrigated lands, but rather dealt with evaluating demand for surface water, and the exclusion of sole source well acreage. I note that the heading in Kansas' Opening Brief refers to the use of nonirrigated acreage to "calculate demand," but their argument relates to the calculation of consumptive use. Kan. Opening Br. at 44.

Comments on the draft of this Fourth Report add to the confusion surrounding this proposed model change. Kansas states that it leads to the anomalous procedure of using a greater and permanent acreage to calculate demand for surface water than the annually determined acreage used to calculate the consumption of the same surface water. Given the current state of the record, Colorado suggests in its comments on the Draft Report that "this is an issue that should be left for the future." I agree. I do not feel confident from the evidence at hand in trying to make a decision on such a technical modeling issue. Once the other modeling changes are made, depending upon Court approval, experts from both states should evaluate Mr. Schroeder's proposed change and try to find the best way to deal with this matter.

SECTION VIII

CONTESTED DRY-UP CREDITS

Kansas challenged certain of the consumptive use credits included in LAWMA's 1997-99 Replacement Plan as approved by Colorado. The plan included credits attributed to LAWMA's acquisition of all or a portion of the shares of the Sisson-Stubbs Ditch, X-Y Canal, Fort Bent Ditch, and the Highland Canal. Common to all of these water rights acquisitions were issues over the amounts of land historically irrigated, and the consumptive use of water attributed to the acquired shares. Additionally, Kansas complained that the volumetric limits accepted by Colorado for the calculation of Highland Ditch credits permitted an expansion of historic use, and raised further issues related to possible subirrigation on alfalfa fields claimed for dry-up.

In December 2002 LAWMA filed an "Application for Change of Water Rights and Plan for Augmentation" with the Colorado District Court, Water Division No. 2 ("Water Court") as required by Colorado law. Colo. Exh. 1468; Kan. Exh. 1123, Rules 5 and 6. This Application seeks appropriate water rights changes for all of the water rights, among others, that were included in LAWMA's Replacement Plan and contested by Kansas. The Application relates to the acquisition of all of the 7.20 cfs of the Stubbs Ditch water right; 67 cfs of the 69 cfs X-Y Canal water right; 2250 shares of the total number of 11,651.2 Fort Bent shares; and 55.95 cfs of the 62.5 cfs Highland Canal water rights. Colo. Exh. 1468, pp. 2, 4. 11, 16. The consumptive use credits for these rights will be determined by the Water Court, and the Application states that such credits "will be left undiverted in the river." Colo. Exh. 1468 at 24-25. The issues raised by Kansas will be before the Water Court, including strict standards for monitoring and verifying lands claimed for dry-up.

Kansas suggests that proceedings before the Colorado Water Court may not provide the protection to which it is entitled under the compact, and that these dry-up issues should be decided by the Supreme Court on my recommendation. I do not agree. The Arkansas River Compact states that, except as otherwise provided, "nothing in this Compact shall be construed as supplanting the administration by Colorado of the rights of appropriators of waters of the Arkansas River in said State as decreed to said appropriators by the courts of Colorado. . . . " Article VIA(2). Colorado has established a system of Water Courts, with specialized water judges, to examine precisely the kind of issues now involved in the LAWMA acquisition of rights. Indeed, all transfers and changes in water rights must be approved under Colorado law by the Water Court. The LAWMA application provides that the replacement water supplies, for which approval is sought, are intended to replace all out-of-priority stream depletions to senior surface water rights in Colorado that are caused by LAWMA well pumping, and also to replace "all stream depletions which would materially deplete the waters of the Arkansas River in usable quantity or availability for use to the water users in Kansas under the

Compact." Colo. Exh. 1468 at 21. The application seeks adjudication of an augmentation plan that "assures compliance with the Arkansas River Compact." *Id*. at 2. To be sure, these various dry-up issues could be decided by the Supreme Court within the parameters of this case. But that would not obviate the Water Court proceedings because senior surface rights in Colorado must still be protected from depletions caused by LAWMA's pumping. What would occur is the possibility of inconsistent judgments between the Colorado courts and the Supreme Court, surely a result to be avoided if possible.

I find that it is not necessary, at this time, for the Supreme Court to decide the final amount of credits that should be allowed in LAWMA's 1997-99 Replacement Plan. Compact compliance for 1997-99 is recommended in this Report without having to rely upon the full amount of LAWMA's claimed credits. That finding can be supported on the basis of Kansas evidence which does not take into account disputed replacement credits. Moreover, future compact compliance, as recommended in Section IX, will be determined over a longer period of time sufficient for the Colorado courts to act. I find, therefore, that the final judgment of the Colorado Water Court, after any appeals, should be used to determine the amount of credits allowed in LAWMA's 1997-99 Replacement Plan, and ultimately applied toward compact compliance, as determined using the H-I model. Credits not subject to Water Court approval, or calculated outside of the H-I model, shall be determined in accord with Colorado's Use Rules and the implementation procedures described in this trial segment. None of these determinations, however, precludes Kansas from seeking review under the Court's original jurisdiction.

Moreover, I find that major Colorado canal companies are likely to protest or appear in the LAWMA Water Court proceedings, and that these canals have essentially the same interests as Kansas in preventing any expansion of use by LAWMA. RT Vol. 254 at 143-44, 147; RT Vol. 257 at 40-41. The Amity Canal, in particular, is expected to be a major objector. Amity has a relatively small number of wells and relies primarily on river flows. RT Vol. 257 at 40. Even upstream junior rights holders have an interest in preventing any enlarged use under the rights acquired by LAWMA. They can be affected by what is termed a "rebound call." RT Vol. 254 at 147. Any expansion of prior use reduces return flows and the supply available to downstream senior rights like the Buffalo Canal [holding a 1885 priority]. In turn, this increases the "calls" against upstream junior rights requiring them to pass more water downstream.

SECTION IX

PROSPECTIVE COMPACT COMPLIANCE MODELING

Both states applied the H-I model to assumed future conditions in an effort to test the long-term adequacy of Colorado's Use Rules. While the Use Rules and Colorado's replacement water program were fully in effect for the 1997-99 period, it is undisputed that these were wet years, and not representative of typical conditions that may be expected in the future, or that were experienced generally in the past. Kan. Exh. 1093 at 6; RT Vol. 246 at 27. Kansas, in particular, did not believe that these were "good years" by which to test the viability of the Use Rules. RT Vol. 237 at 43. Kansas maintained that the low Stateline depletions found in 1997 and 1999 were "mostly a function of the hydrology of those years and not the operation of the replacement plans." *Id*. at 44. The issue, of course, is whether the Use Rules under all conditions will maintain compact compliance, namely, that Arkansas River flows "shall not be materially depleted in usable quantity or availability for use to the water users in Colorado and Kansas. . . . " Art. IV-D.

In making these prospective analyses, both states assumed that the Colorado Use Rules would remain in effect in their present form, and that replacement water would be provided in accordance with the Rules. The results of the Kansas prospective analysis, using 1950-94 hydrology, showed that Colorado would be short in meeting its compact obligations by an average of 11,036 acre-feet per year. Kan. Exh. 1093, Table 15, Col. 32. A shortfall was present in each year, with depletions ranging between 1953 and 19,137 acre-feet. *Id*. On the other hand, the Colorado model results for the same 1950-94 simulated period showed surplus deliveries at the Stateline averaging 5175 acre-feet per year. Colo. Exh. 1408, Table 14b.

The disparate results are directly related to the different modeling assumptions and changes made by each of the states. The modeling approaches employed by each state are discussed in the following sections, but I have concluded that the modeling efforts of both states involve far too much speculation, as well as modeling changes that may well depart from actual conditions, to provide reliable forecasts of whether Colorado's Use Rules will be effective in assuring future compact compliance. Instead, my recommendations for determining compact compliance are found in Section X.

A. Kansas' Prospective Compliance Model.

The Kansas prospective compliance analysis was based upon its revised H-I model used for the 1997-99 period, but with certain additional modifications. Kan. Exh. 1093 at 51. A repeat of the 1950-94 hydrology was retained, along with current institutional conditions (e.g., the 1980 Operating Plan, current levels of transmountain imports, operation of the Winter Water Storage Program). However, changes were made with respect to assumed levels of pumping; the distribution of pumping on the basis of "unmet demand"; the use of permitted and decreed groundwater acreage; and the use of the Penman-Monteith method to establish potential evapotranspiration in place of the Blaney-Criddle procedures.

1. Assumed Future Pumping.

Kansas assumed that future pumping would average 130,000 acre-feet per year over a repeat of 1950-94 hydrologic conditions. Kan. Exh. 1093 at 52, Table 15. The maximum level of pumping is 200,000 acre-feet, which is reached five times during the 1950-94 period. *Id.*, Table 15. Each of these five years was listed as "very dry." Colo. Exh. 1408, Table 11. However, recent dry year experience in 2002 would indicate that the amount of replacement water available would only permit pumping in the order of 100,000 acre-feet. RT Vol. 254 at 113-14. During Mr. Books' examination, I noted that high levels of pumping in the order of 200,000 acre-feet had not been seen for a long time, and looking to the future, "we're not likely to see that much again." RT Vol. 241 at 111. Mr. Book generally agreed. Apparently the higher estimates were made when Kansas thought that more replacement water would be available. *Id.* at 112-13. Nonetheless, Mr. Book still believed that the 130,000 acre-feet average was realistic. *Id*. at 113. Historical pumping from 1970-94, after well development had stabilized, averaged about 170,000 per year, with a peak of about 287,000 acre-feet. *Id*. at 111-12; Kan. Exh. 1093 at 58. However, those numbers reflect pumping before replacement water was required. The Kansas estimates of pumping assume that sufficient amounts of replacement water will be available, and will not act additionally to constrain pumping. RT Vol. 237 at 71-72; RT Vol. 254 at 55-56. Because of this assumption, Kansas experts testified that their analysis was "somewhat insensitive" to the exact magnitude of pumping. RT Vol. 237 at 72, 80. But as a corollary, the availability of replacement water becomes a critical premise. Colorado's estimate of future pumping, as constrained by the availability of replacement supplies, averaged 111,047 acre-feet per year. Colo. Exh. 1408, Table 13.

2. Kansas' Redistribution of Pumping.

A more important part of Kansas' prospective compliance analysis lay not in the amount of assumed pumping, but rather in the way in which the model distributes pumped water. In all prior versions of the H-I model, the use of groundwater had been based on the general assumption that if a section of land contained a well, all of the acreage within that section was assumed to be irrigated with groundwater. RT Vol. 239 at 6, 11-12. This was reflected in the model as a percentage of the acreage in a ditch service area that was irrigated with groundwater. For example, with respect to the Bessemer Canal, the model assumed that 100% of the area was irrigated with wells, while for the Fort Lyon Canal the percentage was only 30%. Kan. Exh. 1093, Table 4; Colo. Exh. 1353, Table

2; RT Vol. 238 at 152; RT Vol. 239 at 12. In determining compliance for the 1997-99 period, both states used versions of the H-I model that included this historic pattern of groundwater use. RT Vol. 238 at 112. However, in its prospective compliance model, Kansas made a significant change, described as "very important" by Mr. Sullivan. RT Vol. 263 at 105. Indeed, if the Kansas prospective compliance model had represented the same amounts and distribution of pumping used by Colorado, the Stateline depletions forecast by Kansas would have been reduced from an average of 11,036 acre-feet per year to approximately 2500 acre-feet. RT Vol. 263 at 107, 109.

In its prospective compliance analysis, Kansas distributed pumping on the basis of "unmet demand." RT Vol. 241 at 121-22; RT Vol. 238 at 18-19; Colo. Exh. 1408 at 62-63. This distribution included lands irrigated solely by groundwater, as well as lands irrigated with supplemental groundwater. Kan. Reply Br. at 57. This was an effort, according to Kansas' experts, to eliminate what they called "excess pumping" in the model. RT Vol. 238 at 16-22, 117, 144. In reality, the issue relates to the consumptive use of groundwater as simulated in the model. Higher consumptive use leads to greater Stateline depletions, and lower consumptive use leads to lower depletions. RT Vol. 238 at 22. Kansas experts testified that prior versions of the model allowed groundwater to be "stacked up" on top of surface water, with the result that the consumptive use of groundwater was too low; or put conversely, that too much pumped water was simulated as returning to the river. RT Vol. 237 at 140; RT Vol. 239 at 11, 15, 49. They said that in the historic run of the model, the pumping input file did not fit the demand for water, and that a better distribution of groundwater was needed. RT Vol. 238 at 18-19, 144.

Kansas produced an analysis which purported to show that in the Colorado Test Model only 26% of all pumped water was consumed, against an expected consumptive use of approximately 65%. Kan. Exh. 1119*. That would mean that the model simulated 74% of pumped water as being returned to the river. In the Kansas Revised Model (used by Kansas for 1997-99 compliance), the analysis concluded that 43% of pumped water was consumptively used. *Id*. Only in the Kansas prospective compliance model did the consumptive use of well water reach usual values. RT Vol. 238 at 97-98.

The Kansas experts understood that Colorado farmers did not actually pump water just to run it down a furrow and back into the river. They recognized the issue of "excess pumping" as an artifact of the H-I model. When asked, however, why this problem surfaced only now, after 12 years of trial, the Kansas response was a bit worrisome. They testified that their understanding of the model had "matured through time as we better and better understand the complexities of the model." RT Vol. 239 at 28. Yet this is a model which was developed by Kansas, which has been defended by Kansas experts over the years, and which has been used throughout three trial segments to determine Stateline depletions.

If there is a concern over the way in which the model simulates the consumptive use of groundwater, the solution proposed by Kansas seems to have its own problems. In an effort to better match pumping to unmet demand, the Kansas revisions reallocate future pumping among certain canals in ways that are quite contrary to actual historic records. Nor is there any evidence that these changes might be expected to occur in the future. For example, for projected 1950-94 conditions, the Kansas model shows no pumping at all for most years by the Catlin Canal, while in the 1997-99 period it actually pumped over 5000 acre-feet each year. Colo. Exh. 1408, Tables 6 and 10; RT Vol. 246 at 106-07. Again, the Lamar Canal shows no pumping at all during the 45-year period, except for 252 acre-feet in a single year. Colo. Exh. 1408, Table 10. During 1997-99, the Lamar Canal actually pumped between 3428 and 6428 acre-feet. Colo. Exh. 1408, Table 6. Other canals showing many, if not most, years of no pumping were the Oxford, Las Animas and Baldwin-Stubbs. Colo. Exh. 1408, Table 10. On the reverse side, the Fort Lyon Canal shows minimum pumping of 22,778 acre-feet and ranging as high as 62,357 acre-feet, while actual pumping in 1997-99 was only 12,169 to 17,098 acre-feet. Colo. Exh. 1408, Table 10; Colo. Exh. 1408, Table 6. The Colorado Canal also showed a substantial increase, with pumping as high as 15,936 acre-feet and never below 4105 acre-feet, even though most of its lands have been dried up. Colo. Exh. 1408, Table 10. During 1997-99 its actual pumping fell between 2347 and 3029 acre-feet. Colo. Exh. 1408, Tables 6 and 10.

Mr. Sullivan testified that the pumping assigned to the Colorado Canal was “not intended to be a prediction of how much water is . . . going to be pumped under the Colorado Canal in the future.” RT Vol. 239 at 130. He simply distributed pumping to meet unmet demand, and said that he “could have distributed the pumping to some other unmet demand under different canals.” *Id*. The same was true with respect to the Fort Lyon Canal which “could have been redistributed elsewhere.” *Id*. at 131. In the Kansas prospective compliance model, Sullivan simulated about 10,000 acre-feet of excess pumping annually. While his analysis reflected a particular distribution, he said the "exact ditch under which it occurs is not crucial to the analysis." RT Vol. 239 at 117, 101-03. Yet the point of the model is to simulate actual conditions, and the model must be anchored to reality as closely as possible. Otherwise, any number of model adjustments can be made simply to produce a desired result. That is not to say that the Kansas pumping distributions here were not aimed at correcting what they perceived to be a genuine shortcoming in the model. Indeed, Mr. Sullivan's goal was to "try to get the model to reflect what is actually going on." RT Vol. 238 at 99-100. However, it is hard to understand how such departures from reality accomplish that objective.

3. Kansas' Irrigated Acreage.

The Kansas prospective compliance model estimated the amount of acreage irrigated by wells using the decreed and permitted acreage for all wells in existence in 1998, including both active and inactive wells. RT Vol. 239 at 23-24, 49. The amount used was 147,308 acres. Kan. Exh. 1093, Table 4. Generally speaking, distributing groundwater over a larger area causes it to become more consumptive and increases depletions. RT Vol. 239 at 51-60; RT Vol. 244 at 89-93. This acreage was also used to calibrate the revised Kansas model for 1950-94, even though admittedly there were substantially fewer wells in the 1950s and 1960s. RT Vol. 239 at 22-23. However, Mr. Sullivan testified that simulating a larger amount of acreage in the model than actually existed would not impact model results, so long as farmers were not applying water in excess of demand. RT Vol. 239 at 24. Without excess pumping, he said the model was not sensitive to the amount of acreage. *Id.* at 24-25. Nonetheless, with regard to this specific model input, actual acreage figures were available from Colorado's 1998 study. And even if Kansas disagreed with those results, its own study showed only approximately 110,000 acres irrigated by wells for the 1997-99 period. Kan. Exh. 1093, Table 3. This figure compares with 147,308 used by Kansas in its prospective compliance analysis.

4. LAWMA Replacement Sources.

Kansas assumed that 12,021 acre-feet annually would be available from LAWMA's main stem replacement sources for each of the 45 years in the prospective analysis. RT Vol. 246 at 109-10. This was the amount included in LAWMA's Replacement Plan application and approved for 1999. RT Vol. 239 at 132-33. Colorado points out, however, that 1999 was a very wet year, and it is unrealistic to project such replacement supplies, which depend upon river flow, to be available in all years. Indeed, Kansas' own expert agreed that these main stem sources would not produce 12,000 acre-feet in a dry year. RT Vol. 239 at 135. He also agreed that depletions shown by the prospective compliance model would be less if the 12,000 acre-feet were not available. *Id*. at 140-142. As represented in the H-I model, LAWMA's total yield from its main stem sources in 2002, a very dry year, was only 5923 acre-feet. Colo. Exh. 1471.

B. Colorado's Prospective Compliance Analysis.

Colorado made three compliance analyses to test the adequacy of its Use Rules. Two of these were made by Mr. Schroeder, the first using his version of the H-I model known as Test Model, and the second using the Revised Test Model. Colo. Exhs. 1353, 1411. Both of these models were calibrated to a later and shorter period, namely 1970-94, than had been previously used by both states. Prior versions of the model had been calibrated using the period of 1950-94. In the calibration process, Mr. Schroeder also made a number of model changes, including the development of different WANT factors for the canals downstream of John Martin Reservoir, and calibrating that area over an even shorter period of 1980-94. RT Vol. 264 at 110-11. These more recent years were not representative of long-term hydrology. All but one year after 1980 were classified as average or wet. Colo. Exh. 1408, Table 11; RT Vol. 265 at 72. In his test models, Mr. Schroeder also based his irrigated acreage from 1969-94 on the 1998 Colorado study figures, even though half the wells were inactive in 1998. RT 260 at 141-42. And in the years prior to 1969, he stepped down the irrigated acreage even further. *Id*. at 142, 144. In any event, the results of both test model runs showed no depletions of usable Stateline flows, taking into account accretions. Colo. Exh. 1353, Table 6; Colo. Exh. 1411 at 37-38, Table 6a at 57. These results received little attention during the trial, perhaps because of the Kansas view that the analyses were oversimplified, since the replacement waters required by the presumptive depletion factors were simulated to be replaced at exactly the locations where the depletions occurred. RT Vol. 243 at 83-84. Of course, this is not what actually happens.

The other Colorado prospective compliance analysis was prepared by Mr. Straw. It, too, showed that application of the Use Rules resulted in sufficient replacement of depletions to usable Stateline flows. RT Vol. 254 at 20. However, one of Mr. Straw's key assumptions with respect to the amount of future pumping was strongly disputed by Kansas. Based on the hydrology of the five years of 1997 through 2001, and the measured amounts of pumping during each of those years, Straw developed supply and demand curves for future amounts of pumped water. Colo. Exh. 1408, Fig. 2; RT Vol. 254 at 56-65. The supply curve represented the amount of replacement water estimated to be available, which acted to constrain the actual use of pumped water. In projecting future supply and demand, he classified each of the years in the 1950-94 period as very wet, wet, average, dry and very dry, which were derived from 1997-2001 conditions. Colo. Exh. 1408, Table 11. The years 1997 and 1999 were ranked as very wet, 1998 and 2000 as wet, and 2001 as average. The projected results of his supply-demand analysis are shown in Table 12 of Colorado Exhibit 1408. The highest demand for groundwater is 182,463 acre-feet under 1954 conditions. However, actual pumping is limited by the supply of replacement water deemed to be available under 1954 conditions, namely, 104,710 acre-feet. Conversely, the highest supply of available replacement water is 158,839 acre-feet shown in 1980. But under those hydrologic conditions, not as much pumped water is deemed to be needed and the demand, and hence the pumping, is only 102,850 acre-feet. *Id*. As a result of this analysis, Mr. Straw's estimated future pumping ranges between approximately 100,000 and 120,000 acre-feet.

While in theory the approach used by Mr. Straw appears to be sound, Kansas experts properly objected that the five pumping data points plotted in Fig. 2 (Colo. Exh. 1408) are not sufficient to support specific values over 45 years. There is only one data point to represent pumping in an average year, and none in dry or very dry years. Mr. Straw also assumed that no additional replacement supplies would be available in the future from agriculture, and that water from the municipalities could be obtained only in wet and very wet years. RT Vol. 254 at 66, 71-79. While these assumptions may turn out to be true, there can be no certainty about agricultural conditions. Yet those assumptions are critical to the Colorado estimate of future pumping. As Kansas notes, the Colorado estimates of pumping were in fact exceeded in two of the five recent years. RT Vol. 262 at 65; RT Vol. 254 at 81. Mr. Straw's analysis was also based upon use of Colorado's Revised Test Model, and is subject to the concerns about that version of the H-I model. Colo. Exh. 1408 at 61-72; RT Vol. 246 at 134-35.

C. Conclusions.

The Kansas prospective analysis is not sufficient to prove that the 1996 Use Rules will not assure compact compliance. I do not recommend, as requested by Kansas to prevent future depletions, that Colorado be required to place water in the Offset Account in the amount of 15% of pumping (in addition to the requirements of the Use Rules). Kan. Opening Br. at 85; Kan. Reply Br. at 71. Depletions of usable Stateline flow for the whole period of 1950-96 have been determined to be 428,005 acre-feet – an average of a little under 10,000 acre-feet per year. These are the depletions without *any* replacement water. Yet the Kansas prospective compliance model shows depletions of 11,036 acre-feet per year even *after* the provision of replacement water as required under the Use Rules. Unless all of the previous Kansas modeling is seriously in error, the prospective compliance model results do not appear realistic. The H-I model results for 1995-96, agreed to by Kansas, showed average depletions of only 3968 acre-feet per year. Jt. Exh. 183. The Use Rules were in effect only for a few months of this period, and then required only 60% replacement water. The Kansas prospective analysis also shows depletions in *every* year. Yet its own modeling for 1997-99 showed compliance in two of the three years. Kan. Exh. 1093, Table 14.

The Use Rules have been fully in effect since 1997, and I have found that Colorado did meet its compact obligations during the 1997-99 period. However, Kansas has a valid concern that these years were exceptionally wet and may not demonstrate that the Use Rules will be adequate over the long term. In this trial segment we have seen the extremes of hydrologic conditions, from very wet years to one of the driest years of record in 2002, yet the Kansas fears have not come to pass. The Colorado pumping response has been far different from the past when replacement supplies were not required. In the dry river conditions of the 1970s, farmers simply turned to the pumping of groundwater, and pumping levels soared to more than 250,000 acre-feet per year. But in 2002, applications to pump were cut dramatically, limited by the fact that sufficient replacement supplies were not available. More experience under the Use Rules is still required, but if the Rules should prove in the future not to supply adequate replacement water, then Colorado will have to adjust in order to fully meet its compact obligations. And from the testimony of Mr. Simpson, head of Colorado's Division of Water Resources, this is a fact well understood. RT Vol. 231 at 113-14, 138; RT Vol. 270 at 143-44, 161-62, 164.

Turning now to the Colorado prospective compliance analyses, I also find that they are not sufficient to prove that the 1996 Use Rules, as they have been applied, will assure future compact compliance. Rule 4.2 of the Use Rules provides presumptive depletion factors of 30% for supplemental wells, 50% for sole source wells, and 75% for sprinkler irrigation systems. Since 1997, replacement water in those percentages has been required. However, Kansas has never been convinced that these replacement percentages are adequate. They were developed through the earlier 1950-85 version of the H-I model which is no longer appropriate. RT Vol. 231 at 126-27. Kansas maintains that the depletion percentages should more closely reflect actual consumptive use. Nonetheless, Kansas does not advocate making a change in the presumptive depletion factors themselves, but instead seeks additional water to be added to the Offset Account directly for the benefit of Kansas. RT Vol. 237 at 146-47; RT Vol. 262 at 85-86. The presumptive depletion factors are designed to protect prior rights in Colorado, as well as Stateline flows for Kansas, and the Kansas experts recognize that a wholesale change in these factors may be an inefficient way to get water to Kansas, if more replacement is required. It should be noted, however, that the Use Rules do give the State Engineer the authority to revise these presumptive stream depletions if he determines that to be necessary, although that authority has not yet been exercised. Rule 4.3. Nonetheless, the intentions of the State Engineer to assure compact compliance, whatever actions that may entail, are discussed in the following Section.

SECTION X

MEASURING COMPACT COMPLIANCE

It is the Kansas position that the H-I model should be used on an annual basis to determine Colorado's compliance with the Arkansas River Compact. Kan. Opening Br.

at 85, Kan. Exh. 1093 at 5. Compliance accounting would run from the beginning of April to the end of March in the following year. Recognizing that recent patterns have shown accretions to occur during the irrigation season and depletions during the winter, Kansas proposes that accretions may be used to offset depletions during the April-March accounting year. Kan. Opening Br. at 64, 66. I find, however, that the H-I model is not sufficiently reliable on a short term basis to determine compliance as recommended by Kansas.

A. Reliability of H-I Model.

Modeling the Arkansas River Basin in Colorado is extraordinarily difficult, and perhaps unprecedented. Yet all of the experts from both states have testified that the use of a computer model is the only way to estimate what the river flows would have been in the absence of post-compact pumping. The modeling effort must represent highly variable river flows over some 150 miles to the Kansas Stateline; the intervention of a major federal reservoir; storage and releases from numerous large private storage reservoirs; transmountain flows brought through tunnels from the west slopes of the Rocky Mountains; surface diversions initially made by some 23 canals operating under a priority system that regulates diversions by the hour; the reuse of all surface flows; ungaged tributary inflows and torrential summer thunder storms; consumptive use of various crops as well as phreatophytes along the river; canal and lateral seepage; irrigation return flows to the river, both on the surface and from groundwater; pumping by upwards of 1000 wells; and the fallowing of land to provide replacement water to offset the impacts of pumping. And the model is then asked to estimate what the usable Stateline flows in the river would have been at any point in time if there had been no postcompact well pumping. Kansas commends the H-I model for doing a "remarkable job," and, indeed, it may perform as well as can be expected under these most complex circumstances. Kan. Reply Br. at 66. At the outset of the trial, one of the distinguished pioneers[16] in computer modeling explained the difficulties of the task. He went on to say that the experts of both states were "extremely well regarded" and among the "best . . . in the country." First Report at 232. But he also cautioned that large errors could be expected in this complex modeling process.

In my view, the Kansas statistical evidence does not convincingly support the accuracy or reliability of the H-I model on an annual or short term basis. Mr. Steven P. Larson, Kansas' chief modeling expert over the last decade of these proceedings, testified that the revised Kansas H-I model provides a "reasonable estimate" of depletions on an annual and even on a monthly basis. RT Vol. 243 at 118-19, 121. However, when pressed about the accuracy of the model results, he said:

> "Well, the term 'accurate' is a little difficult to deal with since it implies that we know what the depletions are and we know, therefore, based on these calculations how far the model might depart from something that's been measured. But since we don't have measurements of the depletions, we can only provide estimates. As to the

[16] Dr. Robert Allan Freeze, see First Report at 232-33.

uncertainty, I don't know what the uncertainty is."[17] *Id.* at 117-18.

