

**Upper Colorado River Consumptive Use
Determination at CRSS Natural Flow Node
Locations Calendar Years 1971-1995**

Methodology Peer Review

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Purpose

The purpose of this report is to document and describe the various methodologies that were utilized to recompute the monthly consumptive use (CU) volumes attributed to the Colorado River Simulation System (CRSS) model's natural flow nodes for the calendar years 1971 through 1995.

Introduction

Jim Prairie was tasked in 1999 with modeling the transport of salt through the Colorado River Basin and the impacts of future water development on the basin wide salinity concentration. The salinity model is an extension of the CRSS model. CRSS is used for various studies related to the water consumption and regulation in the Colorado River Basin. Efforts to calibrate the salinity portion of CRSS prior to 1999 were unsuccessful. A primary task for Jim Prairie was to investigate why the salinity portion of CRSS could not be calibrated and correct the problems. During the investigation Jim discovered that the natural flow data used to populate the CRSS model contained some errors, which made it impossible to effectively calibrate the salinity model.

The natural flow data used to populate CRSS is computed for 21 locations within the Upper Colorado River Basin. These locations, known as natural flow nodes, are inflow points where natural hydrology enters the Colorado River Basin for modeling purposes. The natural flow data is then routed through the modeled diversion and regulation system. The modeled system is controlled by rules that simulate operational policies on the Colorado River system. The model is used to analyze the impacts these policies could have within the Colorado River Basin. The natural flow data in CRSS must accurately reflect the flows that would have historically occurred without the impact of human consumption or regulation of the river system. Then the impacts of these policies can be accurately simulated.

Natural flow data used in CRSS was originally computed for the historic period from 1906 through 1974. Microfiche records were recovered that provided source data and methods used to compute these original natural flows. The official natural flow data used in CRSS for the period from 1906 to 1971 compared well with the data found in the microfiche, however there were a few nodes where the microfiche data did not correlate well with the official natural flow data. Reclamation plans to address these differences in future work. Beginning in the 1970s, it was decided that the natural flow database would be extended in 5 year increments as source data became available. The first 5 year increment was from 1971 to 1975. Only the source data for irrigated agriculture was available for the natural flow computations for this period. Source data used in the natural flow computations for the 5 year increments 1976-1980, 1981-1985, 1986-1990 was in various states of completeness. In the process of investigating the official natural flow data, Jim Prairie recollected the data required for the natural flow computations for the period 1971-1990. In some cases, these data were equivalent to the source data that was originally collected. In other cases, the data were product data from the original source data when the original source data could not be recollected. At the same time,

efforts were undertaken to collect the necessary source data to extend the natural flow database to the next 5 year increment from 1991 to 1995.

In order to discover the extent of the problems with the official natural flow data, the natural flow data for 1971 through 1990 were recomputed using the data that were recollected. Much of these data were found in the Consumptive Uses and Losses Reports and Technical Memorandums issued for the period from 1971 to 1990. Unfortunately, much of the detailed information that was related to Consumptive Uses and Loss Reports was not recovered. The historic reports that were recovered for the review and recomputation were as follows:

Colorado River System Consumptive Uses and Losses Report 1971-1975
Colorado River System Consumptive Uses and Losses Report 1976-1980
Colorado River System Consumptive Uses and Losses Report 1981-1985
Colorado River System Consumptive Uses and Losses Report 1986-1990

Technical information that supported the values in these reports was found for most of the period; however, supporting information was largely missing for the period from 1971 to 1975.

The review evaluated the available data and reconstructed methodologies to estimate the monthly consumptive use at each HUC and CRSS node. In some cases, errors were found in the CU values that were originally published in the Consumptive Uses and Losses Reports. These errors were corrected and documented by Reclamation, and were republished in a corrections report titled "Upper Colorado River Basin Consumptive Uses and Losses Report As Revised After Peer Review 1971-1995." Consistency between the CU data for natural flow development and the CU data in the Consumptive Uses and Losses Reports was a main priority of the review.

The extent of this report is to describe the methodologies that were used by Reclamation to redistribute the CU data from the spatial and temporal scales presented in the Consumptive Uses and Losses Report to the spatial and temporal scales necessary to develop the natural flow data used in CRSS.

This report is divided into five sections each representing the five time periods for which Consumptive Uses and Losses Reports were issued between 1971 and 1995. For the most part, source data, and the computational processes, were consistent within each time period with the exception of data for Arizona and New Mexico. Discussion of these exceptions is included in this report. Each section is further divided based on the type of CU (i.e., Irrigated Agriculture, Livestock, Evaporation, Municipal and Industrial, etc.). These subsections describe the methodology constructed to redistribute the corrected CU data in the Consumptive Uses and Losses Reports to each Upper Colorado Basin HUC and CRSS nodes.

The CU computation methods for Colorado, Utah and Wyoming were largely the same for each of the 5 year increments. Therefore, the methods used to distribute the CU

data to the HUC and CRSS nodes were also similar. However, the CU data for Arizona and New Mexico was computed with methods unique to these locations. For example, since 1973, CU data for the Upper Colorado Basin portion of Arizona has been published in a separate annual report. In many cases the source data for the CU computations in Arizona were collected at different spatial scales than for the three main states mentioned above. The data for New Mexico has also been provided at a different spatial and temporal scale than the three main Upper Basin states. These differences for Arizona and New Mexico required unique methods that were only applied to distribution of Arizona and New Mexico CU data to the corresponding HUCs and CRSS nodes. At the close of each subsection, this report details the changes in the procedures required to accommodate the data for both Arizona and New Mexico.

Consumptive Uses and Losses Computation Review 1971-1975

Below is a description of the source data and the transformation methodology utilized for recomputing the CU for the CRSS nodes for the period from 1971 through 1975. Methodologies were specific to the CU type and are treated separately.

Irrigated Agriculture 1971-1975

The source data for agriculture CU was reported in units of acre-feet/year for a subbasin system defined by evaluation numbers in the 1971-75 Consumptive Uses and Losses Technical Appendix. This subbasin system was not associated with present day USGS HUC or County boundaries and was constructed based on drainage areas within the Upper Colorado River Basin. The evaluation number system boundaries were derived and documented in the 1965 Comprehensive Framework Study. Evaluation number subbasin areas are typically larger than HUCs and smaller than the boundaries that define the major subbasins.

The first step of the recomputation process for agriculture CU during this time period was to disaggregate (or aggregate) the evaluation number based agriculture CU data to HUC based agriculture CU data. This process was performed using a GIS (ArcINFO) to calculate the percentage of the irrigated acreage within each evaluation number that was within each HUC. These percentages were then used to redefine the evaluation number agriculture CU data to HUC agriculture CU data. This process made it possible to maintain consistency in the way data were aggregated to each of the corresponding CRSS nodes.

For the later periods from 1981 through 1995, the Consumptive Uses and Losses Report Technical Memorandum provided agriculture CU in acre-feet/month for each HUC. The average monthly distribution of agriculture CU was used to disaggregate the 1971 through 1975 annual agriculture CU data to monthly agriculture CU data for each HUC.

To estimate the agriculture CU for particular CRSS nodes, the agriculture CU for each HUC were aggregated to the corresponding CRSS nodes. In some cases the CRSS

node was located within a HUC requiring that the HUC agriculture CU data be split between the CRSS node within the HUC and then next CRSS node downstream. A GIS (ArcINFO) was used to determine the percentage of the HUC irrigated acreage above and below the CRSS node. These percentages were used to split the agriculture CU data.

Arizona's only source of agriculture CU from 1971-73 was reported for the state: subbasin (Arizona: San Juan River) in the 1971-75 Consumptive Uses and Losses Report. Limited data were provided in separate reports published for the Upper Basin portion of the state for 1974 and 1975. These AZ reports broke agriculture CU into three categories: Indian Lands, Non-Indian Lands, and incidental losses. In order to match the data for 1971-1973, the three categories were aggregated to a total for years of 1974 and 1975.

The total agriculture CU for AZ from 1971-1975 was distributed to the six (6) HUCs within Arizona and the Upper Colorado Basin using a distribution of agriculture CU data constructed from data from 1981, 1982 and 1983 when agriculture CU source data were available at an agency level spatial scale rather than for the state: subbasin. The agency level source data were distributed to each HUC by distributions of irrigated acreage between HUCs and agencies.

No monthly agriculture CU for Arizona was available from 1971-1995 to develop a distribution. Therefore, historic monthly data from the equivalent HUC or next closest in the bordering state was used to develop an annual to monthly distribution that was applied to the annual data.

Data for New Mexico was computed by Reclamation and available in the same form as the data for Colorado, Utah, and Wyoming. The data were distributed to HUC and CRSS node at a monthly time step using the same procedure as the other Upper Basin States.

Livestock 1971-1975

The source data for livestock CU for the period from 1971 to 1975 were reported for the major subbasins (Upper Colorado, Green, and Colorado-San Juan) in acre-feet/year in the 1971-1975 Consumptive Uses and Losses Report. During this period, the CU from livestock and stockponds were combined into a single annual volume. To separate out the livestock CU from the total volume reported, the distribution of livestock CU and stockpond CU for the period from 1976 to 1995 was used when these uses were reported separately. It was assumed that the relationship between livestock CU and stockpond CU was consistent through the period from 1971 through 1975.

Livestock CU for the major subbasins was distributed to the individual HUCs using the distribution of livestock CU data available from 1986 through 1995 when livestock CU source data were available for each county rather than for each of the major subbasins. The county source data were distributed to each HUC by distributions of

irrigated acreage between HUCs and counties. The location of irrigated agriculture was assumed to represent the general location of livestock.

