

Appendix C

Hydrologic Modeling Documentation 2006-2010 Temporary Excess Capacity Contracts Fryingpan-Arkansas Project

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I. METHODOLOGY, DATA, AND ASSUMPTIONS USED FOR MONTHLY ANALYSIS

INTRODUCTION

This hydrologic analysis was performed by the Bureau of Reclamation's (Reclamation) Technical Service Center (TSC), at the request of the Eastern Colorado Area Office (ECAO) of the Great Plains Region. The purpose of the analysis is to estimate the hydrologic effects on the Arkansas River and associated reservoirs of (1) issuing temporary excess capacity exchange and storage contracts (temporary contracts) for east slope Fry-Ark facilities, namely Pueblo Reservoir, and (2) for not issuing temporary contracts. These two scenarios are referred to as the Proposed Action and the No Action alternatives.

This analysis was performed using a Microsoft Excel spreadsheet. The spreadsheets are available by contacting ECAO. The number and volume of potential contract requests from 2006 through 2010 are unknown. Therefore, the previous 5 years of operations were used to project estimated Contractor yields under the No Action and Proposed Action alternatives and resulting operations from 2006 through 2010. **The hydrologic analysis does not commit or prevent any potential Contractor from receiving a contract. It is a temporal analysis of demand on Arkansas River basin segments as a result of either issuing or not issuing temporary contracts. Please see Table 9 for the temporal demand on basin segments in net acre feet (af) per month.**

In summary, the analysis uses historic flows and existing minimum flow requirements to determine the flow available for exchange/diversion by entities that requested temporary contracts in east slope Fry-Ark facilities (Pueblo Reservoir or Twin Lakes) between 2000 and 2005. Each entity's estimated exchanges/diversions on the Arkansas River, under the No Action and Proposed Action alternatives, were used to calculate the exchange potential to and from Pueblo Reservoir. From those calculations, resultant flows in Arkansas River under the No Action and Proposed Action alternatives were calculated.

The potential storage in Pueblo Reservoir under temporary contracts was estimated from temporary contract requests from 2000 to 2005. Because the purpose of the Environmental Assessment for temporary contracts is to address the effects of temporary contracts from 2006-2010, it was necessary to include a variety of potential contract requests. This includes municipal, agricultural, recreation, and fishery contracts.

Table 1. Entities who received a contract from 2000-2005, and the Contract Volume Modeled for that Type of Water Use for 2006-2010.

| Contractor | Type of Contract | Contract Volume Modeled (af) |
|---|------------------|------------------------------|
| Aurora, City of | M&I | 10,000 |
| Bureau of Land Management | Fishery | 3,000 |
| Catlin Canal Company | Irrigation | 500 |
| Colorado Springs Utilities | M&I | 26,000 |
| Colorado State Parks | Recreation | 4,000 |
| Colorado Water Protective and Development Association | M&I | 8,000 |
| Fountain, City of | M&I | 2,600 |
| Highline Canal Company | Irrigation | 10,000 |
| Lower Arkansas Valley Water Conservancy District | Irrigation | 500 |
| Pueblo West Metropolitan District | M&I | 10,000 |
| Salida, City of | M&I | 800 |
| Security Water District | M&I | 800 |
| St. Charles Mesa Water Conservancy District | M&I | 800 |
| Stratmoor Hills Water and Sanitation District | M&I | 400 |
| Widefield Water and Sanitation District | M&I | 2,600 |
| TOTAL | | 80,000 |

It is estimated that 80,000 acre-feet is available on an “if and when”¹ basis for temporary contracts. In order to analyze the effects of contracting for this amount, each entity’s most recent request was doubled with the following exceptions:

- (1) The Highline Canal Company’s and Aurora’s request, were assumed to not exceed 10,000 acre-feet. The Highline Canal Company contract represents an estimate of potential future requests for irrigation storage for water rights originating below Pueblo Reservoir. Additionally, it is unlikely that Aurora, or a contractor with similar water operations, would request additional storage.
- (2) Colorado Springs Utilities’ storage was assumed to be 26,000 acre-feet.

After preliminary data gathering (described in Sections I and II of this report), the exchange potentials for several reaches and individual gages (Table 2) on the Arkansas River from Turquoise Lake to Rocky Ford were calculated for the No Action and Proposed Action alternatives. Exchanges and diversions under each alternative were used to determine changes to flows in the Arkansas River under each alternative.

¹ “If and When” refers to the availability of storage space for non-project water. Storage space is available if, and when, it is not needed to meet Fry-Ark project purposes.

Table 2. Gages in the Arkansas River Basin where flow changes were calculated.

| Gage Name | Gage Number | Managing Agency |
|--|--------------------|------------------------|
| Lake Fork Creek below Sugar Loaf Dam | LFCBSLCO | Reclamation |
| Arkansas River near Malta | 07083700 | USGS |
| Lake Creek below Twin Lakes Reservoir | LAKBTLCO | Reclamation |
| Arkansas River at Granite | 07086000 | USGS |
| Arkansas River near Wellsville | 07093700 | USGS |
| Arkansas River at Portland | 07097000 | USGS |
| Arkansas River above Pueblo | 07099400 | USGS |
| Arkansas River at Moffat St. at Pueblo | 0709970 | USGS |
| Arkansas River near Avondale | 07109500 | USGS |
| Arkansas River at Catlin Dam near Fowler | 07119700 | USGS |
| Arkansas River at La Junta | 07123000 | USGS |

HISTORIC FLOWS

Historic mean daily flows as measured at various gages on the Arkansas River provide the foundation for this analysis (Table 2). The following discussion is a description of gage data limitations and how they were incorporated into the model:

- There is no data for the Arkansas River at Malta after 9/30/1984 and the missing data at Malta was not estimated because there are no changes in stream flows upstream of Malta.
- There is no historic flow data available for Lake Creek below Twin Lakes from 10/1/1984 through 9/30/1985. For water year 1984, flow in Lake Creek was estimated to be equal to the Arkansas River at Granite * 0.56 - 14.6, not to be less than zero. This equation was obtained using regression analysis between flows in the Arkansas River at Granite and flows in Lake Creek below Twin Lakes Reservoir.
- There is no data for the Arkansas River at Moffat prior to 1988 because that was the year the gage was installed and flow measurement began. The flow estimate for the Arkansas River at the Moffat Street gage was derived by subtracting 20 cfs from flows at the Above Pueblo gage to account for the West Plains diversion.

HISTORIC EXCHANGES ADDED BACK TO THE RECORDED FLOW

In 2004, an intergovernmental agreement (Pueblo IGA) between City of Pueblo, City of Fountain, Colorado Springs Utilities, Pueblo Board of Water Works, City of Aurora, and the Southeastern Colorado Water Conservancy District was negotiated. The Pueblo IGA imposes flow requirements through Pueblo, Colorado (Figure 1 and Table 5). Because the Pueblo IGA resulted in new minimum flow requirements for the signatories, and in turn a new flow regime on the Arkansas River below Pueblo Reservoir, historic exchanges were added back to the gages below Pueblo Reservoir in order to be able simulate the minimum flow limitations of the Pueblo IGA on diversions and exchanges into Pueblo Reservoir under the No Action and Proposed Action Alternatives. Prior to

the development of the Pueblo IGA, Colorado Springs and Aurora had the potential to divert and/or exchange a higher percentage of the Arkansas River flows below Pueblo Reservoir.