The ability of the H-I model to predict diversions from the river, that is, to match model predictions with actual observed diversions, is considered a key to the accuracy of its results. Addressing this measure of the accuracy – or error – of the Kansas revised model, Mr. Larson referred to the tabulation in Kan. Exh. 1113 at page 30. (Appendix Exh. 12.) RT Vol. 243 at 121-22; 124. That exhibit shows that the Kansas model mostly over-predicts diversions in the earlier years, and since 1982 has consistently under-predicted. Colo. Exh. 1412, Table 1, at 34. The maximum under-prediction occurred in 1995 by 22.4%, while the maximum over-prediction occurred in 1960 in almost the same percentage, i.e., 22.2%. RT Vol. 243 at 122-123. These are the extremes. Mr. Larson stated that the percentages in this table, however, may give an indication of the percentage of error one might expect in the model results. RT Vol. 243 at 125-26, 131-32. He concluded that the uncertainty in the model estimates of depletions and accretions could be expected to be on the order of "plus or minus 10 or 20 percent." RT Vol. 243 at 137. Another tabulation demonstrates that the model does not predict "as well" at the extremes, "especially for wet periods." RT Vol. 243 at 80-81. Over the full period of 1950-99, predicted and observed diversions were virtually the same, but during the relatively wet period of 1980-99, the model

[17] With respect to an earlier version of the H-I model, Mr. Larson testified: "I think [the model] provides the best estimate that we can. We don't know what the depletions are, so we can't directly assess that accuracy." RT Vol. 164 at 44.

under-predicted diversions by about 8%, and by 14% in the very wet period of 1995-99. During the drier years of 1950-79, the model over-predicted by 7%. Kan. Exh. 1113 at 28. Under-predicting diversions tends to over-predict Stateline depletions, and vice versa. RT Vol. 231 at 70-74; RT Vol. 265 at 128; Colo. Exh. 1391 at 2; Colo. Exh. 1412 at 7.

The annual variability of the model results again shows up in the comparisons between observed and predicted stream flows. The ability of the model to accurately predict stream flows is also important in estimating depletions. Colo. Exh. 1410 at 45. Over the 1950-99 period, predicted stream flows at the Stateline averaged 144,490 acre-feet per year, while observed flows were 149,296, an average difference of about 3%. Kan. Exh. 1113 at 13. During the period of 1950-94, average predicted and observed flows were essentially the same, i.e., 125,431 and 125,087, respectively. *Id.* Yet individual years show a good deal of variation. For example, in the last 10 years since 1990, the model under-predicted streamflow in 5 years, and over-predicted in 5 years, all interspersed. Kan. Exh. 1113 at 17. The largest under-prediction was 155,373 acre-feet in 1998; the largest over-prediction was 60,050 acre-feet in 1995. *Id.*

All of these comparisons point to the need to smooth out the model results, and to account for the model's tendency to over-predict depletions in wet years, and to under-predict in dry years. Kan. Exh. 1113 at 28, 30; RT Vol. 265 at 129.

Dr. Charles M. Brendecke testified as a rebuttal expert for Colorado on the issue of model reliability. Dr. Brendecke holds a Ph.D. from Stanford University in civil engineering.[18] Since 1986 he has been a principal and president of Hydrosphere Resource Consultants. Earlier he taught at both Stanford and the University of Colorado. Dr. Brendecke has been an expert for Wyoming in the recent case of *Nebraska v. Wyoming* involving the Platte River, and has also been a consultant to the Special Master on technical issues in the case of *Texas v. New Mexico*. He has had extensive modeling experience on the North Platte, Pecos, Rio Grande, Snake and Gunnison Rivers.

Dr. Brendecke presented an error analysis of the H-I model results. He was critical of the Kansas approach to compare predicted diversion and streamflow data with observed amounts over the long period of 1950-94. He said that under-predictions and over-predictions can cancel each other out over a long period of time, so that the result merely shows the "long-run average error." RT Vol. 258 at 103. It does not tell you how accurate the model may be in any given year. RT Vol. 257 at 169-70. Dr. Brendecke, therefore, applied two different statistical approaches to the monthly data for predicting diversions, i.e., calculating the mean absolute error, and the root mean squared error. These results are shown in Colorado Exhibit 1410, Table 3.3a, 3.3b at 34. (Appendix Exh. 13.)

Dr. Brendecke tabulated the average monthly diversions predicted by the Kansas version of the H-I model for

[18] His expert qualifications are found in Colorado Exhibit 1440.

each of the canals over the 1950-94 period. These were then compared with actual observed diversions over the same period of time. Over the full 540 months of the 1950-94 period, predicted and observed diversions matched almost perfectly. But Dr. Brendecke testified that a "more appropriate" evaluation method was to employ the concept of the "mean absolute error." RT Vol. 257 at 170, 173-74. This was designed to show what the difference, or model error, might be in any random month. *Id.* at 174. Dr. Brendecke averaged the amounts of monthly differences without regard as to whether they were over-predictions or under-predictions. *Id.* For example, with respect to the Bessemer Canal, with monthly diversions averaging 5076 acre-feet, one could "expect to be off" by 22% or 1096 acre-feet in any random month. *Id.*, Colo. Exh. 1410, Table 3.3b at 34. The analysis shows some of the other major canals off by even larger amounts and percentages: Colorado Canal, 3001 acre-feet or 41%; Catlin Canal, 1804 acre-feet or 25%; Fort Lyon Canal, 4756 acre-feet or 25%; Amity Canal, 2585 acre-feet or 40%. Colo. Exh. 1410, Table 3.3b at 34.

Dr. Brendecke also performed another calibration statistic designed to remove the positive and negative sign in the error and focus on the magnitude of the error, called the "root mean squared error." RT Vol. 257 at 174. This is also designed to address the problem of errors cancelling each other out over a long period, and showed even greater random error than the mean absolute error approach. RT Vol. 257 at 175; Colo. Exh. 1410, Table 3.3b at 34.

Dr. Brendecke also prepared an error graph comparing the annual Stateline flows predicted by the model with those actually observed over the 1950-98 period. There are under- and over-predictions throughout the period, but in recent years some of the differences are exceptionally large. Colo. Exh. 1410, Table 3.2a at 29. For the years 1990 through 1994 the results were very close, but in 1995 the model over-predicted Stateline flows by more than 50,000 acre-feet, while in 1996 and 1998 it under-predicted by 100,000 and over-predicted by 150,000 acre-feet, respectively. Colo. Exh. 1410, Table 3.2a; RT Vol. 257 at 159-60. These figures, he said, highlighted the danger of using the model "on any kind of short-term basis for making decisions." RT Vol. 257 at 160. The mean absolute error in model predictions of flow at the Stateline was 20,500 acre-feet, or 17%. Colo. Exh. 1410, Table 3.8a at 44.

It should be noted, however, that the error in predicting Stateline flows is not the same as predicting depletions under the compact. Depletions are determined by comparing the results of the historical and compact model runs. RT Vol. 257 at 104-06. It was Dr. Brendecke's overall conclusion that the H-I model, as it now operates, should not be used on a "short term basis." RT Vol. 257 at 167, 179. However, he acknowledged that over a longer period of time, perhaps 10 to 15 years, the model could be used to determine compliance. RT Vol. 257 at 194.

While Dr. Brendecke analyzed the data in terms of certain commonly used statistical concepts, there are innumerable exhibits which plainly show that in any given month or year the model predictions of diversions or river flows differ substantially from actual measured data. (For example, see Colo. Exh. 1394; Kan. Exh. 1093.) Only by using longer term averages do the model simulations more closely match historic data. I find that the H-I model is not sufficiently accurate on a short-term basis to be used to determine compact compliance on a monthly or annual basis.

B. Colorado's Compact Compliance Proposal.

Colorado's proposal for determining compact compliance developed gradually throughout this trial segment. It was first mentioned by Hal D. Simpson, Colorado's State Engineer and head of its Division of Water Resources, on the second day of trial, perhaps prematurely at that time but in response to a question of mine. RT Vol. 216 at 102. But on several later occasions, Mr. Simpson added detail to the proposal and responded to concerns and questions raised by Kansas. The final questions were raised during his cross-examination on the last day of trial. RT Vol. 270 at 151, *et seq.*

The Colorado Use Rules, adopted in 1996, provide that the State Engineer shall use "the Kansas Hydrologic-Institutional Model (HIM) . . . or such other method approved by the Special Master, the United States Supreme Court, or the Arkansas River Compact Administration to determine depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation use." Kan. Exh. 1123, Rule 3.4. The Use Rules were approved, after protest and trial, by the Water Judge for Division 2, effective June 1, 1996. Colo. Exh. 1051, Appendix A. Duane Helton, Colorado's expert in earlier segments of this trial, testified for the State Engineer in support of the proposed Rules, stating that the results of the H-I model were reasonable on a long-term basis. Colo. Exh. 1390 at 1. Mr. Simpson testified that it was never his understanding that the model would be used to determine compact compliance on a monthly or annual basis, that the results are not accurate in such a short time frame. Colo. Exh. 1390 at 14; Colo. Exh. 1391 at 1. Changes have been made in the model since the Use Rules were adopted, and indeed, additional changes have been proposed by both states in this trial segment. However, Mr. Simpson's original opinion has not changed.

In analyzing the "long-term" accuracy of the H-I model, Mr. Simpson examined predictions of streamflows and diversions. Accurate predictions of streamflow and diversions are important to the model's ability to determine Stateline depletions. Colo. Exh. 1391 at 2. He concluded that it was necessary to average streamflow predictions over about 10 years in order to bring the error rate down to approximately 5%. RT Vol. 231 at 111-12. For diversions, it required about 15 years, but he thought "that's too long a period." *Id.* at 112. He settled, therefore, on 10 years as being a "reasonable" period of time. *Id.*

The specific Colorado proposal, as it finally developed over the course of the trial segment, was this: the accounting period would begin with calendar year 1997, the first year that the Use Rules were in full operation. RT Vol. 216 at 103; RT Vol. 231 at 132. The model would be updated annually and run for each calendar year, in the spring of the following year. RT Vol. 231 at 40; RT Vol. 270 at 157-58. Depletions or accretions would be determined annually, and for the first ten years beginning in 1997 (i.e., until 2006) those depletions or accretions would be carried forward to the next year. RT Vol. 231 at 132-133. A simplified illustration of this accounting procedure is found in Colorado Exhibit 1459, included in the Appendix as Exh. 14. In the eleventh year, Colorado would make up any depletions accrued at the end of the ten-year period, or any accretions would be carried forward into year eleven. The process would continue on a moving ten-year basis, dropping year one and adding the year eleven results, dropping year two and adding year twelve, and so forth. RT Vol. 231 at 134. The analysis would be done using the version of the model approved at the conclusion of this trial segment. RT Vol. 231 at 135.

Essentially, after the startup period, the Colorado proposal calls for an annual accounting, with delivery of any replacement water then due, based on the H-I model annual determinations over the prior ten years. Understandably, however, Kansas was concerned about the first 10-year period. Would Colorado accumulate shortages that would not be replaced until years later, or perhaps be so large that they could not be replaced at all in the eleventh year? Neither scenario appears likely. I have found that Colorado deliveries met their compact obligations during 1997-99, the first three years of the initial ten-year proposal. Even the Kansas modeling shows that accretions exceed depletions over the whole three years by 2819 acre-feet. RT Vol. 241 at 47-48; Colo. Exh. 1411, Table 7c. However, Mr. Simpson testified that if there were a "trend" or a "series of years" of depletions, Colorado would "have to make some adjustment." RT Vol. 231 at 113-14, 138; RT Vol. 270 at 143, 161-62, 164. Colorado could require that additional water be placed in the Offset Account for the benefit of Kansas, or it could adjust the Use Rules. RT Vol. 270 at 144, 162.

The Use Rules provide that additional replacement water may be required. Kan. Exh. 1123, Rule 7; RT Vol. 231 at 130-31. Moreover, the Rules allow the presumptive depletion factors to be increased if necessary to prevent "depletions to usable Stateline flows," although Kansas points out that the procedures for such a change allow for Court review. Kan. Exh. 1123, Rule 4.3. While the presumptive depletion factors worked during the 1997-99 wet years, Mr. Simpson acknowledged that he would have to "wait and see" how they perform in dry years. RT Vol. 231

at 122, 129-30. But he pointed out that the Offset Account acts as a buffer against falling short. *Id.* at 124. The Colorado Legislature has established an ongoing fund of a million dollars, replenished to that amount each July 1. The fund is managed by the State Engineer and the Colorado Water Conservation Board, and may be used to acquire additional replacement water. RT Vol. 270 at 145-46. In fact, the fund was used late in the summer of 2002 to acquire an additional 3600 acre-feet of water to be placed in the Offset Account for Kansas. *Id.* at 146. Mr. Simpson testified that it was not in the interest of either Colorado or its farmers to default in its compact obligations. The state doesn't want "a potential second suit from Kansas," and the farmers "obviously don't want their wells curtailed." RT Vol. 270 at 144. Based upon Colorado's actions in recent years, and upon the testimony of Mr. Simpson, I believe the Court can have confidence in Colorado's ability and determination to provide Kansas with the water to which it is entitled under the compact. In the event of serious failure in the Use Rules, Mr. Simpson testified that adjustments would be made in consultation with Kansas. RT Vol. 270 at 163-64.

Other Kansas concerns were addressed by Mr. Simpson. The Use Rules requiring replacement water would be enforced even though Colorado had built up a net credit. RT Vol. 270 at 158. The only exception would be if John Martin Reservoir were spilling and water was passing Garden City, Kansas. RT Vol. 270 at 159. Depletions and accretions would be determined on an annual basis, and after the initial startup, depletions would be made up in the following year. RT Vol. 232 at 18-19; RT Vol. 270 at 148-49, 158. Mr. Book expressed the need for a cap on accumulated accretions so that accretions occurring in wet years would not be used to offset much later dry year depletions. RT Vol. 265 at 29-30. No evidence was presented on this matter, but if necessary some type of limit could be included in any decree, taking limited evidence if the states could not agree.

C. Conclusions.

I conclude that the use of the H-I model over a ten-year period, as proposed by Colorado, is necessary in order to achieve reasonably accurate model results; that the Colorado proposal provides a reasonable way to check upon the effectiveness of the Use Rules to prevent material depletions of usable Stateline flows; that on the basis of present evidence the Use Rules themselves, in conjunction with the Colorado proposal, properly provide for compliance with Colorado's obligations under the Arkansas River Compact; that it is the implementation of the Rules, however, that is critical to compact compliance; and that Colorado has committed to make future adjustments in the Use Rules, if necessary, in order to achieve full compact compliance. Kansas contends that Colorado's compliance proposal violates Article V-5E(5) of the compact which states, "There shall be no allowance or accumulation of credits or debits for or against either State." I disagree. The proposal is simply the most accurate way of determining the actual Kansas entitlement under the compact.

SECTION XI

CONTINUING JURISDICTION AND REQUEST FOR A RIVER MASTER

One of the most vexing issues left to be decided in this case is how to reasonably assure that Colorado will continue to meet its compact obligations. I have found in this Report that the replacement water program implemented by Colorado during the three-year period of 1997-99 provided sufficient flows at the Stateline to offset the impacts of its upstream pumping, namely, that its Use Rules brought Colorado into compact compliance for those years. This is the last period for which complete data were available, and ordinarily my finding, if confirmed, would be sufficient to enter a final decree and end this case. However, the 1997-99 period was unusually wet, and even the Colorado State Engineer testified that it would be necessary to "wait and see" how the Replacement Plans performed over more normal hydrology. RT Vol. 231 at 122, 129-30.

The issue is further complicated by potential issues that continue to surface regarding changes to the H-I model. Both states are bound, at least for now, to the use of the model to determine whether or not there are compact shortages at the Stateline. The experts all agree that depletions can be determined only through the use of a model, and Kansas developed the H-I model which Colorado incorporated into its Use Rules. Yet in each of the trial segments in this case (except for damages) there have been serious disagreements among the experts over updating the model, both as to data input and to model coding. To be sure, many of the model changes and data issues have been settled by agreements between the states. But this segment of the trial forecasts a number of modeling issues that will still need to be settled one way or another in the future applications of the H-I model.

A. Remaining Potential Model Issues.

Evidence adduced during this trial segment indicates that at least these issues will need to be considered in the future use of the H-I model.

1. Phase 2 of the USGS report in regard to measuring the amount of groundwater pumping. RT Vol. 216 at 65-66.
2. Results of Colorado's completed verification program on wells and irrigated acreage. At trial only 426 farm units had been verified out of a total of 725.
3. The commencement of the five-year cycle updating Colorado's irrigated acreage study. RT Vol. 231 at 115; RT Vol. 269 at 61, 66.
4. Proposed changes in the satellite imagery system used by Colorado. RT Vol. 244 at 129-30.
5. Kansas' claim that more data need to be collected on the distribution of surface water. RT Vol. 262 at 82-84.
6. Further investigation of the amount of return flow intercepted by the Amity Canal from Fort Lyon's service area. RT Vol. 236 at 50.
7. Further investigation of the amount of return flow intercepted by the Buffalo Canal from the Amity service area. RT Vol. 264 at 118-22.
8. Any improvements in the calculation of ungaged tributary inflow.

9. Whether any new studies support any adjustments to PET values for salinity, management or otherwise.
10. Proper representation in the model of the various Replacement Plan water sources.
11. Mr. Schroeder's proposed model change discussed in Section VII G on Calculation of Model Demand.
12. Various model calibration issues.

I do not mean to imply that all of these matters will become contentious issues. But these, and still other modeling update requirements, illustrate the kind of matters that require expert agreement or some kind of resolution when compact compliance is dependent upon the results of the H-I model. And all experts agree that continued improvements need to be made to the model to increase its reliability.

B. Model Calibration.

In this last trial segment, Kansas employed two different versions of the H-I model (one for 1997-99 depletions, and one for prospective future compliance), and Colorado used three different versions of the model (its Test Model, Updated Test Model, and Revised Test Model). All of these model versions, by both states, were different from the so-called "approved" version which had been used to determine depletions for 1995-96. Each of these different versions of the H-I model, in the opinion of the expert advocating its use, was sufficiently "calibrated" to determine reasonable estimates of Stateline depletions. Yet all of the results were different. Calibration is achieved by adjusting certain model parameters (WANT factors, canal capacities, diversion reduction factors, etc.) in order to match predictions as closely as possible to observed data. There is no point, however, in trying to determine which past version of the model is "better" calibrated since the changes called for in this Report will require new calibration efforts. Nor is the Court in a position to direct technically how the model should be calibrated in future updates. Nonetheless, there is one calibration issue which deserves attention.

Mr. Schroeder calibrated his Test Model over alternate periods of time: using the traditional period of 1950-94, and also over the shorter and more recent period of 1970-94. For the area downstream of John Martin Reservoir, he used the still shorter period of 1980-94. Schroeder advocated use of the 1970-94 period because he thought that data from these years were more reliable and more representative of future conditions. Colo. Exh. 1411 at 26, *et seq.* Both Book and Larson, Kansas experts, disagreed and recommended continued use of the 1950-94 period, and possibly even adding years. RT Vol. 243 at 152-53, *et seq.*; RT Vol. 264 at 110; RT Vol. 265 at 66-67. They pointed out that the shorter calibration period used by Mr. Schroeder was not representative of long term hydrology. RT Vol. 243 at 152-53. In particular, the period after 1980 included only one "dry" year. All others ranged between average and very wet. Colo. Exh. 1408, Table 11; RT Vol. 265 at 72. In Mr. Book's opinion, using the water supply that occurred in those 15 years results in higher WANT factors that would cause diversions to be over-predicted over the long term. RT Vol. 264 at 110-11. Certainly as the model is used in the future, the calibration period may change. However, I find that the model should not be recalibrated over the shorter periods of time as recommended by Mr. Schroeder.

C. Kansas Proposal to Appoint a River Master.

Kansas recommends, following the precedent in *Texas v. New Mexico*, 482 U.S. 124, 134, 96 L.Ed.2d 105, 107 S.Ct. 2279 (1987), that the Supreme Court appoint a River Master to "enforce the Court's judgment." Kan. Opening Br. at 83. Kansas first states that the River Master, as in the Pecos River case, "would not act as an arbitrator to resolve any Compact or other issue that might arise between the States in the Arkansas River." *Id.* In its Reply Brief, however, Kansas uses more expansive language, characterizing the role of the Pecos River Master as having "broad powers to exercise judgment," and being able to "resolve any disputes" in the implementation of the judgment. Kan. Reply Br. at 69-70.

Colorado responds that the appointment of a River Master in this case "would be to continue this litigation indefinitely." Colo. Exh. 1412 at 30. Colorado distinguishes *Texas v. New Mexico* on the ground that the Pecos River Master's function "is largely ministerial," and it is not credible to suggest that a master here would not be required to exercise judicial functions. Colo. Reply Br. at 64.

D. Texas v. New Mexico, and the Pecos River Decree.

The Pecos River case does indeed have some remarkable similarities to the present Arkansas River litigation. Both cases involve interstate compacts. Both compacts established commissions to administer the compact, but require unanimous agreement for any commission action. Both compacts, as adjudicated, allocate stream flow on the basis of precompact conditions, rather than designating a specific numerical amount of water for the downstream state. The Pecos River Compact provides that New Mexico shall not deplete flows at the Texas state line below the quantity that would have been "available to Texas under the 1947 condition." *Texas v. New Mexico*, 462 U.S. 554, 559, 77 L.Ed. 2d 1, 103 S.Ct. 2558 (1983). However, the compact did incorporate an Inflow-Outflow Manual which provided "a workable methodology for translating New Mexico's obligation into quantities of water." *Texas v. New Mexico*, 482 U.S. 124, 129, 96 L.Ed.2d 105, 107 S.Ct. 2279 (1987). Disputes eventually developed over the accuracy of this inflow-outflow methodology, but these issues were settled in the Special Master's 1984 Report. *Texas v. New Mexico*, 467 U.S. 1238, 82 L.Ed.2d 816, 104 S.Ct. 3505 (1984). In that Report, the Master adopted a curve and table which established the relationship between the inflow to the Pecos River in New Mexico, and the required outflow to Texas at the state line. Kan. Opening Br., App. 2 at 13. In later proceedings, New Mexico like Colorado was found to have depleted the stream flow in violation of the compact, beginning in 1950. The total shortfall on the Pecos River amounted to 340,100 acre-feet over the period 1950-83; on the Arkansas depletions are 428,005 acre-feet from 1950 through 1996.

Looking to enforcement of the final decree in *Texas v. New Mexico*, the successor Special Master[19] recommended that the Court enjoin the Pecos River Commission,[20] or a

[19] Charles J. Myers, former Dean of the Stanford Law School.

[20] The earlier Special Master in the Pecos River litigation was the Hon. Jean Breitenstein, a Judge of the Court of Appeals for the Tenth Circuit and "a recognized expert in western water law." *Texas v. New Mexico*, 482 U.S. 124, 127. He recommended that the court use its equitable powers to reform the compact by imposing a tie-breaking

(Continued on following page)

River Master, "to make the calculations provided for in this Decree." Kan. Opening Br., App. 3 at 46, A-2. It should be recognized that his Report recommended that the past shortfall of 340,100 acre-feet be repaid in water over ten years, so it was necessary to account for the past repayment flows as well as flows required for current compliance.[21] The Court chose to approve a River Master "to make the required periodic calculations." *Texas v. New Mexico*, 482 U.S. 124, 134. In so doing, however, the Court noted that the Master had recommended an additional enforcement mechanism because "applying the approved apportionment formula is not entirely mechanical and involves a degree of judgment." *Id.* at 134. There is, of course, no issue in the present case about making up past shortages in water, and distinguishing that water from current flow requirements. Past shortages are to be compensated by money damages. *Kansas v. Colorado*, 533 U.S. 1 (2001).

The most recent 2002 Report of the Pecos River Master was submitted as an exhibit in this case, and is included in this Report in the Appendix as Exhibit 15. It is not clear from this Report, however, how much judgment may be required in preparing the River Master's annual accounting, and indeed whether or not his duties are essentially ministerial as argued by Colorado. The Report

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procedure on the Pecos River Commission so that it could act without agreement of the states. The Court found that it did not have authority to modify the compact, which was a law of the United States, having been approved by Congress. *Texas v. New Mexico*, 462 U.S. 554, 563-65.

[21] The states later settled the past shortage issue by stipulating to a money judgment. *Texas v. New Mexico*, 494 U.S. 111, 108 L.Ed.2d 98, 110 S.Ct. 1293 (1990).

contains numerous tables of measured flows at various locations, channel losses, diversions, evaporative losses, precipitation, consumptive use and changes in storage, and concludes that there was an annual shortage of 700 acre-feet, but because of the running account kept since 1987 that New Mexico still retained an "overage" of 9900 acre-feet.

What is evident, however, from the Pecos River Master's Report is that he does not adjudicate the kinds of disputes that may be involved in the future application of the H-I model. Any major disputes on the Arkansas River are likely to occur over the model, and not over the collection of basic data. Such model disputes are not easily determined. One expert in hydrologic modeling, an outside university professor, testified particularly to the complexities of the H-I model, and to the lack of documentation on the assumptions used in the model, and how it operates. RT Vol. 230 at 103-09. He said there is no way to truly understand the model without studying the vast record of this trial, and that it would be difficult for an outsider to run the model simply on the basis of the model code. *Id.* at 111-17.

Finally, it is important to note that the amount of Stateline depletions can be very sensitive to model changes. One exhibit compares the depletions stipulated to for 1950-85 with the results of several later versions of the model applied to that same period. Colo. Exh. 1411, Table 6c at 59. The 1950-85 stipulated figure was 328,500 acre-feet. If the version of the H-I model used to determine depletions for 1986-94 were applied to the 1950-85 period, depletions would have been 474,200 acre-feet. If the Kansas revised H-I model were used, the depletions would increase to 586,400 acre-feet. And if the Colorado Revised

Test Model, calibrated for 1970-94, were used for the1950-85 period, the depletions would be 381,600 acre-feet. *Id.*

E. Court Precedents Regarding Enforcement of Interstate Water Decrees.

There appear to be only two interstate water cases in which the Court has actually appointed a River Master as now requested by Kansas. The most recent case, of course, is *Texas v. New Mexico.* The Amended Decree making the appointment and prescribing the duties of the River Master in that case is found in *Texas v. New Mexico*, 485 U.S. 388, 99 L.Ed.2d 450, 108 S.Ct. 1201 (1988). While recognizing that the Court historically has taken "a distinctly jaundiced view of appointing an agent or functionary to implement our decrees," the Court found this to be "one of those occasions when such a mechanism should be employed." *Texas v. New Mexico*, 482 U.S. 124, 134. The Court noted that the "natural propensity of these two States to disagree . . . cannot be ignored." *Id.* And absent some disinterested authority to make determinations binding on the parties, the Court said that it could anticipate a "series of original actions." *Id.* Nonetheless, the River Master was appointed only "to make the calculations provided for in this decree." *Id.* Those calculations were to be done in accordance with a manual which was admitted into evidence as Texas Exhibit 108. Kansas Exhibit 1104; *Texas v. New Mexico*, 485 U.S. at 388. However, the River Master has the authority to modify the manual. His determinations are subject to review by the Court only upon a showing that they are "clearly erroneous." *Id* at 393. Counsel for Kansas state that this authority allows the River Master to "change the quantitative standard for delivery of water at the stateline [which] is essentially the same function as performed by the H-I model." Kan. Comments on Draft Fourth Report at 26. However, there is no evidence to this effect, nor that the River Master has ever changed the manual.

The other appointment of a River Master is found in *New Jersey v. New York*, 347 U.S. 995, 98 L.Ed. 1127, 74 S.Ct. 842 (1954). The decree in that case limited diversions by New York from the Delaware River, but then allowed certain stepped up increases in diversions contingent upon the construction of additional storage reservoirs and releases therefrom, and upon the maintenance of prescribed minimum downstream flows. The River Master was charged with the responsibility of making flow calculations and release requirements in order to maintain the applicable minimum rate of flow downstream. *Id.* at 1002-04. A later opinion describes this appointment as a "rare case," and perhaps questionably adds that the River Master was given "only ministerial acts to perform." *Vermont v. New York*, 417 U.S. 270, 275, 41 L.Ed.2d 61, 94 S.Ct. 2248 (1974).

There are interstate water cases in which a request for a River Master or some type of continuing enforcement authority has been denied. *Wisconsin v. Illinois*, 281 U.S. 179, 196, 74 L.Ed. 799, 50 S.Ct. 266 (1930), required a gradual reduction in diversions from Lake Michigan, correlated with the construction of certain defined sewage treatment facilities over the period from 1930 to 1938. A proposal to appoint a "commission to supervise the work" was rejected in favor of requiring the defendant to file periodic reports with the Clerk of the Court on the progress of construction, and allowing the parties to make application to the Court "for such action as may seem to be suitable." *Id.* at 198.