To estimate the livestock CU for the CRSS nodes, the livestock CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the livestock CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute livestock CU.

To distribute the annual livestock CU to monthly livestock CU, it was assumed that livestock CU occurred proportionally at the same rate as minerals. Therefore, the mineral monthly distribution was used to distribute annual livestock CU to monthly livestock CU.

Livestock CU source data were reported as a total of livestock and stockponds for Arizona from 1971 through 1973 and New Mexico from 1971 through 1975. This data were reported at the same spatial and temporal scale as the other states. New Mexico and Arizona source data were reported as a combined annual total CU volume for livestock and stockponds. The data were distributed to HUC and CRSS node by similar methods described for Colorado, Utah, and Wyoming. The total livestock CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

Starting in 1974, separately published Arizona reports provided livestock CU annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed to HUC and CRSS node by the same method described for Colorado, Utah, and Wyoming.

The mineral monthly distribution was again used to distribute annual livestock CU to monthly livestock CU for both Arizona and New Mexico.

Stockponds 1971-1975

The source data for stockpond CU for the period from 1971 to 1975 were reported for the major subbasins in acre-feet/year in the 1971-1975 Consumptive Uses and Losses Report. During this period, the CU from livestock and stockponds were combined into a single annual volume. To separate out the stockpond CU from the total volume reported, the distribution of livestock CU and stockpond CU for the period from 1976 to 1995 was used when these uses were reported separately. It was assumed that the relationship between stockpond CU and livestock CU was consistent through the period from 1971 through 1975.

Stockpond CU for the major subbasins was distributed to each county/HUC by distributions of irrigated acreage between major subbasins and county/HUCs. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of major

subbasin irrigated acreage within each county/HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage does not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1971 through 1975.

To estimate the stockpond CU for the CRSS nodes, the stockpond CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the stockpond CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute stockpond CU.

To distribute the annual stockpond CU to monthly stockpond CU, it was assumed that stockpond CU occurred proportionally at the same rate as evaporation. The distribution was developed from “old reports” and no supporting data were available at the time of this writing.

Stockpond CU source data for Arizona and New Mexico were reported for the 1971 through 1975 period at the same spatial and temporal scale as the other states. New Mexico and Arizona source data were reported as a combined annual total CU volume for livestock and stockponds for the entire state. The data were distributed by similar methods to those described for Colorado, Utah, and Wyoming. Total stockpond CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation’s Denver office.

Reservoir Evaporation Major 1971-1975

Major Reservoirs were those where monthly storage or elevation data could be obtained. Minor Reservoirs were those where only annual reservoir storage or pool elevation data could be obtained. Source data for major reservoir evaporation for the period from 1971-1975 were available for major subbasins as acre-feet/year from the 1971-1975 Consumptive Uses and Losses Report. A list of the Major Reservoirs accounted for can be found in the Reservoir Evaporation Major section for the period from 1991 to 1995.

Major reservoir evaporation for this period was reported as total evaporation for both major and minor reservoirs. Major reservoir evaporation was separated from the total evaporation reported using a distribution of the major and minor reservoir evaporation for the period from 1976 through 1980 when major and minor reservoir evaporation were reported separately. The percentage of major reservoir evaporation for the period from 1976 to 1980 was used to distribute the total evaporation reported to both major and minor reservoir evaporation for the period from 1971 to 1975.

To distribute the major reservoir evaporation for each subbasin (in acre-feet/year) to each reservoir, an average distribution for the period from 1976 through 1980 was constructed. The average percentage of the subbasin major reservoir evaporation

reported for each Major Reservoir for the period from 1976-1980 was used to estimate the major reservoir evaporation for each reservoir for the period from 1971-1975.

To distribute the major reservoir evaporation for each reservoir in acre-feet/year to monthly major reservoir evaporation, an average monthly distribution of the data for 1986 through 1995 was constructed from source data for these periods. The average percentage of monthly evaporation reported for the 10-year period was used to estimate the monthly major reservoir evaporation for each reservoir for the 1971-1975 period.

Based on the location of the major reservoir within the HUC and CRSS natural flow node framework, the monthly CU volumes calculated for each major reservoir from 1971 to 1975 were aggregated to the appropriate HUCs and CRSS natural flow nodes.

New Mexico and Arizona reported major reservoir evaporation for the 1971-75 time period as a total of major and minor reservoirs by the major subbasin. The same methods utilized in the other states were applied to Arizona and New Mexico to move the data to HUCs and CRSS nodes at a monthly time scale.

Lake Powell, which is the only major reservoir in Arizona, is reported by Reclamation in acre-feet/month. The major reservoir evaporation is not charged to Arizona alone; it is distributed to the Upper Basin states along with the other CRSP reservoirs (Flaming Gorge, Blue Mesa, Morrow Point).

Reservoir Evaporation Minor 1971-1975

Minor reservoirs were those where only annual reservoir storage or pool elevation data could be obtained. For the period from 1971 through 1975, minor reservoir evaporation was reported as a combined total evaporation for both major and minor reservoirs for each major subbasin of the Colorado River. Separation of the minor reservoir evaporation from the total reservoir evaporation reported was performed using an averaged distribution of the minor reservoir evaporation for the period from 1976 through 1980. The average percentage of minor reservoir evaporation for the period from 1976 through 1980 was used to estimate minor reservoir evaporation for the period from 1971 to 1975.

Fish and Wildlife was a CU category by itself that was only reported from 1971 through 1975. This category included reservoir evaporation from reservoirs whose primary purpose was designated for fish and wildlife. The evaporation from these reservoirs was combined with the other minor reservoirs to be consistent with subsequent years (1976 through 1995) where the Fish and Wildlife category was not separately reported.

Beginning in 1976, the reservoir evaporation for each minor reservoir was available from the Consumptive Uses and Losses Technical Memorandum. The minor reservoir evaporation that occurred within each HUC was computed for the period from 1976 through 1980. Distributions were computed to establish the percentage of minor

reservoir evaporation each HUC contributed to each major subbasin. The average percentage of major subbasin minor reservoir evaporation attributed to each HUC during the period from 1976 through 1980 was used to estimate the minor reservoir evaporation for each HUC for the period from 1971 to 1975.

To estimate the monthly minor reservoir evaporation from the annual minor reservoir evaporation a static distribution was used. This static distribution was developed from “old reports” and no supporting data were available at the time of this writing. The distribution assigned a fraction of the total annual evaporation to each month of the year such that the aggregate of the fractions summed to a value of one.

The monthly minor reservoir evaporation was computed for each CRSS node by summing the values for the appropriate HUCs to each of the CRSS nodes. Only one case required the HUC to be split because of the location of the node within the HUC boundary. This HUC was 14010005. The CRSS nodes that this HUC is attributed to are the Colorado River near Cameo, CO and the Colorado River near the CO-UT Stateline. For Minor Reservoir evaporation, 97% of the value for HUC 14010005 was attributed to the Cameo gauge and 3% for the Stateline gauge.

The minor reservoir evaporation and evaporation attributed to Fish and Wildlife for New Mexico and Arizona were reported and distributed with similar methods as the other states. For New Mexico, the method used to distribute the total minor reservoir evaporation and evaporation attributed to Fish and Wildlife to the corresponding HUCs was developed by Reclamation’s Denver office. New Mexico only reported evaporation attributed to Fish and Wildlife, which was reported under the Minor Reservoir category. Arizona minor reservoirs were all located within a single HUC based on the reservoir reported in the Arizona reports. These reservoirs were aggregated together and reported under this HUC.

Municipal & Industrial 1971-1975

Municipal and Industrial (M&I) CU for the period from 1971 to 1975 was reported as an annual consumptive use for the major subbasins. For the period from 1986 to 1995 the M&I CU data were available for each individual HUC. The average distribution percentages for the period from 1986 to 1995 were used to estimate the M&I CU for each HUC for the period from 1971 to 1975.

M&I CU was assumed to be higher during the summer and lower during the winter. A distribution was obtained from Ray Alverado with the Colorado Water Conservation Board. This distribution had a low percentage of 4.5% in November and high percentage in July of 16.5%. The distribution was applied to all annual HUC M&I CU volumes for the period from 1971 to 1975 to obtain monthly M&I CU volumes for each HUC

Monthly M&I CU data for each HUC were aggregated to the appropriate CRSS nodes for natural flow development. There were three HUCs where the M&I CU was

divided between multiple CRSS nodes because these nodes were within HUC boundaries. These HUCs were 14010005, 14020001 and 14020002. For 14010005 10% of the M&I CU was attributed to the Colorado River near Cameo, CO and 90% to the Colorado River near the CO-UT Stateline. For 14020001 10% of the M&I CU was attributed to the Taylor River below Taylor Park Dam and 90% attributed to the Gunnison River below Blue Mesa Dam. For 14020002 80% was attributed to the Gunnison River near Blue Mesa Dam, 10% to the Gunnison River near Crystal Dam and 10% to the Gunnison River near Grand Junction, CO. There was no supporting information explaining why these divisions were made the way they were; however, these appear to be reasonable based on the population distribution within the HUC boundaries.

New Mexico and Arizona source data were the same as the other states. The same methods were applied to distribute the data to HUCs at a monthly time step.

Thermal Power 1971-1975

Thermal power CU was tracked for 13 plants throughout the Upper Colorado River Basin during the period from 1971 to 1976. Each plant reported an annual volume of consumptive use for these years. For each plant, monthly thermal power CU was available in the source data for a period of time. Typically, this monthly data began in the mid-1980s and extended to the late 1990s. For each plant, a monthly distribution was constructed from the monthly thermal power CU data. This distribution was used to distribute the annual thermal power CU data to each of the months of the years where only annual data were available.