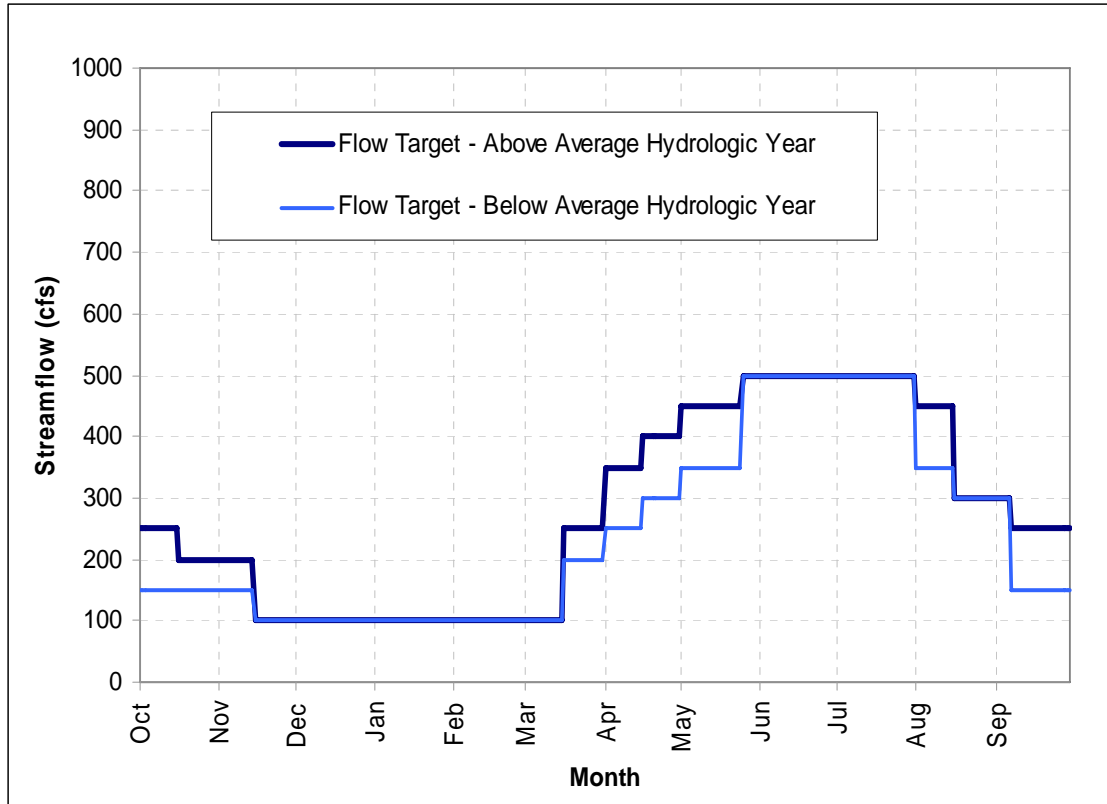


Figure 1. Proposed Recreational Flow Targets at Above Pueblo Gage for Pueblo Flow Management Program.

Historic exchanges by Aurora and CSU were added back to the historic mean daily flows as measured on the Arkansas River below Pueblo Reservoir. Because the Pueblo IGA only affects Arkansas River flows below Pueblo Reservoir, the historic exchanges above Pueblo Reservoir were not added back to the historic gage flow records on the Arkansas River above Pueblo Reservoir.

The gages below Pueblo Reservoir and a description of the respective exchanges that were added back to the historic gage flow records follow:

Arkansas River above Pueblo gage: All exchanges into Pueblo Reservoir by Colorado Springs and Aurora were added back to the historic gage flow.

Arkansas River at Moffat gage: All exchanges into Pueblo Reservoir by Colorado Springs and Aurora were added back to the historic gage flow.

Arkansas River near Avondale: Since this gage is below the Fountain Creek confluence, all exchanges into Pueblo Reservoir by Colorado Springs from the Colorado Canal

system and all of Aurora's exchanges into Pueblo Reservoir were added back to the historic gage flow.

Arkansas River Catlin Canal: Since this gage is below the Fountain Creek confluence and the Colorado Canal, only exchanges into Pueblo Reservoir by Aurora from the Rocky Ford I decree were added back to the historic gage flow. Since there were no Rocky Ford II exchanges prior to the Pueblo IGA and the period of record used for this analysis ends in 2002, and Rocky Ford II exchanges were not added to the gage.

Arkansas River La Junta: No change from historic flows. All water rights operations are upstream from this gage; therefore exchanges should not affect Arkansas River flows at this gage location.

MINIMUM FLOWS AND FLOW MANAGEMENT PROGRAMS

This section discusses the Colorado Water Conservation Board (CWCB) decreed minimum flows and various flow management program regimes on Lake Creek, Lake Fork, and the Arkansas River. The minimum flows presented are decreed minimum flow and flow management programs on the Arkansas River. Some minimum flows could not be simulated as they apply to native flows or other criteria, which were out of the scope of this analysis. The minimum flow requirements that were not simulated are noted below.

The remainder of this section presents a discussion of how the minimum flow requirements were calculated for each decreed minimum flow and flow management program for this analysis. There are no differences in minimum flows between the Proposed Action and the No Action Alternatives, with the exception of minimum flows at the Wellsville gage to account for differences in cooperation with the Upper Arkansas River Flow Program between the Alternatives. The difference at this gage is noted.

Lake Fork: The minimum flows simulated were 15 cfs for the period of April 16 to August 15, and 4 cfs for all other times of the year.

Lake Creek: The flow minimum simulated was 15 cfs for the entire year.

Upper Arkansas Flow Management Program (Wellsville): This is the most limiting of all decreed minimum flows and flow management programs above Pueblo Reservoir with one exception: the minimum flow for Aurora for the last two weeks of August is 260 cfs at the Salida gage. Flow data for the Salida gage was not available for this analysis. The difference between the Upper Arkansas Flow Management Program and the minimum flow at Salida for Aurora is 10 cfs. Given the small difference between the flow requirements at Salida and Wellsville and the lack of flow data for Salida, it was assumed that the flow requirements at Wellsville presented a sufficient limitation on exchanges to the upper basin reservoirs. Further detail is beyond the tolerance for the simulations used in this analysis. For the Proposed Action alternative, the minimum flows for this reach are 700 cfs from July 1 to August 15, and 250 cfs for the remainder of the year (**Table 3**).

For the alternatives, the minimum flows for this reach were 250 cfs for all days of the year.

Table 3. Colorado Department of Natural Resources, Annual Flow Recommendations for the Upper Arkansas Flow Management Program.

| | Fishery cfs | Fishery Egg Incubation cfs | Recreation cfs |
|-----|----------------|-------------------------------------|-------------------|
| Jan | 250 | 250-400 | |
| Feb | 250 | 250-400 | |
| Mar | 250 | 250-400 | |
| Apr | 250 | 250-400 | |
| May | 250 | | |
| Jun | 250 | | |
| Jul | 250 | | 700 |
| Aug | 250 | | 700 |
| Sep | 250 | | |
| Oct | 250 | | |
| Nov | 250 | 250-400 | |
| Dec | 250 | 250-400 | |

The City of Aurora has an additional exchange limitation that is dependent on the flow in the Arkansas River at Wellsville. The maximum exchange and the various flow ranges for which they apply are shown in Table 4.

