Upper Colorado River Basin Water Resources Planning Model User's Manual

October 2009

Colorado's Decision Support Systems

Colorado Water Conservation Board

Colorado Division of Water Resources
Department of Natural Resources

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1. Introduction

1.1 Background

The Colorado Decision Support System (CDSS) consists of a database of hydrologic and administrative information related to water use in Colorado, and a variety of tools and models for reviewing, reporting, and analyzing the data. The CDSS water resources planning models, of which the Upper Colorado River Basin Water Resources Planning Model (Upper Colorado River Model) is one, are water allocation models, which determine availability of water to individual users and projects, based on hydrology, water rights, and operating rules and practices. They are implementations of “StateMod,” a code developed by the State of Colorado for application in the CDSS project. The Upper Colorado River Model Baseline data set, which this document describes, extends from the most currently available hydrologic year (2005) back to 1909. It simulates current demands, current infrastructure and projects, and the current administrative environment as though they were in place throughout the modeled period.

The Upper Colorado River Model was developed as a tool to test the impacts of proposed diversions, reservoirs, water rights and/or changes in operations and management strategies. The model can simulate proposed changes using a highly variable physical water supply constrained by administrative water rights. The Baseline data set can serve as the starting point, demonstrating condition of the stream absent the proposed change but including current conditions. It is recommended the user compare the Baseline simulation results to results from a model to which they have added the proposed features, to determine the performance and effects of the proposed changes.

1.2 Development of the Upper Colorado River Basin Water Resources Planning Model

The Upper Colorado River Model was developed in a series of phases that have spanned 1996 through the present (2009). The earliest effort, designated Phase II following a Phase I scoping task, accomplished development of a calibrated model that simulated an estimated 75 percent of water use in the basin, leaving the remaining 25 percent of the use “in the gage”. The original model study period was 1975 through 1991, which also served as the model’s calibration period.

The objective of the CDSS endeavor was to represent all potential consumptive use within Colorado, and estimate actual consumptive use under water supply limitations. Therefore, in Phase IIIa, the previously unmodeled 25 percent use was added to the model as 65 aggregations of numerous small users. With the introduction of this demand, the calibration was reviewed and refined. The objective of Phase IIIb was to extend the model study period, using automated data filling techniques as well as “old-fashioned” research in the State’s Records office to estimate or obtain historical gage and diversion information. The data set was extended back to 1909 and forward through 1996. The calibration was reviewed using the period 1975 through 1996. The State refined the Upper Colorado River Model again in 2006, adding the “variable efficiency” method for determining irrigation consumptive use and return flows, extending the study period through 2005, and creating daily simulation input files.

StateMod code enhancements made during 2009 allowed the annual Green Mountain Historical User Pool releases to be limited to 66,000 acre-feet. In addition, the Baseline model input files were enhanced during the CRWAS project in 2009 to include the following:

- Current representation of transbasin demands for the Moffat System and Roberts Tunnel, provided by Denver Water Board
- Current representation of Colorado-Big Thompson and Windy Gap transbasin demands, provided by Northern Colorado Water conservancy District
- Current representation of transbasin demands for the Con-Hoosier Project, provided by Colorado Springs Utilities
- More accurate representation of the Ute Water Conservancy District operations in the Plateau Creek basin
- Corrections to water rights associated with power demands on the lower Colorado River Basin

1.3 Results

The key results of the Upper Colorado River Model efforts are as follows:

- A water resources planning model was developed that can make comparative analyses of historical and future water management policies in the Upper Colorado River Basin. The model includes 100 percent of the basin's surface water use.
- The model was calibrated for a study period extending from water year 1975 through 2005.
- The calibration in the Historic simulation is considered very good, based on a comparison of historical to simulated streamflows, reservoir contents, and diversions.
- A Calculated data set was prepared where historical irrigation demands were replaced by calculated demands, which represent the amount of water crops would have used if given a full supply. These demands are the basis for the Baseline data set demands. The Calculated monthly simulation results were compared to historical streamflows, reservoir contents, and diversions. The comparison is considered good.
- A Baseline data set was prepared which, unlike the Historic and Calculated data sets, simulates existing water resources systems on-line and operational for USGS water year 1909 through 2005. The Baseline data set is an appropriate starting point for evaluating various “what if” scenarios over a long hydrologic time period containing dry, average, and wet hydrologic cycles.
- Input data for the Upper Colorado River Model using a daily time-step was developed. As with the monthly model, the daily model may be operated to represent the Historic, Calculated, and Baseline simulations by using the appropriate response file. The purpose of the daily Baseline model data set is to capture daily variations in streamflow and call regime. Depending on the “what if” question the user wishes to investigate, a daily time-step may provide more detail regarding water availability.