The prayer of the Commonwealth of Pennsylvania for the appointment of a river master was denied without prejudice in *New Jersey v. New York*, 283 U.S. 805, 75 L.Ed. 1425, 51 S.Ct. 562 (1931).

In *Wyoming v. Colorado*, 298 U.S. 573, 80 L.Ed. 1339, 56 S.Ct. 912 (1936), the Court entered an injunction against continuing diversions contrary to a prior decree, but refused to appoint a water master to keep the records. *Id.* at 586. The Court expressed the hope that any problems could be solved by "co-operative efforts," and indeed this was accomplished. *Id.* at 586; *Wyoming v. Colorado*, 309 U.S. 572, 84 L.Ed. 954, 60 S.Ct.765 (1940).

The appointment of a South Lake Master was also rejected in *Vermont v. New York*, 417 U.S. 270. That case involved pollution of Lake Champlain and Ticonderoga Creek. The parties reached a stipulated judgment recommended by the Special Master. The proposed decree made no findings as to liability but required various measures over time to reduce both air and water pollution. International Paper Co. was given a full release for all past damages caused by its discharges into water and air. The proposed South Lake Master was authorized to "resolve matters of controversy" between the parties and his decisions were to be final unless exceptions were taken to the Court. *Id.* at 271. The Court stated that referring to the Court such issues "that the future might bring forth" could materially change the Court's function in interstate contests. *Id.* at 277. "Insofar as we would be supervising the execution of a consent decree, we would be acting more in an arbitral rather than a judicial manner." *Id.* The proposals which the South Lake Master might submit to the Court "might be proposals having no relation to law," or to the Court's Art. III jurisdiction. *Id.*

More often than appointing some kind of river master to supervise the decree in these interstate water cases, the Court has merely retained continuing jurisdiction. *New Jersey v. New York*, 283 U.S. 805; *Nebraska v. Wyoming*, 325 U.S. 589, 89 L.Ed. 1815, 66 S.Ct. 1 (1945); *Arizona v. California*, 376 U.S. 340, 11 L.Ed.2d 757, 84 S.Ct. 755 (1964); *Oklahoma v. New Mexico*, 510 U.S. 126, 126 L.Ed.2d 556, 114 S.Ct. 628 (1993); *Nebraska v. Wyoming*, 534 U.S. 40, 151 L.Ed.2d 356, 122 S.Ct. 420 (2001). The traditional provision for continuing jurisdiction reads:

> "Any of the parties may apply at the foot of this decree for its amendment or for further relief. The Court retains jurisdiction of this suit for the purpose of any order, direction, or modification of the decree, or any supplementary decree, that may at any time be deemed proper in relation to the subject matter in controversy." *Arizona v. California*, 376 U.S. 340, 353.

Sometimes specific issues are identified in the decree as remaining within the Court's continuing jurisdiction. *Nebraska v. Wyoming*, 325 U.S. 589, 671-72. More recent consent decrees require, before applying to invoke the Court's continuing jurisdiction, that the parties certify that they have attempted to negotiate in good faith to resolve the dispute, or that it has been first submitted to a stipulated entity designated to assist in implementing the decree. *Oklahoma v. New Mexico*, 510 U.S. 126, 131; *Nebraska v. Wyoming*, 534 U.S. 40, 55.

In 2001 the States of Wyoming, Nebraska and Colorado stipulated to a modified decree determining rights along the North Platte River. *Nebraska v. Wyoming*, 534 U.S. 40. This represented the second time that the decree had been changed. The original decree, the result of eleven years of litigation, was entered in 1945. *Nebraska v. Wyoming*, 325 U.S. 589. It was then amended in 1953. *Nebraska v. Wyoming*, 345 U.S. 981, 97 L.Ed. 1394, 73 S.Ct. 1041 (1953). The recent stipulated modification resulted from an enforcement action filed by Nebraska in 1987. As part of the current modified stipulated decree, Wyoming is limited over ten years to the largest total amount of water consumed for irrigation in any ten consecutive year period between 1952 and 1999. *Nebraska v. Wyoming*, 534 U.S. 40, 43. This amount was determined to be 1,280,000 acre-feet. In determining future compliance with this provision, the stipulation establishes a North Platte Decree Committee. After ten years of accounting, the Committee is charged with reviewing both the methodology and the ten consecutive year limit, pursuant to procedures adopted in the stipulation. *Id.* at 43. If Nebraska, Wyoming and the United States are in agreement on a new methodology and limit for determining consumption, the decree will be modified accordingly. If they do not agree, any of the three parties "may seek recourse to the Court to resolve these issues." *Id.* at 44. The North Platte Decree Committee is also charged with other specific responsibilities, and the Court's continuing jurisdiction extends to the "Failure of the North Platte Decree Committee . . . to act upon, resolve or agree on a matter that has been submitted to the . . . Committee." *Id.* at 56. Moreover, "Any dispute related to compliance or administration [of the decree] shall be submitted to and addressed by the North Platte Decree Committee before a party may seek leave of the Court to bring such dispute before the Court." *Id.* at 55.

In May of this year, the Court also approved another stipulated judgment involving the Republican River.

Kansas v. Nebraska, 123 S.Ct. 1898, 2003 U.S. LEXIS 4058. Kansas' motion to file an original action against Nebraska and Colorado to enforce the 1943 Republican River Compact was granted in 1999. The Final Settlement Stipulation, dated December 15, 2002, provided among other matters for the development of a groundwater model to be completed by June 30, 2003, "but if for any reason they have not done so by that date, binding arbitration will resolve the remaining issues necessary for its establishment." Special Master's Second Report at 2. In fact, the groundwater model was completed as required, and the Special Master's Final Report certifying its adoption was filed September 17, 2003. The result of the model's completion will be the dismissal of all claims, counterclaims and cross-complaints. The decree does not provide for continuing jurisdiction.

The Republican River stipulated decree calls for a number of other joint efforts in the future in the confident expectation that the cooperation that brought their case to such a rapid conclusion will continue to exist. An engineering committee is working on a Groundwater Model Users Manual that will provide details related to the use of the model. The model, with annual updates to the appropriate data files, will be used until such time as any changes are approved by the Republican River Compact Administration. The stipulation does, however, provide for dispute resolution. All matters related to compact administration, or to the stipulation, must first be submitted to the Republican River Compact Administration. If the members of the RRCA are not unanimous on a particular matter, it must then be submitted to non-binding arbitration pursuant to procedures prescribed in the Final Settlement Stipulation. There is the option, pursuant to agreement, also to submit to binding arbitration. Only if these procedures are unsuccessful may a state seek the Court's original jurisdiction. Two of the three members of the Republican River Compact Administration are David L. Pope and Harold D. Simpson, Chief Engineer and State Engineer respectively of Kansas and Colorado, and both important witnesses in the trial of this case.

The emphasis on arbitration is also of interest in this case. Binding arbitration of any future dispute related to the H-I model was proposed during this final trial segment, but was declined by Kansas as a "surrender of an important constitutional right" under Article III, Section 2. Kan. Opening Br. at 85. However, contrasting the Kansas position in this case with its agreement to accept binding arbitration on the groundwater model in the Republican River litigation may not be appropriate. A groundwater model can be far less complex than the H-I stream system model. Moreover, the groundwater model in the Republican River litigation may not play the same decisive compact compliance role that the H-I model holds under Colorado's Use Rules. Nonetheless, the Nebraska-Kansas-Colorado agreement on the Republican River suggests that limited arbitration, perhaps non-binding, might yet be useful for the Arkansas River.

F. Recommendation.

It is my recommendation, in accord with prevailing precedents, that the Court retain continuing jurisdiction in this case for a limited period of time, but that the Kansas request for the appointment of a River Master be denied. None of the interstate water cases supports the appointment of a River Master with authority to decide the kinds of issues that may still arise with respect to continued compliance with the Arkansas River Compact. Any such issues are not likely to be simply "ministerial" in nature. If a River Master is appointed with sufficiently broad authority to resolve modeling issues, it simply becomes easier to continue this litigation. But it is in the opposite direction that movement is needed. If the Court retains jurisdiction for a limited period of time beyond the recommended ten-year startup period (ending in 2006), there will be a full opportunity to see how Colorado's Use Rules operate under different hydrologic conditions. We already know that 1997-99 was a wet period, that 2001 was average, and that 2002 was extremely dry. If the Use Rules are not administered as Mr. Simpson has indicated, or if the results of the H-I model are still seriously in dispute, either state may apply to the Court for appropriate relief. I would recommend, however, that no such application be accepted unless the dispute has first been taken to the Arkansas River Compact Administration. To be sure, the Compact Administration can act only by unanimous vote. But the climate may be changing. The Compact Administration, under the chairmanship of the United States' representative, may again be seen as the best way to administer the compact and settle issues. After some thirteen years of litigation, the major issues between the states have already been determined or will be determined as a result of this Report. If there are future issues, it is to be hoped that the parties will have a greater appreciation for the Court's oft-stated admonition that litigation of these cases "is obviously a poor alternative to negotiation." *Texas v. New Mexico*, 462 U.S. 554, 567, fn. 13, and 575, citing numerous cases.

SECTION XII

RECOMMENDATIONS

Following my Third Report on damages, and the Court's Opinion thereon (533 U.S. 1, 150 L.Ed.2d 72, 121 S.Ct. 2023 (2001), the case was remanded. A substantial effort was then made to settle the remaining issues through mediation, using the former Attorney General of Montana as the mediator. That effort was unsuccessful, however, and trial resumed on June 24, 2002. These trial proceedings concluded on January 17, 2003 when both states rested their respective cases. This Fourth Report includes my decisions and recommendations on all remaining issues. Accordingly, I recommend:

1. That prejudgment interest be calculated as set forth in my Order dated December 2, 2002, and the final damage award be included in the decree. Appendix Exh. 2.

2. That damages be calculated pursuant to Appendix Exhibits 1 and 3, together with appropriate prejudgment interest, and adjustment for inflation as required.

3. That the Court approve my Order of July 25, 2001 rejecting Kansas' proposed evidence on the Winter Water Storage Program. Appendix Exh. 5.

4. That the Court approve my finding that implementation of Colorado's Use Rules, and the replacement water provided thereunder, brought Colorado into compliance with its obligations under the Arkansas River Compact for the period 1997-99. Section III.

5. That the Court approve my finding that Colorado's Measurement Rules, subject to possible revision following completion of Phase 2 of the USGS study, are adequate to

determine well pumping amounts for use in the H-I model, and that it is not necessary to require installation of totalizing flow meters on all of the wells within the H-I model domain. Section IV.

6. That the results of Colorado's irrigated acreage and well studies, as set forth in Section V of this Fourth Report, shall be used in the H-I model.

7. That in the H-I model, potential evapotranspiration (PET) shall be determined through the use of the Penman-Monteith methodology; that the adjustments recommended by Colorado experts are not sufficiently supported by the evidence and should not be made; that as more information may be developed on conditions in the Arkansas River Valley, adjustments made in accordance with recognized professional procedures may be appropriate. Section VI.

8. That the Court approve my findings and conclusions set forth in Section VII of this Fourth Report in regard changes in the H-I model.

9. That the final amounts of Replacement Plan credits to be applied toward Colorado's compact obligations shall be the amounts determined by the Colorado Water Court, and any appeals therefrom. This is not to say, however, that the Colorado Water Courts are empowered to make a final determination on any matter essential to compact compliance at the Stateline, or that Colorado's reliance on such Water Court actions will necessarily satisfy its compact obligations. Replacement credits not subject to Water Court approval, or calculated outside of the H-I model, shall be determined in accord with Colorado's Use Rules and the implementation procedures described in this trial segment. All replacement credits, no

matter how determined, are subject to the right of Kansas to seek relief under the Court's original jurisdiction. Section VIII.

10. That the Court approve my findings that the Kansas prospective compliance analysis is not sufficient to show that the Colorado Use Rules will not assure future compact compliance, and that Colorado should not be required to place water in the Offset Account in the amount of 15% of its pumping, or that its pumping be limited; that the Colorado evidence is not sufficient to prove that the Use Rules, as they have been applied, will necessarily assure future compliance; that the Use Rules, however, contain provisions that allow for the increase of replacement water for the benefit of Kansas, if that should be necessary; and that the actual implementation of the Use Rules over a longer period of time is needed to determine whether Colorado will continue to meet its compact obligations. Section IX.

11. That the Court approve my conclusions found in Section X of this Report accepting Colorado's proposal to use the results of the H-I model over a ten-year period to measure compact compliance, and to make up any depletions as testified to by the Colorado State Engineer.

12. That the Court deny the Kansas request to appoint a River Master to administer the final decree in this case, but that it retain jurisdiction for a limited period of time as recommended in Section XI of this Report.

13. That the case be remanded for the preparation of a final decree in accord with the prior Opinions of the

Court in this case, and with the Recommendations made in this Report, or as the Court may otherwise determine.

Respectfully Submitted,

ARTHUR L. LITTLEWORTH
Special Master

October 16, 2003

APPENDIX

Exhibit 1:

Letters dated August 7, 2003, from Counsel agreeing upon calculations of damages for compact violations in years 1950-94.

MONTGOMERY & ANDREWS
PROFESSIONAL ASSOCIATION
ATTORNEYS AND COUNSELORS AT LAW

[Names and Addresses Omitted in Printing]

August 7, 2003

VIA TELECOPY & U.S. MAIL

The Honorable Arthur L. Littleworth
Special Master
Best Best & Krieger
400 Mission Square
3750 University Avenue, 3rd Floor
Riverside, California 92501

RE: ***Kansas v. Colorado*, No. 105, Original U.S. Supreme Court**

Dear Mr. Littleworth:

Following our telephone conference with you on July 31, the States have conferred regarding what could be identified as being agreed with respect to the calculation of damages. The results are the following. Copies of the tables referred to are attached.

Pursuant to your determinations in the Third Report, the States agreed on the calculation of nominal damages in the years 1950-1998 resulting from Compact violations in the years 1950-1994. The annual nominal values are shown in Table D4 (col. 12) and Table D8 (sum of cols. 2-4) of Exhibit 1 to Kansas' Brief on Unresolved Damages Issues for the Period 1950-1994 ("Table D8") and in Table F of Exhibit C to Colorado's Motion to Determine the Amount of Damages in Prejudgment Interest for the 1950-94 Period (col. 5) ("Table F"). The sum of the annual nominal values for 1950-1998 is $7,059,595, as shown at the bottom of Table F, col. 5.

You inquired about a column in Table F labeled "Damages Adjusted for Inflation," which has a total of $18,391,014. This is not a value that is claimed to represent damages by either Colorado or Kansas. The States agree that it is the sum of the nominal damages in 1998 dollars adjusted for inflation, but is not a value that includes the investment component of prejudgment interest in accordance with the Supreme Court's 2001 Opinion, as calculated by either State.

You also inquired during our conference call whether the values that are the subject of your December 2, 2002 Order ("Order Values") included damages that are the subject of the States' Stipulation re Amount of Damages for 1995-96 and the Rate of Prejudgment Interest on Those Damages ("Stipulated Values"). The answer is that the Order Values do not include the Stipulated Values and are therefore totally separate. The Order Values are based on the damages resulting from Compact violations in the years 1950-1994. The Stipulated Values are based on the damages resulting from Compact violations in the years 1995-1996.

Sincerely yours,

/s/ John B. Draper
John B. Draper

JBD:dlo

cc: David W. Robbins, Esq.
David Davies, Esq.
Leland E. Rolfs, Esq.

Table D4. Summary of Kansas damages from usable depletions to stateline flow, expressed in current year dollars

	Replacement Groundwater (Case1)			Reduced GW Levels (Case 2)			Lost Crop Production (Case 3)			Total Economic Damages		
Year	Direct Gain (Loss) 1	Indirect Gain (Loss) 2	Total Gain (Loss) 3	Direct Gain (Loss) 4	Indirect Gain (Loss) 5	Total Gain (Loss) 6	Direct Gain (Loss) 7	Indirect Gain (Loss) 8	Total Gain (Loss) 9	Direct Gain (Loss) 10	Indirect Gain (Loss) 11	Total Gain (Loss) 12
1950	(88)	9	(79)	(3)	0	(3)	(2,060)	(248)	(2,308)	(2,151)	(239)	(2,390)
1951	(543)	55	(487)	(25)	3	(22)	(14,414)	(1,719)	(16,133)	(14,982)	(1,661)	(16,643)
1952	(490)	50	(440)	(69)	9	(61)	(12,128)	(1,426)	(13,554)	(12,687)	(1,368)	(14,055)
1953	(1,213)	124	(1,089)	(82)	10	(72)	(23,767)	(2,885)	(26,652)	(25,062)	(2,751)	(27,813)
1954	(2,706)	277	(2,429)	(397)	49	(348)	(47,971)	(5,841)	(53,812)	(51,074)	(5,516)	(56,589)
1955	(5,819)	599	(5,220)	(702)	87	(614)	(81,883)	(10,306)	(92,189)	(88,404)	(9,620)	(98,024)
1956	(4,658)	444	(4,214)	(760)	93	(667)	(92,238)	(11,318)	(103,557)	(97,657)	(10,781)	(108,438)
1957	(1,787)	176	(1,611)	(552)	66	(486)	(31,253)	(4,042)	(35,295)	(33,692)	(3,800)	(37,392)
1958	(2,232)	226	(2,006)	(628)	76	(552)	(34,693)	(4,581)	(39,275)	(37,553)	(4,280)	(41,832)
1959	(454)	48	(405)	(466)	56	(410)	(6,772)	(898)	(7,671)	(7,692)	(794)	(8,486)
1960	(7,513)	721	(6,792)	(1,058)	130	(927)	(82,598)	(11,312)	(93,910)	(91,169)	(10,460)	(101,630)
1961	(5,594)	539	(5,055)	(959)	118	(841)	(62,412)	(8,373)	(70,786)	(68,965)	(7,716)	(76,682)
1962	(3,173)	307	(2,866)	(1,229)	151	(1,078)	(36,638)	(4,839)	(41,476)	(41,039)	(4,380)	(45,420)
1963	(6,849)	656	(6,193)	(1,586)	198	(1,388)	(68,535)	(9,165)	(77,700)	(76,970)	(8,311)	(85,281)
1964	(10,533)	984	(9,549)	(3,248)	373	(2,875)	(87,569)	(11,605)	(99,174)	(101,350)	(10,248)	(111,598)
1965	(19,489)	1,886	(17,603)	(1,667)	196	(1,471)	(82,109)	(10,825)	(92,934)	(103,265)	(8,743)	(112,008)
1966	(1,976)	209	(1,766)	(1,670)	193	(1,477)	(28,532)	(3,093)	(31,625)	(32,178)	(2,690)	(34,868)
1967	(1,092)	132	(960)	(1,287)	146	(1,141)	(20,553)	(2,179)	(22,732)	(22,932)	(1,901)	(24,833)
1968	(15,618)	1,578	(14,041)	(2,581)	322	(2,259)	(109,989)	(15,721)	(125,710)	(128,189)	(13,821)	(142,010)
1969	(8,413)	885	(7,529)	(2,003)	257	(1,746)	(48,218)	(6,606)	(54,824)	(58,634)	(5,465)	(64,099)
1970	(8,061)	828	(7,233)	(2,797)	354	(2,443)	(64,547)	(8,993)	(73,540)	(76,405)	(7,811)	(83,216)
1971	(8,239)	835	(7,404)	(2,381)	298	(2,083)	(71,047)	(10,057)	(81,104)	(81,667)	(8,924)	(90,591)
1972	(11,526)	1,116	(10,411)	(3,435)	433	(3,003)	(117,934)	(15,697)	(133,631)	(132,896)	(14,149)	(147,045)
1973	(7,821)	787	(7,035)	(6,187)	772	(5,414)	(113,507)	(13,694)	(127,201)	(127,515)	(12,135)	(139,651)
1974	(12,491)	1,279	(11,211)	(9,390)	1,179	(8,211)	(167,370)	(20,809)	(188,179)	(189,251)	(18,351)	(207,602)
1975	(22,398)	2,357	(20,041)	(10,442)	1,330	(9,112)	(204,730)	(27,501)	(232,231)	(237,571)	(23,813)	(261,384)
1976	(44,914)	4,730	(40,183)	(16,222)	2,083	(14,139)	(287,120)	(42,257)	(329,377)	(348,256)	(35,444)	(383,699)
1977	(38,652)	4,100	(34,552)	(14,082)	1,785	(12,297)	(210,757)	(32,091)	(242,848)	(263,491)	(26,207)	(289,698)
1978	(63,661)	6,785	(56,877)	(27,638)	3,480	(24,158)	(323,375)	(47,393)	(370,768)	(414,674)	(37,129)	(451,803)
1979	(65,435)	7,005	(58,430)	(30,889)	3,710	(27,179)	(317,214)	(46,838)	(364,052)	(413,538)	(36,123)	(449,661)
1980	(16,642)	1,695	(14,946)	(37,140)	4,149	(32,991)	(84,046)	(11,968)	(96,014)	(137,828)	(6,123)	(143,951)
1981	(33,024)	3,494	(29,530)	(42,707)	4,939	(37,768)	(131,223)	(19,069)	(150,293)	(206,954)	(10,637)	(217,591)
1982	(63,363)	6,674	(56,689)	(42,228)	4,917	(37,311)	(208,000)	(31,545)	(239,545)	(313,591)	(19,954)	(333,545)
1983	(12,709)	1,458	(11,251)	(45,878)	5,468	(40,410)	(38,437)	(5,675)	(44,112)	(97,025)	1,251	(95,774)
1984	(15,814)	1,934	(13,880)	(48,112)	5,807	(42,305)	(38,035)	(5,502)	(43,537)	(101,961)	2,240	(99,721)
1985	0	0	0	(62,179)	7,496	(54,684)	(7,859)	(820)	(8,678)	(70,038)	6,678	(63,362)
1986	(51,729)	6,055	(45,673)	(61,206)	7,369	(53,837)	(62,624)	(11,478)	(74,102)	(175,558)	1,946	(173,613)
1987	(7,247)	1,117	(6,130)	(58,818)	8,236	(50,583)	(22,540)	(2,794)	(25,334)	(88,605)	8,559	(82,046)
1988	(35,379)	4,917	(30,462)	(83,248)	11,916	(71,332)	(55,206)	(9,180)	(64,386)	(173,833)	7,653	(166,180)
1989	(46,021)	6,387	(39,633)	(68,987)	10,065	(58,922)	(66,884)	(11,837)	(78,721)	(181,892)	4,615	(177,277)
1990	(94,345)	13,064	(81,281)	(79,351)	11,542	(67,809)	(102,268)	(21,390)	(123,658)	(275,964)	3,216	(272,748)
1991	(123,438)	16,841	(106,597)	(94,503)	13,774	(80,729)	(142,681)	(29,389)	(172,070)	(360,622)	1,227	(359,396)
1992	(130,232)	17,754	(112,478)	(64,358)	9,533	(54,826)	(138,702)	(30,330)	(169,031)	(333,292)	(3,043)	(336,335)
1993	(62,585)	8,459	(54,126)	(63,969)	9,463	(54,506)	(78,120)	(15,367)	(93,487)	(204,674)	2,556	(202,118)
1994	(107,516)	14,554	(92,963)	(98,279)	14,374	(83,905)	(109,999)	(23,069)	(133,069)	(315,794)	5,858	(309,936)
1995	0	0	0	(94,024)	13,624	(80,400)	0	0	0	(94,024)	13,624	(80,400)
1996	0	0	0	(100,349)	14,530	(85,818)	0	0	0	(100,349)	14,530	(85,818)
1997	0	0	0	(89,581)	13,140	(76,440)	0	0	0	(89,581)	13,140	(76,440)
1998	0	0	0	(80,826)	11,922	(68,903)	0	0	0	(80,826)	11,922	(68,903)
Future	0	0	0	(1,998,122)	294,738	(1,703,384)	0	0	0	(1,998,122)	294,738	(1,703,384)

sec-imp.wb2; Table D4, cell a1 (February 2002)

Table D8. Summary of Kansas damages from useable depletions to stateline flow according to Court ruling

	Annual Current Dollar Damages			Annual Damages (1950-84)-a			Annual Damages (1985-98)-b		
	Direct Impacts		Indirect	1985 Dollars			1998 Net Present Value		
Year	Farm	State	Impact	Farm	State	Indirect	Farm	State	Indirect
1950	2,105	46	239	9,397	205	1,067			
1951	14,662	321	1,661	60,444	1,322	6,846			
1952	12,416	271	1,368	50,223	1,098	5,533			
1953	24,524	538	2,751	98,464	2,158	11,044			
1954	49,985	1,089	5,515	199,939	4,358	22,059			
1955	86,519	1,885	9,620	347,366	7,570	38,622			
1956	95,563	2,094	10,781	378,036	8,284	42,649			
1957	32,837	755	3,800	125,737	2,892	14,551			
1958	36,486	1,067	4,280	135,843	3,972	15,934			
1959	7,465	227	794	27,603	840	2,935			
1960	88,643	2,526	10,460	322,229	9,183	38,025			
1961	67,036	1,930	7,716	241,238	6,944	27,768			
1962	39,885	1,154	4,380	142,108	4,111	15,607			
1963	74,855	2,115	8,311	263,217	7,436	29,225			
1964	98,681	2,669	10,248	342,518	9,265	35,570			
1965	99,322	3,943	8,743	339,272	13,468	29,865			
1966	30,866	1,311	2,690	102,507	4,355	8,934			
1967	21,935	998	1,901	70,664	3,214	6,124			
1968	123,210	4,978	13,821	380,961	15,393	42,734			
1969	56,348	2,285	5,465	165,207	6,701	16,022			
1970	72,358	3,047	7,811	200,663	8,451	21,662			
1971	78,368	3,299	8,924	208,207	8,765	23,710			
1972	127,531	5,364	14,149	328,286	13,809	36,422			
1973	122,367	5,148	12,135	296,547	12,477	29,408			
1974	181,612	7,638	18,351	396,379	16,671	40,052			
1975	227,981	9,590	23,813	455,963	19,179	47,626			
1976	334,203	14,052	35,444	631,990	26,574	67,025			
1977	252,857	10,634	26,207	448,968	18,881	46,532			
1978	397,961	16,714	37,129	656,758	27,582	61,274			
1979	396,870	16,668	36,123	588,199	24,703	53,538			
1980	132,427	5,401	6,123	172,926	7,053	7,995			
1981	198,843	8,111	10,637	235,374	9,601	12,591			
1982	301,301	12,290	19,954	335,959	13,704	22,249			
1983	93,151	3,873	(1,251)	100,633	4,185	(1,352)			
1984	97,890	4,071	(2,240)	101,376	4,216	(2,320)			
1985	67,244	2,794	(6,676)				225,555	6,084	(18,831)
1986	168,656	6,902	(1,945)				505,401	13,802	(4,991)
1987	84,700	3,906	(6,559)				227,687	7,281	(15,513)
1988	166,112	7,721	(7,653)				403,108	13,581	(16,445)
1989	174,589	7,303	(4,615)				382,596	12,044	(9,047)
1990	265,332	10,632	(3,216)				523,015	16,100	(5,791)
1991	346,724	13,898	(1,227)				617,171	19,399	(2,026)
1992	319,630	13,662	3,043				517,447	17,807	4,644
1993	196,337	8,337	(2,556)				292,524	10,385	(3,615)
1994	302,780	13,014	(5,858)				415,994	15,699	(7,744)
1995	90,387	3,637	(13,624)				114,675	4,246	(16,607)
1996	96,467	3,882	(14,530)				112,853	4,313	(16,594)
1997	86,116	3,465	(13,140)				93,160	3,650	(14,001)
1998	77,699	3,127	(11,922)				77,699	3,127	(11,922)
Sum 1950-84 in 1985'$				8,961,202	328,620	877,527			
Net Present Value 1998'$				30,058,561	715,536	2,475,328	4,508,887	147,517	(138,484)
						Sum NPV 1998'$			37,767,346
						Future Damages 1998'$			1,703,384
						TOTAL 1998'$			39,470,730
Net Present Value 2002'$ - c				40,415,417	877,724	3,234,016	6,062,450	180,954	(180,929)
						Sum NPV 2002'$			50,589,632
						Future Damages 2002'$			2,290,295
						TOTAL 2002'$			52,879,927

a: Values calculated using CPI shown in Table D5.
b: Values calculated using compound factors shown in Table D5.
c: Values calculated using compound factors shown in Table D5A.
NOTE: Dollar values for 2002 represent a date of January 1, 2002.
Settlement after this date will require appropriate adjustment in interest charges.
JOHNS Secimp Options.wb2 : Table D6 cell AS122 (August 2002)