Table 4. Aurora flow limitation (contingent on flow at Wellsville).

| | Aurora Exchange limitations above Pueblo | | | | | | |
|--|--|-----|-----|------|------|------|------|
| Lower limit, cfs | 0 | 250 | 500 | 1000 | 1500 | 2000 | 3000 |
| Upper limit, cfs | 249 | 499 | 999 | 1499 | 1999 | 2999 | |
| Exchange Rate, cfs | 0 | 50 | 75 | 125 | 175 | 250 | 500 |
| Note: The Upper and Lower limits apply to the flow at Wellsville and the exchange rate is Aurora's exchange rate for the given flow range at Wellsville. | | | | | | | |

Arkansas River at Portland: Aurora has decreed exchange curtailments at the Arkansas River at Portland gage. The exchange curtailments are required when native flows are below 155 cfs and all senior water rights are diverting. This minimum flow exchange curtailment was not simulated, as no data was available from the simulation analysis to assess when all senior rights are diverting or to calculate native flows

Participants of the Pueblo IGA through the City of Pueblo: The minimum of 85 cfs at the combined flow location was not simulated due to lack of information. Data were not available regarding the inflows from Runyon Lake that are included in the combined flow location discussed in the Pueblo IGA. Therefore, this analysis could not adequately

simulate these flow limitations. However, Pueblo IGA flow limitations were simulated at the Arkansas River above Pueblo and Moffat Street gages.

The minimum flow requirements for the Pueblo IGA vary depending on the time of year and the most probable flow at the Salida gage. The logic of the Pueblo IGA indicates that if the most probable flow calculated at the Salida gage is greater than 100% of average it is an average year, between 100% and 70% of average it is a drier year, and less than 70% of average is considered dry conditions. There is no minimum flow requirement if the most probable flow at the Salida gage is less than 70% of average. The annual flow regimes supported by the Pueblo IGA for average and drier years are shown in Table 5 and Figure 1.

Table 5. Flow requirements for the Pueblo IGA through the City of Pueblo.

| Period | Average Year, cfs | Drier Year, cfs |
|-----------------------------|-------------------|-----------------|
| October 1 to October 15 | 250 | 150 |
| October 16 to November 14 | 200 | 150 |
| November 15 to March 15 | 100 | 100 |
| March 16 to March 31 | 250 | 200 |
| April 1 to April 15 | 350 | 250 |
| April 16 to April 30 | 400 | 300 |
| May 1 to May 22 | 450 | 350 |
| May 23 to July 31 | 500 | 500 |
| August 1 to August 15 | 450 | 350 |
| August 16 to September 7 | 300 | 300 |
| September 8 to September 30 | 250 | 150 |

There are no differences between the Proposed Action and No Action Alternatives for this minimum flow because the Pueblo IGA states that all entities will implement the terms of the Pueblo IGA as long as the entities continue to seek long-term contracts for “if and when” storage in Pueblo Reservoir.

Colorado Springs and Aurora Moffat Street gage: At the gage, there are decreed mandatory exchange curtailments for Colorado Springs and Aurora. Both parties must curtail exchanges if St. Charles Mesa Water District is diverting, flow in the Arkansas River at Moffat Street is less than 50 cfs, and the specific conductance in the Arkansas River is greater than 850 uS/cm. The minimum flow for this gage was simulated only during the winter water storage program (WWSP), which exists from November 15 to March 15 each year. The assumption used in this analysis was that St. Charles Mesa only diverts during the winter (because St. Charles Mesa gets its water from the Bessemer Ditch in the summer) and that the specific conductance is greater than 850 uS/cm whenever the flow is less than 50 cfs. This means that flows are curtailed whenever flows are less than 50 cfs from November 15 to March 15.

Aurora Moffat Street gage: The minimum flow requirements for this gage apply only to the Rocky Ford I and II decrees and the Highline Canal lease. The minimum flow requirement of 0 cfs applies if the most probable flow at the Salida gage is less than 70% of average. Otherwise, the minimum flow requirement is 57 cfs at the Moffat Street gage.

Aurora Avondale: The minimum flow for this reach is only related to Aurora’s Rocky Ford I & II decrees. These decrees prevent a dry streambed between Pueblo Reservoir and the Rocky Ford head gate. Thus, a minimum flow of 10 cfs was used in the analysis. The Rocky Ford II decree has an additional minimum flow of 500 cfs when Rocky Ford II water is stored in Lake Meredith or Lake Henry. However, neither the Proposed Action nor the No Action alternatives propose to store water in Lake Meredith or Lake Henry, therefore this minimum flow is not included in the model.

Aurora Catlin: The decreed minimum flow requirement for the Rocky Ford I & II decrees at this location are intended to prevent a dry streambed between Pueblo Reservoir and the Rocky Ford head gate. A minimum flow of 10 cfs is required.

Aurora La Junta: The decreed minimum flow requirement for this location applies only to the Rocky Ford I and II decrees. The maximum diversion rates for the Rocky Ford I & II rights vary depending on the time of year and are presented in Table 6 and Table 7. This minimum flow is applied depending on whether the flow at La Junta is greater than 35 cfs. If the flow at La Junta is greater than 35 cfs, Rocky Ford I & II are allowed to take their maximum daily diversion rate; otherwise, the diversion is 0. It should be stressed that this model does not simulate whether Rocky Ford I or II would be able to divert their maximum on that day. To do so, would require simulation of water rights, which were not available for all potential contractors in this analysis.

Table 6. Summary of Rocky Ford I Diversion Rates.

| | Mar 15-31 | April | May | June | July | Aug | Sep 1-15 | Sep 16-30 | Oct |
|-----------------------|--------------|-------|------|------|------|------|-------------|--------------|-----|
| Daily Rate (cfs) | 11 | 19 | 23 | 32 | 32 | 30 | 20 | 25 | 13 |
| Monthly Total (ac-ft) | 370 | 1129 | 1412 | 1901 | 1964 | 1841 | 594 | 743 | 798 |

Table 7. Summary of Rocky Ford II Diversion Rates and Volumes.

| | Mar 15-31 | April | May | June | July | Aug | Sep 1-15 | Sep 16-30 | Oct |
|-----------------------|--------------|-------|-----|------|------|------|-------------|--------------|-----|
| Daily Rate (cfs) | 7 | 13 | 15 | 21 | 21 | 20 | 13 | 17 | 9 |
| Monthly Total (ac-ft) | 236 | 774 | 863 | 1166 | 1208 | 1150 | 387 | 506 | 553 |

FLOW AVAILABLE FOR EXCHANGE

To calculate the flow available for exchange (flow above minimum flow requirements), the spreadsheet uses the decreed minimum and flow management program flows in Lake Creek, Lake Fork, and the Arkansas River, as well as the historic mean daily flows or the historic mean daily flows with historic exchanges added back to the recorded gage. The first step in this procedure was to subtract any known minimum flow requirement at a gage from the historic flow above Pueblo Reservoir or historic-plus-exchanges added to the recorded gage flow below Pueblo Reservoir (referred to as historic flow for the remainder of the document).

The flow available for exchange or diversion was assumed to be zero if the historic flow is less than the minimum flow requirement. The remainder of this section describes the exchange analysis for various flow points in the system.

Arkansas River above Pueblo Reservoir (Aurora and Colorado Springs): For the purposes of this analysis, it was assumed that no flows would be exchanged directly to Turquoise Reservoir through river exchange. Therefore, the flow available for exchange or diversion into the upper basin reservoirs is the minimum of the flow available in Lake Creek below Twin Lakes Reservoir and the flow available in the Arkansas River at Wellsville.