Based on the location of these plants within the Upper Colorado River Basin, the CU for each plant was assigned to the appropriate HUCs and CRSS nodes. There were no plants located within HUCs where CRSS nodes resided within the HUC boundaries. Therefore, no HUC thermal power CU data were split between CRSS nodes.

Thermal power was reported in both Arizona and New Mexico as described for the other states.

Minerals 1971-1975

Mineral CU source data were available for the major subbasins as acre-feet/year from the Consumptive Uses and Losses Report for 1971 through 1975. To estimate the mineral CU for individual HUCs, an average distribution was constructed from data collected for the period from 1986 to 1995. During this later period, mineral CU data were reported at the HUC level in the Technical Memorandum. An average distribution of the HUC level mineral CU data in each major subbasin was constructed from the 1986 through 1995 data. This distribution was then applied to the major subbasin mineral CU source data for 1971 through 1975 to produce estimates for the mineral CU for each HUC. HUC mineral CU data were aggregated to each appropriate CRSS node. There were 7 cases where HUC mineral CU data were divided between a CRSS node within the HUC and the next node downstream. In 6 of the 7 cases, the HUC mineral CU data were

divided in half. In the seventh case (HUC number 14020002), the HUC mineral CU data were divided in thirds among 2 internal CRSS nodes and one node downstream from the HUC.

No source data were available to describe the monthly distribution of mineral CU. Mineral CU was assumed to be nearly constant throughout the year. The distribution used to estimate monthly mineral CU for each HUC attributed 8.0% of the annual CU to the months of October through April. September and May were attributed 8.5% of the annual CU and June, July and August accounted for 9.0% of the annual CU. This distribution was not based on any scientific data and was an educated guess as to how mineral CU should be distributed to the months of the year.

Arizona did not report mineral CU. New Mexico reported an annual value aggregated by major subbasin similar to Colorado, Utah, and Wyoming. This value was disaggregated to HUCs with a distribution developed by Reclamation's Denver office and to CRSS nodes as described for the other states. The annual data were distributed to monthly with the distribution described for the other states.

Imports & Exports 1971-1975

Export source data were available for each individual export structure for the period from 1971 through 1975. In most cases, the export data were available for each month but there were several instances where the source data were available as an annual volume of export. For these annual exports, distributions were constructed from source data for later periods when monthly source data were available or from USGS gage records. The monthly distributions constructed were applied to the annual export data for 1971-1975 to estimate the monthly exports. Monthly export data were allocated to the appropriate HUCs and CRSS nodes based on location.

Import source data were also available for each individual import during the period from 1971 to 1975. Most imports accounted for in the recomputation of CU were transfers within the Colorado River Basin and did not involve the transfer of water from outside the Colorado River Basin to inside the basin. In other words, most of the imports were associated with exports that were also being accounted for in the CU computations. The exception is the Utah import, Tropic and East Fork Canal, which imports water from the Sevier River. The CU computations accounted for ten imports. Nine of the ten imports had monthly source data available for the 1971 through 1975 period. For the one import with annual source data (Tropic and East Fork Canal), the monthly import data were estimated with a distribution constructed from USGS canal gauge records for the period from 1950 to 1960. Each monthly import was allocated as a negative CU volume to the appropriate HUC and CRSS node based on location.

Arizona did not report exports or imports. New Mexico reported only one export. The export source data were available in the same form as Colorado, Wyoming, and Utah and distributed to HUC and CRSS node as in the other states.

Consumptive Uses and Losses Computation Review 1976-1980

Below is a description of the source data and the transformation methodology utilized for re-computing the consumptive use for the CRSS nodes for the period from 1976 through 1980. Methodologies were specific to the consumptive use type and are treated separately.

Irrigated Agriculture 1976-1980

The source data for agriculture CU was reported in units of acre-feet/year for a subbasin system defined by evaluation numbers in the 1976-80 Consumptive Uses and Losses Technical Appendix. This subbasin system was not associated with present day USGS HUC or County boundaries and was constructed based on drainage areas within the Upper Colorado River Basin. The evaluation number system boundaries were derived and documented in the 1965 Comprehensive Framework Study. Evaluation number subbasin areas are larger than HUCs and smaller than the boundaries that define the major subbasins.

The first step of the recomputation process for agriculture CU during this time period was to disaggregate (or aggregate) the evaluation number based agriculture CU data to HUC based agriculture CU data. This process was performed using a GIS (ArcINFO) to calculate the percentage of the irrigated acreage within each evaluation number that was within each HUC. These percentages were then used to redefine the evaluation number agriculture CU data to HUC agriculture CU data. This process made it possible to maintain consistency in the way data were aggregated to each of the corresponding CRSS nodes.

For the later periods from 1981 through 1995, the Consumptive Uses and Losses Report Technical Memorandum provided agriculture CU in acre-feet/month for each HUC. The average monthly distribution of agriculture CU was used to disaggregate the 1976 through 1980 annual agriculture CU data to monthly agriculture CU data for each HUC.

To estimate the agriculture CU for particular CRSS nodes, the agriculture CU for each HUC were aggregated to the corresponding CRSS nodes. In some cases the CRSS node was located within a HUC requiring that the HUC agriculture CU data be split between the CRSS node within the HUC and then next CRSS node downstream. A GIS (ArcINFO) was used to determine the percentage of the HUC irrigated acreage above and below the CRSS node. These percentages were used to split the agriculture CU data.

Limited data were available for irrigated agriculture for Arizona. These data were published in annual reports by Reclamation as required by legislation. The annual reports were published for the Upper Colorado River Basin portion of Arizona from 1976-80. The Arizona reports broke agriculture CU into three categories, Indian Lands, Non-Indian Lands, and incidental losses. The three categories were aggregated into a total use for the Upper Basin portion of Arizona.

The total agriculture CU for AZ from 1976-1980 was distributed to the six (6) HUCs contained in the Upper Basin portion of AZ using the distribution of agriculture CU data available from 1981-83 when agriculture CU source data were available by agency rather than for the major subbasin. The agency source data were distributed to each HUC by distributions of irrigated acreage between HUCs and agencies.

No monthly agriculture CU for Arizona was available from 1971-1995 to develop a distribution. Therefore, historic monthly data from the equivalent HUC or next closest in the bordering state was used to develop an annual to monthly distribution that was applied to the annual data.

Data for New Mexico was computed by Reclamation and available in the same form as the data for Colorado, Utah, and Wyoming. The data were distributed to HUC and CRSS node at a monthly time step using the same procedure as for Colorado, Utah and Wyoming.

Livestock 1976-1980

The source data for livestock CU for the period from 1976 to 1980 were reported for the major subbasins in acre-feet/year in the 1976-1980 Consumptive Uses and Losses Report. Livestock CU for the major subbasins was distributed to the individual HUCs using the distribution of livestock CU data available from 1986 through 1995 when livestock CU source data were available for each county rather than for each of the major subbasins. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties.

To estimate the livestock CU for the CRSS nodes, the livestock CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the livestock CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute livestock CU.

To distribute the annual livestock CU to monthly livestock CU, it was assumed that livestock CU occurred proportionally at the same rate as minerals. Therefore, the mineral monthly distribution was used to distribute annual livestock CU to monthly livestock CU.

Livestock CU source data for Arizona were reported for the 1976 through 1980 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed to the CRSS nodes by the same methods described for Colorado, Utah, and Wyoming.

Livestock CU source data were reported as a total of livestock and stockpounds for New Mexico. These data were reported at the same spatial and temporal scale as Colorado, Utah and Wyoming. The data were distributed to individual HUCs and CRSS

nodes by similar methods described for Colorado, Utah, and Wyoming. The total livestock CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

The mineral monthly distribution was again used to distribute annual livestock CU to monthly livestock CU for both Arizona and New Mexico.

Stockponds 1976-1980

The source data for stockpond CU for the period from 1976 to 1980 were reported for the major subbasins in acre-feet/year in the 1976-1980 Consumptive Uses and Losses Report. Stockpond CU for the major subbasins was distributed to each county/HUC by distributions of irrigated acreage between major subbasins and county/HUCs. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of major subbasin irrigated acreage within each county/HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage did not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1976 through 1980.

To estimate the stockpond CU for the CRSS nodes, the stockpond CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the stockpond CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute stockpond CU.

To distribute the annual stockpond CU to monthly stockpond CU, it was assumed that stockpond CU occurred proportionally at the same rate as evaporation. The distribution was developed from "old reports" and no supporting data were available at the time of this writing.

Stockpond CU source data for New Mexico were reported at the same spatial and temporal scale as Colorado, Utah and Wyoming. The data were distributed by similar methods to those described for Colorado, Utah, and Wyoming. Total stockpond CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

Stockpond CU source data for Arizona was reported for the 1976 through 1980 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed to HUCs and CRSS nodes by month with the same method described for Colorado, Utah, and Wyoming.

Reservoir Evaporation Major 1976-1980

Source data for the major reservoir evaporation for the period 1976 through 1980 were available for individual reservoirs in acre-feet/year. These data were obtained from the 1976-1980 Consumptive Uses and Losses Report Technical Memorandum. Each major reservoir was assigned to the corresponding HUCs and CRSS nodes depending on the location of the reservoir within the Upper Colorado River Basin. The major reservoir evaporation for the 1976-1980 period was computed by aggregating the individual reservoir data to the corresponding HUCs and CRSS nodes. A list of the Major Reservoirs accounted for can be found in the Reservoir Evaporation Major section for the period from 1991 to 1995.