App. 4

Table F. Colorado's estimate of money damages due to stateline depletions from 1950 through 1984, expressed in both 1998 and 2002 dollars, including adjustments for inflation and prejudgment interest

	Annual Current Dollar Damages			Sum of	CPI Factors	Damages	Prejudgment	Total
	Direct Impacts		Indirect	Nominal	For	Adjusted	Interest	Estimated
Year	Farm	State	Impact	Damages	1998 = 1.00	For Inflation	Added	Damages
1950	2,105	46	239	2,390	6.7751	16,190		16,190
1951	14,662	321	1,661	16,643	6.2787	104,497		104,497
1952	12,416	271	1,368	14,055	6.1445	86,361		86,361
1953	24,524	538	2,751	27,813	6.0984	169,615		169,615
1954	49,985	1,089	5,515	56,589	6.0681	343,390		343,390
1955	86,519	1,885	9,620	98,024	6.0908	597,046		597,046
1956	95,563	2,094	10,781	108,438	6.0010	650,742		650,742
1957	32,837	755	3,800	37,392	5.7946	216,672		216,672
1958	36,486	1,067	4,280	41,832	5.6401	235,940		235,940
1959	7,465	227	794	8,486	5.6014	47,534		47,534
1960	88,643	2,526	10,460	101,630	5.5068	559,649		559,649
1961	67,036	1,930	7,716	76,682	5.4515	418,030		418,030
1962	39,885	1,154	4,380	45,420	5.3974	245,145		245,145
1963	74,855	2,115	8,311	85,281	5.3268	454,276		454,276
1964	98,681	2,669	10,248	111,598	5.2581	586,789		586,789
1965	99,322	3,943	8,743	112,008	5.1746	579,596		579,596
1966	30,866	1,311	2,690	34,868	5.0309	175,417		175,417
1967	21,935	998	1,901	24,833	4.8802	121,191		121,191
1968	123,210	4,978	13,821	142,010	4.6839	665,160		665,160
1969	56,348	2,285	5,465	64,099	4.4414	284,688		284,688
1970	72,358	3,047	7,811	83,216	4.2010	349,595		349,595
1971	78,368	3,299	8,924	90,591	4.0247	364,601		364,601
1972	127,531	5,364	14,149	147,045	3.8995	573,404		573,404
1973	122,367	5,148	12,135	139,651	3.6712	512,681		512,681
1974	181,612	7,638	18,351	207,602	3.3063	686,391		686,391
1975	227,981	9,590	23,813	261,384	3.0297	791,925		791,925
1976	334,203	14,052	35,444	383,699	2.8647	1,099,173		1,099,173
1977	252,857	10,634	26,207	289,698	2.6898	779,220		779,220
1978	397,961	16,714	37,129	451,803	2.5000	1,129,508		1,129,508
1979	396,870	16,668	36,123	449,661	2.2452	1,009,570		1,009,570
1980	132,427	5,401	6,123	143,951	1.9782	284,757		284,757
1981	198,843	8,111	10,637	217,591	1.7932	390,180		390,180
1982	301,301	12,290	19,954	333,545	1.6891	563,398		563,398
1983	93,151	3,873	(1,251)	95,774	1.6365	156,738		156,738
1984	97,890	4,071	(2,240)	99,721	1.5688	156,445		156,445
1985	67,244	2,794	(6,676)	63,362	1.5149	95,985	116,823	212,808
1986	168,656	6,902	(1,945)	173,613	1.4872	258,202	256,011	514,213
1987	84,700	3,906	(6,559)	82,046	1.4349	117,725	101,730	219,455
1988	166,112	7,721	(7,653)	166,180	1.3779	228,972	171,272	400,244
1989	174,589	7,303	(4,615)	177,277	1.3145	233,034	152,559	385,593
1990	265,332	10,632	(3,216)	272,748	1.2471	340,152	193,172	533,325
1991	346,724	13,898	(1,227)	359,396	1.1968	430,114	204,430	634,544
1992	319,630	13,662	3,043	336,335	1.1618	390,753	149,146	539,898
1993	196,337	8,337	(2,556)	202,118	1.1280	227,995	71,298	299,293
1994	302,780	13,014	(5,858)	309,936	1.0999	340,888	83,061	423,949
1995	90,387	3,637	(13,624)	80,400	1.0696	85,992	16,322	102,314
1996	96,467	3,882	(14,530)	85,818	1.0389	89,155	11,417	100,572
1997	86,116	3,465	(13,140)	76,440	1.0156	77,631	5,178	82,809
1998	77,699	3,127	(11,922)	68,903	1.0000	68,903	0	68,903
Sums	6,521,837	260,385	277,373	7,059,595		18,391,014	1,532,419	19,923,433

Adjusting the sum of estimated damages to 2002 dollars results in the following estimate of damages: 26,666,048

Including the estimated future damages, also expressed in 2002 dollars, adds the following amount: 2,332,318

The sum of estimated historical and future damages, expressed in 2002 dollars is the following amount: 28,998,366

This table appears in Johnsse8.wb2, Page Table D6, Cell BY 120. It was created on July 21, 2002 and is on the may2002 subdirectory.

HILL & ROBBINS, P.C.
ATTORNEYS AT LAW
100 BLAKE STREET BUILDING
1441 EIGHTEENTH STREET
DENVER, COLORADO 80202-5932

[Names and Addresses Omitted In Printing]

August 7, 2003

VIA TELECOPY AND U.S. MAIL

Special Master Arthur L. Littleworth
Best, Best & Krieger
400 Mission Square Building
3750 University Avenue, 3rd Floor
Riverside, CA 92501

Re: ***Kansas v. Colorado*, No. 105, Original U.S. Supreme Court**

Dear Mr. Littleworth:

We concur with Mr. Draper's letter of today's date.

Very truly yours,

/s/ David W. Robbins
David W. Robbins

DWR/rmm

cc: John B. Draper, Esq.
Carol Angel

APPENDIX

Exhibit 2:

Order of Special Master dated December 2, 2002, regarding prejudgment interest.

IN THE SUPREME COURT OF THE UNITED STATES

STATE OF KANSAS, Plaintiff, v. STATE OF COLORADO, Defendant, UNITED STATES OF AMERICA, Intervenor	)	No. 105 Original

ORDER RE APPLICATION OF PREJUDGMENT INTEREST FOR THE 1950-94 PERIOD

(Filed Dec. 2, 2002)

INTRODUCTION

As part of the trial segment beginning June 24, 2002 which concerns the issues of possible Stateline depletions for the years 1997-99 and future Compact compliance, the states were asked to confer on the modifications to the calculation of damages for 1950-94 as required by the Supreme Court's Opinion of June 11, 2001. In my Third Report, I had recommended approval of the analyses used by Kansas experts to determine such damages, but had not accepted all of the data on which they relied. Instead, in certain instances I recommended that data compiled by Colorado experts be used. My recommendations in this regard were approved by the Court, requiring a recalculation of what the parties refer to as "nominal damages." These are the actual dollar values of the various damage components at the time a loss occurred. Such nominal damages did not include any adjustment either for inflation, or for prejudgment interest representing lost investment opportunities.

As a result of these out of Court efforts, the states have agreed upon the amount of nominal damages for the years 1950-94. The approved methodology and data for the recalculation of nominal damages appears in my Third Report in Sections V, VI, VII, VIII, IX and X, and are summarized in the Colorado Motion on page 3. The states have also agreed upon the adjustments to nominal damages required for inflation, calculated in 2002 dollars. Colorado has always acknowledged that nominal damages should be adjusted for inflation, and the states are now in agreement upon the specific rates for such adjustment.

In their negotiations, however, the states disagreed over the application of the Supreme Court's Opinion with respect to prejudgment interest. I asked the states to brief this remaining issue, and as part of the briefing process, Colorado filed a specific Motion reflecting its position. The Kansas briefs may be accepted as its response, and they set forth Kansas' position on the prejudgment interest issue.

The Colorado Motion seeks a determination that damages for the 1950-94 period, adjusted for inflation, are $28,998,366 in 2002 dollars. The corresponding Kansas calculation is $52,879,927. The difference depends upon whether or not prejudgment interest accrues after 1985 on the damages that occurred during the period 1950-85. There is no dispute over the fact that the Supreme Court's Opinion precludes prejudgment interest (apart from an inflation adjustment) for damages that occurred before Kansas filed this action, i.e., at the end of 1985.

SPECIAL MASTER'S THIRD REPORT

In the trial proceedings leading up to my Third Report, the issues surrounding prejudgment interest were extensively argued: i.e., whether prejudgment interest was allowable at all as a matter of law; if so, whether such an award was dependent upon a balancing of the equities; whether any award should run from commencement of the first Compact violation in 1950, or at some later date; and what should be the rate of any prejudgment interest. It was the Colorado position that the unliquidated nature of the damages precluded any award of prejudgment interest, as a matter of law. I found against Colorado on this issue, and the Supreme Court overruled Colorado's exception. 533 U.S. 1 at 12. Kansas, on the other hand, argued that prejudgment interest is not an added remedy, but is simply part of providing full compensation to an injured party, and is required by recent case law as well as the economic principle of the "time value of money." It was the Kansas position that prejudgment interest, including a component for inflation and lost investment opportunities, should be awarded as a matter of course on the Stateline shortages beginning in 1950. I also rejected the Kansas view, finding that prejudgment interest should not be awarded according to any rigid theory of compensation for money withheld, but rather should be governed by considerations of fairness and a balancing of the equities. Kansas' exception to this finding was also overruled by the Court. 533 U.S. 1 at 16.

In my Third Report, I did not wholly accept the position of either state. I found that the law now permits prejudgment interest to be included in any damage award for violation of an interstate water compact, but that the amount is to be governed by "considerations of fairness," and the remedy taken as a whole must be "fair and equitable." *Jackson County v. United States,* 308 U.S. 343, 352, 84 L.Ed. 313, 60 S.Ct. 285 (1939); *Texas v. New Mexico,* 482 U.S. 124, 134, 96 L.Ed.2d 105, 107 S.Ct. 2279 (1987). For reasons set forth in my Third Report, I concluded that prejudgment interest should be included in this case at the rates proposed by Kansas, but only from 1969 when Colorado knew or should have known of its Compact violations. I rejected the notion of requiring full prejudgment interest rates during 1950-68 when neither state saw any wrongdoing, or thought that Compact violations were occurring. Only with hindsight and sophisticated computer modeling do we now know that Stateline depletions occurred during those early years. Specifically, I recommended the inclusion of prejudgment interest, "but only from 1969 to the date of judgment," and that actual damages for 1950-68 should be adjusted for inflation (which Colorado had always proposed), "but should not bear compound interest reflecting the loss of use of those monies." Third Report at 107.

Prejudgment interest was perhaps the principal issue in the Supreme Court's consideration of my Third Report. Although its Opinion on this issue was not unanimous, the Court agreed that damages should include an award of prejudgment interest, but that the equities did not support interest from the date of the first violation of the Compact in 1950, "but rather favor an award beginning at a later date." 553 U.S. 1 at 14. Considering such "later date," the Court went on to state:

> "Specifically, Colorado suggests that prejudgment interest should begin to accrue in 1985 rather than 1969. The choice between the two dates is surely debatable; it is a matter over which

> reasonable people can – and do – disagree. After examining the equities for ourselves, however, a majority of the Court has decided that the later date is the more appropriate." 533 U.S. 1 at 15.

The Court therefore overruled the states' objections, except that Colorado's objection was sustained "insofar as it challenges the award of interest for the years prior to 1985." 533 U.S. 1 at 16.

ARGUMENTS OF THE STATES

First, it may be helpful to outline the matters on which the states agree. For damages caused by depletions occurring *after* 1985 when the action was filed, they agree that prejudgment interest is appropriate, at rates reflecting both inflation and lost investment opportunities. Moreover, they agree upon the specific amounts of such damages through 1994. They further acknowledge that under the Supreme Court decision, damages occurring before the action was filed, i.e., for the 1950-85 period, may not bear interest that reflects lost investment opportunities. This is a separate matter from an adjustment for inflation to which Colorado has always agreed. Remaining at issue, however, is the question of how the total amount of damages for the early 1950-85 period (adjusted for inflation) should be treated after 1985, and until entry of Judgment. Kansas maintains that such total, after 1985, should begin to bear full prejudgment interest, at rates including both inflation and lost investment opportunities. Colorado, while acknowledging the need to adjust for inflation, argues that such damages are exempt from any other prejudgment interest. Approximately 24 million dollars is dependent upon this decision. In 2002 dollars, the Kansas approach puts total damages for the 1950-94 period at $52,879,927. Colorado's analysis leads to a total of $28,998,366.

It is Kansas' position that the Supreme Court's decision of June 11, 2001 "left open" the question of whether prejudgment interest should begin to accrue on *all* damages existing as of 1985, or only on the "additional damages" occurring after filing the suit in 1985. Kansas Brief at 4. Colorado, on the other hand, states that the only issue is whether the Supreme Court "intended to overrule" the Special Master's recommendation, citing from the Third Report:

> "I thus recommend that actual damages for the period 1950-68 should be adjusted for inflation, but should not bear compound interest reflecting the loss of use of those monies." Colorado Brief at 2, 5, 9.

Colorado argues that the Supreme Court simply changed the Special Master's 1969 date to 1985. Colorado Brief at 10.

In connection with the argument before the Supreme Court on my Third Report, I directed the states to calculate what the total amount of damages would have been if the Court were to have accepted my recommendations in their entirety. The states were able to agree that the total amount of damages for the period 1950-94, adjusted to 1998 dollars and calculated on the basis of the Third Report, came to approximately 38 million dollars, and this information was conveyed to the Court. The states received no direction on how to calculate these damages. The meaning of the Third Report in this respect lay with the two states.

It is significant, therefore, that in reaching the 38 million dollar figure, the states did not calculate prejudgment interest in the manner that Kansas now suggests. That is, the states did not take the pre-1969 damages, and then subject that total to prejudgment interest for 1969 and all the years following. Rather, they treated damages for the period 1950-68 as being completely exempt from any interest reflecting lost investment opportunities. That component of prejudgment interest was added by the states only to those damages occurring in 1969 and afterwards. In essence, the states followed the methodology now urged by Colorado, except that they were dealing with 1969 instead of 1985.

Kansas does not dispute the fact that this was the construction given to my Third Report when the states advised the Court of the 38 million dollar figure. However, Kansas argues that the determinative question at present is not how the states interpreted the Third Report, but rather "the basis on which the Supreme Court intended to award prejudgment interest upon its review of the Third Report." November 22, 2002 letter. They say that the "only result consistent with the Court's rationale is an award of interest that takes into account Kansas' lost opportunity to invest its damages over the period from 1985 to the date of judgment." *Id.* I cannot agree.

Initially, the Justices appear to have held three separate views concerning prejudgment interest. Four members of the Court agreed with my view "that interest should run from the time when Colorado knew or should have known it was violating the Compact," that is, from 1969. 533 U.S. 1 at 15, fn. 5. Under these circumstances, the states had advised the Court that damages would total approximately 38 million dollars. Three Justices, however, "would not allow any prejudgment interest." *Id.* It was their view that the state of the law in 1949 was insufficiently evolved "for Colorado to have had notice that the courts might award prejudgment interest if it violated its obligations under the Compact." 533 U.S. 1 at 11, fn. 4. Finally, two members of the Court were of the opinion that "prejudgment interest should run from the date of the filing of the complaint," i.e., from 1985. 533 U.S. 1 at 15, fn. 5. Clearly there was no sentiment on the Court to increase damages, including prejudgment interest, over the amount recommended in my Third Report. Indeed, the final action of the Court was to reduce my recommended award. The Court stated that "[I]n order to produce a majority for a judgment" the four Justices who agreed with the Third Report voted to endorse the Colorado position, explaining:

> "Given the uncertainty over the scope of the damages that prevailed during the period between 1968 and 1985 and the fact that it was uniquely in Kansas' power to begin the process by which those damages would be quantified, Colorado's request that we deny prejudgment interest for that period is reasonable." 533 U.S. 1 at 15, 16.

Yet the theory of calculating prejudgment interest that is now proposed by Kansas would move the award in the opposite direction. I believe the Court intended to exempt all damages occurring before the suit was filed from any prejudgment interest (not including an adjustment for inflation.) Prejudgment interest should apply *only* to those damages occurring after filing suit, i.e., after 1985.

While the Court has ruled that interest should begin to accrue in 1985, Kansas argues the Court did not identify "the principal amount on which interest should accrue." Kan. Brief at 10, also at 2, 4. That principal amount, according to Kansas, should be the nominal damages occurring from 1950 through 1984, which would then accrue interest "compounded over the period 1985 through 2001 [or to date of judgment] at interest rates accounting for inflation and lost investment opportunities." Kan. Brief at 3. Kansas cites a number of cases, arguing that these precedents "leave no doubt" that its approach "is the correct one." Kan. Brief at 4. However, these cases merely reflect general law and do not help with the Court's meaning in this case. The Kansas approach presupposes that the Supreme Court's intent cannot be ascertained from its Opinion, and with this fundamental assumption I cannot agree. Looking to the Court as a whole, the plain direction was to limit the application of prejudgment interest.

I find that the Colorado position properly applies the Court's intent, and accordingly, the Colorado Motion is hereby granted.

DATED: December 2, 2002

/s/ Arthur L. Littleworth
ARTHUR L. LITTLEWORTH
Special Master

PROOF OF SERVICE BY MAIL

STATE OF CALIFORNIA, COUNTY OF RIVERSIDE

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years and not a party to the within entitled action; my business address is Best, Best & Krieger, 3750 University Avenue, 400 Mission Square, Riverside, California 92502.

I am readily familiar with Best, Best & Krieger's practice for collecting and processing correspondence for mailing with the United States Postal Service. Under that practice, all correspondence is deposited with the United States Postal Service the same day it is collected and processed in the ordinary course of business.

On December 2, 2002, I served the within **ORDER RE APPLICATION OF PREJUDGMENT INTEREST FOR THE 1950-94 PERIOD** by placing a copy of the document in a separate envelope for each addressee named below and addressed to each such addressee as follows:

John B. Draper, Esq.
Montgomery & Andrews
325 Paseo de Peralta
P.O. Box 2307
Santa Fe, New Mexico 87504-2307

David W. Robbins, Esq.
Hill & Robbins
100 Blake Street Building
1441 Eighteenth Street
Denver, Colorado 80202

Theodore B. Olson
Solicitor General
United States Department of Justice
Main Building, Room 5259
950 Pennsylvania Avenue NW
Washington D.C. 20530

James J. DuBois, Esq.
U.S. Department of Justice
General Litigation Section
999 18th Street, Suite 945
Denver, Colorado 80202

On December 2, 2002, at the office of Best, Best & Krieger, 3750 University Avenue, 400 Mission Square, Riverside, California 92502, I sealed and placed each envelope for collection and deposit by Best, Best & Krieger in the United States Postal Service, following ordinary business practices.

I declare under penalty of perjury under the laws of the State of California, that the foregoing is true and correct.

Executed on December 2, 2002, at Riverside, California.

/s/ Sandra L. Simmons
Sandra L. Simmons

APPENDIX

Exhibit 3:

Stipulation filed July 14, 2003, re Amount of Damages for 1995-96 and the Rate of Prejudgment Interest on Those Damages.

No. 105, Original

In The
Supreme Court of the United States

STATE OF KANSAS,
Plaintiff,
v.
STATE OF COLORADO,
Defendant,
and
UNITED STATES OF AMERICA,
Intervenor.

STIPULATION RE AMOUNT OF DAMAGES FOR 1995-96 AND THE RATE OF PREJUDGMENT INTEREST ON THOSE DAMAGES

(Filed Jul 14, 2003)

This Stipulation is entered into this 11th day of July, 2003, by the State of Kansas (hereinafter "Kansas") and the State of Colorado (hereinafter "Colorado"), subject to approval by the Special Master of the United States Supreme Court.

RECITALS:

WHEREAS, Article IV-D of the Arkansas River Compact (hereinafter "the Compact"), 63 Stat. 145, provides as follows:

> This Compact is not intended to impede or prevent future beneficial development of the Arkansas River basin in Colorado and Kansas by Federal or State agencies, by private enterprise, or by combinations thereof, which may involve construction of dams, reservoir[s], and other works for the purposes of water utilization and control, as well as the improved or prolonged functioning of existing works: Provided, that the waters of the Arkansas River, as defined in Article III, shall not be materially depleted in usable quantity or availability for use to the water users in Colorado and Kansas under this Compact by such future development or construction.

WHEREAS, Arthur L. Littleworth, Special Master, in his July 1994 Report recommended that the United States Supreme Court (hereinafter "the Court") find that post-Compact well pumping in Colorado had materially depleted the usable flow of the Arkansas River at the Colorado-Kansas Stateline in violation of Article IV-D of the Compact, and the Court did so and remanded the case to the Special Master for determination of the unresolved issues, *see Kansas v. Colorado*, 514 U.S. 673, 693-694, 115 S.Ct. 1733, 1745 (1995);

WHEREAS, the Special Master recommended in his Third Report dated August 11, 2000 (hereinafter "Third Report"), that the depletions of usable Stateline flows caused by post-Compact well pumping in Colorado for the 1995-96 period be determined to be 7,935 acre-feet, and neither Kansas nor Colorado filed an exception to this recommendation;

WHEREAS, the Special Master also recommended in his Third Report that the Court confirm his ruling that a suitable remedy in this case should be in monetary damages based upon Kansas' losses, which recommendation was confirmed by the Court, *see Kansas v. Colorado*, 533 U.S. 1, 6, 121 S.Ct. 2023, 2027 (2001);

WHEREAS, the Special Master further recommended in his Third Report that the Court confirm his ruling that the unliquidated nature of Kansas' claim for damages did not bar an award of prejudgment interest, which ruling was confirmed by the Court in *Kansas v. Colorado*, 533 U.S. at 10-12, 121 S.Ct. at 2029-2030; and

WHEREAS, Kansas and Colorado desire to reach an agreement on the amount of money damages that should be awarded to Kansas for the depletions of usable Stateline flow in violation of the Compact for the 1995-96 period and the rate of prejudgment interest that should be awarded on such damages;

NOW THEREFORE, Kansas and Colorado stipulate and agree as follows:

1. The amount of money damages, in 2002 dollars, that should be awarded to Kansas for depletions of usable Stateline flows caused by post-Compact well pumping in Colorado in violation of Article IV-D of the Compact for the 1995-96 period is $236,664.

2. Prejudgment interest on the money damages awarded to Kansas for the 1995-96 period as stipulated in paragraph 1 should be calculated at the rate of six percent

(6%) per year, simple interest, beginning on January 1, 2003, and prorated to the day of payment.

3. This stipulation is made as a compromise and settlement of the amount of money damages and the rate of prejudgment interest that should be awarded on such money damages for the 1995-96 period only. Neither this stipulation nor the payment of such damages and prejudgment interest by Colorado shall constitute an agreement on the amount of money damages that should be awarded for any other period for violation of the Compact or on the appropriate rate of prejudgment interest on money damages for any other period.

4. The States request that the money damages awarded to Kansas for the 1995-96 period, and the prejudgment interest upon such damages, as stipulated herein, be included in the Court's judgment for damages and prejudgment interest for the 1950-94 period, unless earlier paid.

STATE OF KANSAS

Phill Kline
Attorney General of Kansas

Eric Rucker
Chief Deputy Attorney General

David Davies
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/s/ John B. Draper
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Attorneys for Defendant
State of Colorado

APPROVED:

/s/ Arthur L. Littleworth July 14, 2003
RTHUR L. LITTLE WORTH Date
Special Master

APPENDIX

Exhibit 4:

Joint Report of the States in regard to mediation efforts, filed January 3, 2002.

No. 105, ORIGINAL

In The

SUPREME COURT OF THE UNITED STATES

October Term, 2001

STATE OF KANSAS

Plaintiff,

v.

STATE OF COLORADO,

Defendant.

JOINT REPORT OF THE STATES

(Filed Jan 3, 2002)

The State of Colorado, through its Attorney General Ken Salazar, and the State of Kansas, through its Attorney General Carla Stovall, hereby jointly report to the Special Master as required by Order of the Special Master dated September 28, 2001:

1. In order to pursue settlement of the remaining issues in the above captioned case, Kansas and Colorado retained former Montana Attorney General Joseph P. Mazurek, currently a member of the firm of Crowley, Haughey, Hanson, Toole & Dietrich, P.L.L.P., and Harley R. Harris, of the firm of Luxan & Murfitt, PLLP, as Mediators for the settlement negotiations.

2. The representatives of the States met jointly with the Mediators on September 29th (basin tour), October

17th, November 5th and 6th, December 3rd, and December 12th, 2001, and had other meetings and numerous telephonic contacts with the Mediators.

3. Unfortunately, despite the excellent services of the Mediators and the considerable efforts of the States, including extensive personal involvement of the Attorneys General themselves, it has not been possible to settle the remaining issues in the case at this time. The States, however, intend to continue to consider the possibility of settlement, especially upon completion of the final expert reports and related discovery.

4. The States have discussed the scheduling of the remaining expert reports, depositions and trial, and request that the Special Master hold a telephonic conference with the States as soon as convenient after January 1, 2002 to finalize the trial preparation schedule.

Respectfully submitted this 31st day of December, 2001.

/s/ David W. Robbins
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*Counsel of Record

CERTIFICATE OF SERVICE

I, John M. Cassidy, a member of the Bar of this Court, hereby certify that on the 28th day of December, 2001, I caused to be mailed, first class postage prepaid, a true and correct copy of the foregoing JOINT REPORT OF THE STATES, addressed to each of the following:

The Hon.
Arthur L. Littleworth
Special Master
Best, Best & Krieger
400 Mission Square
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Riverside, CA 92501
(Original and two copies)

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I further certify that all parties required to be served have been served.

/s/ John M. Cassidy
John M. Cassidy
Kansas Assistant
Attorney General

APPENDIX

Exhibit 5:

Order filed July 25, 2001, Denying Request of Kansas in Regard to Winter Water Storage Program.

IN THE SUPREME COURT OF THE UNITED STATES

STATE OF KANSAS, Plaintiff, v. STATE OF COLORADO, Defendant, UNITED STATES OF AMERICA, Intervenor.	))))))))))	No. 105 Original

ORDER DENYING REQUEST OF KANSAS IN REGARD TO WINTER WATER STORAGE PROGRAM

(Filed Jul. 25, 2001)

In May of 1998 trial proceedings were held to consider Colorado's compliance with its compact obligations for the period 1995-96. I determined that depletions of usable Stateline flow resulting from postcompact well pumping during the 1995-96 period amounted to 7,935 acre-feet. My recommendations to the Supreme Court in my Third Report included that determination, bringing total depletions for the period 1950-96 to 428,005 acre-feet. No exceptions were taken to that recommendation in the Third Report.

Recently the States have been preparing for additional trial proceedings to determine depletions from well pumping, if any, for the years following 1996. Expert reports have been exchanged on compliance through 1999, on studies of irrigated acreage in Colorado, on approaches to determine the amounts of pumping, and on performance of the H-I model. Depositions of various experts have been taken, and the time for delivering the last Kansas expert reports to Colorado on power conversion coefficients was extended to May 11, 2001. The date for commencement of the next trial segment has not yet been set.

On May 9, 2001 Kansas sought permission by letter to submit to Colorado and the United States, presumably for use in the next trial segment on compact compliance, an analysis by the Kansas experts of the need for future replacement water "to offset future depletions of usable stateline flows caused by the Colorado Winter Water Storage Program" (sometimes "WWSP"). Kansas stated that this analysis was directed toward assessing "the additional replacement water necessary for compliance by Colorado in the future with the Arkansas River Compact." Kansas made clear that the analysis was not to be the basis for any claim of past damages, but simply addressed the question of "the extent to which there will be a need in the future for Colorado water users to provide replacement water" to offset depletions from the Winter Water Storage Program.

Both Colorado and the United States responded by letters dated May 30, 2001 to this request, and Kansas replied on July 14. A final letter response was received from Colorado on July 15.

Colorado opposed the request on the grounds that it was not timely, and not within the scope of the remand order by the Supreme Court in its 1995 Opinion. Colorado's final reply letter added the argument that the issues now raised by Kansas should go first to the Arkansas River Compact Administration. The United States also opposed the Kansas request on the grounds of lack of jurisdiction. The United States referred to the conclusion in my First Report, namely, that Kansas had failed to prove its claim that the Winter Water Storage Program caused depletions in violation of the compact. When the Supreme Court overruled Kansas' exception to that conclusion, the United States argues that the claim was effectively dismissed. The United States also contends that there are practical considerations which militate against allowing evidence of the WWSP's "future impacts" in this proceeding.