Arkansas River above Pueblo (City of Aurora): Aurora has additional exchange limitations that must be considered. Based on the flow in the Arkansas River at Wellsville, there are maximum amounts of water that Aurora can exchange into the upper basin of the Arkansas River. The flow ranges and maximum exchange rates for each flow range are shown in Table 4. Aurora's flow available for exchange is limited to the minimum of the flow available for exchange considering other minimum flow requirements calculated as flow available for exchange or diversion (*Arkansas River above Pueblo Reservoir (Aurora and Colorado Springs)*) and the maximum exchange rate based on the flow in the Arkansas River at Wellsville.

Between Pueblo Reservoir and Fountain Creek (Non-Pueblo IGA participants): For non-IGA participants, there are no minimum flow requirements between Pueblo Reservoir and Fountain Creek. Therefore, in the analysis this value is represented by the minimum of the flow in the Arkansas River at the Above Pueblo and Moffat Street gages.

Non-Pueblo IGA limits between Pueblo Reservoir and Fountain Creek (for Colorado Springs): Colorado Springs can exchange up to one-half of the native inflow into Pueblo Reservoir during the WWSP season (November 15 to March 15). This information on native inflows to Pueblo Reservoir is not available in this analysis; therefore, the most that Colorado Springs can exchange into Pueblo Reservoir is one-half of the total flow into the reservoir during the winter. The other non-IGA limitation on Colorado Springs exchanges into Pueblo Reservoir is the flow requirements for St. Charles Mesa during the WWSP season (50 cfs and specific conductance levels greater than 850 uS/cm). During the remainder of the year, exchanges were assumed to be limited to the flow in the Arkansas River between Pueblo Reservoir and Fountain Creek.

Non-Pueblo IGA limits between Pueblo Reservoir and Fountain Creek (for the City of Aurora): Regardless of the IGA, Aurora cannot divert Rocky Ford I & II or Highline Canal water at Pueblo Reservoir unless the flow in the Arkansas River at the Moffat Street gage is greater than 57 cfs. Also, the St. Charles Mesa flow limitations of a minimum of 50 cfs at the Moffat Street gage were not included because the 50 cfs limitation is less restrictive than the 57 cfs limitation.

Between Pueblo Reservoir and Fountain Creek (PuebloIGA Participants other than Aurora and Colorado Springs): This is the minimum of the flow in the Arkansas River at

the above Pueblo gage minus the minimum flow requirement for the Pueblo IGA and zero.

Pueblo IGA Limits between Pueblo Reservoir and Fountain Creek (City of Aurora): This is the minimum flow as compared between *Non-Pueblo IGA limits between Pueblo Reservoir and Fountain Creek (for the City of Aurora)* and *Between Pueblo Reservoir and Fountain Creek (Pueblo IGA Participants other than Aurora and Colorado Springs)*. This limit represents the minimum of the 57 cfs minimum flow limitation at the Moffat Street gage and the flow limitations imposed by the Pueblo IGA. The non-Pueblo IGA and other limitations were calculated separately. It was assumed that the Recovery of Yield Program (ROY Program) created by the Pueblo IGA allows signatories to recover the yield they lose that is attributable to implementing the flow regime detailed under the Pueblo IGA. Any yields that are lost due to other mandatory flow curtailments are assumed to be unrecoverable. Therefore, it is only the increment of yield lost due to the Pueblo IGA that is subject to the ROY Program.

Pueblo IGA limits between Pueblo Reservoir and Fountain Creek (Colorado Springs): This is the minimum flow as compared between *Non-Pueblo IGA limits between Pueblo Reservoir and Fountain Creek (for Colorado Springs Utilities)* and *Between Pueblo Reservoir and Fountain Creek (Pueblo IGA Participants other than Aurora and Colorado Springs)*. This limit represents the minimum of the St. Charles Mesa limitations and one-half of the flow in Pueblo Reservoir and the limits imposed by the Pueblo IGA.

Avondale Rocky Ford I and II-Aurora: There is a minimum flow of 10 cfs to prevent a dry streambed.

Catlin Rocky Ford I and II Aurora: There is a minimum flow of 10 cfs at Catlin to prevent a dry streambed.

Arkansas River-La Junta: If the flow is greater than the minimum flow requirement at La Junta (35 cfs), the flow available for diversion is the maximum daily diversion rate for the Rocky Ford I & II decrees are equal to those presented in Table 6 and Table 7.

HISTORIC EXCHANGES BY COLORADO SPRINGS

Colorado Springs has been issued temporary contracts in the past. The impact of these contracts on the river depends on whether it occurs above or below Pueblo Reservoir. Above Pueblo Reservoir, the difference between Colorado Springs' historic use of temporary contract space and the city's assumed 2006-2010 requests represents the additional impact on the river as a result of issuing a contract for this year. Adding the impacts from 2006-2010's temporary contract requests to the historic impacts would duplicate potential impacts. Below Pueblo Reservoir, the assumed impact on the river is the maximum of the city's historic use of temporary contract space and its assumed 2005-2010 requests. Using the maximum of the temporary contract request and historic use does not over estimate the impacts because the historic exchanges below Pueblo

Reservoir were added back to the historic gage flow. The different handling of historic exchanges above and below Pueblo Reservoir was due to the Pueblo IGA (including the ROY program). Because this IGA was effectuated in 2005, Colorado Springs should not be able to exchange as much into Pueblo Reservoir as they have historically.

Colorado Springs' historic exchange data into and out of Pueblo Reservoir are available beginning in 1989. In order to calculate monthly exchange totals, the historic daily exchanges by Colorado Springs were summed. These monthly totals were compared to y Colorado Springs Utilities' assumed 2006-2010 temporary contract requests. Above Pueblo Reservoir, if there were historic exchanges, the estimated exchange was reduced so that the impacts to the river were not overestimated. Below Pueblo Reservoir, the estimated exchange is the maximum of the historic exchange and the assumed 2006-2010 requests. All historic exchanges were assumed to occur for the Proposed Action alternative.

Requested, Pueblo Reservoir Net FAP Return flows from Fountain Creek: This is the maximum of either Colorado Springs' assumed 2006-2010 yields or the historic exchanges from Fountain Creek. The historic exchange from Fountain Creek includes exchanges into Pueblo Reservoir and flows exchanged directly to Twin Lakes. The inclusion of flow exchanged directly to Twin Lakes was done as part of this analysis based on the assumption that water will be exchanged directly to Twin Lakes and the Fountain Valley Conduit (FVC) from Fountain Creek before it would be exchanged into Pueblo Reservoir. The assumption of exchanging directly to FVC or Twin Lakes was necessary in order to simulate the No Action alternative.

Net requested release from Pueblo Reservoir exchanged to Twin Lakes Arkansas Exchange: This release equals the maximum of either Colorado Springs' assumed 2006-2010 yield minus the historic river exchange between Pueblo Reservoir and Twin Lakes, and zero. For purposes of this analysis;

- If the historic exchange > estimated assumed 2006-2010 yield: no additional exchange would be considered, however;
- If the historic exchange < estimated assumed 2006-2010 yield: the additional exchange request was assumed to = [(assumed 2006-2010 yield) – (historic exchange)].

Because historic exchange data were available, it was possible to identify months when the historic exchange was greater than Colorado Springs Utilities' assumed 2006-2010 exchange. The space requested in Pueblo Reservoir in 2005 is greater than what has been requested in the past. Therefore, the assumption was made that the amount of water exchanged from Pueblo to Twin Lakes Reservoir would be at least as much as historic including direct exchanges from Fountain Creek to Twin Lakes.