Beginning in 1986, monthly major reservoir evaporation for each reservoir was available in the Consumptive Uses and Losses Technical Memorandum. Annual major reservoir evaporation for each reservoir was distributed to monthly major reservoir evaporation for the period from 1976 to 1980 using distributions constructed for each reservoir from the monthly data from 1986 through 1995.

Arizona and New Mexico reported major reservoir evaporation for the 1976-78 time period by individual reservoirs in acre-feet/year. The same methods utilized in the other states were applied to Arizona and New Mexico to move the data to CRSS nodes and HUC and finally to a monthly time scale.

Reservoir Evaporation Minor 1976-1980

Minor reservoirs were those where only annual reservoir storage or pool elevation data could be obtained. Beginning in 1976, the reservoir evaporation for each Minor Reservoir was available from the Consumptive Uses and Losses Technical Memorandum. The minor reservoir evaporation was computed for the period from 1976 through 1980 by aggregating the data for all minor reservoirs within the corresponding HUCs.

Minor reservoir evaporation for each CRSS node was computed by summing the HUC minor reservoir evaporation data to the appropriate CRSS nodes. There was only one case where it was necessary to split a HUC's minor reservoir evaporation between two nodes. This HUC was 14010005. 97% of the minor reservoir evaporation was distributed to the CRSS node located on the Colorado River near Cameo, CO. and 3% was distributed to the node located on the Colorado River near the CO-UT Stateline.

To estimate the monthly minor reservoir evaporation from the annual minor reservoir evaporation a single distribution was used. This distribution was developed from "old reports" and no supporting data were available at the time of this writing. The distribution assigned a fraction of the total annual evaporation to each month of the year such that the aggregate of the fractions summed to a value of one.

Minor reservoir evaporation was not reported for New Mexico. The Arizona reports reported individual annual minor reservoirs evaporation. The reservoirs were all located within a single HUC and, therefore, aggregated together and reported under the appropriate HUC. The annual data were distributed to monthly with the same distribution described for the other states.

Municipal & Industrial 1976-1980

Municipal and Industrial (M&I) CU for the period from 1976 to 1980 was reported as an annual consumptive use for the major subbasins. For the period from 1986 to 1995 the M&I CU data were available for each individual HUC. The distributions of HUC M&I CU data within each subbasin for the period from 1986 to 1995 were used to estimate the M&I CU for each HUC for the period from 1976 to 1980.

M&I CU was assumed to be higher during the summer and lower during the winter. A distribution was obtained from Ray Alverado with the Colorado Water Conservation Board. This distribution had a low percentage of 4.5% in November and high percentage in July of 16.5%. The distribution was applied to all annual HUC M&I CU volumes for the period from 1976 to 1980 to obtain monthly M&I CU volumes for each HUC

Monthly M&I CU data for each HUC were aggregated to the appropriate CRSS nodes for natural flow development. There were three HUCs where the M&I CU was divided between multiple CRSS nodes because these nodes were within HUC boundaries. These HUCs were 14010005, 14020001 and 14020002. For 14010005 10% of the M&I CU was attributed to the Colorado River near Cameo, CO and 90% to the Colorado River near the CO-UT Stateline. For 14020001 10% of the M&I CU was attributed to the Taylor River below Taylor Park Dam and 90% attributed to the Gunnison River below Blue Mesa Dam. For 14020002 80% was attributed to the Gunnison River near Blue Mesa Dam, 10% to the Gunnison River near Crystal Dam and 10% to the Gunnison River near Grand Junction, CO. There was no supporting information explaining why these divisions were made the way they were; however, these appear to be reasonable based on the population distribution within the HUC boundaries.

New Mexico and Arizona source data were the same as the other states. The same methods were applied to distribute the data to HUCs at a monthly time step.

Thermal Power 1976-1980

Thermal power CU was tracked for 13 plants throughout the Upper Colorado River Basin during the period from 1976 to 1980. Each plant reported an annual volume of consumptive use for these years. For each plant, monthly thermal power CU was available in the source data for a period of time. Typically, this monthly data began in the mid-1980s and extended to the late 1990s. For each plant, a monthly distribution was constructed from the monthly thermal power CU data. This distribution was used to

distribute the annual thermal power CU data to each of the months of the years where only annual data were available.

Based on the location of these plants within the Upper Colorado River Basin, the CU for each plant was assigned to the appropriate HUCs and CRSS nodes. There were no plants located within HUCs where CRSS nodes resided within the HUC boundaries. Therefore, no HUC thermal power CU data were split between CRSS nodes.

Thermal power was reported in both Arizona and New Mexico as described for the other states.

Minerals 1976-1980

Mineral CU source data were available for the major subbasins as acre-feet/year from the Consumptive Uses and Losses Report for 1976 through 1980. To estimate the mineral CU for individual HUCs, an average distribution was constructed from data collected for the period from 1986 to 1995. During this later period, mineral CU data were reported at the HUC level in the Technical Memorandum. An average distribution of the HUC level mineral CU data in each major subbasin was constructed from the 1986 through 1995 data. This distribution was then applied to the major subbasin mineral CU source data for 1976 through 1980 to produce estimates for the mineral CU for each HUC. HUC mineral CU data were aggregated to each appropriate CRSS node. There were 7 cases where HUC mineral CU data were divided between a CRSS node within the HUC and the next node downstream. In 6 of the 7 cases, the HUC mineral CU data were divided in half. In the seventh case (HUC number 14020002), the HUC mineral CU data were divided in thirds among 2 internal CRSS nodes and one node downstream from the HUC.

No source data were available to describe the monthly distribution of mineral CU. Mineral CU was assumed to be nearly constant throughout the year. The distribution used to estimate monthly mineral CU for each HUC attributed 8.0% of the annual CU to the months of October through April. September and May were attributed 8.5% of the annual CU and June, July and August accounted for 9.0% of the annual CU. This distribution was not based on any scientific data and was an educated guess as to how mineral CU should be distributed to the months of the year.

Arizona did not report mineral CU. New Mexico reported an annual value aggregated by major subbasin similar to Colorado, Utah, and Wyoming. This value was disaggregated to HUCs with a distribution developed by Reclamation's Denver office. Mineral CU for New Mexico was distributed to the CRSS nodes in the same manner as described for Colorado, Utah and Wyoming. The annual data were distributed to monthly with the distribution described for the other states.

Imports & Exports 1976-1980

Export source data were available for each individual export structure for the period from 1976 through 1980. In most cases, the export data were available for each month but there were several instances where the source data were available as an annual volume of export. For these annual exports, distributions were constructed from source data for later periods when monthly source data were available or from USGS gage records. The monthly distributions constructed were applied to the annual export data for 1976-1980 to estimate the monthly exports. Monthly export data were allocated to the appropriate HUCs and CRSS nodes based on location.

Import source data were also available for each individual import during the period from 1976 to 1980. Most imports accounted for in the recomputation of CU were transfers within the Colorado River Basin and did not involve the transfer of water from outside the Colorado River Basin to inside the basin. In other words, most of the imports were associated with exports that were also being accounted for in the CU computations. The exception is the Utah import, Tropic and East Fork Canal, which imports water from the Sevier River. The CU computations accounted for ten imports. Nine of the ten imports had monthly source data available for the 1976 through 1980 period. For the one import with annual source data (Tropic and East Fork Canal), the monthly import data were estimated with a distribution constructed from USGS canal gauge records for the period from 1950 to 1960. Each monthly import was allocated as a negative CU volume to the appropriate HUC and CRSS node based on location.

Arizona did not report exports or imports. New Mexico reported only one export. The export source data were available in the same form as Colorado, Wyoming, and Utah and distributed to HUC and CRSS node with the same method as these other states.

Consumptive Uses and Losses Computation Review 1981-1985

Below is a description of the source data and the transformation methodology utilized for recomputing the consumptive use for the CRSS nodes for the period from 1981 through 1986. Methodologies were specific to the consumptive use type and are treated separately.

Irrigated Agriculture 1981-1985

Agriculture CU source data for the period 1981 through 1985 were reported for individual HUCs in acre-feet/year. These data were obtained in the 1981-85 Consumptive Uses and Losses Technical Memorandum.

Beginning in 1981, the Technical Memorandum also contained output printouts from the XCONS program that were used to compute agriculture CU. This output included a monthly estimate of agriculture CU in inches/month for each HUC. These data were used to construct a monthly distribution for each HUC and each year. These

distributions were then used to distribute the annual agriculture CU to monthly agriculture CU.

To estimate the agriculture CU for a particular CRSS node, the agriculture CU for each HUC above a particular node were added together. In some cases the CRSS node was located within a HUC. For these cases, the agriculture CU for the HUC containing the node was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The agriculture CU for the HUC was divided between the HUC containing the node and the next node downstream by estimating the percentage of HUC irrigated acreage above and below the residing node.

The annual Arizona reports provided agriculture CU by agency as an annual total. The HUC that held each agency was determined to properly assign agriculture CU to a HUC. No monthly agriculture CU for Arizona was available from 1971-1995 to develop a distribution. Therefore, historic monthly data from the equivalent HUC or next closest in the bordering state was used to develop an annual to monthly distribution that was applied to the annual data.

Data for New Mexico were computed by Reclamation and available in the same form as the data for Colorado, Utah, and Wyoming. The data were distributed to HUC and CRSS node at a monthly time step using the same procedure as the other states.