The Kansas position is that the earlier proceedings addressed only the question of whether Colorado *had* violated the compact through the WWSP during the years 1976-1985. Kansas states that this was a question of liability; what it now seeks is a remedy for the future. One of the unresolved issues in the case, according to Kansas, is whether compact violations can be expected from the WWSP "in the future." Prospective compact compliance in this regard is heightened, Kansas argues, because of efforts currently underway to enlarge the physical storage capacity of Pueblo Reservoir and to expand the operation of the Winter Water Storage Program. Kansas also replies that the suggestion that it should first seek relief before the Arkansas River Compact Administration is not helpful since that body cannot act unless both States agree.

In its 1986 complaint filed with the Supreme Court, Kansas did not directly address the impacts of the Winter Water Storage Program. The complaint first alleges that Colorado and its water users have materially depleted the usable and available Stateline flows of the Arkansas River. Specifically, the complaint then refers to the impacts of groundwater pumping of approximately 150,000 acre-feet per year; compact violations resulting from the operations of Trinidad Reservoir; and Colorado's rejection of the

Compact Administration's resolution of July 24, 1951, allegedly requiring that any re-regulation of native river water be approved by the Compact Administration. This latter allegation, which was the subject of a major pretrial order, related to Pueblo Reservoir and to the operation of the Winter Water Storage Program. In a pretrial order dated September 15, 1989 [found in my First Report, Vol. III at 338], I granted Colorado's Motion for Partial Summary Judgment, determining that neither the 1951 Resolution of the Compact Administration, nor the compact itself, required prior Administration approval for the re-regulation of native river waters, as found in the Winter Water Storage Program. However, I reserved for trial the question of whether the actual impact of the program on usable Stateline flows caused a violation of the compact.

The Winter Water Storage Program began in 1976 upon completion of Pueblo Reservoir, a United States facility. Under the program, Arkansas River flows were stored in Pueblo Reservoir during the winter for later summer irrigation. Previously, winter flows had been diverted in part to irrigate bare fields, thereby increasing the soil moisture for the next growing season. The basic issue was whether winter storage and later summer use caused material Stateline depletions compared to the historic practices of winter irrigation. Evidence on the program's operation was received from its inception in 1976 through 1986-87. This segment of the trial dealt only with claimed depletions through 1985. The WWSP went through several annual changes, and was finally approved by a decree of the Colorado Water Court in 1987. That decree basically confirmed the operating plan that had been in effect since 1983.

A substantial portion of the liability phase of the trial was devoted to the Winter Water Storage Program. Indeed, the principal involvement of the United States focused on that issue. The evidence addressed the early development of the program; notice to Kansas at least as early as 1970; a computer model analysis by the USGS before the program was commenced predicting that the program would increase rather than decrease Stateline flows; computer modeling by both Kansas and Colorado on the impact of the program; expert testimony by the United States on the accuracy of the Kansas modeling efforts; extensive expert testimony comparing consumptive use under the program with that occurring under prior winter irrigation practices; testimony on the merits of using the Blainey-Criddle equation to determine potential evapotranspiration versus use of the Ritchie methodology; and numerous other technical matters fundamental to the computer model studies. In short, during the liability phase of the trial, there was a comprehensive evaluation of the entire program.

I concluded that Kansas did not prove that the WWSP caused material Stateline depletions, and Kansas' exception to that finding was overruled by the Supreme Court. (514 U.S. 673, 131 L.Ed.2d 759, 115 S.Ct. 1733 (1995) As Kansas notes, my conclusion was "not to say that the WWSP has not adversely impacted Stateline flows, but rather that Kansas has failed to prove that it has." (First Report, Vol. II at 335.) Nonetheless, Kansas had a full opportunity to prove its claim. Kansas did not do so, and the Winter Water Storage Program as it has been known in this case may not be considered now to cause Stateline depletions in violation of the compact.

The Stateline depletions which have been determined thus far have resulted only from postcompact well pumping. Yet Kansas now seeks to introduce expert testimony assessing the "additional replacement water" which may be necessary in the future "to offset depletions to usable flows at the Stateline due to the Winter Water Storage Program." This supply, it is said, would be a "supplement" to the replacement water otherwise needed to offset the effects of well pumping. However, I cannot see how additional replacement water can be ordered without overturning the Supreme Court's prior decision on liability in regard to the WWSP. Kansas states that it has no intent "to ask for any revisions to the current or future operating procedures" of the WWSP. If that is true, the Kansas claims have already been fully heard and determined, and continued operation of the same program in the future does not give rise to a compact violation.

There is some suggestion, however, that what Kansas fears is a future expansion of the program "which will exacerbate the effects of the current Program." This apparently turns on the possible enlargement of the storage capacity of Pueblo Reservoir, although Colorado points out that such enlargement is far from being authorized. Apparently all that has been done is to call for a study. On May 3, 2001, H.R.1714 was introduced to authorize, among other things, the Secretary of the Interior to *conduct studies* for the enlargement of Pueblo Dam and Reservoir and Sugarloaf Dam and Turquoise Lake, Fryingpan-Arkansas Project, Colorado. There is not even an indication that the bill has become law.

If the Winter Water Storage Program should be expanded in the future, Kansas will then have to assess the impact of such new development and take whatever action that may be appropriate. By virtue of this case, however, there is not continuing jurisdiction in the Supreme Court over potential future violations of the compact. Put in traditional terms, Kansas does not present an issue that is ripe for determination. My task in this case is to assist the Court in deciding the issues that Kansas put forward in its 1986 complaint, as amended, and the case is defined and limited by those issues.

Kansas, understandably, may be reluctant to put faith in the compact provisions and the Arkansas River Compact Administration to investigate and remedy potential violations. Nonetheless, the compact is the agreement the States have made, and the Supreme Court may not be viewed as a handy replacement for the provisions of the compact. Moreover, the future may not be the same as the past. The relations between the States during the course of this trial have been generally marked by exemplary cooperation. Agreements have been reached on some issues that otherwise would have been extremely expensive and time consuming to try. It is to be hoped that this same good faith approach may carry over into the Compact Administration after a final judgment has been entered here.

DATED: July 25, 2001

/s/ Arthur L. Littleworth
ARTHUR L. LITTLEWORTH
Special Master

PROOF OF SERVICE BY MAIL

STATE OF CALIFORNIA, COUNTY OF RIVERSIDE

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years and not a party to the within entitled action; my business address is Best, Best & Krieger, 3750 University Avenue, 400 Mission Square, Riverside, California 92502.

I am readily familiar with Best, Best & Krieger's practice for collecting and processing correspondence for mailing with the United States Postal Service. Under that practice, all correspondence is deposited with the United States Postal Service the same day it is collected and processed in the ordinary course of business.

On July 25, 2001, I served the within **ORDER DENYING REQUEST OF KANSAS IN REGARD TO WINTER WATER STORAGE PROGRAM** by placing a copy of the document in a separate envelope for each addressee named below and addressed to each such addressee as follows:

John B. Draper, Esq.
Montgomery & Andrews
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P.O. Box 2307
Santa Fe, New Mexico 87504-2307

David W. Robbins, Esq.
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100 Blake Street Building
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Office of the Solicitor General
United States Department of Justice
Constitution Avenue & Tenth Street, N.W.
Washington D.C. 20530

James J. DuBois, Esq.
U.S. Department of Justice
General Litigation Section
999 18th Street, Suite 945
Denver, Colorado 80202

On July 25, 2001, at the office of Best, Best & Krieger, 3750 University Avenue, 400 Mission Square, Riverside, California 92502, I sealed and placed each envelope for collection and deposit by Best, Best & Krieger in the United States Postal Service, following ordinary business practices.

I declare under penalty of perjury under the laws of the State of California, that the foregoing is true and correct.

Executed on July 25, 2001, at Riverside, California.

/s/ Sandra L. Simmons
Sandra L. Simmons

APPENDIX

Exhibit 6:

Kansas Exhibit 1123, Amended Rules and Regulations Governing the Diversion and Use of Tributary Ground Water in the Arkansas River Basin, Colorado.

AMENDED
RULES AND REGULATIONS
GOVERNING THE DIVERSION AND USE
OF TRIBUTARY GROUND WATER
IN THE ARKANSAS RIVER BASIN, COLORADO

(Filed June 4, 1996)

ORDER OF THE STATE ENGINEER

IT IS ORDERED that the Rules and Regulations governing the use, control, and protection of surface and ground water rights located in the Arkansas River and its tributaries, which rules and regulations became effective on February 19, 1973, shall be amended and replaced by the following rules and regulations which are adopted and approved by the state engineer.

AMENDED RULES AND REGULATIONS

Rule 1. *Scope*. These Rules apply to all diversions of tributary ground water in the Arkansas River basin in Colorado except diversions by decreed or permitted wells as described in section 37-92-602, wells located within a designated ground water basin which withdraw designated ground water, decreed and/or permitted wells which withdraw nontributary ground water, and exposure of ground water in connection with extraction of sand and gravel by open mining as defined in section 34-32-103(9), 14 C.R.S. In addition, these Rules shall not apply to ground water within the Dawson, Denver, Arapahoe, or Laramie-Fox Hills aquifers in the Denver Basin, as shown on the attached map, or to ground water within the Cheyenne and Dakota aquifers.

Rule 2. *Definitions*.

The following definitions are applicable to these Rules:

a. "Decreed pre-compact ground water rights" mean water rights to divert tributary ground water in the Arkansas River Basin in Colorado with a priority senior to December 14, 1948, awarded in (1) decrees entered prior to June 7, 1969; or (2) decrees which were entered in proceedings which were pending on that date; or (3) decrees which were entered on or after June 7, 1969, by the Water Judge for Water Division 2, with respect to water rights which are diverted by means of wells, the priorities for which had not been established or sought in any prior decree or proceeding, if the person claiming the water right filed an application for determination of the water right and priority not later than July 1, 1972, and such application was approved and confirmed by the Water Judge for Water Division 2.

b. "Division engineer" means the division engineer for Water Division 2.

c. "Durbin usable flow method with the Larson coefficients" means the Durbin approach to determine depletions to usable Stateline flow with modifications made by Steven Larson, as described in the July 1994 Report by Arthur L. Littleworth, Special Master, in *Kansas v. Colorado*, No. 105, Original, United States Supreme Court.

d. "Kansas Hydrologic-Institutional Model" means the computer model, as revised by the Kansas replacement experts, *Colorado*, No. 105, Original, United

States Supreme Court, as described in the July 1994 Report by Arthur L. Littleworth, Special Master.

e. "Out-of-priority depletions to senior surface water rights in Colorado" mean stream depletions caused by diversions of tributary ground water in the Arkansas River Basin in Colorado which would deprive senior surface water rights in Colorado of the amount of water to which said surface water rights would have been entitled in the absence of such ground water diversions.

f. "Post-compact ground water diversions" mean (1) diversions of tributary ground water from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline by well users having water rights with a priority of, or junior to, December 14, 1948, and (2) diversions of tributary ground water by well users having decreed pre-compact water rights for irrigation use in excess of the pre-compact pumping allowances of such rights, except to the extent permitted by Rule 3.3.

g. "Stream depletions" means depletions to the Arkansas River or other natural streams in the Arkansas River Basin in Water Division 2 caused by diversions of tributary ground water in the Arkansas River Basin in Colorado.

h. "Tributary ground water in the Arkansas River Basin in Colorado" means all underground water as defined in section 37-92-103(11), 15 C.R.S., in the State of Colorado tributary to the Arkansas River or other natural streams in the Arkansas River Basin in Water Division 2.

i. "Unit response functions" mean a mathematical method to determine the timing and location of stream depletions or accretions from a unit stress on an aquifer.

j. "Usable Stateline flow" means the flow of waters of the Arkansas River, as defined in Article III of the Arkansas River Compact, as determined by gaging stations located at or near the Stateline in accordance with the Arkansas River Compact, the depletion of which would materially deplete waters of the Arkansas River in usable quantity or availability for use to the water users in Kansas under the Arkansas river Compact.

k. "Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline" mean those aquifers as delineated on the attached map.

l. "Waters imported into the Arkansas River Basin" or "imported waters" mean waters brought into the Arkansas River Basin from other river basins.

m. "Well user" means the owner of a water right to divert tributary ground water in the Arkansas River Basin in Colorado and any person having the right to use such a water right owned by another, including successors, lessees, contractees, or assigns.

n. Any other term used in these Rules that is defined in Article 90 or 92, 15 C.R.S., or in Article III of the Arkansas River Compact, is used with the meaning given therein.

Rule 3. *Ground Water Diversions and Depletions Affecting Usable Stateline Flow*.

Rule 3.1. *Ground Water Diversions for Irrigation Use by Post-compact Ground Water Rights Affecting Usable Stateline Flow*. On or after June 1, 1996, all diversions of tributary ground water for irrigation use from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline by well users having water rights with a priority of, or junior to, December 14, 1948, shall be totally discontinued unless depletions to usable Stateline flow caused by such diversions are replaced in accordance with a plan approved by the state and division engineers pursuant to these Rules.

Rule 3.2. *Ground Water Diversions for Irrigation Use By Decreed Pre-Compact Ground Water Rights Affecting Usable Stateline Flow*. On or after June 1, 1996, all diversions of tributary ground water for irrigation use from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline by well users having decreed pre-compact ground water rights shall be limited to an aggregate total of 15,000 acre-feet per year (November 1 through October 31) unless depletions to usable Stateline flow caused by diversions of amounts greater than 15,000 acre-feet per year are replaced in accordance with a plan approved by the state and division engineers pursuant to these Rules.

Rule 3.3. *Pre-compact Pumping Allowances*. For the purpose of implementing Rule 3.2, each decreed pre-compact ground water right for irrigation use from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline shall be allocated an annual pre-compact pumping allowance for the purpose of determining depletions to usable Stateline Flow. The annual pre-compact pumping allowance for each decreed pre-compact ground water right for irrigation use shall be determined by multiplying 15,000 acre-feet times the decreed capacity of that ground water right, weighted depending on whether the ground water right is used as a supplemental or as a sole source supply, and dividing by the total weighted decreed capacity of all decreed pre-compact ground water rights for irrigation use. Ground water rights used as a supplemental supply shall be given a weight of sixty percent (60%) and ground water rights used as a sole source supply shall be given a weight of one-hundred percent (100%). The state and division engineers shall prepare a list of all decreed pre-compact ground water rights for irrigation use from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline by the effective date of these Rules, which list shall set forth the annual pre-compact pumping allowance for each such right. A well user having a decreed pre-compact ground water right for irrigation use may divert more than the annual pre-compact pumping allowances of that right in any one year (November 1 through October 31), provided, that the well user having such a right is included in a plan approved by the state and division engineers which includes other well users having such rights and who will not divert more than their combined annual pre-compact pumping allowances in any one year unless they replace depletions to usable Stateline flow caused by such additional diversions. *Notwithstanding this annual pre-compact pumping allowance, well users having decreed pre-compact ground water rights for irrigation use shall be subject to all other rules and regulations applicable to diversions of tributary ground water in the Arkansas River Basin in Colorado, including replacement of out-of-priority depletions to senior surface water rights in Colorado pursuant to Rule 4.1.*

Rule 3.4. *Determination of Depletions to Usable Stateline Flows*. The state and division engineers shall use the Kansas Hydrologic-Institutional Model (HIM) and the Durbin usable flow method with the Larson coefficients, or such other method approved by the Special Master, the United States Supreme Court, or the Arkansas River Compact Administration to determine depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation use. To the extent that replacement of out-of-priority depletions to senior surface water rights in Colorado in accordance with these Rules is not sufficient to replace all depletions to usable Stateline flow caused by post-compact ground water diversions of irrigation use, the state and division engineers shall allocate all unreplaced depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation use to well users based upon the well's location, the amount pumped, whether the well is a sole source or supplemental source of supply, the method of irrigation, and such other information as is available to the state and division engineers to allocate such unreplaced depletions, and taking into account reductions in depletions to usable Stateline flow resulting from augmentation water provided in accordance with these Rules, including return flows from imported or other fully consumable waters to which well users, or their successors, lessees, contractees, or assigns are entitled based on their right to use or reuse such return flows.

Rule 3.5. *Conditions for Approval of Plans Allowing Post-compact Ground Water Diversions*. As a condition to approval of any plan allowing post-compact ground water diversions for irrigation use, the state and division engineers shall require replacement of any and all depletions to usable Stateline flow and may require a well user or entity acting on behalf of well users to furnish water in advance to replace anticipated depletions to usable Stateline flow which will not be replaced by replacement of out-of-priority depletions to senior surface water rights in Colorado.

Rule 4. *Ground Water Diversions from the Valley Fill Aquifer and Other Specified Aquifers Affecting Senior Surface Water Rights in Colorado.*

Rule 4.1. *Diversions of Tributary Ground Water from the Valley Fill Aquifer and Other Specified Aquifers Affecting Senior Surface Water Rights in Colorado*. On or after June 1, 1996, all diversions of tributary ground water

a. from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline; and

b. from the alluvium of Fountain Creek and the alluvium of the Arkansas River from Pueblo to Pueblo Dam, as shown on the attached map,

shall be totally discontinued unless out-of-priority depletions to senior surface water rights in Colorado are replaced in accordance with: (1) a decreed plan for augmentation approved by the Water Judge in accordance with the procedures of sections 37-92-302 to 37-92-305, 15 C.R.S.; or (2) a plan approved by the state and division engineers in accordance with these Rules; or (3) a substitute supply plan approved by the state engineer pursuant to section 37-80-120 which is consistent with these Rules. Replacement of depletions in accordance with this Rule shall not relieve a well user of an obligation to replace depletions to usable Stateline flow.

Rule 4.2. *Determination of Stream Depletions; Presumptive Stream Depletions*. To determine stream depletions for plans required by Rule 4.1, the state and division engineers shall be governed by the following:

a. For diversions of ground water used as a supplemental supply for flood and furrow irrigation, the presumptive stream depletions shall be thirty percent (30%) of the amount diverted. The state and division engineers may increase the presumptive stream depletions to more than thirty percent (30%), but not more than the presumptive stream depletions for diversions of ground water used as a sole source of supply for flood and furrow irrigation, for well users who use ground water as a supplemental supply for flood and furrow irrigation but do not have a reasonably adequate surface supply for the acreage irrigated (for example, well users who have sold a portion of their surface water rights or do not own sufficient shares in a mutual ditch company to irrigate the acreage irrigated compared to other shareholders in the company). To determine whether a well user has a reasonably adequate surface supply for the acreage irrigated, the state and division engineers shall consider the acreage which may be legally irrigated with the surface water rights owned or used by the well user and the relative amount of surface and ground water applied to such acreage averaged over the previous five years. The following table may be used as a guideline for increasing the presumptive stream depletions:

Surface Water Used (%)	Flood/Furrow Depletion (%)
50 or greater	30
40-49	33
30-39	36
20-29	39
10-19	42
1-9	45
0	50

b. For diversions of ground water used as a sole source of supply for flood and furrow irrigation, the presumptive stream depletions shall be fifty percent (50%) of the amount diverted.

c. For diversions of ground water used as a sole source of supply in sprinkler irrigation systems, the presumptive stream depletions shall be seventy-five percent (75%) of the amount diverted.

d. For diversions of ground water for other uses, the state and division engineers shall determine stream depletions based on information submitted by the well user and the individual facts and circumstances of each case or may establish presumptive stream depletions for particular uses.

Rule 4.3. *Review and Revision of Presumptive Stream Depletions*. The presumptive stream depletions established in Rule 4.2 shall be reviewed by the state engineer annually to determine whether the presumptive stream depletions are adequate to prevent material injury to senior surface water rights in Colorado and depletions to usable Stateline flows, and the presumptive stream depletions shall be revised as the state engineer determines is necessary. The state engineer shall publish any revisions to the presumptive stream depletions in the manner prescribed by statute for changes to these Rules and regulations.

Rule 5. *Other Diversions of Tributary Ground Water Affecting Senior Surface Water Rights in Colorado.* On or after June 1, 1996, all diversions of tributary ground water in the Arkansas River Basin within the scope of these Rules and not covered by Rule 4.1 shall be totally discontinued unless out-of-priority depletions to senior surface water rights in Colorado are replaced in accordance with: (1) a decreed plan for augmentation approved by the Water Judge in accordance with the procedures of sections 37-92-302 to 37-92-305, 15 C.R.S.; or (2) a plan approved by the state and division engineers in accordance with these Rules; or (3) a substitute supply plan approved by the state engineer pursuant to section 37-80-120 which is consistent with these Rules. To determine stream depletions for plans required by this Rule, the state and division engineers shall determine such depletions based on an acceptable site-specific depletion analysis provided by the well user or plan proponent or, in the absence of such an analysis, shall determine stream depletions in accordance with Rule 4.2.

Rule 6. *Criteria for Determining the Adequacy of Augmentation Water*. In reviewing plans submitted pursuant to these Rules, the state and division engineers shall determine the adequacy of each source of water proposed for use as augmentation water, including, where necessary, the historical consumptive use of each water right. This determination shall be based upon acceptable studies of the augmentation source provided by the well user or plan proponent. Return flows from diversions of waters imported into the Arkansas River Basin or other fully consumable waters proposed for use as augmentation water shall be determined by the state and division engineers based on acceptable studies and information provided by the well user or plan proponent. A water right, other than imported waters or other fully consumable waters, which has not been decreed for augmentation use may be used as augmentation water in a plan approved by the state and division engineers pursuant to these Rules; however, as a condition to approval of a plan, the state and division engineers may require the well user or plan proponent to file an application for change of water right and obtain a decree approving the use of the water right for augmentation use within a reasonable period of time. In no case, however, shall a water right, other than imported waters or other fully consumable waters, which has not been decreed for augmentation use be used as a permanent source of augmentation water for more than 10 years in a plan approved by the state and division engineers pursuant to these Rules.

Rule 7. *Conditions for Approval of Plans*. Based on stream depletions determined in accordance with these Rules, the state and division engineers may approve a plan to divert tributary ground water which provides sufficient augmentation water in amount, time, and location to replace out-of-priority depletions to senior water rights in Colorado and any and all depletions to usable Stateline flow caused by such diversions. Acceptable plans shall be approved annually and shall include such terms and conditions as, in the opinion of the state and division engineers, are necessary to prevent injury to senior surface water rights in Colorado and depletions to usable Stateline flow. Plans may be amended during the year if approved by the state and division engineers. As a condition to approval of a plan, the state and division engineers may require augmentation water in excess of the amount necessary to replace stream depletions determined in accordance with Rule 4.2 or Rule 5 to address situations where projected augmentation water may not be available, such as a dry year.

Rule 8. *Determination of the Timing and Location of Stream Depletions; Unit Response Functions*. To determine the timing and location of stream depletions caused by diversions of tributary ground water, the state and division engineers shall develop unit response functions for wells diverting from the Valley Fill Aquifer and surficial aquifers along the Arkansas River between Pueblo and the Stateline. These unit response functions may be used to determine the timing and location of return flows from diversions of imported waters and other fully consumable waters. To determine the timing and location of stream depletions caused by other diversions of tributary ground water, water users may use appropriate ground water models or other methods acceptable to the state and division engineers to calculate the timing and location of stream depletions based on the location of the well, the rate of pumping, the use being made of the ground water, and the aquifer's boundaries and characteristics.

Rule 9. *Responsibilities of the State and Division Engineers*. The state and division engineers shall administer, distribute, and regulate ground water within the scope of these Rules in accordance with the provisions of the Arkansas River Compact, the constitution of the state of Colorado and other applicable laws, and written instructions and orders of the state engineer, including these Rules, and no other official, board, commission, department, or agency of the state of Colorado, except as provided in article 92 of title 37, C.R.S., and article 8 of title 25, C.R.S., has jurisdiction and authority with respect to said administration, distribution, and regulation. The state and division engineers shall curtail all diversions of ground water within the scope of these Rules, the depletions from which are not replaced as to prevent out-of-priority depletions to senior water rights in Colorado and depletions to usable stateline flow in accordance with these Rules.

Rule 10. *Responsibilities of Well Users and Other Entities Subject to These Rules*. Well users alone or in concert may submit plans in accordance with these Rules. Water conservancy districts, irrigation districts, mutual or public ditch and reservoir companies, municipalities, or other entities which are governed by a board of directors may initiate and submit plans in accordance with these Rules. Well users shall be responsible for complying with these Rules, verifying the accuracy of information submitted in accordance with these Rules, and complying with the terms and conditions of plans approved in accordance with these Rules. Water conservancy districts, irrigation districts, mutual or public ditch and reservoir companies, municipalities, or other entities which are governed by a board of directors which initiate and submit plans in accordance with these Rules shall be responsible for notifying the state and division engineers of any well user in a plan approved in accordance with these Rules who is not in compliance with the terms of the plan and for doing all things required by such plans; however, the state and division engineers shall be responsible for enforcement of these Rules and the terms of the Arkansas River Compact; and, notwithstanding the submission of a plan by an entity on behalf of a well user, should the plan prove insufficient, the well user shall be responsible for replacement of out-of-priority depletions to senior surface rights in Colorado and depletions to usable Stateline flow.

Rule 11. *Plans for June 1, 1996, to March 31, 1997, and Thereafter*. To provide a reasonable period to allow well users to develop plans required by these Rules and to secure the augmentation water necessary for such plans, the state and division engineers may approve a plan to divert tributary ground water for the period June 1, 1996, to March 31, 1997, if the well user or an entity acting on behalf of the well user provides sufficient augmentation water in amount, time, and location to replace 60 percent (60%) of the out-of-priority depletions to senior surface water rights in Colorado determined in accordance with these Rules and all depletions to usable Stateline flow caused by such diversions. On or after April 1, 1997, full replacement of out-of-priority depletions to senior surface rights in Colorado and depletions to usable Stateline flow shall be required and no plan shall be approved which does not provide for full replacement of such depletions in accordance with these Rules.

Rule 12. *Submission of Monthly Pumping or Power Records*. Any well user or entity acting on behalf of well users who desires approval of a plan to divert tributary ground water pursuant to these Rules must furnish records to the division engineer, in a manner prescribed by the division engineer, on a monthly basis, or a less frequent basis if authorized by the division engineer, of the amounts diverted pursuant to the plan. In the case of wells powered by electricity, as a condition to approval of a plan, the well user must authorize the power supplier to provide power records to the division engineer on a monthly basis. Further, if authorized by statute, in the event the well user fails to comply with the terms of a plan approved pursuant to these Rules or fails to furnish or pay for augmentation water necessary for such a plan, the state or division engineer may issue an order to the power supplier to discontinue energy to the well unless and until the well user has complied with the terms of such a plan or furnished or paid for augmentation water necessary for such a plan.

Rule 13. *Information Which Must Be Furnished*. By June 1, 1996, and by February 1 of each year thereafter (except as provided below), any well user who desires approval of a plan to divert tributary ground water pursuant to these Rules, or will be included in a plan submitted by an entity on behalf of the well user, shall file a signed statement with the division engineer, on a form approved by the division engineer, containing the following information for each well used by the well user to be included in the plan:

a. the name, address, and telephone number of the well user and the well owner, if different than the well user;

b. the name of the entity which will provide augmentation water;

c. the location of each well;

d. the structure identification number (if one has been assigned) of each well. If no structure identification number has been assigned to a well, the well user shall also furnish the following information:

(1) the permit or registration number of each well,

(2) the appropriation date and adjudication date of each water right diverted through each well,

(3) the court case number of the proceeding in which each water right diverted through each well was decreed;

e. the use of ground water diverted from each well;

f. the source of energy used to divert ground water from each well;

g. in the case of wells powered by electricity, the name of the electric utility company which supplies energy used to divert ground water from each well, the power meter/service number as it appears on the bill from the electric utility company, and the account number;

h. in the case of wells used for irrigation,

(1) whether each well is used as a supplemental irrigation supply or a sole source of irrigation supply,

(2) the method of irrigation (flood, furrow, sprinkler, surge, drip, etc.) of each well,

(3) if used as a supplemental irrigation supply, a description of the surface rights or the name of the ditch or reservoir company and number of shares used in conjunction with each well; and

i. in the case of diversions of ground water for uses other than irrigation, information sufficient to allow the state and division engineers to determine stream depletions.