HISTORIC EXCHANGES BY AURORA

The City of Aurora has been issued temporary contracts in the past. The impact on the river depends on whether the impact occurs above or below Pueblo Reservoir. Above

Pueblo Reservoir, the difference between Aurora's historic use of temporary contract space and the city's assumed 2006-2010 yields represents the additional impact on the river of issuing a contract in 2006-2010. Adding the impacts from the assumed 2006-2010 yields to the historic impacts could duplicate contract effects. Below Pueblo Reservoir, the impact on the river is assumed to be the maximum of their historic use of temporary contract space and their assumed 2006-2010 request. Using the maximum of the assumed 2006-2010 temporary contract request and historic use does not cause an overestimation of the impacts on this reach because the historic exchanges below Pueblo Reservoir were added back to the historic gage flow. The different handling of historic exchanges above and below Pueblo Reservoir is a result of the Pueblo IGA (including the ROY program). Because the Pueblo IGA was effectuated in 2005, Aurora should not be able to divert as much of their water rights into Pueblo Reservoir as they have historically.

Aurora's historic exchange data into and out of Pueblo Reservoir are available beginning in 1993. The historic daily exchanges by Aurora were summed to obtain monthly totals (af/mth). These monthly totals were compared to Aurora's assumed 2006-2010 temporary contract requests. If there were historic exchanges above Pueblo Reservoir, the assumed 2006-2010 estimated exchange was reduced by the historic exchange so that the impacts to the river would not be overestimated. Below Pueblo Reservoir, the estimated exchange equals the maximum of the historic exchange and Aurora's assumed 2006-2010 requests. All historic exchanges were assumed to occur for the Proposed Action alternative.

Historic Exchange Values Assumptions:

Meredith to Pueblo: These were assumed to be the same as Colorado Canal exchanges.

Rocky Ford to Pueblo: These were assumed to be equal to the Rocky Ford I exchanges since Rocky Ford II has no historic diversions at Pueblo Reservoir prior to 2004.

Pueblo Reservoir to Twin Lakes: Due to the time of year that the majority (by volume) of these exchanges have occurred (late summer through earlier winter), it was assumed that these were contract exchanges. In 2001, there were some exchanges in December and the only way to make an exchange in December is via contract. Another affirmation that these were contract exchanges is the large volumes that occur in a single day (i.e., 470 af on 6/19/02, 500 af on 7/3/02).

Net Colorado Canal to Pueblo Reservoir: This is the maximum of the assumed 2006-2010 contract requests and or the historic exchanges from Lake Meredith of the Colorado Canal system. Because historic exchange data was available, it was possible to identify months when the historic exchange was greater than Aurora's assumed 2006-2010 exchange. The space requested in Pueblo Reservoir is the same as has been requested in

the past. Therefore, it was assumed that the amount exchanged into Pueblo would be at least as great as has occurred historically.

Net Rocky Ford I to Pueblo Reservoir: This is the maximum of the assumed 2006-2010 yield or the historic diversion of Rocky Ford I water at Pueblo Reservoir.

Net River Exchange from Pueblo Reservoir to the Upper Basin: This is the maximum of Aurora's assumed 2006-2010 yields minus the historic river exchange between Pueblo Reservoir and Twin Lakes, and zero. For purposes of this analysis;

- If the historic exchange > assumed 2006-2010 yields: it was assumed that no additional exchange took place, however,
- If the historic exchange < assumed 2006-2010 yields: it was assumed the additional exchange request = [(assumed 2006-2010 yields) –(historic exchange)].

Net Contract exchange from Pueblo Reservoir to Turquoise: It was assumed that these exchanges are contract exchanges. First, this assumption was made based on what typically occurs in the Arkansas River basin, which is that no river exchanges are made to Turquoise Reservoir. Second, Aurora typically makes a 2,500 af contract exchange with Pueblo Board of Water Works (PBWW) every year and the volume of Aurora's assumed 2006-2010 requests to Turquoise Reservoir is 2,500 af. It is noted that PBWW's contract exchange with Aurora can be up to 4,000 af annually per their agreement. This is the equivalent of the maximum of the assumed 2006-2010 yields minus the historic contract exchange between Pueblo Reservoir and Twin Lakes, and zero. For purposes of this analysis;

- If the historic exchange > assumed 2006-2010 yields: it was assumed that no additional exchange would take place, however,
- If the historic exchange < assumed 2006-2010 yields: it was assumed the additional exchange request = [(assumed 2006-2010 yields) – (historic exchange)].

CONTRACT REQUESTS

This section details information provided by the various entities requesting temporary contracts in east slope Fry-Ark facilities. The analysis assumes that water released to the Arkansas River for purposes other than well augmentation during the WWSP (November 15 to March 15) is stored by the WWSP and is not actually released to the Arkansas River. This assumption is applied to Aurora, Colorado Springs, and the City of Salida. The analysis also used the assumption that any exchanges to the upper basin from November 15 to March 15 are contract exchanges with entities other than Reclamation, which applied to Colorado Springs. Contract exchanges with entities other than Reclamation were handled as river exchanges in this analysis.

Similar to physical exchanges, Reclamation's proposed contract exchanges would affect the reach of the river between the two exchanging points. In this case, it would be the Arkansas River from Twin Lakes to Pueblo Reservoir. However, contract exchanges do not have an immediate effect on the river. Their effect is born at that time that the

exchanged water would have been delivered via the Arkansas River from Twin Lakes to Pueblo Reservoir. A 10,000 af contract exchange is included in this analysis. Based on past Fry-Ark operations the 10,000 af would have been delivered from November 15th-March 15th. The delivery of 10,000 af was distributed over the 167-day delivery period and converted to cfs. Flows under the Proposed Action alternative from November 15th-March 15th were reduced by the delivery (in cfs) foregone as a result of a contract exchange.

YEAR CLASSIFICATION

The classification of water year type (wet, dry, or average) was done to better understand the effects of granting temporary contracts over a five-year period. Classification information is from Chapter 5 of the Water Resources Technical Memorandum for the EA on Aurora's long-term contract in Pueblo Reservoir. The flow regime implemented under the Pueblo IGA, is dependent on the most probable flow at the Salida gage. Table 8 lists the designation of water year types and ranks used in this analysis.

Table 8. Hydrologic Year Classification for Salida Gage.

| Water Year | Salida: Most Probable Flow | | Rank (n _i) | Non-Exceedance Probability (P _i) | Hydrologic Classification |
|------------|----------------------------|---------|------------------------|--|---------------------------|
| | (% of Average) | (ac-ft) | | | |
| 1982 | 115% | 356,500 | 16 | 0.727 | Wet |
| 1983 | 108% | 334,800 | 14 | 0.636 | Avg |
| 1984 | 150% | 465,000 | 20 | 0.909 | Wet |
| 1985 | 103% | 319,300 | 13 | 0.591 | Avg |
| 1986 | 117% | 362,700 | 17 | 0.773 | Wet |
| 1987 | 94% | 291,400 | 11 | 0.500 | Avg |
| 1988 | 77% | 238,700 | 4 | 0.182 | Dry |
| 1989 | 63% | 195,300 | 2 | 0.091 | Dry |
| 1990 | 74% | 229,400 | 3 | 0.136 | Dry |
| 1991 | 85% | 263,500 | 8 | 0.364 | Avg |
| 1992 | 79% | 244,900 | 6 | 0.273 | Dry |
| 1993 | 111% | 344,100 | 15 | 0.682 | Avg |
| 1994 | 89% | 275,900 | 10 | 0.455 | Avg |
| 1995 | 185% | 573,500 | 21 | 0.955 | Wet |
| 1996 | 138% | 427,800 | 19 | 0.864 | Wet |
| 1997 | 135% | 418,500 | 18 | 0.818 | Wet |
| 1998 | 86% | 266,600 | 9 | 0.409 | Avg |
| 1999 | 95% | 294,500 | 12 | 0.545 | Avg |
| 2000 | 77% | 238,700 | 4 | 0.182 | Dry |
| 2001 | 83% | 257,300 | 7 | 0.318 | Avg |
| 2002 | 25% | 77,500 | 1 | 0.045 | Dry |
| Dry | 83% | | | | |
| Average | 99% | | | | |
| Wet | 111% | | | | |