1.4 Future Enhancements

The Upper Colorado River Model was developed to include 100 percent of the basin's consumptive use through a combination of explicit and aggregated structures. The Upper Colorado River Model could be enhanced in the future by incorporating additional information gained by consulting with the Division Engineer, the U.S. Bureau of Reclamation, and other major water users regarding historical and future reservoir operations.

1.5 Acknowledgements

CDSS is a project of the Colorado Water Conservation Board (CWCB), with support from the Colorado Division of Water Resources. The Upper Colorado River Model was developed and enhanced at different stages by Riverside Technology, Inc., Boyle Engineering Corporation, Leonard Rice Engineers, Inc., and CWCB staff.

2. What's in This Document

2.1 Scope of this Manual

This reference manual describes the CDSS Upper Colorado River Water Resources Planning Model, an application of the generic water allocation model StateMod and one component of the Colorado Decision Support System. It is intended for the reader who:

- Wants to understand basin operations and issues through review of the model,
- Needs to evaluate the model's applicability to a particular planning or management issue,
- Intends to use the model to analyze a particular Upper Colorado River Basin development or management scenario,
- Is interested in estimated conditions in the Upper Colorado River Basin under current development over a range of hydrologic conditions, as simulated by this model, and in understanding the modeling estimates.

For this manual to be most effective, the reader should have access to a complete set of data files for the Upper Colorado River Model, as well as other CDSS documentation as needed (see below).

The manual describes content and estimates in the model, implementation issues encountered, approaches used to estimate parameters, and results of both calibrating and simulating with the model. Limited general information is provided on the mechanics of assembling data sets and using various CDSS tools.

2.2 Manual Contents

This manual is divided into the following sections:

Section 3 The Upper Colorado River Basin – describes the physical setting for the model, provides general review of water resources development, and issues in the basin.

Section 4 Modeling Approach – provides an overview of methods and techniques used in the Upper Colorado River Model, addressing an array of typical modeling issues such as:

- Aerial extent and spatial detail, including the model network diagram
- Study period
- Aggregation of small structures
- Data filling methods

- Simulation of processes related to irrigation use, such as delivery loss, soil moisture storage, crop consumptive use, and returns of excess diversions
- Development of baseflows
- Calibration methods

Much of Section 4 is common to the other CDSS West Slope models and the Rio Grande model, although the section refers specifically to the Upper Colorado River Model.

Section 5 Baseline Data Set – refers to the Monthly Baseline data set input files for simulating under current demands, current infrastructure and projects, and the current administrative environment, as though they were in place throughout the modeled period. The data set is generic with respect to future projects, and could be used as the basis against which to compare a simulation that includes a new use or operation. The user is advised, before appropriating the data set, to become fully aware of how demands and operations are represented. Elements of these are subject to interpretation, and could legitimately be represented differently.

This section is organized by input file. The first is the response file, which lists the other files and therefore serves as a table of contents within the section. The content, source of data, and particular implementation issues are described for each file in specific detail.

Section 6 Baseline Results – presents summarized results of the Monthly Baseline simulation. It shows the state of the basin as the Upper Colorado River Model characterizes it under Baseline conditions. Both total flow and flow legally available to new development are presented for key sites.

Section 7 Calibration – describes the calibration process and demonstrates the model's ability to replicate historical conditions under historical demand and operations. Comparisons of streamflow, diversions, and reservoir levels are presented.

Section 8 Daily Baseline Results – describes the Daily Baseline data set and presents summarized results of the Daily Baseline simulation. It shows the state of the basin as the Upper Colorado River Model characterizes it under Baseline conditions, and compares available and simulated flows to the Monthly Baseline simulation.

Appendices A through C – present historical technical memoranda specific to the Upper Colorado River Model, written at various phases of the model's development. The body of the manual contains references to other CDSS technical memos that were more general in scope, and are available at the CDSS website (http://cdss.state.co.us).

Appendix D – discusses the comparison of historical measured data to the Monthly Calculated data set simulation. The Calculated data set expands on the historical calibration by using calculated irrigation demands based on crop requirements, in lieu of demands based on historical irrigation diversions. Comparisons of streamflow, diversions, and reservoir levels are presented.

Appendix E – discusses the comparison of historical measured data to the Daily Historic data set simulation. The daily time-step is capable of simulating diversions based on the large and small flow events that occur within a monthly time step. Comparisons of streamflow, diversions, and reservoir levels are presented.

There is some overlap of topics both within this manual and between this and other CDSS documentation. To help the user take advantage of available sources, pointers are included as applicable under the heading “**Where to find more information**,” throughout this manual.

2.3 What’s in other CDSS documentation

The user may well find the need to supplement this manual with information from other CDSS documentation. This is particularly true for the reader who wants to:

- Make significant changes to the Upper Colorado River Model to implement specific future operations,
- Introduce changes that require regenerating the baseflow data file,
- Regenerate input files using the Data Management Interface (DMI) tools and HydroBase,
- Develop a StateMod model for a different basin.