An entity acting on behalf of well users may compile and submit the foregoing information for well users in a manner acceptable to the division engineer, but the well user must sign a statement on a form approved by the division engineer which verifies the information submitted by the entity. These forms shall be maintained in the files of the entity and a copy furnished to the division engineer. If a well user fails to file a statement in compliance with this Rule, the state and division engineers may deny a plan to divert tributary ground water or require the well user to be excluded from a plan submitted by an entity on behalf of the well user until the well user has complied with this Rule.

Once a well user has filed a signed statement with the division engineer in compliance with this Rule, or an entity acting on behalf of the well user has submitted the foregoing information for the well user in compliance with this Rule, the well user shall not be required to submit a statement thereafter to be included in a plan unless any information on the statement has changed; however, the state and division engineers may require any well user to provide additional information in the future to determine whether the well user has a reasonably adequate surface supply.

Rule 14. *Applications for Approval of Plans to Divert Tributary Ground Water*. No later than June 1, 1996, and no later than March 1 of each year thereafter, a well user or an entity acting on behalf of well users who desires approval of a plan to divert tributary ground water pursuant to these Rules must file with the division engineer an application in writing setting forth a complete description of the plan, including:

a. the name and address of each well user who will be included in the plan;

b. the information required in paragraphs c. through i. of Rule 13 for each well which will be included in the plan;

c. an estimate of the amount of ground water to be diverted by well users who will be included in the plan;

d. each source of water to be used as augmentation water in the plan and the amount of augmentation water available on a monthly basis;

e. the amount, time, and location of stream depletions from ground water diversions under the plan or how the amount, time, and location of such depletions will be determined; and

f. a detailed description of how out-of-priority depletions to senior water rights in Colorado and depletions to usable Stateline flow will be replaced under the plan.

If a well user or entity acting on behalf of well users who seeks approval of a plan to divert tributary ground water pursuant to these Rules does not know every source of water to be used as augmentation water in a plan or the amount of augmentation water available by March 1 of any given year, the state and division engineers may grant temporary approval of a plan until June 1 upon such terms and conditions as, in the opinion of the state and division engineers, will be adequate to prevent out-of-priority depletions to senior surface water rights in Colorado and depletions to usable Stateline flow until the well user or entity acting on behalf of well users can provide a complete description of the plan.

Rule 15. *Orders, Costs, and Attorneys' Fees*. Any person who diverts ground water in violation of these

Rules or in violation of the terms of a plan approved by the state and division engineers pursuant to these Rules shall be subject to an order by the state or division engineer issued pursuant to section 37-92-502, 15 C.R.S., and may be subject to court proceedings and the state's costs, including reasonable attorney fees, and any fine authorized by statute. Because ground water diversions in violation of these Rules could deplete usable Stateline flows in violation of the Arkansas River Compact or cause material injury to water rights in Colorado having senior priorities, the state or division engineer may enter upon, and order any person to permit the entry upon, private property to plug, lock, or otherwise disable any well which has been used to divert ground water in violation of these Rules or in violation of a plan approved pursuant to these Rules.

Rule 16. *Tabulation, Pumping Records, and Summaries of Plans*. To ensure compliance with these Rules, the state and division engineers shall tabulate diversions of ground water from the aquifers listed in Rule 4.1 at regular intervals and shall make such tabulations available for inspection by the public in the office of the division engineer. The state and division engineers shall prepare annual summaries of plans which have been approved by the state and division engineers allowing diversions of ground water from the aquifers listed in Rule 4.1 and shall make such summaries available for inspection by the public in the office of the division engineer. As a condition to approval of any plan to divert ground water pursuant to these Rules, the state and division engineers may require a well user or an entity submitting a plan on behalf of well users to prepare a summary of diversions of ground water and replacement of depletions under the plan.

Rule 17. *Severability*. If any portion of these Rules is found to be invalid, the remaining portion of the Rules shall remain in force and unaffected.

Rule 18. *Effective date*. These amended Rules shall become effective June 1, 1996, and shall remain in effect until amended as provided by law. The Statement of Basis and Purposes for these Rules has been filed with the water court and is available for review at the office of the state engineer in Denver, Colorado and at the office of the division engineer in Pueblo, Colorado.

Dated this 4th day of June, 1996.

STATE OF COLORADO

/s/ Hal D. Simpson
HAL D. SIMPSON
State Engineer

BY THE COURT

/s/ John Anderson
JOHN ANDERSON
Water Court Judge
Water Division 2
State of Colorado

APPENDIX

Exhibit 7:

Kansas Exhibit 1134, Memorandum dated February 18, 2002, from AGUA Board of Directors to AGUA Membership.

To: AGUA Membership

From: AGUA Board of Directors

Date: February 18, 2002

RE: "2002 Drought"

This letter is to inform you of the drought situation we are facing this year! Due to a lack of sufficient storage in the reservoirs, the dry winter and water available to the farmers. The AGUA Board of Directors hereby warns all farmers to be prepared for a cut of at least 50% of water available to the well users in AGUA and the cost of the water is going to beat least 50% more (possibly $25.00 per acre foot, rather than the $10.00 per acre foot of depletions last year) than in the years past. Please consider this notice as a warning for the farmers in AGUA.

We, AGUA, will allocate water on a percentage basis for each member in AGUA according to purchases made in the last five years. Depending on what your last five year average is, will be determined on how much water you will be offered. Your bill will go out in the first week of March and must be received prior to April 1st. If additional waters come available, these waters will be offered on the same percentage as it was allocated at first.

Due to the drought conditions this year, AGUA, CWPDA, The Division of Water Resources, CSU Extension Office & the Conservancy District is planning a workshop for our members in our augmentation plans. On March 1st, in LaJunta at the Otero Junior College on Friday, we will have our first workshop. The second workshop will be held the following day at the Lake Pueblo State Park just to the South of the Pueblo Dam on Saturday. The workshops will help you in many ways from measuring and keeping track of your water usage to ideas on what, how and how much to plant for this growing season. Attached is a press release by the CSU Extension Service from Rocky Ford. If you are able to attend the meeting please come to either of the workshops. Also, please call the AGUA office and let us know which date you can make it. Although reservations are not required, we want to make sure we have plenty of room and refreshments for everyone.

Hope to see you there!

Jeanette Bryan, Manager

APPENDIX

Exhibit 8:

Colorado Exhibit 1384, Table 11, Comparison of AGUA 2002 Replacement Requirements and Replacement Source Availability.

TABLE 11

COMPARISON OF AGUA 2002 REPLACEMENT REQUIREMENTS AND REPLACEMENT SOURCE AVAILABILITY

March 1, 2002 (includes Dummy Well Depletions)

(all amounts in acre-feet)

Location		Apr 2002	May 2002	Jun 2002	Jul 2002	Aug 2002	Sep 2002	Oct 2002	Nov 2002	Dec 2002	Jan 2003	Feb 2003	Mar 2003	Plan Year Total
Arkansas River Below Pueblo (Rule 3, 4 and Rule 5 Wells)														
Total Replacement Required:		556.0	737.7	958.8	1,235.2	1,384.8	1,383.4	1,331.3	1,100.7	862.2	725.4	622.9	572.5	11,470.8
Excelsior Ditch	Amount Available	0.0	186.0	465.0	279.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	930.0
@ 75% of Average	Credit (no loss)	0.0	186.0	465.0	279.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	930.0
Cherokee Metro	Amount Available	86.0	63.0	59.0	58.0	57.0	58.0	61.0	65.0	82.0	89.0	95.0	89.0	862.0
Return Flows	Credit (11.8 % loss)	75.9	55.6	52.0	51.2	50.3	51.2	53.8	57.3	72.3	78.5	83.8	78.5	760.4
Pueblo	Amount Available	40.0	200.0	190.0	445.0	740.0	785.0	730.0	470.0	191.0	90.0	20.0	0.0	3,901.0
Reusable Water	Credit (no loss)	40.0	200.0	190.0	445.0	740.0	785.0	730.0	470.0	191.0	90.0	20.0	0.0	3,901.0
SECWCD Fry-Ark	Amount Available	455.0	319.0	285.0	498.0	635.0	592.0	588.0	607.0	621.0	573.0	535.0	512.0	6,220.0
1st Use & RF	Credit (no loss)	455.0	319.0	285.0	498.0	635.0	592.0	588.0	607.0	621.0	573.0	535.0	512.0	6,220.0
Total All Sources	Amount Available	581.0	768.0	999.0	1,280.0	1,432.0	1,435.0	1,379.0	1,142.0	894.0	752.0	650.0	601.0	11,913.0
	Total Credits	570.9	760.6	992.0	1,273.2	1,425.3	1,428.2	1,371.8	1,134.3	884.3	741.5	638.8	590.5	11,811.4
Excess(+) or Deficit(-)		14.8	22.9	33.2	38.0	40.5	44.8	40.5	33.6	22.1	16.1	15.9	18.0	340.5
Arkansas River Above Pueblo (Rule 5 Wells)														
Total Replacement Required:		7.3	9.7	12.4	15.5	16.2	15.2	13.5	10.3	7.9	6.9	6.3	6.4	127.6
Pueblo	Amount Available	8.0	11.0	13.0	17.0	17.0	16.0	15.0	12.0	9.0	8.0	7.0	7.0	140.0
Reusable Water	Credit (1% loss)	7.9	10.9	12.9	16.8	16.8	15.8	14.9	11.9	8.9	7.9	6.9	6.9	138.6
Excess(+) or Deficit(-)		0.7	1.2	0.5	1.3	0.6	0.7	1.4	1.5	1.0	1.0	0.6	0.5	11.0
Fountain Creek (Rule 4 and Rule 5 Wells)														
Total Replacement Required:		51.7	92.1	123.1	170.2	151.5	143.7	114.5	58.9	37.2	29.5	24.9	31.6	1,029.0
SECWCD Fry-Ark	Amount Available	25.0	50.0	80.0	125.0	110.0	100.0	70.0	15.0	10.0	5.0	5.0	5.0	600.0
Return Flows	Credit (no loss)	25.0	50.0	80.0	125.0	110.0	100.0	70.0	15.0	10.0	5.0	5.0	5.0	600.0
Cherokee Metro	Amount Available	30.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	35.0	30.0	25.0	30.0	500.0
Return Flows	Credit (10% loss)	27.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	31.5	27.0	22.5	27.0	450.0
Total All Sources	Total Available	55.0	100.0	130.0	175.0	160.0	150.0	120.0	65.0	45.0	35.0	30.0	35.0	1,100.0
	Total Credits	52.0	95.0	125.0	170.0	155.0	145.0	115.0	60.0	41.5	32.0	27.5	32.0	1,050.0
Excess(+) or Deficit(-)		0.3	2.9	2.0	(0.2)	3.5	1.3	0.5	1.1	4.3	2.5	2.6	0.4	21.0
All Reaches (All Wells)														
Total Replacement Required		615.0	839.6	1,094.2	1,420.9	1,552.5	1,542.2	1,459.3	1,170.0	907.4	761.9	654.1	610.5	12,627.4
Total Replacement Credits		630.9	866.6	1,130.0	1,460.2	1,597.3	1,589.2	1,501.8	1,206.3	934.8	781.5	673.3	629.5	13,001.4
Excess Replacement Credits		15.9	27.0	35.8	39.2	44.8	47.0	42.5	36.4	27.5	19.6	19.2	19.0	373.9

APPENDIX

Exhibit 9:

Colorado Exhibit 1267, App. A, Letter dated March 26, 1999, from Office of the State Engineer, State of Colorado, approving LAWMA's 1999 Replacement Plan.

STATE OF COLORADO

OFFICE OF THE STATE ENGINEER
Division of Water Resources
Department of Natural Resources

[SEAL]

[Names and Addresses Omitted in Printing]

Don Higbee
Lower Arkansas Water Management Association
PO Box 1161
Lamar, CO 81052

James E. Slattery
Helton & Williamsen, P.C.
384 Inverness Drive South, Suite 144
Englewood, CO 80112

RE: Lower Arkansas Water Management Association
Arkansas River Replacement Plan

Dear Mr. Higbee & Mr. Slattery:

We have reviewed your February 26, 1999 application on behalf of the Lower Arkansas Water Management Association (LAWMA) for an Arkansas River Replacement Plan for the plan year April 1, 1999 through March 31, 2000 pursuant to the **AMENDED RULES AND REGULATIONS GOVERNING THE DIVERSION AND USE OF TRIBUTARY GROUND WATER IN THE ARKANSAS RIVER BASIN, COLORADO** ("Rules") approved in Case No. 95CW211. Based on your application and the subsequent listing of well data verified by you, there are **548 wells** included in this replacement plan, of which **518 wells** will be active for the execution of this plan. A listing of wells covered by this plan is attached at Enclosure 1.

Total pumping by the active wells in this plan is estimated to be **101,924 acre-feet** during the plan year.

Of the total pumping, 83,321 acre-feet will be from irrigation wells producing from the valley-fill and surficial aquifers subject to Rule 3, 10,490 acre-feet will be from wells producing from the valley-fill, and surficial aquifers subject to Rule 4, and 8,113 acre feet will be from wells in other aquifers subject to Rule 5 of the Rules.

The estimate of potential depletions to senior surface water rights in Colorado and depletions to Stateline flow during this plan year is **28,736 acre-feet**. The estimate of potential out-of-priority depletions to senior surface water rights in Colorado and depletions to usable Stateline flow, to be replaced during this plan year, is **19,774 acre-feet** based upon the above pumping estimates, the actual pumping from previous plan years, estimates of depletions including the presumptive depletions given in Rule 4.2 of the Rules, the delayed response of well pumping on the surface streams and the application of the usability factors determined by Larson to estimate depletions to usable Stateline flow as applied in Table 7 of your plan application.

Because 100% of the out-of-priority depletions to senior surface water rights in Colorado will be replaced during this plan year and because depletions to usable Stateline flow have been estimated using the method described in paragraph 5 of the **Resolution Concerning an Offset Account in John Martin Reservoir for Colorado Pumping As Amended March 30, 1998**, no additional quantity has been determined for the replacement of depletions to usable Stateline flow. The effectiveness of this replacement plan in replacing depletions to usable Stateline flow will be evaluated at the end of the plan year to determine if any additional replacements are required to replace depletions to usable Stateline flow caused by post-compact diversions of ground water pursuant to this plan.

LAWMA proposes to use the following sources of replacement water:

1. Credit for a portion of the releases from the Transit Loss Account attributable to LAWMA replacement plan wells for depletions above the Buffalo Canal headgate. (Estimated to yield 1,300 acre-feet.)

2. Credit from the non-consumptive portion of transit loss of deliveries purchased by LAWMA and delivered to the Offset Account. (Estimated to yield 300 acre-feet.)

3. An allocation of 1,800 acre-feet of Fry-Ark return flow water.

4. Consumptive use credits from 1,323 shares of the Fort Bent Ditch listed in Table 7A of your application. The shares are expected to yield 500 acre-feet.

5. Consumptive use credits from 50 shares of the Lamar Canal obtained by arrangement with the City of Lamar. The shares are expected to yield 40 acre-feet.

6. Excess consumptive use credits from Lamar Canal shares owned by Colorado Beef which Colorado Beef will not use in its Substitute Water Supply Plan. These credits are expected to yield 700 acre-feet.

7. Consumptive use credits from the use of all but 1.5 cfs of the X-Y Canal. These credits are expected to yield 6,208 acre-feet.

8. Consumptive use credits from full use of the Manvel Canal. These credits are expected to yield 2,500 acre-feet.

9. Consumptive use credits from use of the Stubbs portion of the Sisson-Stubbs Ditch. Consumption associated with this right is estimated at 473 acre-feet.

10. Consumptive use credits from the use of 3569 out of 3800 shares of the Highland Canal. These credits are expected to yield 4,625 acre-feet. The consumptive use water will be stored in the Offset Account in John Martin Reservoir.

11. Credit from the non-consumptive portion of transit loss of deliveries to the Offset Account of replacement water from the Highland Canal. (Estimated to yield 275 acre-feet.)

12. Article II Account water in John Martin Reservoir from the X-Y Graham, Manvel, and Stubbs portion of the Sisson-Stubbs ditches. The plan proposal uses 1,000 acre-feet of this water.

13. Treated discharge from the Greystone Consultant's ground water remediation that exceeds the replacement requirement of their substitute water supply plan. These credits are expected to yield 53 acre-feet.

Your projected yield from these replacement sources is 19,774 acre-feet which matches the stream depletions which have been estimated for this plan year. The actual yields from the replacement sources listed above will depend on the actual water availability during this plan year and the application of the conditions of approval listed below.

It is estimated that an additional **14,500 acre-feet** of stream depletions, beyond what will occur during this plan year, will occur after the March 31, 2000 expiration date of this plan due to diversions of ground water during the life of this plan and pumping done under previous plans. Replacement of these depletions is proposed to be accomplished by the commitment of the renewable sources of replacement water listed above.

The State and Division Engineers have reviewed the plan and the adequacy of each source of water provided for use as augmentation water, including, where necessary, the historical consumptive use of each water right, and return flows from diversion of waters imported into the Arkansas River Basin or other fully consumable waters proposed for use as augmentation water. In accordance with Section 25-8-202(7), C.R.S. and Senate Bill 89-181 Rules and Regulations adopted on February 4, 1992, the State Engineer has determined that subject to the terms and conditions below, the replacement supply is of a quality to meet the requirements of use to senior appropriators.

Based on stream depletions determined in accordance with the Rules, and consistent with other provisions of the Rules, the State and Division Engineers have determined that, subject to the terms and conditions set forth below, it appears the plan to divert tributary ground water will provide sufficient augmentation water in amount, time, and location to replace out-of-priority depletions to senior surface water rights in Colorado and all depletions to usable Stateline flow caused by such diversions and may therefore be approved pursuant to Rule 7 of the Rules.

This plan is hereby approved pursuant to the following conditions:

1. The **518 active wells** in this plan shall not divert more than **101,924 acre-feet** of ground water without first obtaining an amendment to the plan. No inactive wells, individual wells with zero estimated pumping, or groups of wells in farm units with zero estimated pumping which are covered by this plan shall be pumped without first obtaining an amendment to the plan. Additional wells may only be included in this plan if an amendment to the plan is obtained. Any request for amendment must include identification of the subject wells, an estimate of the amount of water each well will pump by month, an update of the total stream depletions by reach and month including post-plan depletions, and identification of the source of additional replacement water. Approval of an amendment will be contingent upon the association demonstrating it has sufficient replacement water to cover the additional well depletions. Requests for the emergency activation of wells covered by this plan or the emergency inclusion of new wells may be submitted with information indicating that a valid measurement method is in place and with current information required by Rule 13 of the Rules. Temporary approval for pumping can be made pending a complete request for amendment of the plan which must follow within 30 days of the approval of the emergency request.

2. Under the provisions of the **Resolution Concerning an Offset Account in John Martin Reservoir for Colorado Pumping As Amended March 30, 1998** and the **Stipulation RE Offset Account in John Martin Reservoir** LAWMA will provide the initial 500 acre-foot storage charge into the Offset Account in accordance with

the Resolution. Table 7 of LAWMA's plan application is an acceptable description of the concept of replacement operations with any replacements for depletions to usable Stateline flow made by use of LAWMA's direct flow water rights below John Martin Reservoir or the delivery of water to the Offset Account where it will be available for delivery when requested by Kansas. The actual augmentation credits generated from these various sources are subject to the conditions set forth below.

3. Depletions to usable Stateline flow will be estimated using the method described in paragraph 5 of the **Resolution Concerning an Offset Account in John Martin Reservoir for Colorado Pumping As Amended March 30, 1998.**

4. Water available for in-priority ditch diversions and resulting credits of the X-Y ditch and Manvel canal direct flow water rights will be measured at the Carlton stream gage. LAWMA will need to demonstrate through additional engineering analysis the comparison between the use of the Carlton gage and the Granada gage when data is available for periods when the Buffalo Canal is placing a call.

5. The augmentation credits derived from the use of the water rights listed above as replacement sources will be based on the consumptive use factors and credit limits used for last year's plan, subject to amendment based on further review. All parcels of dried up land used to generate augmentation credits will be inspected during the irrigation season to verify dry up. The final verification of dry up will be in the form of an affidavit signed by an individual having personal knowledge of the dry up for this year's entire irrigation season for each parcel of land

used in the approved replacement plan. All affidavits must be provided to the Division Engineer by November 15, 1999 in order that the final determination of augmentation credits for the irrigation season can be made.

6. The approval of this replacement plan is limited to only that pumping which results in depletions which cause injury that can be replaced by the water provided by this plan on the mainstem of the Arkansas River If a Rule 5 well in this plan causes depletions on a tributary of the Arkansas River, affecting senior surface water rights, where this plan cannot provide replacement water, the well will be subject to curtailment until arrangements are made to provide replacement water at a point which will preclude injury to the calling senior surface water right on the tributary.

7. Water available for augmentation credit resulting from LAWMA's use of the Highland Canal will be measured through an augmentation station returning to the river from the canal. Measurement will be accomplished using an orifice rating table determined from measurements at Wasteway #3. LAWMA's proposal for administration and operation of Highland Canal water rights dated March 11, 1999 is currently being evaluated. Any changes resulting from the evaluation of this proposal will be incorporated into this plan by amendment.

8. The amount of credit from transit loss account releases will be reduced 10% to account for losses not attributable from wells such as evaporation and evapotranspiration. LAWMA can demonstrate through additional engineering analysis what the actual percentage should be for future years.

9. For all water rights used as permanent replacement sources in this plan but not decreed for augmentation use, LAWMA must ensure that an application for a change of water right is filed in Water Court seeking to obtain a decree approving the use of the water right for augmentation use within a reasonable amount of time, but in no case longer than 10 years from the time of first augmentation use, in accordance with Rule 6 of the Rules.

10. Pumping of the alternate point of diversion wells covered by this plan will be reported for both in priority pumping and out of priority pumping on a monthly basis in order to benefit from the amount of pumping which is done in priority.

11. This plan assumes that return flows from deliveries of Fryingpan-Arkansas Project water will be available in amount, time, and location to replace a portion of the out-of-priority depletions to senior surface water rights in Colorado and thereby prevent some depletions to usable Stateline flow. The State and Division Engineers have determined that the estimates of Fry-Ark return flow to be used in this plan are reasonable. If, however, the Fry-Ark return flows prove to be insufficient in amount, time, or location to replace out-of-priority depletions to senior surface water rights in Colorado, LAWMA agrees to either: 1) curtail pumping by its member wells, or 2) obtain additional sources of replacement water as the State and Division Engineers may direct. LAWMA shall confer with the Division Engineer as requested to determine the amount, time, and location of Fry-Ark return flows.

12. Approval of this plan does not guarantee that the amount of replacement water made available pursuant to this plan will replace out-of-priority depletions to senior

surface water rights in Colorado, to the extent required by Rule 11 of the Rules, or depletions to usable Stateline flows caused by post-compact ground water diversions pursuant to the plan; and, notwithstanding approval of this plan, should the plan prove insufficient, each well user covered by the plan shall be responsible for replacement of out-of-priority depletions to senior surface water rights in Colorado to the extent required by Rule 11 of the Rules, and depletions to usable Stateline flows caused by post-compact ground water diversions.

13. The State and Division Engineers shall determine depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation use pursuant to Rule 3.4 of the Rules. To the extent that replacement of out-of-priority depletions to senior surface water rights in Colorado and deliveries of water to the Stateline pursuant to the plan are not sufficient to replace all depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation use, the State and Division Engineers will allocate all unreplaced depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation use to well users in this plan to replace additional depletions to usable Stateline flow. LAWMA agrees to provide any additional replacement water necessary to replace depletions to usable Stateline flow caused by post-compact ground water diversions for irrigation by its members as determined by the State and Division Engineers in accordance with Rule 3.4 of the Rules.

14. LAWMA agrees to replace out-of-priority depletions to senior surface water rights in Colorado and depletions to usable Stateline flows occurring after the expiration date of the plan (March 31, 2000) which are caused by diversions of ground water during the life of the plan by

committing its renewable sources of replacement water for this purpose.

15. LAWMA will provide data to the Division Engineer's office, or other entity designated by the State Engineer, in a standard format designated by the State or Division Engineer, and at such times as are necessary to ensure timely computations to determine compliance of the LAWMA's member wells. Accounting must include all information requested, including but not limited to pumping by member wells, and deliveries of replacement water. Specifically, both owner/user supplied pumping data and replacement operations data for the previous month must be provided to the Division Engineer by no later than the 10th of each month. Reports of pumping by individual wells which are not in compliance with the provisions of the approved plan must be submitted as they are detected.

16. LAWMA must monitor its member wells so as to be able to verify their compliance with the plan. Should any well user be out of compliance with the plan, LAWMA must notify the State and Division Engineers of that fact as provided for in Rule 10 of the Rules. In particular, LAWMA will monitor the overall performance of this replacement plan by comparing the wellhead depletions corresponding to the projected annual pumping with the actual depletions from reported pumping for each well or farm unit in the plan. Action will be taken if the total pumping by a well user covered by the plan is about to exceed the total amount of projected pumping. Options for appropriate actions are to:

a) Notify the Division Engineer when a well user's pumping is out of compliance with the terms of the approved plan and request that the Division Engineer stop the well from pumping in excess of its limit.

b) Notify the Division Engineer of the purchase of more replacement water, in addition to the water already purchased for the plan, to cover the additional depletions caused by any additional pumping by the well or wells in question.

c) Notify the Division Engineer of a reallocation of the replacement water already purchased or otherwise available to the plan. Indicate to the Division Engineer which wells covered by the plan will pump less than originally planned or alternatively demonstrate that existing replacement sources will make available sufficient quantities to allow additional pumping by the well or wells in question.

17. In accordance with amendments to Section 25-8-202-(7), C.R.S. and "Senate Bill 89-181 Rules and Regulations" adopted on February 4, 1992, the State Engineer shall continue to determine whether or not the replacement supply is of a quality to meet requirements of use to senior appropriators. As such, water quality data or analysis may be requested at any time to determine if the water quality is appropriate for downstream water users.

18. No change or improvement of the delivery or application method of water from member wells may be made which would result in material depletion of usable quantity or availability for use of water to users in Colorado and Kansas in violation of Paragraph D, Article IV, of the Arkansas River Compact.

19. **From preliminary snowpack measurements, it appears that runoff for the 1999 irrigation year may be below average. As a result, the yield of some replacement supplies may be less than estimated. However, with the commitment of at least 24,121 acre-feet of water in LAWMA's Article II accounts,**

there should be sufficient resources to provide replacements for the predicted stream depletions for the 1999 plan year. Therefore, I encourage LAWMA to carefully monitor pumping by its member wells and to implement the measures described in condition 16 as required.

20. Acceptance of these conditions must be made in writing to the Division Engineer (310 East Abriendo, Suite B, Pueblo CO 81004, FAX (719) 544-0800) by 5:00 p.m., March 31, 1999. The name, address, and phone number of a contact person who will be responsible for the operation and accounting of this plan must be provided with the acceptance.

I want to thank you for your cooperation and compliance with the amended rules during the past year and for your continued cooperation and compliance in the future. Your efforts are greatly appreciated. I would like to also remind you that you must comply with the Measurement Rules. If you have any questions do not hesitate to contact any of my staff in Denver or Pueblo.

Sincerely,

/s/ Hal D. Simpson
Hal D. Simpson
State Engineer

1 Enclosure

cc: Steve Witte Division Engineer
David W. Robbins, Hill & Robbins
John B. Draper, Montgomery & Andrews
Dale E. Book, Spronk Water Engineers

APPENDIX

Exhibit 10:

Kansas Exhibit 1093, Table 14, Predicted Depletions to Stateline Flow, Revised Kansas H-I model (1997-1999).