II. CALCULATION OF EXCHANGE POTENTIAL USING MONTHLY DATA

The previous portion of this document describes how the flow available for exchange was calculated in each reach of the Arkansas River and how the estimated 2006 through 2010 exchanges/diversions in to and out of Pueblo Reservoir were calculated. This section describes how that information is used to calculate exchange potential for contractors.

ARKANSAS RIVER AT LA JUNTA

The exchange potential for this gage was calculated first for two reasons. First, the flow at the La Junta gage only affects the Rocky Ford I & II exchanges, which makes for simplified calculations. Second, if the Rocky Ford I & II exchanges are limited by flow at La Junta, the exchange requirement in the upstream reaches are reduced. This procedure was followed throughout the spreadsheet model. Exchange potential was calculated as far downstream as possible and used to calculate the exchange potential in the next upstream reach. La Junta is the furthest downstream gage that was simulated.

The analysis used the flow available at La Junta and the net requested exchange into Pueblo Reservoir for the Rocky Ford I and II decrees to calculate the exchange potential into Pueblo Reservoir. This is designated as a *potential exchange* because storage constraints could limit the physical amount of water exchanged into Pueblo Reservoir.

The analysis also assumed that Aurora would place the maximum of their estimated 2005 exchanges and their historic exchanges in Pueblo Reservoir. The net exchange request represents the maximum of the assumed 2006-2010 requests and their historic exchange, not to be less than zero. This means that any historic exchanges that have occurred in the past were still assumed to occur in the future, as the space in Pueblo Reservoir is not expected to deviate from historic conditions. Computations for this analysis are described in the remainder of this section.

Aurora's historic exchanges into Pueblo Reservoir were added back to the historic gage flow. The minimum flow requirement at La Junta equals the curtailment of Rocky Ford I and II exchanges when flow at La Junta is below 35 cfs. This is only during recoup. The analysis does not reveal when this would affect Rocky Ford I & II exchanges to Pueblo Reservoir so the assumption was made that it affected all Rocky Ford I & II exchanges. Exchanges to Pueblo Reservoir are only allowed in this spreadsheet if flow at La Junta is above 35 cfs.

ARKANSAS RIVER AT CATLIN

The analysis used the flow available at Catlin and the exchange potential into Pueblo Reservoir for the Rocky Ford I and II decrees after considering flows at La Junta to calculate the exchange potential into Pueblo Reservoir. The exchange is considered *potential* because storage constraints could limit the actual amount exchanged into Pueblo Reservoir.

The only exchange limitation at this gage is a minimum flow of 10 cfs in the Arkansas River at Catlin. All exchanges other than the Rocky Ford I & II and the Colorado Canal exchanges would not affect flows in the Arkansas River at Catlin, because the original points of diversion are upstream of Catlin.

ARKANSAS RIVER AT AVONDALE

There are a number of rights and estimated exchanges into Pueblo Reservoir that would affect the Arkansas River at Avondale. This includes all the Colorado Canal and Highline Canal exchanges/diversions (City of Fountain, Colorado Water Protection and Development Association, Lower Arkansas Water Conservancy District, and Pueblo West's No Action). No minimum flow requirements are simulated at Avondale other than that exchanges cannot cause the flow in the Arkansas River to go below 10 cfs.

The exchange potential for the Rocky Ford I & II rights considering the La Junta and Catlin gages are used to calculate the exchange potential at Avondale. Also, the net exchange (the maximum of Aurora's historic Colorado Canal exchange and their assumed 2006-2010 Colorado Canal exchanges, not to be less than zero) is used to calculate the exchange potential at Avondale. All other exchange requests are from the doubling of the estimated 2005 exchanges into Pueblo Reservoir provided by the requesting entities and do not affect this reach.

All rights and assumed 2006-2010 exchanges into Pueblo Reservoir that would affect the Arkansas River at Avondale share the available flow. This analysis does not include water rights information. The purpose of the analysis was to calculate the likely effect of temporary contracts in 2006-2010 on flows in the Arkansas River, thus it is less important which entity takes the water versus the total volume of water taken.

Once the total exchange potential was calculated at this gage, the exchange potential for individual entities was computed as a portion of the whole. The calculation is the individual entity's exchange request divided by the entire request for all entities multiplied by the total exchange potential. The individual exchange potentials are needed to calculate the effects on storage in Pueblo Reservoir given each entity's requested storage space in Pueblo Reservoir.

ARKANSAS RIVER BETWEEN PUEBLO RESERVOIR AND FOUNTAIN CREEK

There are several potential contractors that could affect the Arkansas River between Pueblo Reservoir and Fountain Creek including all of the exchanges from the mouth of Fountain Creek to Pueblo Reservoir (Colorado Springs, Fountain, Security, Widefield, and Stratmoore Hills). The minimum flow requirements that were simulated in this reach (other than the Pueblo IGA exchange limitations and that exchanges cannot cause the flow in the Arkansas River to go below 0 cfs) are that Aurora's Rocky Ford I & II and Highline lease cannot cause flows to go below 57 cfs and Colorado Springs' limitation of

one-half the inflow into Pueblo Reservoir during the winter. It was assumed that ROY Program created by the Pueblo IGA allows signatories to recover the yield they lose that is attributable to implementing the flow regime detailed under the Pueblo IGA. The ROY Program was formed to recover the increment of yield lost due to the Flow Management Program created in the Pueblo IGA. Therefore, for the purposes of this analysis, any yields that are lost due to other mandatory flow curtailments are assumed to be unrecoverable. Therefore, exchange potential is calculated separately for all exchange/diversion curtailments prior to calculating the exchange potential using the Pueblo IGA flow limitations. Signatories to the Pueblo IGA have noted that although the ROY Program was not formed to recover lost yield of other mandatory flow curtailments, and is not currently being used for that purpose, there is nothing that prohibits the ROY Program from doing so in the future.

The exchange potential for all rights at the Avondale gage is used to calculate the exchange potential between Pueblo Reservoir and Fountain Creek. Also, the net exchange was used to calculate the exchange potential between Pueblo Reservoir and Fountain Creek.

All rights and estimated exchanges into Pueblo Reservoir that would affect the Arkansas River between Pueblo Reservoir and Fountain Creek (with the exception of Aurora's Rocky Ford I & II and Highline lease) share the available flow. This analysis did not consider water right priority dates. The purpose of the analysis was to calculate the likely effect of temporary contracts in 2006-2010 on flows in the Arkansas River, thus it is less important which entity takes the water versus the volume of water taken.

Once the total exchange potential was computed at this gage, the exchange potential for individual entities was calculated as a portion of the whole. The computation was the individual entity's exchange request divided by the entire request for all entities multiplied by the total exchange potential. The individual exchange potentials are needed to calculate the effects on storage in Pueblo Reservoir given each entity's requested storage space in Pueblo Reservoir.