An ample body of documentation exists for CDSS, and is still growing. A user’s biggest challenge may be in efficiently finding the information they need. This list of descriptions is intended to help in selecting the most relevant data source:

Basin Information – the report “Upper Colorado River Basin Information” provides information on specific structures, operations, and practices within the basin. While the information was gathered in support of the planning model when it was first undertaken, it is widely useful to anyone doing any kind of water resources investigation or analysis.

DMI user documentation – user documentation for **StateDMI** and **TSTool** is currently available, and covers aspects of executing these codes against the HydroBase database (Creating data sets for StateMod is only one aspect of their capabilities). The DMIs preprocess some of the StateMod input data. For example, StateDMI computed coefficients for distributing baseflow gains throughout the model and aggregated water rights for numerous small structures. TSTool filled missing time series data and computed headgate demands for irrigation structures. Thus the documentation, which explains algorithms for these processes, is helpful in understanding the planning model estimates. In addition, the documentation is essential for the user who is modifying and regenerating input files using the DMIs.

StateMod documentation – the StateMod user manual describes the model in generic terms and specific detail. Section 3 - Model Description and Section 7 - Technical Notes offer the best descriptions of StateMod functionality, and would enhance the Upper Colorado River Model user’s understanding of results. If the user is modifying input files, they should consult Section 4 - Input Description to determine how to format files. To analyze model results in detail, they should review Section 5 - Output Description, which describes the wide variety of reports available to the user.

Self-documented input files – an important aspect of the StateMod input files is that their genesis was documented in the files themselves. Command files that directed the DMIs creation of the files were echoed in the file header. Generally, the model developers have incorporated comments in the command file that explain use of options, sources of data, etc.

Technical Memoranda – many aspects of the modeling methods adopted in CDSS were explored in feasibility or pilot studies before being implemented. Historical technical memoranda and reports for these activities are available on the CDSS website:

- Phase IIIb Task Memorandum 10.1 – Data Extension Feasibility
- Task Memorandum 10.2 – Evaluate Extension of Historical Data
- Task Memorandum 11.5 – Characterize Streamflow Data
- Task Memorandum 11.7 – Verify Diversion Estimates
- Task Memorandum 11.10 – Fill Missing Baseflow Data (include Mixed Station Model user instruction)
- Daily Yampa Model Task Memorandum 2 – Pilot Study
- Daily Yampa Model Task Memorandum 3 – Selecting a Daily or Monthly Model
- Variable Efficiency Evaluation Task Memorandum 1.3 – Run StateMod to create baseflows using the Variable Efficiency and Soil Moisture Accounting Approach
- Variable Efficiency Evaluation Task Memorandum 1.5 – Compare StateMod Variable Efficiency and Soil Moisture Accounting Historical Model Results to Previous CDSS Model Results and Historical Measurements
- CDSS Memorandum "Upper Colorado River Basin Representative Irrigation Return Flow Patterns"
- Task Memorandum 2.09-10 Consumptive Use Model – Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Upper Colorado River Basin
- Upper Colorado River Basin Historical Crop Consumptive Use Report

3. The Upper Colorado River Basin

The Upper Colorado River basin lies in west-central Colorado, with the headwaters originating at the Continental Divide in Rocky Mountain National Park. The Upper Colorado River flows in a westerly direction through forested mountains and irrigated valleys before it leaves the state in Mesa County downstream of the City of Grand Junction. The basin encompasses all or a large majority of Grand, Summit, Eagle, Garfield and Pitkin counties; and portions of Mesa, Routt, and Gunnison counties in Colorado. **Figure 3.1** is a map of the basin.

3.1 Physical Geography

The Upper Colorado River basin is approximately 9,916 square miles in size (excluding the Gunnison River basin). It ranges in elevation from 12,800 feet at its headwaters to 4,325 feet near the Colorado-Utah state line. The Upper Colorado River is the primary stream in the basin, with major tributaries including the Gunnison River, Fraser River, Williams Fork, Blue River, Muddy Creek, Eagle River, Roaring Fork River, Rifle Creek, and Plateau Creek. Average annual streamflow in the upper drainage (USGS gage near Grand Lake, Colorado) is approximately 57,000 acre-feet, which increases to an annual average of 4.9 million acre-feet below Grand Junction, Colorado (USGS gage near the state line), including the Gunnison River inflows, for water year 1975 through 2005. The water rights of the Gunnison River basin are not included in the Upper Colorado River Model; rather the Gunnison River is treated as a gaged inflow in the Upper Colorado River Model at USGS gage 09152500.