Livestock 1981-1985

The source data for livestock CU for the period from 1981 to 1985 were reported for the major subbasins in acre-feet/year in the 1981-1985 Consumptive Uses and Losses Report. Livestock CU for the major subbasins was distributed to the individual HUCs using the distribution of livestock CU data available from 1986 through 1995 when livestock CU source data were available for each county rather than for each of the major subbasins. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties.

To estimate the livestock CU for the CRSS nodes, the livestock CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the livestock CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute livestock CU.

To distribute the annual livestock CU to monthly livestock CU, it was assumed that livestock CU occurred proportionally at the same rate as minerals. Therefore, the mineral monthly distribution was used to distribute annual livestock CU to monthly livestock CU.

Livestock CU source data for Arizona were reported for the 1981 through 1985 time period annually by county. The county source data were distributed to each HUC by

distributions of irrigated acreage between HUCs and counties. The data were distributed to HUC and CRSS node by the same methods described for Colorado, Utah, and Wyoming.

Livestock CU source data were reported as a total of livestock and stockponds for New Mexico. These data were reported at the same spatial and temporal scale as Colorado, Utah and Wyoming. The data were distributed to HUC and CRSS node by similar methods described for Colorado, Utah, and Wyoming. The total livestock CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

The mineral monthly distribution was again used to distribute annual livestock CU to monthly livestock CU for both Arizona and New Mexico.

Stockponds 1981-1985

The source data for stockpond CU for the period from 1981 to 1985 were reported for the major subbasins in acre-feet/year in the 1981-1985 Consumptive Uses and Losses Report. Stockpond CU for the major subbasins was distributed to each county/HUC by distributions of irrigated acreage between major subbasins and county/HUCs. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of major subbasin irrigated acreage within each county/HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage does not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1981 through 1985.

To estimate the stockpond CU for the CRSS nodes, the stockpond CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the stockpond CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute stockpond CU.

To distribute the annual stockpond CU to monthly stockpond CU, it was assumed that stockpond CU occurred proportionally at the same rate as evaporation. The distribution was developed from "old reports" and no supporting data were available at the time of this writing.

Source data for New Mexico for stockpond CU were reported as a total of livestock and stockponds. This source data were distributed to livestock CU and stockpond CU based on the average percentage split of the source data reported for the period from 1986 to 1995. This method was similar to that performed for source data collected for the 1971 through 1975 period. The data were further distributed to HUC and CRSS node by month with similar methods to those described for Colorado, Utah, and Wyoming. The total stockpond CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

Stockpond CU source data for Arizona were reported for the 1981 through 1985 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed to HUC and CRSS node by month with the same method described for Colorado, Utah, and Wyoming.

Reservoir Evaporation Major 1981-1985

Source data for the major reservoir evaporation for the period 1981 through 1985 were available for individual reservoirs in acre-feet/year. These data were obtained from the 1981-1985 Consumptive Uses and Losses Report Technical Memorandum. Each major reservoir was assigned to the corresponding HUCs and CRSS nodes depending on the location of the reservoir within the Upper Colorado River Basin. The major reservoir evaporation for the 1981 through 1985 period was computed by aggregating the individual reservoir data to the corresponding HUCs and CRSS nodes. A list of the Major Reservoirs accounted for can be found in the Reservoir Evaporation Major section for the period from 1991 to 1995.

Beginning in 1986, monthly major reservoir evaporation for each reservoir was available in the Consumptive Uses and Losses Technical Memorandum. Annual major reservoir evaporation for each reservoir was distributed to monthly major reservoir evaporation for the period from 1981 to 1985 using distributions constructed for each reservoir from the monthly data from 1986 through 1995.

Arizona and New Mexico reported major reservoir evaporation for the 1981-85 time period by individual reservoirs in acre-feet/year. The same methods utilized in the other states were applied to Arizona and New Mexico to disaggregate the data to CRSS nodes and HUC and finally to a monthly time scale.

Reservoir Evaporation Minor 1981-1985

Minor reservoirs were those where only annual reservoir storage or pool elevation data could be obtained. Beginning in 1976, the annual reservoir evaporation for each Minor Reservoir was available from the Consumptive Uses and Losses Technical Memorandum. The minor reservoir evaporation for each year was computed for the period from 1981 through 1985 by summing the individual minor reservoir evaporation data to the appropriate HUCs.

Minor reservoir evaporation for each CRSS node was computed by summing the HUC minor reservoir evaporation data to the appropriate CRSS nodes. There was only one case where it was necessary to split a HUC's minor reservoir evaporation between two nodes. This HUC was 14010005. 97% of the minor reservoir evaporation was distributed to the CRSS node located on the Colorado River near Cameo, CO. and 3% was distributed to the node located on the Colorado River near the CO-UT Stateline.

To estimate the monthly minor reservoir evaporation from the annual minor reservoir evaporation a single distribution was used for all CRSS nodes. This distribution was developed from “old reports” and no supporting data were available at the time of this writing. The distribution assigned a fraction of the total annual evaporation to each month of the year such that the aggregate of the fractions summed to a value of one.

Minor reservoir evaporation was reported by the state of New Mexico and the Arizona report annually by individual minor reservoirs evaporation. The reservoirs were all located within their appropriate HUC. The annual data were distributed to monthly with the same distribution described for the other states.

Municipal & Industrial 1981-1985

Municipal and Industrial (M&I) CU for the period from 1981 to 1985 was reported as an annual consumptive use for the major subbasins. For the period from 1986 to 1995 the M&I CU data were available for each individual HUC. The distributions of HUC M&I CU data within each subbasin for the period from 1986 to 1995 were used to estimate the M&I CU for each HUC for the period from 1981 to 1985.

M&I CU was assumed to be higher during the summer and lower during the winter. A distribution was obtained from Ray Alverado with the Colorado Water Conservation Board. This distribution had a low percentage of 4.5% in November and high percentage in July of 16.5%. The distribution was applied to all annual HUC M&I CU volumes for the period from 1981 to 1985 to obtain monthly M&I CU volumes for each HUC

Monthly M&I CU data for each HUC were aggregated to the appropriate CRSS nodes for natural flow development. There were three HUCs where the M&I CU was divided between multiple CRSS nodes because these nodes were within HUC boundaries. These HUCs were 14010005, 14020001 and 14020002. For 14010005 10% of the M&I CU was attributed to the Colorado River near Cameo, CO and 90% to the Colorado River near the CO-UT Stateline. For 14020001 10% of the M&I CU was attributed to the Taylor River below Taylor Park Dam and 90% attributed to the Gunnison River below Blue Mesa Dam. For 14020002 80% was attributed to the Gunnison River near Blue Mesa Dam, 10% to the Gunnison River near Crystal Dam and 10% to the Gunnison River near Grand Junction, CO. There was no supporting information explaining why these divisions were made the way they were; however, these appear to be reasonable based on the population distribution within the HUC boundaries.

New Mexico and Arizona source data were the same as the other states. The same methods were applied to distribute the data to HUCs at a monthly time step.

Thermal Power 1981-1985

Thermal power CU was tracked for 13 plants throughout the Upper Colorado River Basin during the period from 1981 to 1985. Each plant reported an annual volume

of consumptive use for these years. For each plant, monthly thermal power CU was available in the source data for a period of time. Typically, this monthly data began in the mid-1980s and extended to the late 1990s. For each plant, a monthly distribution was constructed from the monthly thermal power CU data. This distribution was used to distribute the annual thermal power CU data to each of the months of the years where only annual data were available.

Based on the location of these plants within the Upper Colorado River Basin, the CU for each plant was assigned to the appropriate HUCs and CRSS nodes. There were no plants located within HUCs where CRSS nodes resided within the HUC boundaries. Therefore, no HUC thermal power CU data were split between CRSS nodes.

Thermal power was reported in both Arizona and New Mexico as described for the other states.

Minerals 1981-1985

Mineral CU source data were available for the major subbasins as acre-feet/year from the Consumptive Uses and Losses Report for 1981 through 1985. To estimate the mineral CU for individual HUCs, an average distribution was constructed from data collected for the period from 1986 to 1995. During this later period, mineral CU data were reported at the HUC level in the Technical Memorandum. An average distribution of the HUC level mineral CU data in each major subbasin was constructed from the 1986 through 1995 data. This distribution was then applied to the major subbasin mineral CU source data for 1981 through 1985 to produce estimates for the mineral CU for each HUC. HUC mineral CU data were aggregated to each appropriate CRSS node. There were 7 cases where HUC mineral CU data were divided between a CRSS node within the HUC and the next node downstream. In 6 of the 7 cases, the HUC mineral CU data were divided in half. In the seventh case (HUC number 14020002), the HUC mineral CU data were divided in thirds among 2 internal CRSS nodes and one node downstream from the HUC.

No source data were available to describe the monthly distribution of mineral CU. Mineral CU was assumed to be nearly constant throughout the year. The distribution used to estimate monthly mineral CU for each HUC attributed 8.0% of the annual CU to the months of October through April. September and May were attributed 8.5% of the annual CU and June, July and August accounted for 9.0% of the annual CU. This distribution was not based on any scientific data and was an educated guess as to how mineral CU should be distributed to the months of the year.

Arizona did not report mineral CU. New Mexico reported an annual value aggregated by major subbasin similar to Colorado, Utah, and Wyoming. This value was disaggregated to HUCs with a distribution developed by Reclamation's Denver office. The mineral CU data for New Mexico were distributed to CRSS nodes in a similar manner as described for the other states. The annual data were distributed to monthly with the distribution described for the other states.