The exchange potentials for Aurora's Rocky Ford I & II and Highline lease were calculated in a similar manner after calculating the exchange potential for all other rights between Pueblo Reservoir and Fountain Creek. The exchange potentials for the other rights were removed from the available flow. The minimum of this flow and the flow available at the Moffat Street gage (considering a minimum flow of 57 cfs) is the flow available for Aurora's Rocky Ford I & II and Highline lease.

PUEBLO IGA FLOW LIMITATIONS

This analysis used the Pueblo IGA Flow Regime to determine the limitations on exchanges/diversions imposed by the Pueblo IGA on participants. The exchange potential for all rights between Pueblo Reservoir and the mouth of Fountain Creek were used to calculate the exchange potential for the Pueblo IGA participants. All rights and exchange potentials for the Pueblo IGA participants into Pueblo Reservoir that would

affect the Arkansas River between Pueblo Reservoir and Fountain Creek share the available flow. The purpose of the analysis was to calculate the likely effect of temporary contracts in 2006-2010 on flows in the Arkansas River, thus it is less important which entity takes the water versus the volume of water taken.

Once the total exchange potential was calculated at this gage, the exchange potential for individual entities was calculated as a portion of the whole. The computation was the individual entity's exchange request divided by the entire request for all entities multiplied by the total exchange potential. The individual exchange potentials are needed to calculate the effects on storage in Pueblo Reservoir given each entity's previously requested storage space in Pueblo Reservoir.

Because Reclamation's understanding is that the ROY Agreement only allows the Pueblo IGA participants to recover that portion of the yield lost because of the Pueblo IGA and because there were no water rights considered in this analysis, it was necessary to calculate the Pueblo IGA limitations on exchanges/diversion separately. This analysis only computed the additional limitation that would be placed on exchanges/diversions by Pueblo IGA participants because of the stipulations of the Pueblo IGA. Therefore, it was necessary to calculate the limitations due to all other minimum flow limitations prior to performing the same calculations for the Pueblo IGA.

MUNICIPAL USE OF HIGHLINE CANAL COMPANY² (AGRICULTURAL) LEASE

For the 2006-2010 analysis it was assumed that Highline Canal Company or a similar agricultural entity would lease up to 10,000 af per year to an upstream municipal entity. If the water is used for municipal purposes, it must be stored in a municipal account. For the purposes of this analysis, the lease was split between Aurora and Colorado Springs, similar to their operations from 2000-2005. The analysis performs calculations to determine if there is space in Colorado Springs' temporary storage space in Pueblo Reservoir for Colorado Springs' share of the Highline Canal Lease. If there was space, one-half of the lease water was stored in Colorado Springs' account. If the space was limited, the amount needed to fill Colorado Springs' account was stored in Colorado Springs' account and the remainder was stored in Aurora's account. In the following month, the analysis attempted to balance the accounts so that 50 percent of the Highline lease goes to each entity (Colorado Springs and Aurora), thus the lease is split on an annual basis. This process continued every month until the end of the year with the result that the entire lease is used in most years.

RECOVERY OF YIELD (ROY) USING HOLBROOK RESERVOIR

This analysis also calculates the ROY from the use of Holbrook Reservoir. This includes storage in Holbrook Reservoir, exchanges from Holbrook, and accrual of water in Holbrook. The amount of water placed in Holbrook Reservoir equates to the volume

² This does not include the projected 10,000 af irrigation account simulated to represent potential demand for irrigation storage identified in Table 1.

requested for exchange into Pueblo Reservoir minus the amount actually exchanged into Pueblo Reservoir. In other words, the entity had the right and the water available to exchange into Pueblo Reservoir, but the Pueblo IGA prevented them from doing so.

Storage of ROY water in Holbrook Reservoir is controlled by several factors. The first factor is the unused exchange potential that could not be exchanged into Pueblo Reservoir. This is water that is stored in Holbrook Reservoir under the ROY agreement. The analysis did not consider a storage limitation on Holbrook Reservoir other than the ROY storage could not be greater than the capacity of Holbrook Reservoir (6,000 af). The second factor that controls ROY storage in Holbrook Reservoir is the volume of water exchanged out of Holbrook Reservoir into Pueblo Reservoir.

The volume of water exchanged out of Holbrook Reservoir is also dependent on several factors: (1) the amount of water stored in the Pueblo IGA participant's storage in Holbrook Reservoir, (2) the availability of storage in the Pueblo IGA participant's temporary contract space in Pueblo Reservoir, and (3) the availability of flow for exchange between Pueblo Reservoir and Holbrook Reservoir was considered. No contract exchanges between Pueblo Reservoir and Holbrook Reservoir were simulated in this analysis due to the inability to simulate the WWSP.

ARKANSAS RIVER BETWEEN PUEBLO RESERVOIR AND TWIN LAKES

In this analysis, there are three potential contractors' temporary contract operations that were modeled, totaling 39,000 af of storage, and 10,000 af of exchange that could affect flows above Pueblo Reservoir by exchanging water into upper basin reservoirs. These are the Bureau of Land Management (BLM), Colorado Springs, and Aurora. Colorado Springs' and Aurora's exchanges into the upper basin are considered a net exchange (the 2005 exchange request minus historic exchange, not to be less than zero). The BLM and Colorado Springs exchanges were simulated first and the remaining flow available was used to calculate Aurora's exchange. The exchange potential for the other rights was removed from the flow available for exchange. The minimum of this flow and the flow available (considering other exchange limitations that apply only to Aurora) is the flow available for Aurora's exchange into the upper basin. This analysis used the assumption that Aurora's exchange rights are junior to the others in the upper basin above Pueblo Reservoir.

Once the total exchange potential was calculated at this gage, the exchange potential for individual entities was computed as a portion of the whole. The calculation equaled the individual entity's exchange request divided by the entire request for all entities multiplied by the total exchange potential. The individual exchange potentials were used to calculate the effects on storage in Pueblo Reservoir given each entity's requested storage space in Pueblo Reservoir.

ACCOUNTING FOR INDIVIDUAL TEMPORARY STORAGE CONTRACTS

This analysis used the calculated exchange potentials and the exchanges/diversions in to and out of Pueblo Reservoir to perform accounting for temporary contract space in Pueblo Reservoir.

Because monthly data was used, it is possible to have water being stored in temporary contract space in Pueblo Reservoir and water being used from that space in the same month. Furthermore, because temporary contract space in Pueblo Reservoir is limited, the first situation could lead to the requesting entity not being able to store in Pueblo Reservoir. Therefore, withdrawals were made from Pueblo using accruals prior to storing any water in Pueblo Reservoir. This allowed for the maximum use of temporary contract space in Pueblo Reservoir. Any remaining accrual was added to storage in Pueblo Reservoir. The withdrawals were then removed from Pueblo and the end of month storage is calculated.

The exchange/diversion into Pueblo Reservoir was always limited to the requested exchange/diversion into Pueblo Reservoir minus any direct withdrawals from accruals to Pueblo Reservoir and temporary contract space available in Pueblo Reservoir. Throughout this analysis exchange/diversion into Pueblo Reservoir is constrained first by flow management programs and decreed minimum flows and second by accounting in Pueblo Reservoir.

Exchanges/releases from the temporary contracting space in Pueblo Reservoir are constrained by the amount requested from storage and the amount stored in the temporary contract space. The exchange/release from Pueblo Reservoir has been constrained by flow management programs and decreed minimum flows prior to doing accounting in Pueblo Reservoir.