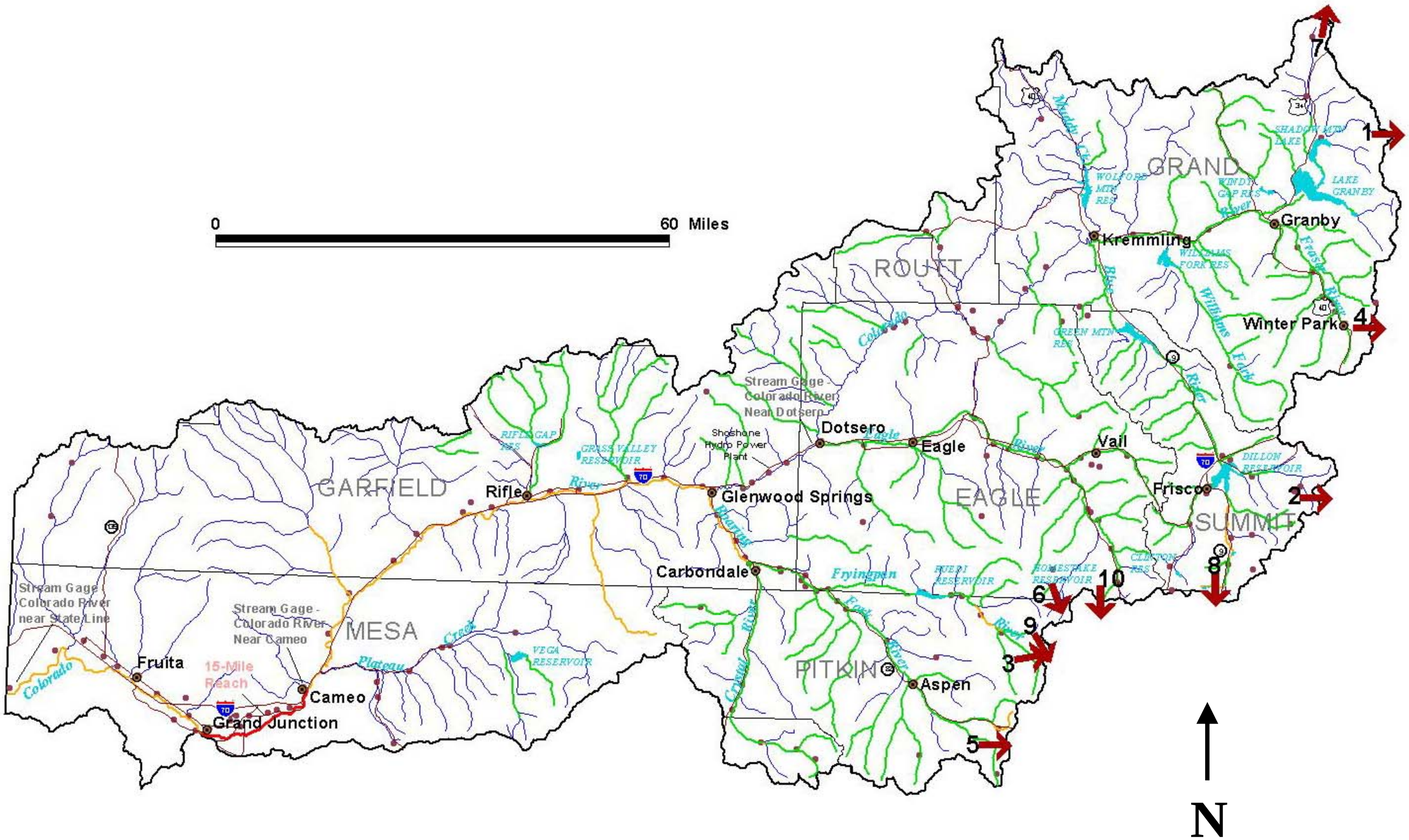


Figure 3.1 – Upper Colorado River Basin

3.2 Human and Economic Factors

The area remains moderately populated, with the 2000 census estimates placing the combined populations of Eagle, Garfield, Grand, Mesa, Pitkin, and Summit Counties at 252,567. Grand Junction and Glenwood Springs are the major population centers in the basin, with approximately 42,000 and 7,700 residents in 2000 and growth rates of 45 percent and 18 percent, respectively, from 1990 to 2000. Summit and Eagle Counties grew over 83 percent and 90 percent, respectively, from 1990 to 2000. Modest population growth was experienced in Pitkin and Mesa Counties at 17 percent and 25 percent, respectively, over the 1990 to 2000 period. The towns of Aspen and Vail experienced 25 and 28 percent growth, respectively, over the 1990 to 2000 time period. Population growth was generally concentrated in the lower portions of the basin at the existing major population centers. Growth was seen in the upper portions of the basin at a more modest pace. This attests to the continued importance of recreation-based activities, as the ski areas and other outdoor recreation opportunities draw people and increase tourism within the basin.