Imports & Exports 1981-1985

Export source data were available for each individual export structure for the period from 1981 through 1985. In most cases, the export data were available for each month but there were several instances where the source data were available as an annual volume of export. For these annual exports, distributions were constructed from source data for later periods when monthly source data were available or from USGS gage records. The monthly distributions constructed were applied to the annual export data for 1981-1985 to estimate the monthly exports. Monthly export data were allocated to the appropriate HUCs and CRSS nodes based on location.

Import source data were also available for each individual import during the period from 1981 to 1985. Most imports accounted for in the recomputation of CU were transfers within the Colorado River Basin and did not involve the transfer of water from outside the Colorado River Basin to inside the basin. In other words, most of the imports were associated with exports that were also being accounted for in the CU computations. The exception is the Utah import, Tropic and East Fork Canal, which imports water from the Sevier River. The CU computations accounted for ten imports. Nine of the ten imports had monthly source data available for the 1981 through 1985 period. For the one import with annual source data (Tropic and East Fork Canal), the monthly import data were estimated with a distribution constructed from USGS canal gauge records for the period from 1950 to 1960. Each monthly import was allocated as a negative CU volume to the appropriate HUC and CRSS node based on location.

Arizona did not report exports or imports. New Mexico reported only one export. The export source data were available in the same form as Colorado, Wyoming, and Utah and distributed to HUC and CRSS node with the same method as in these other states.

Consumptive Uses and Losses Computation Review 1986-1990

Below is a description of the source data and the transformation methodology utilized for recomputing the consumptive use for the CRSS nodes for the period from 1986 through 1990. Methodologies were specific to the consumptive use type and are treated separately.

Irrigated Agriculture 1986-1990

Agriculture CU source data for the period 1986 through 1990 were reported for individual HUCs in acre-feet/year. These data were obtained in the 1986-90 Consumptive Uses and Losses Technical Memorandum.

For the 1986 through 1990 period, the Technical Memorandum also contained output printouts from the XCONS program that was used to compute agriculture CU. This output included a monthly estimate of agriculture CU in inches/month for each HUC. These data were used to construct a monthly distribution for each HUC and each

year. These distributions were then used to distribute the annual agriculture CU to monthly agriculture CU.

To estimate the agriculture CU for a particular CRSS node, the agriculture CU for each HUC above a particular node were added together. In some cases the CRSS node was located within a HUC. For these cases, the agriculture CU for the HUC containing the node was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The agriculture CU for the HUC was divided between the HUC containing the node and the next node downstream by estimating the percentage of HUC irrigated acreage above and below the residing node.

The annual Arizona reports provided irrigated agriculture CU by agency. Each agency was assigned to the corresponding HUC that the agency fell into. In all cases the agency CU was simply aggregated to the corresponding HUCs and was not divided between HUCs. Monthly agriculture CU for Arizona was unavailable from 1971-1995 to develop a distribution from annual to monthly. Historic monthly data from an equivalent neighboring HUC or in the bordering state was used to develop an annual to monthly distribution.

The state of New Mexico provided annual agriculture CU by county. To distribute the county data to an appropriate HUC, the ratio of irrigated acreage for the fraction of the HUC in the county divided by the total county irrigated acres was multiplied by the annual county agriculture CU. The annual data were distributed to monthly using monthly CU data from 1981 through 1985 Technical Memorandum to construct a distribution.

Livestock 1986-1990

The source data for livestock CU for the period from 1986 to 1990 were reported for each county within the Upper Colorado River Basin. The county source data for livestock CU were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of county irrigated acreage within each HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage does not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1986 through 1990.

To estimate the livestock CU for the CRSS nodes, the livestock CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the livestock CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute livestock CU.

To distribute the annual livestock CU to monthly livestock CU, it was assumed that livestock CU occurred proportionally at the same rate as minerals. Therefore, the mineral monthly distribution was used to distribute annual livestock CU to monthly livestock CU.

Livestock CU source data for Arizona were reported for the 1986 through 1990 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed to CRSS node by the same method described for Colorado, Utah, and Wyoming.

Livestock CU source data were reported by the state of New Mexico as an annual total for the portion of New Mexico in the Upper Basin. The data were distributed to HUCs with a distribution developed by Reclamation's Denver office. The data were distributed to HUC and CRSS node by similar methods described for Colorado, Utah, and Wyoming. The total livestock CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

The mineral monthly distribution was again used to distribute annual livestock CU to monthly livestock CU for both Arizona and New Mexico.

Stockponds 1986-1990

The source data for stockpond CU for the period from 1986 to 1990 were reported for the major subbasins in acre-feet/year. Stockpond CU for the major subbasins was distributed to each county/HUC by distributions of irrigated acreage between major subbasins and county/HUCs. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of major subbasin irrigated acreage within each county/HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage does not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1986 through 1990.

To estimate the stockpond CU for the CRSS nodes, the stockpond CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the stockpond CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute stockpond CU.

To distribute the annual stockpond CU to monthly stockpond CU, it was assumed that stockpond CU occurred proportionally at the same rate as evaporation. The distribution was developed from "old reports" and no supporting data were available at the time of this writing.

Stockpond CU source data for New Mexico were reported at the same spatial and temporal scale as Colorado, Utah and Wyoming. The data were distributed to HUC and

CRSS node by month with similar methods to those described for Colorado, Utah, and Wyoming. The total stockpond CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

Stockpond CU source data for Arizona were reported for the 1986 through 1990 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed to HUC and CRSS node by month with the same method described for Colorado, Utah, and Wyoming.

Reservoir Evaporation Major 1986-1990

Source data for the major reservoir evaporation for the period 1986 through 1990 were available for individual reservoirs in acre-feet/month. These data were obtained from the 1986-1990 Consumptive Uses and Losses Report Technical Memorandum. Each major reservoir was assigned to the corresponding HUCs and CRSS nodes depending on the location of the reservoir within the Upper Colorado River Basin. The major reservoir evaporation for the 1986 through 1990 period was computed by aggregating the individual reservoir data to the corresponding HUCs and CRSS nodes. A list of the Major Reservoirs accounted for can be found in the Reservoir Evaporation Major section for the period from 1991 to 1995.

Beginning in 1986, monthly major reservoir evaporation for each reservoir was available in the Consumptive Uses and Losses Technical Memorandum. No distribution was necessary for distributing annual major reservoir evaporation to monthly.

Arizona and New Mexico reported major reservoir evaporation for the 1986-90 time period by individual reservoirs in acre-feet/month. The same methods utilized in the other states were applied to Arizona and New Mexico to move the data to CRSS nodes and HUCs.

Reservoir Evaporation Minor 1986-1990

Minor reservoirs were those where only annual reservoir storage or pool elevation data could be obtained. Beginning in 1976, the annual reservoir evaporation for each Minor Reservoir was available from the Consumptive Uses and Losses Technical Memorandum. The minor reservoir evaporation for each year was computed for the period from 1986 through 1990 by summing the individual minor reservoir evaporation data to the appropriate HUCs.

Minor reservoir evaporation for each CRSS node was computed by summing the HUC minor reservoir evaporation data to the appropriate CRSS nodes. There was only one case where it was necessary to split a HUC's minor reservoir evaporation between two nodes. This HUC was 14010005. 97% of the minor reservoir evaporation was distributed to the CRSS node located on the Colorado River near Cameo, CO. and 3% was distributed to the node located on the Colorado River near the CO-UT Stateline.

To estimate the monthly minor reservoir evaporation from the annual minor reservoir evaporation a single distribution was used for all CRSS nodes. This distribution was developed from “old reports” and no supporting data were available at the time of this writing. The distribution assigned a fraction of the total annual evaporation to each month of the year such that the aggregate of the fractions summed to a value of one.

Minor reservoir evaporation was reported by the state of New Mexico and the Arizona report annually by individual minor reservoirs evaporation. The reservoirs were all located within their appropriate HUC. The annual data were distributed to monthly with the same distribution described for the other states.

Municipal & Industrial 1986-1990

For the period from 1986 to 1990 annual M&I CU data were available for each individual HUC. These data were computed by the USGS for the years 1986 and 1990. Inclusive years were computed by Reclamation through linear interpolation.

M&I CU was assumed to be higher during the summer and lower during the winter. A distribution was obtained from Ray Alverado with the Colorado Water Conservation Board. This distribution had a low percentage of 4.5% in November and high percentage in July of 16.5%. The distribution was applied to all annual HUC M&I CU volumes for the period from 1986 to 1990 to obtain monthly M&I CU volumes for each HUC

Monthly M&I CU data for each HUC were aggregated to the appropriate CRSS nodes for natural flow development. There were three HUCs where the M&I CU was divided between multiple CRSS nodes because these nodes were within HUC boundaries. These HUCs were 14010005, 14020001 and 14020002. For 14010005 10% of the M&I CU was attributed to the Colorado River near Cameo, CO and 90% to the Colorado River near the CO-UT Stateline. For 14020001 10% of the M&I CU was attributed to the Taylor River below Taylor Park Dam and 90% attributed to the Gunnison River below Blue Mesa Dam. For 14020002 80% was attributed to the Gunnison River near Blue Mesa Dam, 10% to the Gunnison River near Crystal Dam and 10% to the Gunnison River near Grand Junction, CO. There was no supporting information explaining why these divisions were made the way they were; however, these appear to be reasonable based on the population distribution within the HUC boundaries.

The state of New Mexico provided a total M&I CU that was distributed to the appropriate HUC with a distribution developed by Reclamation’s Denver office. The annual Arizona reports provided M&I CU by individual locations. The data for each location were distributed to the appropriate HUC. The same annual to monthly distribution described for the other states as applied to New Mexico and Arizona data.