Because of the low actual storage in Pueblo Reservoir in 2005, storage capacity in Pueblo Reservoir was not considered a limiting factor.

The inflows into Pueblo Reservoir, the outflows from Pueblo Reservoir, and the end of month temporary contract storage in Pueblo Reservoir were calculated for each month of each year. These values were then averaged for wet, dry, and average conditions.

The year-to-year interactions of temporary contracts were simulated by using carry-over storage in the temporary contract space in Pueblo Reservoir. The greater the volume of water carried over from one contracting year to the next, the less affect the contracts will have on Arkansas River hydrology, as the contracting entities will have limited storage in their temporary contract space.

SIMULATING THE NO ACTION ALTERNATIVE

The model for the temporary contracts is set up to make deliveries from accruals before storing water in Pueblo Reservoir. This maximizes the use of storage in Pueblo Reservoir. It also allows for the simulation of the No Action.

For the No Action, the Fountain Valley Authority entities (Colorado Springs, Security, Widefield, Fountain, and Stratmoore Hills) are may exchange water directly to the intake for the Fountain Valley Pipeline. The Colorado Canal entities are allowed to make exchanges directly to Twin Lakes. Pueblo West is allowed to make deliveries directly to their intake. Colorado Springs is allowed to make exchanges directly from the mouth of Fountain Creek to Twin Lakes. Finally, Aurora has stated they could deliver their water to the Colorado Canal for later exchange to Twin Lakes, use available exchange potential for their Rocky Ford water rights, or use Pueblo to divert their Rocky Ford Rights, and could use instantaneous contract exchanges with Pueblo Board of Water Works to move the water out of Pueblo Reservoir. All other entities would not be able to make any exchanges or alternative points of diversion in the Arkansas River Basin, as Pueblo Reservoir would not be available to store and regulate the water.

CALCULATING FLOW CHANGES IN THE ARKANSAS RIVER

The inflows and outflows from Pueblo Reservoir were used to determine the affect on stream flows by stream reach on the Arkansas River. These stream reaches are located above Pueblo Reservoir, between Pueblo Reservoir and Fountain Creek, between Fountain Creek and the Colorado Canal Headgate, and between the Colorado Canal Headgate and the Rocky Ford Headgate, and below the Rocky Ford Headgate.

This analysis calculated the average monthly flow in cfs for nine locations on the Arkansas River, one location on Lake Fork Creek, and one location on Lake Creek (Table 2). Four locations are located upstream of Pueblo Reservoir, two locations are between Pueblo Reservoir and Fountain Creek, and three locations are below Fountain Creek. The four locations above Pueblo Reservoir are the Arkansas River at Malta, Granite, Wellsville, and Portland. The two locations between Pueblo Reservoir and Fountain Creek are the Above Pueblo and the Moffat Street gages. The three locations below Fountain Creek are the Arkansas River at Avondale, Catlin, and La Junta. Catlin is below the Highline Canal and Colorado Canal diversions, but above the Rocky Ford diversion. La Junta is below all the diversions. The location on Lake Fork Creek is at Lake Fork below Turquoise Reservoir and the location on Lake Creek is on Lake Creek below Twin Lakes. The Arkansas River at Malta has no data after water year 1984 and Lake Creek below Twin Lakes is missing data for water year 1985.

This analysis compared average monthly flows in cfs at eight locations on the Arkansas River for years classified as hydrologically dry, wet, and average. The comparison is between flows for the Proposed Action alternative versus the No Action alternative. The first column for each location on the Arkansas River is the average monthly flow for the No Action alternative. The second column is the average monthly flow for the Proposed

Action alternative and the third/final column is the difference between the No Action and the Proposed Action alternatives as explained in the Environmental Assessment.

Table 9: Net Temporal Demand (af/mth) analyzed on the Arkansas River at the Portland, Above Pueblo, and Avondale gages

| | Portland af/mth | Above Pueblo af/mth | Avondale af/mth |
|-----|--------------------|---------------------------|--------------------|
| Jan | -55 | -40 | + |
| Feb | -30 | -35 | + |
| Mar | -5 | -495 | -270 |
| Apr | -205 | -570 | -820 |
| May | -1920 | -495 | -930 |
| Jun | -1340 | -920 | -1260 |
| Jul | + | -685 | -1460 |
| Aug | + | -110 | -675 |
| Sep | -625 | -15 | -450 |
| Oct | -430 | -195 | -450 |
| Nov | -325 | -261 | + |
| Dec | -40 | -450 | -165 |

LIMITATIONS OF THE ANALYSIS

There are some limitations to the analysis. First and foremost, is the lack of water rights in the analysis. Including water rights could further limit exchanges/diversions to and from Pueblo Reservoir; therefore this limitation has the potential to overestimate hydrologic effects.

The second limitation is the lack of water accounting for Pueblo Reservoir capacity in the model. The model assumes that there is space in Pueblo Reservoir to store the water from the temporary contracts. The model does not differentiate between Fry-Ark Project and other storage project flows and native flows. In order to compensate and assure the alternatives wouldn't negatively affect project operations, estimated storage under temporary contracts was superimposed on historic storage in Pueblo Reservoir in dry, average, and wet years to assure that additional temporary storage would not cause reservoir levels to vary outside of historic operations.

Water accounting also affects some minimum flow requirements that are dependent on native flows and these limitations were not simulated in this model. Including native flows, would further limit exchanges/diversions to and from Pueblo Reservoir. Therefore, this limitation also has the potential to overestimate the hydrologic effects of the alternatives.

Some assumptions had to be made in order to simulate various minimum flow requirements. These are:

- St. Charles Mesa only diverts during the winter and that the specific conductance is >850 uS/cm whenever the flow is < 50 cfs. This assumption does not affect the analysis, as the Pueblo IGA limitations are more restrictive.
- Without knowing when recoup is occurring at the La Junta gage, this analysis assumed this limitation applied all the time to be conservative. If recoup is not occurring all the time, Aurora could exchange more Rocky Ford I & II water into Pueblo Reservoir.

The analysis assumes that any historic exchanges by Colorado Springs and Aurora would be the at least as much, or more as occurred historically. The analysis assumes that water released to the Arkansas River for purposes other than well augmentation during the WWSP (Nov 15 to Mar15) goes into the WWSP and is not actually released to the Arkansas River. This applies to Aurora, Colorado Springs, and the City of Salida. The analysis also assumes that any exchanges to the upper basin during this period are contract exchanges.

All rights and exchange potentials to and from Pueblo Reservoir that would affect the Arkansas River, share the available flow, as this analysis does not include water rights, therefore the analysis has the potential to overestimate contractor yields as a result of the alternatives.

SUMMARY

This analysis was performed using a Microsoft Excel spreadsheet. The basic procedure for the analysis was to use historic flows and minimum flow requirements to determine the flow available for exchange/diversion by potential future contractors. This information combined with estimated exchanges/diversions under the alternatives was used to calculate the exchange potential. The exchange potential for each alternative is used to calculate each entity's (1) actual storage in Pueblo Reservoir and actual exchanges/diversions to and from Pueblo Reservoir (Proposed Action), or (2) deliveries to alternate points of diversion (No Action). The exchanges/diversions under each alternative were used to calculate flows (average monthly cfs) in Arkansas River and Pueblo Reservoir storage (average monthly acre-feet) in response to the Proposed Action and No Action alternatives.