The major water use in the basin is irrigation, with several thousand irrigation ditches diverting from the mainstem and the numerous tributary streams throughout the basin. Diversions from many of the small irrigation ditches average one or two thousand acre-feet per year. There are also several larger irrigation ditches, such as the Government Highline Canal which diverts approximately 770,000 acre-feet per year. According to the State's geographical information system (GIS) records, total irrigated acreage in the basin (based on 1993 imagery) was approximately 271,000 acres. Irrigated acreage dropped slightly to about 230,000 acres in 2000.

Another major water use in the Upper Colorado River is transmountain diversions. These diversions serve water supply needs for irrigation and municipal uses along the Front Range and eastern plains of Colorado. Major transmountain diversions and the average amount diverted over the model calibration period 1975-2005 are as follows:

- Colorado-Big Thompson (CBT) Project exported approximately 232,000 acre-feet per year via the Alva B. Adams Tunnel for irrigation and municipal use in northern and eastern Colorado,
- City of Denver's Moffat Tunnel System diverted over 57,000 acre-feet per year,
- City of Denver's Roberts Tunnel System diverted approximately 58,600 acre-feet per year,
- Fryingpan-Arkansas Project exported approximately 51,000 acre-feet per year for irrigation and municipal use in southeastern Colorado,
- Independence Pass Transmountain Diversion System diverted approximately 38,500 acre-feet per year for municipal, industrial, and irrigation uses primarily in the Arkansas River basin,
- Homestake Diversion Project diverted approximately 24,000 acre-feet per year from the Upper Eagle River tributaries for municipal use in Colorado Springs and Aurora.

Other major water uses in the Upper Colorado River basin include power generation, industrial, municipal, and transbasin diversions within the basin. Principal power generation diverters include Shoshone Power Station, Grand Valley Power Plant, and Molina Power Plant, with collective historical diversions of approximately 1,064,000 acre-feet per year. Mining operations and snowmaking constitute the remaining major industrial uses in this basin. Diversions for municipal use include large population centers, municipal districts (i.e. Ute Water Conservancy District), and numerous small towns.

In addition to direct ditch diversions, there are 20 operational reservoirs in the model, including three that represent aggregations of numerous small facilities on Grand Mesa. Four reservoirs, including Rifle Gap Reservoir, Harvey Gap Reservoir, Vega Reservoir, and Leon Creek Aggregated Reservoir, are used primarily for irrigation. Six reservoirs, including Shadow Mountain/Grand Lake (modeled as one storage facility), Granby Reservoir, Willow Creek Reservoir, Meadow Creek Reservoir, Homestake Reservoir, and Upper Blue Reservoir, are predominantly used to store water for transmountain diversions. Bonham Aggregated Reservoir and Cottonwood Aggregated Reservoir serve industrial uses. The remaining reservoirs, including Williams Fork Reservoir, Green Mountain Reservoir, Dillon Reservoir, Clinton Gulch Reservoir, Ruedi Reservoir, and Wolford Mountain Reservoir, serve multiple uses, including municipal, industrial, irrigation, recreation, and endangered fish instream flows. With the exceptions of Meadow Creek Reservoir (1975), Clinton Gulch Reservoir (1977) and Wolford Mountain Reservoir (1995), all the above reservoirs were constructed prior to the 1975-2005 water year calibration period. Wolcott Reservoir and Eagle Park Reservoir are included in the model but only as placeholders for additional future scenarios. Three of these reservoirs are below the 4,000 acre-feet cutoff for inclusion in the model. However, Upper Blue Reservoir (2,113 acre-feet capacity) was added in Phase IIIa to better represent Continental Hoosier system operations; Cottonwood Aggregated Reservoir (3,812 acre-feet capacity) was included to better model the Molina Power Plant in the Collbran Project; and Eagle Park Reservoir was included for future modeling of augmentation operations in the Eagle River Basin.

There are also ten non-operational aggregated reservoirs and one aggregated stock pond in the model. These were added in Phase IIIa to represent an additional 89,833 acre-feet of decreed storage.

3.3 Water Resources Development

The Upper Colorado River basin has experienced substantial water resources development in the form of storage projects and pipelines developed by private groups and federal agencies. **Table 3.1** presents a timeline of key developments within the basin.