Table 14

Predicted Depletions to Stateline Flow
Revised Kansas H-I Model
(1997-1999)

	Run ID	Flags
Base Condition:	C03	HHHH
Test Condition:	C04	CHH0

Monthly Results

		Predicted Stateline Flow			Usable Stateline Flow			Usable	
Year	Mo	HHHH	CHH0	Depletion or (Accretion)	HHHH	CHH0	Depletion or (Accretion)	Dep or (Acr) w/seas lmt	Seasonal Dep & Accr
1997	1	8,086	10,096	2,011	2,822	3,524	702	702	
1997	2	7,884	9,666	1,783	2,751	3,374	622	622	
1997	3	5,668	7,058	1,390	1,978	2,463	485	485	1,809
1997	4	9,983	10,308	325	8,176	8,442	266	266	
1997	5	14,237	14,538	301	11,660	11,906	247	247	
1997	6	96,499	65,820	-30,680	39,553	36,516	-3,037	-3,037	
1997	7	35,000	35,000	0	28,665	28,665	0	0	
1997	8	49,755	33,203	-16,552	34,926	27,193	-7,733	-292	
1997	9	21,000	21,000	0	17,199	17,199	0	0	
1997	10	21,951	25,391	3,440	17,978	20,795	2,817	2,817	0
1997	11	7,757	10,127	2,369	2,707	3,534	827	827	
1997	12	12,952	19,061	6,109	4,520	6,652	2,132	2,132	
1998	1	19,101	21,492	2,391	6,666	7,501	834	834	
1998	2	17,381	19,545	2,164	6,066	6,821	755	755	
1998	3	28,794	29,301	508	10,049	10,226	177	177	4,725
1998	4	21,819	17,350	-4,469	17,869	14,210	-3,660	-2,935	
1998	5	9,434	10,009	575	7,727	8,198	471	471	
1998	6	13,907	16,392	2,485	11,390	13,425	2,035	2,035	
1998	7	44,823	44,704	-119	34,437	34,426	-12	0	
1998	8	26,323	26,168	-156	21,559	21,431	-127	0	
1998	9	21,000	21,000	0	17,199	17,199	0	0	
1998	10	21,175	21,699	523	17,343	17,771	428	428	0
1998	11	10,192	12,495	2,303	3,557	4,361	804	804	
1998	12	9,994	12,012	2,018	3,488	4,192	704	704	
1999	1	19,351	16,649	-2,702	6,753	5,810	-943	-943	
1999	2	16,570	18,034	1,464	5,783	6,294	511	511	
1999	3	16,054	16,862	808	5,603	5,885	282	282	1,358
1999	4	21,225	20,772	-453	17,384	17,013	-371	-371	
1999	5	167,459	151,243	-16,216	46,578	44,973	-1,605	-709	
1999	6	73,273	67,808	-5,466	37,254	36,713	-541	0	
1999	7	37,969	37,042	-927	31,097	30,337	-760	0	
1999	8	78,137	69,029	-9,108	37,736	36,834	-902	0	
1999	9	21,000	21,000	0	9,459	10,453	994	994	
1999	10	18,810	19,677	866	1,862	1,948	86	86	0
1999	11	9,850	11,571	1,721	3,438	4,038	601	601	
1999	12	19,266	19,530	263	6,724	6,816	92	92	693
Calendar Year Totals									
1997		290,773	261,267	-29,506	172,937	170,264	-2,673	4,768	1,809
1998		243,943	252,165	8,223	157,350	159,760	2,410	3,274	4,725
1999		498,964	469,215	-29,749	209,670	207,114	-2,556	543	2,050
Total		1,033,679	982,647	-51,032	539,956	537,137	-2,819	8,585	**8,585**

1997 Offset Account Credit: 1,935

Remaining Depletions to Usable Stateline Flows: **6,650**

APPENDIX

Exhibit 11:

Kansas Exhibit 1122, Amendments to Rules Governing the Measurement of Tributary Ground Water Diversions Located in the Arkansas River Basin.

AMENDMENTS TO RULES GOVERNING THE MEASUREMENT OF TRIBUTARY GROUND WATER DIVERSIONS LOCATED IN THE ARKANSAS RIVER BASIN

AUTHORIZATION

In order for the State Engineer and Division Engineer for Water Division 2 to properly administer the waters of the Arkansas River basin and to comply with the Arkansas River Compact, it has become necessary to adopt amendments to the rules governing the measurement of tributary ground water diversions located in the Arkansas River Basin. The State Engineer's authority to promulgate the amendments to these rules is based on section 37-80-104, C.R.S., which requires the State Engineer to make and enforce such regulations with respect to deliveries of water as will enable the state of Colorado to meet its compact commitments; section 37-92-501, C.R.S., which authorizes the State Engineer to adopt rules and regulations to assist in the performance of the administration, distribution and regulation of the waters of the state in accordance with the constitution of the state of Colorado, the provisions of Article 92 (The Water Rights Determination and Administration Act of 1969) and other applicable laws; and section 37-92-502(5), C.R.S., which authorizes the State Engineer to order any owner or user of a water right to install and maintain at such owner's or user's expense necessary meters, gauges, or other measuring devices and to report at reasonable times to the appropriate Division Engineer the readings of such meters, gauges or other measuring devices.

ORDER OF THE STATE ENGINEER

IT IS ORDERED that the following rules and amendments to the rules governing the measurement of tributary ground water diversions located in the Arkansas River Basin are adopted by the State Engineer.

Rule 1. **Scope**. These rules are applicable to all wells located in the Arkansas River basin **except** decreed and/or permitted wells as described in section 37-92-602, C.R.S.; wells located within a designated ground water basin; decreed and/or permitted nontributary well; permitted wells subject to sections 37-90-137(4), C.R.S.; and wells permitted and decreed for not more than 50 gallons per minute that are part of a judicially approved plan for augmentation.

Rule 2. Definitions:

A. The following definitions are applicable to these rules governing the measurement of tributary ground water diversion located in the Arkansas River basin:

1. **"Compound system"** means a system where more than one electrical device is operated from the same electrical power meter.

2. **"Complex system"** means any system where the total dynamic head at the pump will vary due to multiple discharge locations in a pipeline, or where the method of delivery will vary between open discharge, gated pipe, or sprinkler system during a single irrigation season, or where multiple wells discharge into a common pipeline.

3. **"Inactive well"** means any well that is not in use and is disconnected from a power source.

4. **"Power coefficient"** means the amount of electrical energy expressed as kilowatt hours (KWH) consumed in pumping one acre-foot of water.

5. **"Tributary well(s)"** are those wells that produce underground water and ground water as defined in section 37-92-103(11), C.R.S.

B. Any other term used in these rules that is defined in Article 90 or 92 is used with the meaning given therein.

Rule 3. All wells within the scope of these rules shall either, **by July 15, 1994**, be equipped with a totalizing flow meter that is installed and maintained according to manufacturer's specifications and recommendations or, **by October 1, 1994**, be rated to determine a power coefficient.

3.1

3.1.1 When a totalizing flow meter is used, it shall be the owner's responsibility to keep the meter in acceptable operating condition. Any meter designed and manufactured for the purpose of measuring the flow of water, and which has a totalizing feature, shall be considered to be acceptable for purposes of these rules. The State Engineer may adopt standards and specifications for the installation, calibration, testing, repair, and maintenance of meters. An installed flow meter shall be determined to be in accurate operating condition when the indicated flow of the meter is within plus or minus 5% of an independent field measurement made using calibrated test equipment. Recalibration may be required by the Division Engineer if the Division Engineer determines an error was made.

3.1.2 As a minimum, totalizing flow meters shall be: properly verified in the field to be in accurate working condition under the supervision of an individual or entity approved annually by the State Engineer to do such tests when installed; contain sufficient recording digits to assure that "roll over" to zero does not occur within three years; and shall be maintained by the well owner so as to provide a continuous, accurate record of withdrawals. If the meter is not operational, the well shall not be pumped unless a working meter is installed or unless a specific backup water measurement program approved by the State Engineer is put into effect. Totalizing flow meters are required to be re-verified in the field to be in accurate working condition under the supervision of an individual or entity annually approved by the State Engineer every four years after the date of original installation and flow meters in existence as of **July 5, 1994**, shall be certified to be in accurate working condition under the supervision of an individual or entity annually approved by the State Engineer by June 15, 1995, and re-verified to be in accurate working condition every four years thereafter. The Division Engineer shall be notified in writing of the date and person performing the re-verification.

3.2 The State Engineer may adopt standards and specifications for power coefficient testing. As a minimum, power coefficients shall: be determined utilizing rating procedures approved by the State Engineer and conducted under the supervision of an individual or entity annually approved by the State Engineer to do such tests; be conducted when the pumping system has stabilized, i.e., both operating pressure and pumping drawdown has not changed more than 10% in the last hour; have been determined on or after April 1, 1992; include the pumping drawdown and operating pressure at the time the test was conducted; and be updated through re-rating at least every four years. The Division Engineer shall be notified in writing of the date and person performing the re-rating.

3.3 If the well(s) are part of a complex or compound system, or if the pump is driven by internal combustion means, the owner or user of the well must utilize the totalizing flow meter method (Rules 3.1.1 and 3.1.2), unless the provisions of Rule 3.6 are applicable.

3.4 All flow measuring equipment utilized in verification of accuracy and working condition in the field and/or rating of wells must be calibrated bi-annually to be accurate within plus or minus 2%, unless a variance is granted by the Division Engineer.

3.5 Re-rating of power coefficients shall be required more frequently than every 4 years if any of the following occur:

3.5.1 A new or re-worked pump and/or motor is installed on the well.

3.5.2 The well is re-worked to change the yield of the well.

3.5.3 The system that the pump discharges into is modified in such a manner as to change the power coefficient or the discharge of the pump.

3.5.4 Any other alteration to the system which changes the discharge of the pump or power coefficient.

3.5.5 Additional tests may also be required if the Division Engineer conducts or reviews tests and determines an error was made.

3.6 Owners and/or users of wells within the scope of these rules who use the power coefficient method and whose well discharges into a pressurized pipeline system with more than one point of discharge during a normal irrigation season must submit two Power Consumption Coefficient (PCC) measurements as required under the scope of these rules. One measurement must be taken under maximum head (minimum yield) and one measurement must be conducted under minimum head (maximum yield) conditions. A registered professional engineer, or a person approved upon written request to the State Engineer, must annually evaluate the range of pumping conditions and provide an analysis which determines the representative condition and PCC for that condition. This analysis must be provided within 30 days of the initiation of pumping for that year. If the Division Engineer determines that the operation of the well does not agree with the representative condition, the lower PCC will be used to compute pumping volumes.

Rule 4. All owners of wells within the scope of these rules who choose to install totalizing flow meters shall provide notice in writing to the Division Engineer for Water Division No. 2 by **July 15, 1994**, stating: the name and address of the owner of the well(s); the name and address of the user of the well(s) (if different than the owner); the well permit number(s); the decree or case number(s); the legal description of the location of the well(s); the meter manufacturer; the meter model number; the meter size; the meter serial number(s); the volumetric units (gallons or acre-feet); the name of power utility company and power company account number (if applicable); the kilowatt hour meter reading on the date of installation (if applicable); the beginning totalizing flow meter reading; and the date of installation. Notification to the Division Engineer shall be on a form prescribed by the State Engineer. The Division Engineer shall be notified of any method of well measurement changes on a form prescribed by the State Engineer.

Rule 5. All owners of wells within the scope of these rules who choose to utilize the power coefficient method shall provide notice in writing to the Division Engineer for Water Division No. 2 by **October 1, 1994**, stating: the name and address of the owner of the well(s); the name and address of the user of the well(s) (if different than the owner); the well permit number(s); the decree or case number(s); the legal description of the location of the well(s); the power meter serial number(s); the utility company name; the power company account number; the power coefficient; the date of power coefficient rating; the kilowatt hour meter reading on the date of the power coefficient rating; the name and address of the State Engineer approved individual or entity supervising the power coefficient rating; the current transformer (C.T.) factor, if applicable; and the potential transformer (P.T.) factor, if applicable. Notification to the Division Engineer shall be on a form prescribed by the State Engineer. The Division Engineer shall be notified of any method of changes on a form prescribed by the State Engineer.

Rule 6.

6.1 Data as to monthly amounts of water pumped from wells within the scope of these rules shall be for the period of November 1, to October 31, (coinciding with the Arkansas River compact year) and shall be filed with the Division Engineer no later than **January 31, 1995 and every consecutive year thereafter**. The submission of data as to the amounts diverted by any well(s) in conformance with the requirements of the Amended Rules and Regulations for the Diversion and Use of Tributary Ground Water in the Arkansas River basin shall be deemed sufficient to satisfy the requirements of this rule for such well(s) **after January 31, 1997**.

6.2 For the year 1994, owners utilizing the power coefficient method shall calculate the amount of water pumped using monthly power records for the period of November 1, 1993 through October 31, 1994.

6.3 Data shall be submitted on forms prescribed by the State Engineer. Such forms shall also include a consent to release power data to the Division Engineer. If a well user or owner's power account number changes for any reason, the user or owner must notify the Division Engineer of the new account number on a form prescribed by the Division Engineer within 45 days following the change.

Rule 7. Inactive wells.

7.1.1 Inactive wells are excluded from these rules provided a sworn affidavit is filed with the Division Engineer by July 15, 1994 and March 1, every consecutive year thereafter, stating the status of the well as inactive. However, after March 1, 1996, inactive wells are excluded from these rules provided a sworn affidavit is filed with the Division Engineer within 30 days after the well has become inactive. Such sworn affidavit shall state that the well is inactive and shall include: the name and address of the owner of the well(s); the name and address of the user of the well(s), if different than the owner; the well permit number(s); the decree or case number(s); the legal description of the location of the well(s); and a statement that the well(s) are disconnected from any power source. If the well owner desires to have the power to the well remain connected for any reason, approval of such must be first obtained from the State Engineer pursuant to Rule 11. Should the well(s) become active at any time, all aspects of these rules are immediately in effect. Notification to the Division Engineer shall be on a form prescribed by the State Engineer.

7.1.2 Once a sworn inactive well affidavit is filed with the Division Engineer, no further filings are required unless the owner or user wishes to remove the well from inactive status. When an owner or user desires to change the well back to active status, notification to the Division Engineer is immediately required. No operation of the well can occur until such notification and compliance with all State Engineer rules and regulations has taken place.

Rule 8. No water shall be withdrawn from any well not in compliance with these rules except to determine a power coefficient or to install a totalizing flow meter.

Rule 9. Failure to comply with any of these rules will subject the well owner and/or user to court proceedings and the state's costs, including reasonable attorneys fees, associated with enforcement of these rules pursuant to section 37-92-503, C.R.S. Prior to filing any court action, the Division Engineer shall notify the well owner of the violation in writing and shall advise the well owner of the date by which the violation must be corrected to avoid court proceedings, which date shall be at least ten days following the mailing of the notice to the well owner or personal service on the well owner.

Rule 10. If any portion of these rules is found to be invalid, the remaining portion of the rules shall remain in force and unaffected.

Rule 11. When the strict application of any provisions of these rules would cause unusual hardship, the State Engineer may grant a variance for a specific instance provided a written request for the variance is made to the State Engineer and the State Engineer finds the request justifiable.

IT IS FURTHER ORDERED that these amended rules shall become effective on the 29th day of February, 1996, and shall remain in effect until amended as provided by law. Any person desiring to protest these rules may do so in the manner provided in section 37-92-501, C.R.S. Any such protest to these rules must be filed by the end of the month following the month in which these rules are published.

Dated this 26th day of February, 1996.

/s/ H. D. Simpson
Hal D. Simpson
State Engineer

APPENDIX

Exhibit 12:

Kansas Exhibit 1113, Analysis of HIM Output for Diversions, Revised Kansas H-I Model.

ANALYSIS OF HIM OUTPUT FOR DIVERSIONS
Revised Kansas HIM (1/02)

1950-99	Upstream			Downstream			Total		
Total	Obs	Pred	Pred/Obs	Obs	Pred	Pred/Obs	Obs	Pred	Pred/Obs
1950	633,027	628,864	99.3%	213,488	198,861	93.1%	846,515	827,725	97.8%
1951	699,296	681,284	97.4%	190,609	148,749	78.0%	889,905	830,033	93.3%
1952	773,704	807,925	104.4%	179,314	179,191	99.9%	953,018	987,116	103.6%
1953	609,967	655,477	107.5%	147,525	166,358	112.8%	757,492	821,835	108.5%
1954	374,193	421,647	112.7%	98,371	140,722	143.1%	472,564	562,369	119.0%
1955	533,628	600,791	112.6%	193,916	228,863	118.0%	727,544	829,654	114.0%
1956	484,381	525,591	108.5%	125,712	131,061	104.3%	610,093	656,652	107.6%
1957	1,221,504	1,238,456	101.4%	179,522	169,191	94.2%	1,401,026	1,407,647	100.5%
1958	832,065	883,186	106.1%	194,783	197,934	101.6%	1,026,848	1,081,120	105.3%
1959	652,588	728,997	111.7%	222,886	180,984	81.2%	875,474	909,981	103.9%
1960	661,530	765,849	115.8%	116,630	184,725	158.4%	778,160	950,574	122.2%
1961	790,325	893,480	113.1%	162,378	139,895	86.2%	952,703	1,033,375	108.5%
1962	879,209	932,225	106.0%	159,684	137,996	86.4%	1,038,893	1,070,221	103.0%
1963	467,737	506,467	108.3%	92,240	129,478	140.4%	559,977	635,945	113.6%
1964	489,338	520,179	106.3%	58,216	78,385	134.6%	547,554	598,564	109.3%
1965	950,915	1,072,196	112.8%	162,945	146,820	90.1%	1,113,860	1,219,016	109.4%
1966	648,219	732,329	113.0%	197,349	160,332	81.2%	845,568	892,661	105.6%
1967	659,876	657,349	99.6%	207,699	147,817	71.2%	867,575	805,166	92.8%
1968	724,633	846,177	116.8%	151,938	165,333	108.8%	876,571	1,011,510	115.4%
1969	849,960	903,923	106.3%	115,154	141,645	123.0%	965,114	1,045,568	108.3%
1970	1,027,315	1,081,394	105.3%	202,502	165,642	81.8%	1,229,817	1,247,036	101.4%
1971	735,173	789,642	107.4%	166,213	145,936	87.8%	901,386	935,578	103.8%
1972	621,684	700,401	112.7%	135,959	143,588	105.6%	757,643	843,989	111.4%
1973	926,438	979,131	105.7%	151,448	170,438	112.5%	1,077,886	1,149,569	106.7%
1974	536,321	610,637	113.9%	94,731	115,167	121.6%	631,052	725,804	115.0%
1975	641,212	705,989	110.1%	108,231	108,811	100.5%	749,443	814,800	108.7%
1976	525,274	600,523	114.3%	91,812	120,235	131.0%	617,086	720,758	116.8%
1977	357,273	400,350	112.1%	71,394	82,232	115.2%	428,667	482,582	112.6%
1978	490,054	524,514	107.0%	79,981	68,268	85.4%	570,035	592,782	104.0%
1979	727,543	760,561	104.5%	121,041	142,478	117.7%	848,584	903,039	106.4%
1980	936,615	951,963	101.6%	184,530	234,092	126.9%	1,121,145	1,186,055	105.8%
1981	506,966	489,435	96.5%	151,700	171,455	113.0%	658,666	660,890	100.3%
1982	869,003	839,284	96.6%	193,269	163,285	84.5%	1,062,272	1,002,569	94.4%
1983	1,137,841	1,052,358	92.5%	215,093	239,237	111.2%	1,352,934	1,291,595	95.5%
1984	1,224,044	1,167,676	95.4%	192,250	231,025	120.2%	1,416,294	1,398,701	98.8%
1985	1,191,999	994,207	83.4%	231,315	197,814	85.5%	1,423,314	1,192,021	83.7%
1986	1,010,165	917,503	90.8%	205,538	179,722	87.4%	1,215,703	1,097,225	90.3%
1987	983,497	874,094	88.9%	219,030	219,582	100.3%	1,202,527	1,093,676	90.9%
1988	709,159	671,466	94.7%	227,732	199,721	87.7%	936,891	871,187	93.0%
1989	685,399	632,583	92.3%	150,860	188,755	125.1%	836,259	821,338	98.2%
1990	669,903	612,342	91.4%	181,342	192,987	106.4%	851,245	805,329	94.6%
1991	632,815	628,107	99.3%	162,271	161,664	99.6%	795,086	789,771	99.3%
1992	649,659	616,332	94.9%	198,541	176,934	89.1%	848,200	793,266	93.5%
1993	863,691	805,822	93.3%	217,804	175,343	80.5%	1,081,495	981,165	90.7%
1994	868,450	844,733	97.3%	245,327	211,583	86.2%	1,113,777	1,056,316	94.8%
1995	1,143,739	892,121	78.0%	261,360	198,165	75.8%	1,405,099	1,090,286	77.6%
1996	1,036,929	842,325	81.2%	211,160	161,062	76.3%	1,248,089	1,003,387	80.4%
1997	1,049,882	953,376	90.8%	248,303	180,671	72.8%	1,298,185	1,134,047	87.4%
1998	1,017,579	965,594	94.9%	201,724	210,693	104.4%	1,219,303	1,176,287	96.5%
1999	917,490	956,140	104.2%	205,791	156,720	76.2%	1,123,281	1,028,747	91.6%

APPENDIX

Exhibit 13:

Colorado 1410, Table 3.3a, 3.3b at page 34,
Calibration Results for Canals (1950-1994)
Using Appropriate Evaluation Criteria.

Table 3.3a Calibration Results for Canals (1950-1994) Using Appropriate Evaluation Criteria

CANALS Station	Historical Avg. Irr.Seas. Diversion (af)	Model Error in acre-feet and as % BIAS	%	MAE	%	RMSE	%	Model Efficiency (NS Criterion)	Irr. Season Correlation
Bessemer	52528	38	0%	4593	9%	6008	11%	0.78	0.8847
Booth Orchard	7458	5	0%	347	5%	460	6%	0.99	0.3713
Excelsior	2058	-1	0%	1059	51%	1610	78%	0.35	0.6093
Collier	763	-1	0%	526	69%	703	92%	0.07	0.3349
Colorado	71456	119	0%	10522	15%	15215	21%	0.77	0.8843
Highline	65744	62	0%	6569	10%	9476	14%	0.81	0.9027
Oxford Farmers	21089	3	0%	3671	17%	4313	20%	0.60	0.7729
Otero	5187	11	0%	1273	25%	1773	34%	0.80	0.8941
Catlin	70409	-1	0%	11147	16%	13196	19%	0.60	0.7872
Ft. Lyon	170200	8149	5%	20669	12%	27401	16%	0.88	0.9446
Rocky Ford	35003	-16	0%	3165	9%	3872	11%	-0.40	0.1744
Holbrook	30092	-230	-1%	7039	23%	8987	30%	0.83	0.9110
Las Animas	26691	23	0%	3203	12%	3883	15%	0.59	0.8216
Ft Bent	15275	3	0%	2470	16%	3147	21%	0.46	0.7016
Keese	4652	-5	0%	799	17%	988	21%	0.13	0.4505
Amity	76511	198	0%	13287	17%	16371	21%	0.66	0.8114
Lamar	33014	20	0%	5966	18%	7752	23%	0.49	0.7053
Hyde	1682	4	0%	637	38%	855	51%	0.07	0.4136
Manvel	1194								
XY Graham	7200	16	0%	2189	30%	3009	42%	0.49	0.7027
Buffalo	17443	-4	0%	3049	17%	3823	22%	0.15	0.5150
Sisson	236	-3	-1%	200	85%	340	144%	0.33	0.5734
Ft. Lyon Storage	17881	2360	13%	10072	56%	17545	98%	0.65	0.8943

Table 3.3b Calibration Results for Canals (1950-1994) Using Appropriate Evaluation Criteria

CANALS Station	Historical Avg. Mon. Diversion (af)	Model Error in acre-feet and as % BIAS	%	MAE	%	RMSE	%	Model Efficiency (NS Criterion)	Monthly Correlation
Bessemer	5076	3	0%	1096	22%	1774	35%	0.82	0.9117
Booth Orchard	760	0	0%	138	18%	207	27%	0.89	0.8895
Excelsior	193	0	0%	151	78%	318	165%	0.52	0.7206
Collier	65	0	0%	59	90%	142	219%	0.35	0.5988
Colorado	7329	-27	0%	3001	41%	4643	63%	0.69	0.8330
Highline	6704	5	0%	1208	18%	1939	29%	0.87	0.9321
Oxford Farmers	2028	0	0%	558	28%	883	44%	0.79	0.8929
Otero	555	1	0%	366	66%	624	112%	0.58	0.7669
Catlin	7186	0	0%	1804	25%	2478	34%	0.80	0.8961
Ft. Lyon	19342	1194	6%	4756	25%	7199	37%	0.80	0.8991
Rocky Ford	3695	-1	0%	820	22%	1063	29%	0.71	0.8523
Holbrook	3358	97	3%	1859	55%	3060	91%	0.59	0.7785
Las Animas	2597	2	0%	585	23%	791	30%	0.85	0.9255
Ft Bent	1329	0	0%	481	36%	737	55%	0.73	0.8582
Keese	418	0	0%	157	38%	218	52%	0.66	0.8228
Amity	6474	17	0%	2585	40%	4144	64%	0.71	0.8475
Lamar	2988	2	0%	1075	36%	1590	53%	0.70	0.8413
Hyde	155	0	0%	99	64%	146	94%	0.30	0.6181
Manvel	109								
XY Graham	643	1	0%	344	53%	538	84%	0.55	0.7552
Buffalo	1617	0	0%	652	40%	865	53%	0.61	0.7994
Sisson	24	0	-1%	36	147%	87	357%	0.12	0.3543
Ft. Lyon Storage	3453	188	5%	2233	65%	5581	162%	0.54	0.7887

APPENDIX

Exhibit 14:

Colorado Exhibit 1459, illustrative 10-year compliance program.

Year	Depletions Accretions	Total Yr. 10	Total Yr. 11	Total Yr. 12	Total Yr. 13	Total Yr. 14
1	+1	1				
2	+2	3	2			
3	+3	6	5	3		
4	-1	5	4	2	-1	
5	-2	3	2	0	-3	-2
6	+1	4	3	1	-2	-1
7	-2	2	1	-1	-4	-3
8	-1	1	0	-2	-5	-4
9	-2	-1	-2	-4	-7	-6
10	+2	+1	0	-2	-5	-4
11	+1		+1	-1	-4	-3
12	-2			-3 +3	-6	-5
13	+2				-4 +4	-3
14	+5					+2

Years 13 and 14 reflect payments in years 12 and 13.

APPENDIX

Exhibit 15:

Colorado Exhibit 1407, Pecos River Compact Report of the River Master, Water Year 2001, Accounting Year 2002, Final Report, June 26, 2002.

PECOS RIVER COMPACT

Report of the River Master

Water Year 2001

Accounting Year 2002

Final Report

June 26, 2002

Neil S. Grigg
River Master of the Pecos River
749 S. Lemay, Ste. A3, PMB 330
Fort Collins, Colorado 80524

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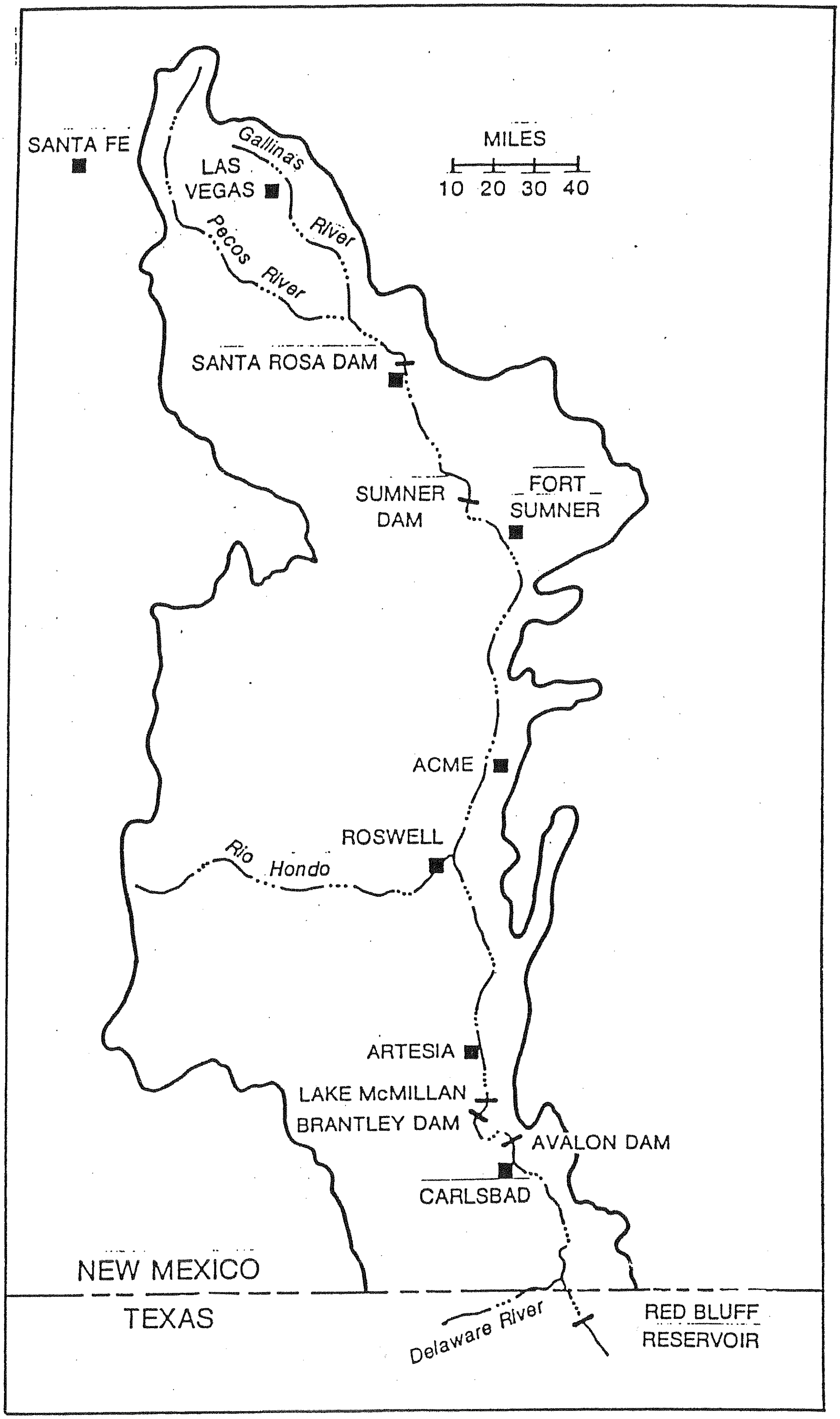

Map of Pecos River Basin Showing Accounting Reaches

PECOS RIVER COMPACT
Supreme Court of the United States
No. 65, Original
Amended Decree

Final Report of the River Master
Water Year 2001 – Accounting Year 2002
June 26, 2002

Purpose of the Report. In its Amended Decree issued March 28, 1988 the Supreme Court of the United States appointed a River Master of the Pecos River and directed him to " . . . Deliver to the parties a Preliminary Report setting forth the tentative results of the calculations required by Section III.B.1 of this Decree by May 15 of the accounting year . . . " and to consider " . . . any written objections to the Preliminary Report submitted by the parties prior to June 15 of the accounting year . . . " and to deliver " . . . to the parties a Final Report setting forth the final results of the calculations required by Section III.B.1 of this Decree by July 1 of the accounting year." This is the required Final Report with the determination of:

a. The Article III(a) obligation;

b. Any shortfall or overage, which calculation shall disregard deliveries of water pursuant to an Approved Plan;

c. The net shortfall, if any, after subtracting any overages accumulated in previous years, beginning with water year 1987.