Thermal Power 1986-1990

Thermal power CU was tracked for 13 plants throughout the Upper Colorado River Basin during the period from 1986 to 1990. During this period, each plant reported a monthly volume of consumptive use.

Based on the location of these plants within the Upper Colorado River Basin, the CU for each plant was assigned to the appropriate HUCs and CRSS nodes. There were no plants located within HUCs where CRSS nodes resided within the HUC boundaries. Therefore, no HUC thermal power CU data were split between CRSS nodes.

Thermal power was reported in both Arizona and New Mexico as described for the other states.

Minerals 1986-1990

Annual mineral CU source data for the period from 1986 to 1990 were available for each HUC. These data were computed by the USGS for the years of 1986 and 1990. Inclusive years were computed by Reclamation through linear interpolation. Each HUC mineral CU data were aggregated to the appropriate CRSS node for natural flow development. There were 7 cases where HUC mineral CU data were divided between a CRSS node within the HUC and the next node downstream. In 6 of the 7 cases, the HUC mineral CU data were divided in half. In the seventh case (HUC number 14020002), the HUC mineral CU data were divided in thirds among 2 internal CRSS nodes and one node downstream from the HUC.

No source data were available to describe the monthly distribution of mineral CU. Mineral CU was assumed to be nearly constant throughout the year. The distribution used to estimate monthly mineral CU for each HUC attributed 8.0% of the annual CU to the months of October through April. September and May were attributed 8.5% of the annual CU and June, July and August accounted for 9.0% of the annual CU. This distribution was not based on any scientific data and was an educated guess as to how mineral CU should be distributed to the months of the year.

Arizona did not report mineral CU. The state of New Mexico reported an annual value for the entire portion of the state in the Upper Colorado River Basin. This value was disaggregated to HUCs with a distribution developed by Reclamation's Denver office and to CRSS nodes as described for the other states. The annual data were distributed to monthly with the distribution described for the other states.

Imports & Exports 1986-1990

Export source data were available for each individual export structure for the period from 1986 through 1990. In most cases, the export data were available for each month but there were several instances where the source data were available as an annual volume of export. For these annual exports, distributions were constructed from source

data for later periods when monthly source data were available or from USGS gage records. The monthly distributions constructed were applied to the annual export data for 1986-1990 to estimate the monthly exports. Monthly export data were allocated to the appropriate HUCs and CRSS nodes based on location.

Import source data were also available for each individual import during the period from 1986 to 1990. Most imports accounted for in the recomputation of CU were transfers within the Colorado River Basin and did not involve the transfer of water from outside the Colorado River Basin to inside the basin. In other words, most of the imports were associated with exports that were also being accounted for in the CU computations. The exception is the Utah import, Tropic and East Fork Canal, which imports water from the Sevier River. The CU computations accounted for ten imports. Nine of the ten imports had monthly source data available for the 1971 through 1975 period. For the one import with annual source data (Tropic and East Fork Canal), the monthly import data were estimated with a distribution constructed from USGS canal gauge records for the period from 1950 to 1960. Each monthly import was allocated as a negative CU volume to the appropriate HUC and CRSS node based on location.

Arizona did not report exports or imports. New Mexico reported only one export. The export source data were available in the same form as Colorado, Wyoming, and Utah and distributed to HUC and CRSS node with the same method as in these other states.

Consumptive Uses and Losses Computation Review 1991-1995

Below is a description of the source data and the transformation methodology utilized for computing the consumptive use for the CRSS nodes for the period from 1990 through 1995. Methodologies were specific to the consumptive use type and are treated separately.

Irrigated Agriculture 1991-1995

Agriculture CU source data for the period 1991 through 1995 were reported for individual HUCs in acre-feet/year. These data were obtained from the 1991-95 Consumptive Uses and Losses Technical Memorandum.

For the 1991 through 1995 period, the Technical Memorandum also contained output printouts from the XCONS program that was used to compute agriculture CU. This output included a monthly estimate of agriculture CU in inches/month for each HUC. These data were used to construct a monthly distribution for each HUC and each year. These distributions were then used to distribute the annual agriculture CU to monthly agriculture CU.

To estimate the agriculture CU for a particular CRSS node, the agriculture CU for each HUC above a particular node were added together. In some cases the CRSS node was located within a HUC. For these cases, the agriculture CU for the HUC containing the node was divided so that a percentage was assigned to the node within the HUC and

the remainder assigned to the next node downstream. The agriculture CU for the HUC was divided between the HUC containing the node and the next node downstream by estimating the percentage of HUC irrigated acreage above and below the residing node.

The annual Arizona reports provided irrigated agriculture CU by agency. Each agency was assigned to the corresponding HUC that the agency fell into. In all cases the agency CU was simply aggregated to the corresponding HUCs and was not divided between HUCs. Monthly agriculture CU for Arizona was unavailable from 1971-1995 to develop a distribution from annual to monthly. Historic monthly data from an equivalent neighboring HUC or in the bordering state was used to develop an annual to monthly distribution.

The state of New Mexico provided annual agriculture CU by county. To distribute the county data to an appropriate HUC, the ratio of irrigated acreage for the fraction of the HUC in the county divided by the total county irrigated acres was multiplied by the annual county agriculture CU. The annual data were distributed to monthly using monthly CU data from the 1981 through 1985 Technical Memorandum to construct a distribution.

Livestock 1991-1995

The source data for livestock CU for the period from 1991 to 1995 were reported for each county within the Upper Colorado River Basin. The county source data for livestock CU were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of county irrigated acreage within each HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage does not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1991 through 1995.

To estimate the livestock CU for the CRSS nodes, the livestock CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the livestock CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute livestock CU.

To distribute the annual livestock CU to monthly livestock CU, it was assumed that livestock CU occurred proportionally at the same rate as minerals. Therefore, the mineral monthly distribution was used to distribute annual livestock CU to monthly livestock CU.

Livestock CU source data for Arizona were reported for the 1991 through 1995 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed

to HUC and CRSS node by similar methods described for Colorado, Utah, and Wyoming. The total livestock CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

Livestock CU source data were reported by the state of New Mexico as an annual total for the portion of New Mexico in the Upper Basin. The data were distributed to HUCs with a distribution developed by Reclamation's Denver office. The data were distributed to CRSS nodes by the same methods described for Colorado, Utah, and Wyoming.

The mineral monthly distribution was again used to distribute annual livestock CU to monthly livestock CU for both Arizona and New Mexico.

Stockponds 1991-1995

The source data for stockpond CU for the period from 1991 to 1995 were reported for the major subbasins in acre-feet/year. Stockpond CU for the major subbasins was distributed to each county/HUC by distributions of irrigated acreage between major subbasins and county/HUCs. This distribution was constructed using a GIS (ArcINFO) to compute the percentage of major subbasin irrigated acreage within each county/HUC. The irrigated acreage coverage for the basin was a 1995 snapshot. It was assumed that the spatial distribution of irrigated acreage does not change appreciably through time and that the snapshot was a good representation of the distribution of irrigated acreage from 1991 through 1995.

To estimate the stockpond CU for the CRSS nodes, the stockpond CU for all HUCs above a particular node and below the next node upstream were added together. In some cases CRSS nodes were located within HUC boundaries. In these cases the stockpond CU for the HUC was divided so that a percentage was assigned to the node within the HUC and the remainder assigned to the next node downstream. The percentages used to distribute agriculture CU were also used to distribute stockpond CU.

To distribute the annual stockpond CU to monthly stockpond CU, it was assumed that stockpond CU occurred proportionally at the same rate as evaporation. The distribution was developed from "old reports" and no supporting data were available at the time of this writing.

Stockpond CU source data for New Mexico were reported at the same spatial and temporal scale as Colorado, Utah and Wyoming. The data were distributed to HUC and CRSS node by month with methods similar to those described for Colorado, Utah, and Wyoming. The total stockpond CU for New Mexico was distributed to HUCs with a distribution developed by Reclamation's Denver office.

Stockpond CU source data for Arizona were reported for the 1991 through 1995 time period annually by county. The county source data were distributed to each HUC by distributions of irrigated acreage between HUCs and counties. The data were distributed

to HUC and CRSS node by month with the same method described for Colorado, Utah, and Wyoming.

Reservoir Evaporation Major 1991-1995

Source data for the major reservoir evaporation for the period 1991 through 1995 were available for individual reservoirs in acre-feet/month. These data were obtained from the 1991-1995 Consumptive Uses and Losses Report Technical Memorandum. Each major reservoir was assigned to the corresponding HUCs and CRSS nodes depending on the location of the reservoir within the Upper Colorado River Basin. The major reservoir evaporation for the 1991 through 1995 period was computed by aggregating the individual reservoir data to the corresponding HUCs and CRSS nodes.

The Major Reservoirs that were accounted are consistent for the entire recomputation period (1971-1990) as well as for the computations for 1991-1995. These Major Reservoirs are described in Table 1.

Table 1. Major Reservoirs Accounted in CU Recomputations

Colorado	Utah	Wyoming	New Mexico	Arizona
Blue Mesa	Bottle Hollow ¹	Big Sandy ¹	Lemon	Lake Powell
Crawford ¹	Currant Creek	Eden ¹	Navajo	
Crystal	Flaming Gorge	Fontenelle	Vallecito	
Dillon	Huntington North			
Fruitgrowers ¹	Joe's Valley			
Granby Dam	Meeks Cabin			
Green Mountain	Moon Lake ¹			
Jackson Gulch	Redfleet			
McPhee	Scofield			
Morrow Point	Stateline			
Paonia	Starvation			
Ridgway	Steinaker			
Rifle Gap	Strawberry (Solider Creek)			
Reudi				
Shadow Mountain				
Silver Jack				
Taylor Park				
Vega ¹				
Williams Fork				
Willow Creek				
Wolford Mountain				

¹ The data set are incomplete from 1971-1975; therefore, these were included as minor reservoirs until data can be obtained.