Table 3.1
Key Water Resources Developments

Date	Project (West Slope Reservoirs)	Agency
1882	Grand Valley Irrigation Canal	Grand Valley Irrigation Company
1890	Grand River Ditch	Water Supply and Storage Company
1915	Grand Valley Project	United States Bureau of Reclamation
1919	Orchard Mesa Irrigation District	Orchard Mesa Irrigation District
1935	Independence Pass Transmountain Diversion System (Grizzly Reservoir)	Twin Lakes Reservoir and Canal Company
1936	Fraser River Collection System (Meadow Creek Reservoir, Williams Fork Reservoir)	Denver Water Board
1938	Colorado-Big Thompson Project (Grand Lake and Shadow Mountain Reservoir, Granby Reservoir, Willow Creek Reservoir, Green Mountain Reservoir, Windy Gap Reservoir)	United States Bureau of Reclamation
1940	Williams Fork Diversion Project (Williams Fork Reservoir)	Denver Water Board
1948	Continental-Hoosier Diversion System (Upper Blue Lakes, Wolford Mountain Reservoir, Homestake Reservoir)	City of Colorado Springs
1959	Williams Fork Reservoir	Denver Water Board
1961	Homestake Diversion Project (Homestake Reservoir)	City of Colorado Springs - City of Aurora
1963	Collbran Project (Vega Reservoir, Bonham Reservoir, Big Creek Reservoirs, Leon Creek Reservoirs, Cottonwood Creek Reservoirs)	United States Bureau of Reclamation
1964	Blue River Diversion System (Dillon Reservoir, Williams Fork Reservoir, Wolford Reservoir)	Denver Water Board
1968	Silt Project (Rifle Gap Reservoir, Harvey Gap Reservoir)	United States Bureau of Reclamation
1972	Fryingpan-Arkansas Project (Ruedi Reservoir	United States Bureau of Reclamation
1995	Wolford Mountain Reservoir	Colorado River Water Conservation District
TBA	Wolcott Reservoir	Colorado River Water Conservation District

3.4 Water Rights Administration and Operations

The primary call on the river during the irrigation season, known as the Cameo call, is located in the Grand Valley Area where some of the most senior water rights in the basin exist. This call is activated if the combined flows at the Cameo gage (USGS gage 09095500) and the Plateau Creek gage (USGS gage 09105000) fall below 2,260 cubic feet per second (cfs). The other significant call that affects the entire basin is at Shoshone Power Plant, located eight miles downstream of the Dotsero gage (USGS gage 09070500). Senate Document 80 stipulates how water should be administered to satisfy demands at this location.

Two distinct periods revolving around Green Mountain Reservoir operations with respect to the Shoshone call define the historical water rights administration in the Upper Colorado River basin. Prior to 1985, the division engineer administered the river according to a strict interpretation of Senate Document 80. If flows fell below the 1,250 cfs minimum at the Dotsero gage, transmountain diversions were curtailed or replaced. If streamflow in the Upper Colorado River did not satisfy the Shoshone call, Green Mountain Reservoir would release water to satisfy the shortage. Following the publication of a new operating policy at Green Mountain and a restructuring of its reservoir accounts in 1984, the administration policy described above was revised. From 1985 forward, the division engineer began operating Green Mountain Reservoir as a true replacement facility to Western Slope beneficiaries. In addition, transmountain diversions senior to the Shoshone call were able to divert in priority. This change in policy triggered earlier releases than previously observed from Green Mountain Reservoir.

3.5 Section 3 References

1. Colorado River Decision Support System Upper Colorado River Basin Water Resources Planning Model, Boyle Engineering Corporation, January 1998.

2. Colorado River Mainstem Basin Facts, Colorado Water Conservation Board, available at http://cwcb.state.co.us

3. Census and Population Estimate Data, Colorado Demography Office, available at http://dola.colorado.gov/demog/Demog.cfm

4. Upper Colorado River Basin Information Report, July 2006.

4. Modeling Approach

This section describes the approach taken in modeling the Upper Colorado River Basin, from a general perspective. It addresses scope and level of detail of this model in both the space and time domains, and describes how certain hydrologic processes are parameterized.

4.1 Modeling Objectives

The objective of the Upper Colorado River Modeling effort was to develop a water allocation and accounting model that water resources professionals can apply to evaluations of planning issues or management alternatives. The resulting “Baseline” input data set is one representation of current water use, demand, and administrative conditions, which can serve as the base in paired runs comparing river conditions with and without proposed future changes. By modifying the Baseline data set to incorporate the proposed features to be analyzed, the user can create the second input data set of the pair.

The model estimates the basin’s current consumptive use by simulating 100 percent of basin demand. This objective was accomplished by representing large or administratively significant structures at model nodes identified with individual structures, and representing many small structures at “aggregated” nodes. Although the model was first developed and calibrated for the period from 1975 forward, the data set was extended backward to 1909, creating a long-term data set reflecting a wide variety of hydrologic subsequences and conditions.

Another objective of the CDSS modeling effort was to achieve good calibration, demonstrated by agreement between historical and simulated streamflows, reservoir contents, and diversions when the model was executed with historical demands and operating rules. This objective was achieved, as demonstrated in Section 7.

4.2 Model coverage and extent

4.2.1. Network Diagram

Figure 4.1 shows the network diagram for the Upper Colorado River Model. It includes over 700 nodes for the river system. The network begins with the headwaters of the Upper Colorado River and ends at the Colorado-Utah Border.