Result of Calculations and Statement of Shortfall or Overage. The results of the calculations in this Final Report show that New Mexico's delivery in Water Year 2001 was a shortfall of 700 acre-feet. The accumulated overage since the beginning of Water Year 1987 is 9,900 acre-feet.

/s/ Neil S. Grigg
Neil S. Grigg
River Master of the
Pecos River

Pecos River Compact

Accumulated Shortfall or Overage

June 26, 2002

Water Year	Annual Overage or Shortfall, AF	Accumulated Overage or Shortfall, AF
1987	15,400	15,400
1988	23,600	39,000
1989	2,700	41,700
1990	-14,100	27,600
1991	-16,500	11,100
1992	10,900	22,000
1993	6,600	28,600
1994	5,900	34,500
1995	-14,100	20,400
1996	-6,700	13,700
1997	6,100	19,800
1998	1,700	21,500
1999	1,400	22,900
2000	-12,300	10,600
2001	-700	9,900

Table 1. General Calculation of Annual Departures, TAF, WY 2001			
6/25/02			
	1999	2000	2001
B.1.a. Index Inflows			
(1) Annual flood inflow			
(a) Gaged flow Pecos R bel Alamogordo Dam	96.8	166.1	114.9
(b) Flood Inflow Alamogordo - Artesia (Table 2)	37.4	-4.9	-13.5
(c) Flood Inflow Artesia - Carlsbad (Table 3)	16.1	8.3	4.1
(d) Flood Inflow Carlsbad - State Line (Table 4)	21.9	4.4	1.2
Total (annual flood inflow)	172.2	173.9	106.7
(2) Index Inflow (3-year avg)			150.9
B.1.b. 1947 Condition Delivery Obligation			61.8
(Index Outflow)			
B.1.c. Average Historical (Gaged) Outflow			
Gaged Flow Pecos River at Red Bluff NM	75.2	58.2	43.7
Gaged Flow Delaware River nr Red Bluff NM	6.6	1.0	0.3
(1) Total Annual Historical Outflow	81.8	59.2	44.0
(2) Average Historical Outflow (3-yr average)			61.7
B.1.d. Annual Departure			-0.1
C. Adjustments to Computed Departure			
1. Adjustments for Depletions above Alam Dam			
a. Depletions Due to Irrigation (Table 5)	-3.4	0.9	2.3
b. Depl fr Operation of Santa Rosa Reservoir (Table 6)	3.6	2.4	2.8
c. Transfer of Water Use to Upstream of AD	0	0	0
Recomputed Index Inflows			
(1) Annual flood inflow			
(a) Gaged flow Pecos R bel Alamogordo Dam	97.0	169.4	120.0
(b) Flood Inflow Alamogordo - Artesia	37.4	-4.9	-13.5
(c) Flood Inflow Artesia - Carlsbad	16.1	8.3	4.1
(d) Flood Inflow Carlsbad - State Line	21.9	4.4	1.2
Total (annual flood inflow)	172.4	177.2	111.8
Recomputed Index Inflow (3-year avg)			153.8
Recomputed 1947 Condition Del Outflow			63.5
(Index Outflow)			
Recomputed Annual Departures			-1.8
Credits to New Mexico			
C.2 Depletions Due to McMillan Dike			1.1
C.3 Salvage Water Analysis			0
C.4 Unappropriated Flood Waters			0
C.5 Texas Water Stored in NM Reservoirs			0
C.6 Beneficial C.U. Delaware River Water			0
Final Calculated Departure, TAF			-0.7

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Table 2. Determination of Flood Inflows, Alamogordo Dam to Artesia (B.3)

Water Year 2001

6/25/02

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOT
Flow bel Alamog Dam	0.1	0.4	3.3	6.1	46.6	6.5	30.6	6.0	6.8	5.8	0.7	2.1	114.9
FtSumner Irrig Div	0.0	0.0	2.3	5.5	5.8	5.6	5.7	5.7	5.3	4.7	0.0	0.0	40.6
Ft Sumner ID Return	0.9	0.6	1.5	1.7	2.6	2.6	2.6	2.6	2.4	2.1	1.1	0.9	21.5
Flow past FS IDist	0.9	1.1	2.5	2.3	43.3	3.5	27.5	2.9	3.9	3.2	1.7	3.0	95.9
Channel loss	0.1	0.2	0.7	1.4	6.2	1.4	4.4	1.6	1.0	0.9	0.7	0.3	18.8
Residual Flow	0.8	0.9	1.8	0.9	37.1	2.1	23.1	1.3	2.9	2.3	1.1	2.7	77.1
Base Inflow	4.2	3.7	3.5	2.4	2.2	1.7	0.9	1.0	0.7	1.0	2.1	2.4	25.7
River Pump Divers	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.5
Residual, Artesia	4.9	4.6	5.3	3.3	39.2	3.7	23.9	2.2	3.5	3.3	3.2	5.1	102.3
Pecos Flow Artesia	5.7	4.8	7.3	3.6	30.5	6.6	17.8	1.6	1.3	1.8	3.6	4.4	88.7
Flood Inflow, AD-Art	0.7	0.1	2.0	0.3	-8.7	2.9	-6.2	-0.6	-2.2	-1.5	0.4	-0.7	-13.5

Note: Whenever the computed flow past the District is less than the return flow, set the flow past the District equal to the return flow (Manual, B.3.d).

Table 3. Determination of Flood Inflows, Artesia to Carsbad, WY 2001 (B.4)

6/25/02

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOT
Rio Penasco at Dayton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourmile Draw nr Lakew	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Seven Rivers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rocky Arroyo at Hwy Br	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Flood Inflow, Art-DS3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pecos R at Dam Site 3	1.5	1.6	3.3	13.5	14.5	16.5	12.4	8.5	7.2	6.4	6.6	4.0	96.0
CB Sprgs New Water, T7	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-11.0
Total Inflow, DS3 - CB	0.6	0.7	2.4	12.5	13.6	15.5	11.5	7.6	6.3	5.4	5.7	3.1	85.0
Evap Loss, Lake Avalon, T10	0.2	0.3	0.2	0.5	0.5	0.6	0.6	0.5	0.4	0.4	0.1	0.2	4.4
Storage Chg, Lake Aval, T11	0.5	0.2	-2.2	0.1	0.1	-0.1	0.1	0.0	0.2	0.1	-0.7	0.7	-1.0
Carls ID diversions	0.0	0.0	3.2	11.8	12.1	14.7	11.4	7.1	5.9	5.3	0.0	0.0	71.4
93% CID diver	0.0	0.0	3.0	11.0	11.3	13.6	10.6	6.6	5.5	4.9	0.0	0.0	66.4
Other depletions	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	1.4
Dark Canyon at Csbad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pecos b Dark Canyon	1.7	2.4	1.4	0.8	0.4	0.4	0.3	0.2	0.2	0.6	6.3	3.1	17.8
Pecos R at Carlsbad	1.7	2.4	1.4	0.8	0.4	0.4	0.3	0.2	0.2	0.6	6.3	3.1	17.8
Total Outflow	2.5	3.1	2.5	12.5	12.3	14.7	11.7	7.5	6.4	6.0	5.9	4.1	89.0
Flood Inflow, DS3-CB	1.9	2.3	0.0	0.0	-1.2	-0.9	0.2	-0.1	0.1	0.6	0.2	1.0	4.0
Flood Inflow, Art-CB	1.9	2.3	0.0	0.0	-1.2	-0.9	0.2	-0.1	0.1	0.6	0.2	1.0	4.1

Table 4. Summary Table for Computations, Carlsbad to State Line - WY 2001

4/20/02

	BCB - RB	BCB - RB	Del R	DC
	RM	USGS	USGS	
Jan	67	0	2	0
Feb	2	0	1	0
Mar	431	286	10.9	0
Apr	82	194	2.4	0
May	0	71	0	0
Jun	40	171	0	0
Jul	54	119	0	0
Aug	48	81	65.5	0
Sep	425	415	3.4	0
Oct	0	39.7	0	0
Nov	0	33.7	0	0
Dec	0	61.5	0	0
Total	1148	1471.9	85.2	0

Summary of flood inflows, Carlsbad to State Line, TAF	
Red Bluff - Carlsbad + Dark C RM calcs)	1.1
Delaware River (USGS Computation	0.1
Total Flood Inflow, Carlsbad to State Line	1.2

Table 5. Depletions Due to Irrigation Above Alamogordo Dam - WY 2001 (C.1.a)

4/20/02

	APR	MAY	JUN	JUL	AUG	SEPT	OCT	TOTAL
Precip Las Vegas FAA AP	0.21	0.89	2.08	1.38	2.02	0.44	0.32	7.34
Eff prec Las Veg FAA AP	0.21	0.86	1.89	1.30	1.85	0.43	0.31	6.85
Precip Pecos Natl Monument	0.67	0.74	1.18	2.05	4.71	0.50	0.02	9.87
Eff Precip Pecos RS	0.65	0.72	1.13	1.87	3.69	0.49	0.02	8.57
Precip Santa Rosa	0.28	1.22	3.09	0.66	1.27	1.16	0.35	8.03
Eff Precip Santa Ro	0.27	1.17	2.65	0.64	1.21	1.11	0.34	7.39
Average eff precip, ft	0.03	0.08	0.16	0.11	0.19	0.06	0.02	0.63
Consumptive use, ft	0.19	0.36	0.36	0.30	0.27	0.18	0.11	1.77
CU less eff precip, ft	0.16	0.28	0.20	0.19	0.08	0.12	0.09	1.14
Acres (most recent inventory)	11529							
Streamflow depletion, AF	13101							
1947 depletion, AF	10804							
Difference, TAF	-2.3							
Adjustment to Gaged Flow - Pecos River below Alamogordo Dam =						2.3		

Table 6. Depletions Due to Santa Rosa Reservoir Operations - WY 2001 - (C.1.b)

6/25/02

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
LS 1989 tables used Jan-Oct; 2001 table used Nov-Dec.													
Lk Sumner ga ht, avg	56.05	57.90	59.51	59.08	54.96	41.88	42.14	41.46	36.95	32.99	37.84	43.37	47.01
LS content, AF, avg	31151	35563	39693	38563	28720	9095	9331	8745	5605	3618	5234	8814	
LS area, acres, avg	2288	2481	2650	2605	2172	896	921	855	582	433	528	807	
LS evap, inches	1.86	3.71	4.04	12.49	11.21	14.30	15.10	11.83	10.25	7.00	2.44	3.03	97.26
.77 LS Evap	1.43	2.86	3.11	9.62	8.63	11.01	11.63	9.11	7.89	5.39	1.88	2.33	74.89
LS Precip, inches	0.73	0.65	1.27	0.03	0.65	0.97	0.61	0.99	0.77	0.34	1.08	0.08	8.17
Net LS Evap, inches	0.70	2.21	1.84	9.59	7.98	10.04	11.02	8.12	7.12	5.05	0.80	2.25	66.72
LSum Evaploss, TAF	0.13	0.46	0.41	2.08	1.44	0.75	0.85	0.58	0.35	0.18	0.04	0.15	7.41
L S Rosa ga ht, avg	4.87	6.58	10.76	17.31	20.65	21.08	2.40	96.37	4.96	6.98	5.98	7.61	17.13
LSR content, AF, avg	13203	14661	18857	27339	32753	33508	11241	7317	13277	15025	14134	15619	
LSR area, acres, avg	825	899	1101	1491	1745	1771	753	534	827	931	853	960	
LSR evap, inches	3.72	4.98	7.12	9.12	8.93	12.58	12.38	9.39	7.96	6.49	4.13	3.76	90.56
.77 LSR Evap	2.86	3.83	5.48	7.02	6.88	9.69	9.53	7.23	6.13	5.00	3.18	2.90	69.73
LSR precip, inches	1.57	1.03	1.71	0.25	1.29	2.00	0.57	2.60	1.59	0.39	1.60	0.20	14.80
Net LSR Evap, inches	1.29	2.80	3.77	6.77	5.59	7.69	8.96	4.63	4.54	4.61	1.58	2.70	54.93
LSR Evaploss, TAF	0.09	0.21	0.35	0.84	0.81	1.13	0.56	0.21	0.31	0.36	0.11	0.22	5.20
Total evaploss, TAF	0.22	0.67	0.75	2.92	2.26	1.88	1.41	0.78	0.66	0.54	0.15	0.37	12.61
Sum contents, AF	44354	50224	58550	65902	61473	42603	20572	16062	18882	18643	19368	24433	
1947 area, acres	2042	2254	2690	2880	2801	1998	1094	978	1021	1011	1042	1299	
1947 evaploss, TAF	0.12	0.41	0.41	2.30	1.86	1.67	1.00	0.66	0.61	0.43	0.07	0.24	9.79
current-1947evaploss	0.10	0.25	0.34	0.62	0.39	0.21	0.40	0.12	0.05	0.11	0.08	0.12	2.82
						Annual adjustment for excess evaporation =							2.8
ADJUSTMENT FOR EXCESSIVE STORAGE IN SANTA ROSA RESERVOIR													
			2000	2000	2001	2001							
			Gage	Storage	Gage	Storage							
EndYear Sumner Sto			4254.91	28612	4244.92	10158							
EndYear S R Sto			4704.22	12670	4707.98	15977							
Sum				41282		26135							
Sto Adjustment, AF						0							
Adjustm Ex Evap, TAF						2.8							
Total Adjustment,TAF						2.8							

Table 7. Carlsbad Springs New Water WY 2001 - (B.4.c)				
6/25/02				
	TAF	cfs	Totals	
Pecos R bel DC, cfs	17.8	24.6	24.6	
Dark Canyon, cfs	0	0.0	0.0	
Pecos R bel Lake Av,	9.6	13.3	13.3	
Depletion, cfs			2.0	
CID lag seep, cfs (Table 8)			7.1	
Return flow, cfs			1.0	
Lake Av lagged seep, cfs (Table 9)			17.4	
PR seepage, cfs			3.0	
Carls new water, cfs			-15.2	
Carls new wat, TAF			-11.0	
Carls new wat monthly, TAF			-0.9	

Table 8. Carlsbad Main Canal Seepage Lagged - WY 2001 - [B.4.c.(1)(e)]													
6/25/02													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
WY 2001													
CID, TAF	0.0	0.0	3.2	11.8	12.1	14.7	11.4	7.1	5.9	5.3	0.0	0.0	71.4
days/mo	31	28	31	30	31	30	31	31	30	31	30	31	365
cfs	0.0	0.0	51.7	198.6	196.9	246.5	184.9	115.0	99.0	85.5	0.0	0.0	98.2
cfs, qtr avg			17.8			213.9			133.3			28.8	
2000		1Q	2Q	3Q	4Q								
FLOWS, cfs				198.6	33.6								
SEVEN %				13.9	2.4								
2001		1Q	2Q	3Q	4Q								
FLOWS, cfs		17.8	213.9	133.3	28.8								
SEVEN %		1.2	15.0	9.3	2.0								
LAG		3.7	8.3	9.9	6.6	Avg =	7.1	cfs					

Table 9. Lake Avalon Leakage Lagged - WY 2001 - B.4.c.(1)(g)

6/25/02													
WY 2001	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOT
WS NM rept	75.44	75.91	73.30	73.06	73.09	72.91	73.16	73.19	73.20	73.44	73.50	72.10	
ga ht, avg*	18.44	18.91	16.30	16.06	16.09	15.91	16.16	16.19	16.20	16.44	16.50	15.10	
cfs	26.1	28.4	15.9	14.8	14.9	14.0	15.2	15.4	15.4	16.6	16.9	10.2	
days	31	28	31	30	31	30	31	31	30	31	30	31	365
cfs avg	23.3			14.6			15.4			14.5			16.9
2000		1Q	2Q	3Q	4Q								
cfs				15.2	18.7								
2001		1Q	2Q	3Q	4Q								
cfs		23.3	14.6	15.4	14.5								
lag cfs		20.4	18.2	16.4	14.8	Avg =	17.4	cfs					

* Computed as WS elev by NM Report minus Gage datum at 3257.0 (USBR datum)

Table 10. Evaporation Loss at Lake Avalon - WY 2001 - (B.4.f)

4/20/02	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOT
Av WS NM Rept	75.44	75.91	73.30	73.06	73.09	72.91	73.16	73.19	73.20	73.44	73.50	72.10	
Avalon ga ht, avg, ft*	18.44	18.91	16.30	16.06	16.09	15.91	16.16	16.19	16.20	16.44	16.50	15.10	
Avg area Avalon, ac.	768	815	630	616	617	607	622	623	624	638	642	562	
Panevap Brantley, in.	4.65	5.60	6.09	12.74	13.28	16.85	16.90	13.11	11.42	9.10	4.80	4.34	118.88
Lakeevap Brantley, in.	3.58	4.31	4.69	9.81	10.23	12.97	13.01	10.09	8.79	7.01	3.70	3.34	91.54
Precip Brantley, in.	0.54	0.32	0.58	0.05	0.53	1.48	2.15	0.26	1.14	0.12	1.17	0.00	8.34
Netevap, inches	3.04	3.99	4.11	9.76	9.70	11.49	10.86	9.83	7.65	6.89	2.53	3.34	83.20
Evaploss Av, TAF	0.2	0.3	0.2	0.5	0.5	0.6	0.6	0.5	0.4	0.4	0.1	0.2	4.4

* Computed as WS elev by NM Report minus Gage datum at 3257.0 (USBR datum)

Table 11. Change in Storage, Lake Avalon - 2001 - (B.4.g)
(Gage heights are end of month)
6/25/02

	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOT
	2000	2001												
WS NM Rept		75.70	76.00	72.80	73.00	73.10	73.00	73.10	73.10	73.40	73.10	72.40	73.60	
Gage EOM, ft*	18.00	18.70	19.00	15.80	16.00	16.10	16.00	16.10	16.10	16.40	16.10	15.40	16.60	
Storage, AF	2494	3027	3266	1026	1147	1209	1147	1209	1209	1397	1461	790	1525	
Change sto, TAF		0.5	0.2	-2.2	0.1	0.1	-0.1	0.1	0.0	0.2	0.1	-0.7	0.7	-1.0

* Computed as WS elev by NM Report minus Gage datum at 3257.0 (USBR datum)

Table 12. Data Required for River Master Manual Calculations, Water Year 2001

6/25/02	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
STREAMFLOW GAGING RECORDS, TAF													
Pecos R b Sumner Dam	0.1	0.4	3.3	6.1	46.6	6.5	30.6	6.0	6.8	5.8	0.7	2.1	114.9
Fort Sumner Main C	0.0	0.0	2.3	5.5	5.8	5.6	5.7	5.7	5.3	4.7	0.0	0.0	40.6
Pecos R nr Artesia	5.7	4.8	7.3	3.6	30.5	6.6	17.8	1.6	1.3	1.8	3.6	4.4	88.7
Rio Penasco at Dayton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fourmile Draw nr Lakewood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Seven Rivers nr Lkwd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rocky Arroyo at Hwy Br nr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pecos R at Dam Site 3	1.5	1.6	3.3	13.5	14.5	16.5	12.4	8.5	7.2	6.4	6.6	4.0	96.0
Pecos bel Avalon Dam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	2.8	9.6
Carlsbad Main Canal	0.0	0.0	3.2	11.8	12.1	14.7	11.4	7.1	5.9	5.3	0.0	0.0	71.4
Dark Canyon at Carlsbad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pecos below Dark Canyon	1.7	2.4	1.4	0.8	0.4	0.4	0.3	0.2	0.2	0.6	6.3	3.1	17.8
Pecos R at Red Bluff	4.9	4.7	4.5	3.3	2.1	2.0	1.9	1.9	2.0	2.2	8.4	5.7	43.7
Delaware R nr Red Bluff	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3
GAGE HEIGHTS													
Avalon gage ht, end mo	75.70	76.00	72.80	73.00	73.10	73.00	73.10	73.10	73.40	73.10	72.40	73.60	
Avalon gage ht, avg	75.44	75.91	73.30	73.06	73.09	72.91	73.16	73.19	73.20	73.44	73.50	72.10	
Alamogordo ga ht, end mo	57.13	58.69	59.61	58.52	43.44	40.04	42.24	39.92	35.16	31.99	41.98	44.92	
Alamogordo gage ht, avg	56.05	57.90	59.51	59.08	54.96	41.88	42.14	41.46	36.95	32.99	37.84	43.37	
Lake S Rosa ga ht, end mo	5.51	7.59	13.95	20.50	20.50	21.32	87.75	4.08	5.63	6.32	7.24	7.98	
Lake S Rosa ga ht, avg	4.87	6.58	10.76	17.31	20.65	21.08	2.40	96.37	4.96	6.98	5.98	7.61	
PRECIPITATION, INCHES													
Brantley Lake	0.54	0.32	0.58	0.05	0.53	1.48	2.15	0.26	1.14	0.12	1.17	0.00	8.34
Las Vegas FAA AP	0.77	0.85	1.23	0.21	0.89	2.08	1.38	2.02	0.44	0.32	1.40	0.11	11.70
Pecos National Monument	1.20	0.52	0.78	0.67	0.74	1.18	2.05	4.71	0.50	0.02	0.36	0.38	13.11
Santa Rosa	1.09	0.89	2.27	0.28	1.22	3.09	0.66	1.27	1.16	0.35	0.22	0.25	12.75
Lake Santa Rosa	1.57	1.03	1.71	0.25	1.29	2.00	0.57	2.60	1.59	0.39	1.60	0.20	14.80
Sumner Lake	0.73	0.65	1.27	0.03	0.65	0.97	0.61	0.99	0.77	0.34	1.08	0.08	8.17
PAN EVAPORATION, INCHES													
Lake Santa Rosa	3.72	4.98	7.12	9.12	8.93	12.58	12.38	9.39	7.96	6.49	4.13	3.76	90.56
Lake Sumner	1.86	3.71	4.04	12.49	11.21	14.30	15.10	11.83	10.25	7.00	2.44	3.03	97.26
Brantley Lake	4.65	5.60	6.09	12.74	13.28	16.85	16.90	13.11	11.42	9.10	4.80	4.34	118.88
OTHER REPORTS													
Base Acme-Art, TAF (USGS)	4.2	3.7	3.5	2.4	2.2	1.7	0.9	1.0	0.7	1.0	2.1	2.4	25.7
Pump depl Ac-Artesia, TAF	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.5
NM irrig inv, acres (3/9/2000)													11529
NM Transfer water use, TAF													0
NM salvaged water, TAF													0
Texas, water stored NM, TAF	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Texas, use Del water, TAF													

APPENDIX

RIVER MASTER'S RESPONSE TO STATES' OBJECTIONS

RESPONSE TO STATES' OBJECTIONS
Final Report, Accounting Year 2002

NEW MEXICO'S OBJECTIONS

1. *Table 12. Data Required for River Master's Manual Calculations*, *WY 2001:*

New Mexico reported errors in River Pumper data for April through November. The data for WY 2001 was not entered on Table 12. The objection is accepted and Table 12 has been revised.

2. *Table 11. Change in Storage, Lake Avalon – 2001 – (B.4.g):*

New Mexico reported errors in storage values for Lake Avalon for March through December. The objection is accepted and Table 11 has been revised. The total change in storage is shown as – 1.0 TAF.

3. *Table 9. Lake Avalon Leakage Lagged – 2001 – (B.4.c.1.g):*

New Mexico reported two errors on Table 12. The leakage value for December was in error and days shown for February should be 28 rather than 29. The objection is accepted. Table 9 was revised to show a lagged leakage of 17.4 cfs, rather than 17.1 cfs. The difference in 17.4 and 17.5 cfs, reported by New Mexico, appears to be in rounding off of numbers.

4. *Table 8. Carlsbad Main Canal Seepage Lagged – 2001 – (B.4.c.1.e):*

New Mexico noted that February should be shown with 28 days in Table 8. The objection is accepted, and the table has been revised.

5. *Table 7. Carlsbad Springs New Water – 2001 – (B.4.c):*

New Mexico reported that Table 7 should be revised to reflect changes in Table 9. The objection is accepted and Table 7 has been revised.

6. *Table 6. Depletions due to Santa Rosa Reservoir Operations – 2001 – (C.1.b):*

The River Master could not check New Mexico's first objection about gage height for November. The Preliminary Report's gage height figure of 5.98 feet was contained in New Mexico's letter to the River Master of March 15, 2002. The River Master could not find where New Mexico got its figure of 6.84 feet. Also, the calculation is the same with either value. New Mexico's second point is about a calculation of sum of contents using the resulting figures. These objections are rejected.

New Mexico reported an error in the interpolation for the July and November 1947 area calculation. The objection for July is accepted. The objection for November is rejected because it is based on the issue described in the previous paragraph.

Table 8 has been revised and now has the same value reported by New Mexico, 2.8 TAF adjustment.

7. *Table 3. Flood Inflow, Artesia to Carlsbad, WY 2001 (B.4):*

New Mexico's objections about Table 3 involve carry over of computations from Items 2 and 5 above. The objections are accepted, and Table 3 has been revised. The difference of 0.1 TAF between the River Master's and New Mexico's values is due to rounding.

8. *Table 2. Flood Inflow, Alamogordo to Artesia, WY 2001 (B.3):*

New Mexico's objection about Table 2 involves carry over of computations from Item 1 above. The objection is accepted, and Table 2 has been revised.

9. *Table 1. General Calculations of Annual Departures, TAF, WY 2001:*

As a result of New Mexico's objections, Table 1 has been revised to show a shortfall of 0.7 TAF, rather than a shortfall of 1.4 TAF.

TEXAS'S OBJECTIONS

Texas noted differences between the Preliminary Report and USGS data for reservoir content values of Sumner and Santa Rosa lakes. These differences do occur and are explained as follows. The River Master's Manual instructs the River Master to use the latest gage height, area, and content tables to compute reservoir surface areas and contents (see Table 6 of Preliminary Report). From the inception of accounting under the Amended Decree, the procedure has been to obtain average and end-of-month gage heights and to look up surface areas and contents. A few years ago, the procedure was instituted whereby New Mexico obtains the gage data and reports it (See New Mexico's letter to the River Master of March 15, 2002). This procedure saves time and provides a common database for annual accounting. The River Master has observed that data computed this way differs from USGS content data, but does not know how USGS computes the content data. If the procedure is of concern to either state, it is suggested that the states agree on revised procedure.

FINAL CALCULATED DEPARTURE.

The Preliminary Report's Final Calculated Departure was – 1.4 TAF. After considering the states' objections, the Final Determination is – 0.7 TAF.