It is important to note that the evaporation data for Blue Mesa, Flaming Gorge and Lake Powell were computed based on CRSS evaporation methods and were not based on historic data. For these reservoirs, the average monthly elevations were used to compute the average surface area for the month. The surface area was then multiplied by a monthly evaporation coefficient in units of feet. Comparison between the CRSS method computed evaporation data for these reservoirs and historic evaporation data did not indicate any major differences between the datasets.

For the period from 1991 to 1995, monthly major reservoir evaporation for each reservoir was available in the Consumptive Uses and Losses Technical Memorandum. No distribution was necessary for distributing annual major reservoir evaporation to monthly.

Arizona and New Mexico reported major reservoir evaporation for the 1991-95 time period by individual reservoirs in acre-feet/month. The same methods utilized in the other states were applied to Arizona and New Mexico to move the data to CRSS nodes and HUCs.

Reservoir Evaporation Minor 1991-1995

Minor reservoirs were those where only annual reservoir storage or pool elevation data could be obtained. Beginning in 1976, the annual reservoir evaporation for each Minor Reservoir was available from the Consumptive Uses and Losses Technical Memorandum. The minor reservoir evaporation for each year was computed for the period from 1991 through 1995 by summing the individual minor reservoir evaporation data to the appropriate HUCs.

Minor reservoir evaporation for each CRSS node was computed by summing the HUC minor reservoir evaporation data to the appropriate CRSS nodes. There was only one case where it was necessary to split a HUC's minor reservoir evaporation between two nodes. This HUC was 14010005. 97% of the minor reservoir evaporation was distributed to the CRSS node located on the Colorado River near Cameo, CO. and 3% was distributed to the node located on the Colorado River near the CO-UT Stateline.

To estimate the monthly minor reservoir evaporation from the annual minor reservoir evaporation, a single distribution was used for all CRSS nodes. This distribution was developed from "old reports" and no supporting data were available at the time of this writing. The distribution assigned a fraction of the total annual evaporation to each month of the year such that the aggregate of the fractions summed to a value of one.

Minor reservoir evaporation was reported by the state of New Mexico and the Arizona report annually by individual minor reservoirs evaporation. The reservoirs were

all located within their appropriate HUC. The annual data were distributed to monthly with the same distribution described for the other states.

Municipal & Industrial 1991-1995

For the period from 1991 to 1995 annual M&I CU data were available for each individual HUC. These data were computed by the USGS for the years 1991 and 1995. Inclusive years were computed by Reclamation through linear interpolation.

M&I CU was assumed to be higher during the summer and lower during the winter. A distribution was obtained from Ray Alverado with the Colorado Water Conservation Board. This distribution had a low percentage of 4.5% in November and high percentage in July of 16.5%. The distribution was applied to all annual HUC M&I CU volumes for the period from 1991 to 1995 to obtain monthly M&I CU volumes for each HUC.

Monthly M&I CU data for each HUC were aggregated to the appropriate CRSS nodes for natural flow development. There were three HUCs where the M&I CU was divided between multiple CRSS nodes because these nodes were within HUC boundaries. These HUCs were 14010005, 14020001 and 14020002. For 14010005 10% of the M&I CU was attributed to the Colorado River near Cameo, CO and 90% to the Colorado River near the CO-UT Stateline. For 14020001 10% of the M&I CU was attributed to the Taylor River below Taylor Park Dam and 90% attributed to the Gunnison River below Blue Mesa Dam. For 14020002 80% was attributed to the Gunnison River near Blue Mesa Dam, 10% to the Gunnison River near Crystal Dam and 10% to the Gunnison River near Grand Junction, CO. There was no supporting information explaining why these divisions were made the way they were; however, these appear to be reasonable based on the population distribution within the HUC boundaries.

The state of New Mexico provided a total M&I CU that was distributed to the appropriate HUC with a distribution developed by Reclamation's Denver office. The annual Arizona reports provided M&I CU by individual locations. The data for each location were distributed to the appropriate HUC. The same annual to monthly distribution described for the other states were applied to New Mexico and Arizona data.

Thermal Power 1991-1995

Thermal power CU was tracked for 13 plants throughout the Upper Colorado River Basin during the period from 1991 to 1995. During this period, each plant reported a monthly volume of consumptive use.

Based on the location of these plants within the Upper Colorado River Basin, the CU for each plant was assigned to the appropriate HUCs and CRSS nodes. There were no plants located within HUCs where CRSS nodes resided within the HUC boundaries. Therefore, no HUC thermal power CU data were split between CRSS nodes.

Thermal power was reported in both Arizona and New Mexico as described for the other states.

Minerals 1991-1995

Annual mineral CU source data for the period from 1991 to 1995 were available for each HUC. These data were computed by the USGS for the years of 1991 and 1995. Inclusive years were computed by Reclamation through linear interpolation. Each HUC mineral CU data were aggregated to the appropriate CRSS node for natural flow development. There were 7 cases where HUC mineral CU data were divided between a CRSS node within the HUC and the next node downstream. In 6 of the 7 cases, the HUC mineral CU data were divided in half. In the seventh case (HUC number 14020002), the HUC mineral CU data were divided in thirds among 2 internal CRSS nodes and one node downstream from the HUC.

No source data were available to describe the monthly distribution of mineral CU. Mineral CU was assumed to be nearly constant throughout the year. The distribution used to estimate monthly mineral CU for each HUC attributed 8.0% of the annual CU to the months of October through April. September and May were attributed 8.5% of the annual CU and June, July and August accounted for 9.0% of the annual CU. This distribution was not based on any scientific data and was an educated guess as to how mineral CU should be distributed to the months of the year.

Arizona did not report mineral CU. The state of New Mexico reported an annual value for the entire portion of the state in the Upper Colorado River Basin. This value was disaggregated to HUCs with a distribution developed by Reclamation's Denver office and to CRSS nodes as described for the other states. The annual data were distributed to monthly with the distribution described for the other states.

Imports & Exports 1991-1995

Export source data were available for each individual export structure for the period from 1991 through 1995. In most cases, the export source data were available for each month but there were several instances where export source data were available as an annual volume of export. For these annual exports, distributions were constructed from source data for later periods when monthly source data were available or from USGS gage records. The monthly distributions constructed were applied to the annual export data for 1991-1995 to estimate the monthly exports. Monthly export data were allocated to the appropriate HUCs and CRSS nodes based on location.

Import source data were also available for each individual import during the period from 1991 to 1995. Most imports accounted for in the recomputation of CU were transfers within the Colorado River Basin and did not involve the transfer of water from outside the Colorado River Basin to inside the basin. In other words, most of the imports were associated with exports that were also being accounted in the CU computations. The exception is the Utah import, Tropic and East Fork Canal, which imports water from

the Sevier River. The CU computations accounted for ten imports. Nine of the ten imports had monthly source data available for the 1991 through 1995 period. For the one import with annual source data (Tropic and East Fork Canal), the monthly import data were estimated with a distribution constructed from USGS canal gauge records for the period from 1950 to 1960. Each monthly import was allocated as a negative CU volume to the appropriate HUC and CRSS node based on location.

Arizona did not report exports or imports. New Mexico reported only one export. The export source data were available in the same form as Colorado, Wyoming, and Utah and distributed to HUC and CRSS node with the same method as in these other states.

General Recommendations

The methods implemented by Reclamation to compute the natural flow dataset used in CRSS and the Consumptive Uses and Losses Reports has proven to be a very data intensive process. Historically the computation process and the data requirements of the process have not been well documented by those who have undertaken the project. As time has elapsed since the original computation of the data, much of the required source data, methods, and assumptions were not accounted for and were not available for this review.

For this reason, various methods were developed to estimate historic source data from other historic periods when source data were available. These methods may or may not be valid for the period for which they were used. But given the scarcity of the actual source data, there was little else that could have been done to fill in the temporal gaps. These various methods reviewed for this document appeared to be reasonable solutions when source data were missing.

It was noted that the computational methods did change from period to period and was most likely a result of poor documentation as to what method was used for the previous period. This proved to complicate the recomputation process and introduced the potential for inconsistency in the data.

Computations used in the recomputation process were not complicated or difficult to comprehend; however, the management of the data necessary for these computations was complicated. Future computation of CU data should implement a data storage system that archives not only the source data necessary for the computations but also the methods by which the CU data is computed.

Outstanding Issues or Questions

1. From 1971-75 the XCONS program used to compute agriculture CU appears to have had some flaws. We are unsure how these affect the final CU values.
2. Does the dramatic decrease in mineral CU from 1971-1995 appear reasonable?
3. Is the assumption that livestock consumes water in the same monthly proportion as minerals appropriate? Can we develop a better distribution?

4. Is the inconsistency in how major reservoir evaporation is generated reasonable? (i.e., Flaming Gorge, Blue Mesa, Lake Powell are generated with CRSS methods and other Majors handled differently.)
5. Is it reasonable to use a temporal distribution from other time periods to distribute annual data to monthly when monthly is unavailable?
6. Need to develop a new method to distribute monthly minor reservoir evaporation. There is not source data for the current distribution.
7. Is it reasonable to compute CU for Colorado, Utah, and Wyoming with one set of methods and then do something completely different for New Mexico and Arizona?