4.2.2. Diversion Structures

4.2.2.1 Key Diversion Structures

Early in the CDSS process it was decided that, while all consumptive use should be represented in the models, it was not practical to model each and every water right or diversion structure individually. Seventy-five percent of use in the basin, however, should be represented at strictly correct river locations relative to other users, with strictly correct priorities relative to other users. With this objective in mind, key structures to be “explicitly” modeled were identified by:

- Identifying net absolute water rights for each structure and accumulating each structure’s decreed amounts
- Ranking structures according to net total absolute water rights
- Identifying the decreed amount at 75 percent of the basin wide total decreed amount in the ranked list
- Generating a structures/water rights list consisting of structures at or above the threshold decreed amount
- Field verifying structures/water rights, or confirming their significance with basin water commissioners, and making adjustments

Based on this procedure, 11 cubic feet per second (cfs) was selected as the cutoff value for the Upper Colorado River basin. Key diversion structures are generally those with total absolute water rights equal to or greater than this cutoff. The Upper Colorado River Model includes approximately 345 key diversion structures.

Groups of key structures on the same tributary that operate in a similar fashion to satisfy a common demand are sometimes combined into “diversion systems”. Diversion systems are modeled the same as other key structures.

Where to find more information

- Section 3 of the CDSS document “Upper Colorado River Basin Information” lists candidate key structures and in some cases indicates why structures were or were not designated as “key”. These decisions were often based on Water Commissioner input, which is also documented in the Upper Colorado River Basin Information section “Basin Meeting Notes”.

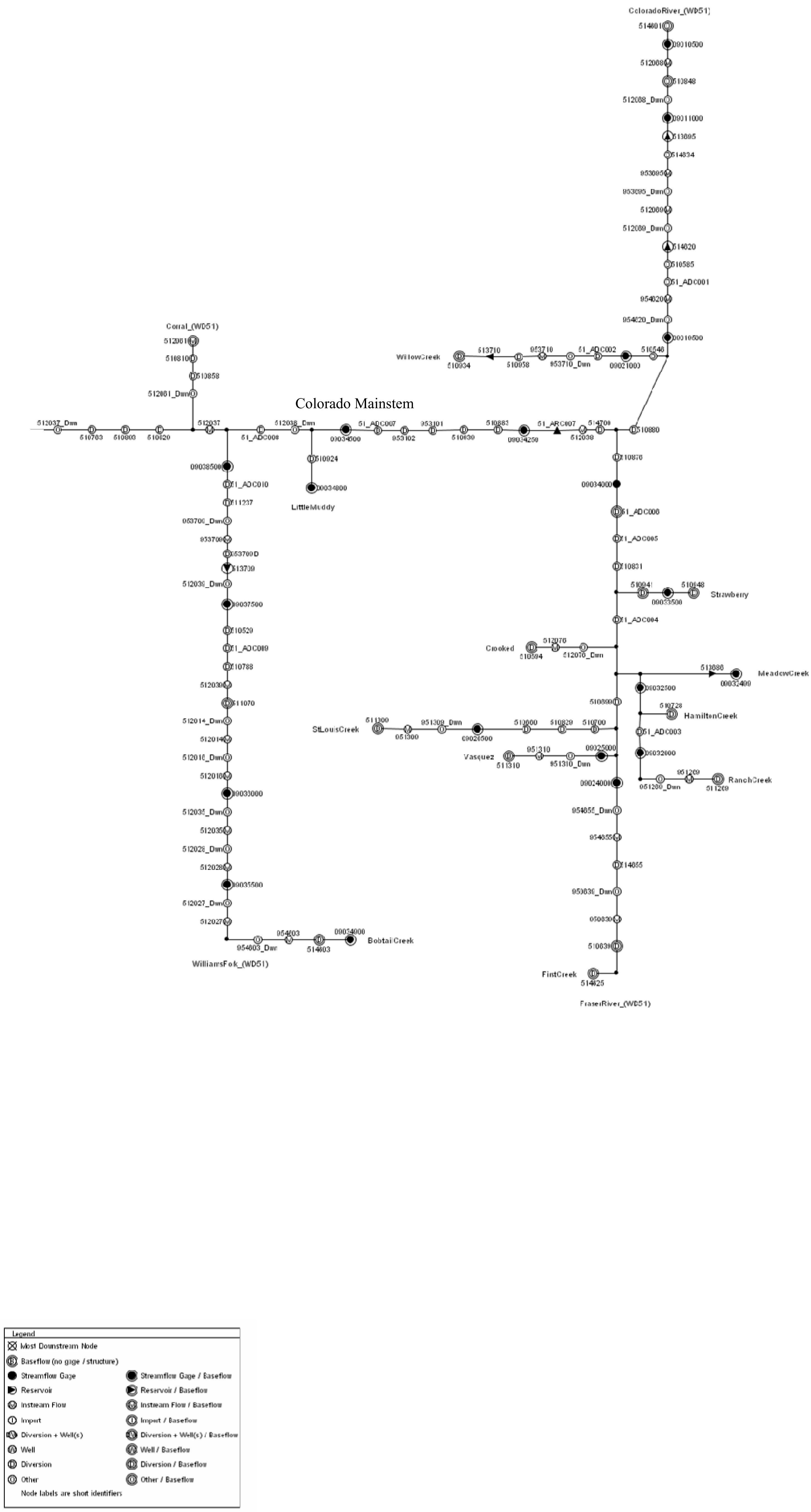


Figure 4.1a Network Diagram – Upper Colorado River Model from the Headwaters to below Williams Fork

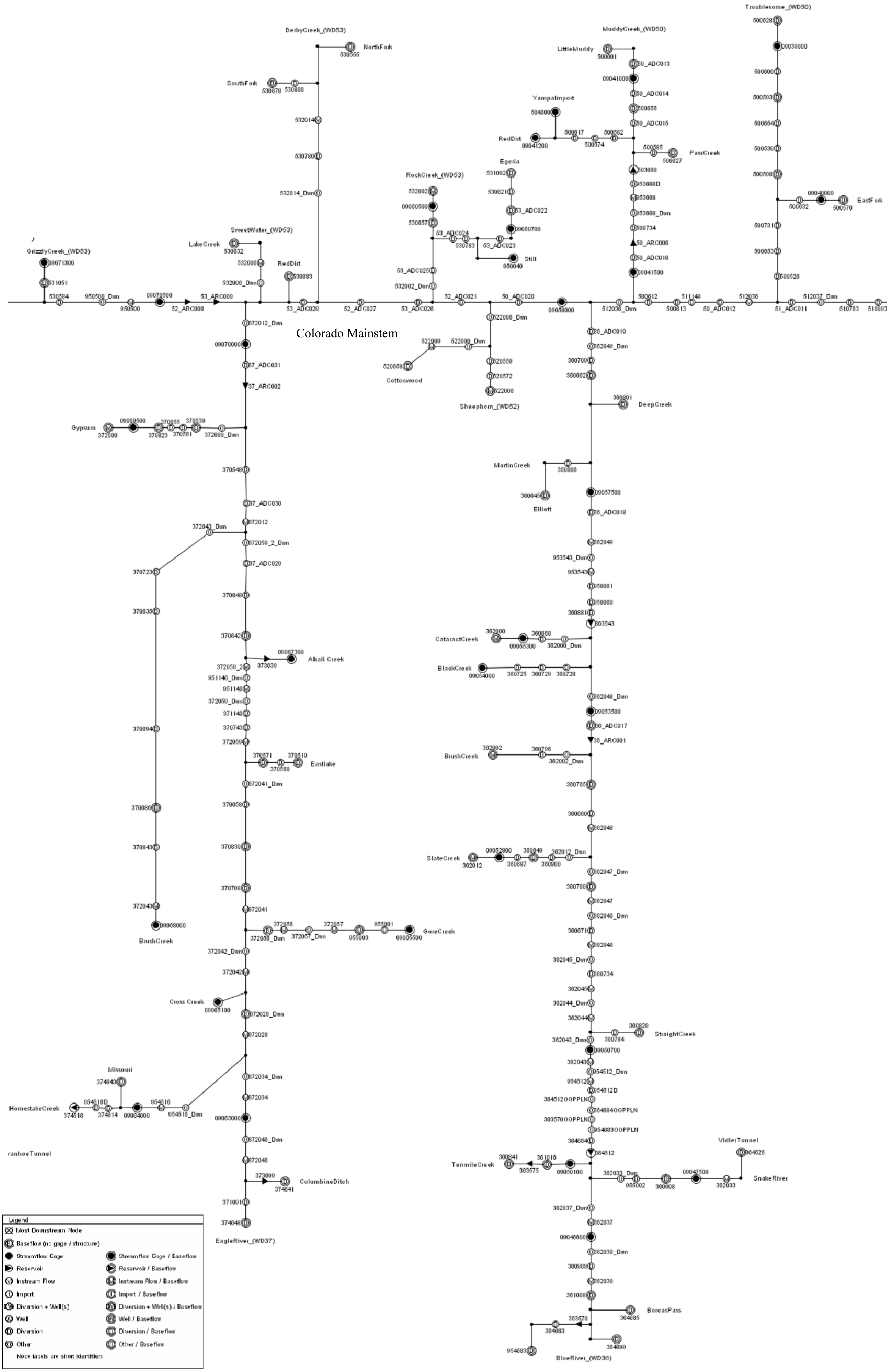


Figure 4.1b Network Diagram – Upper Colorado River Model from below Williams Fork to below Eagle River

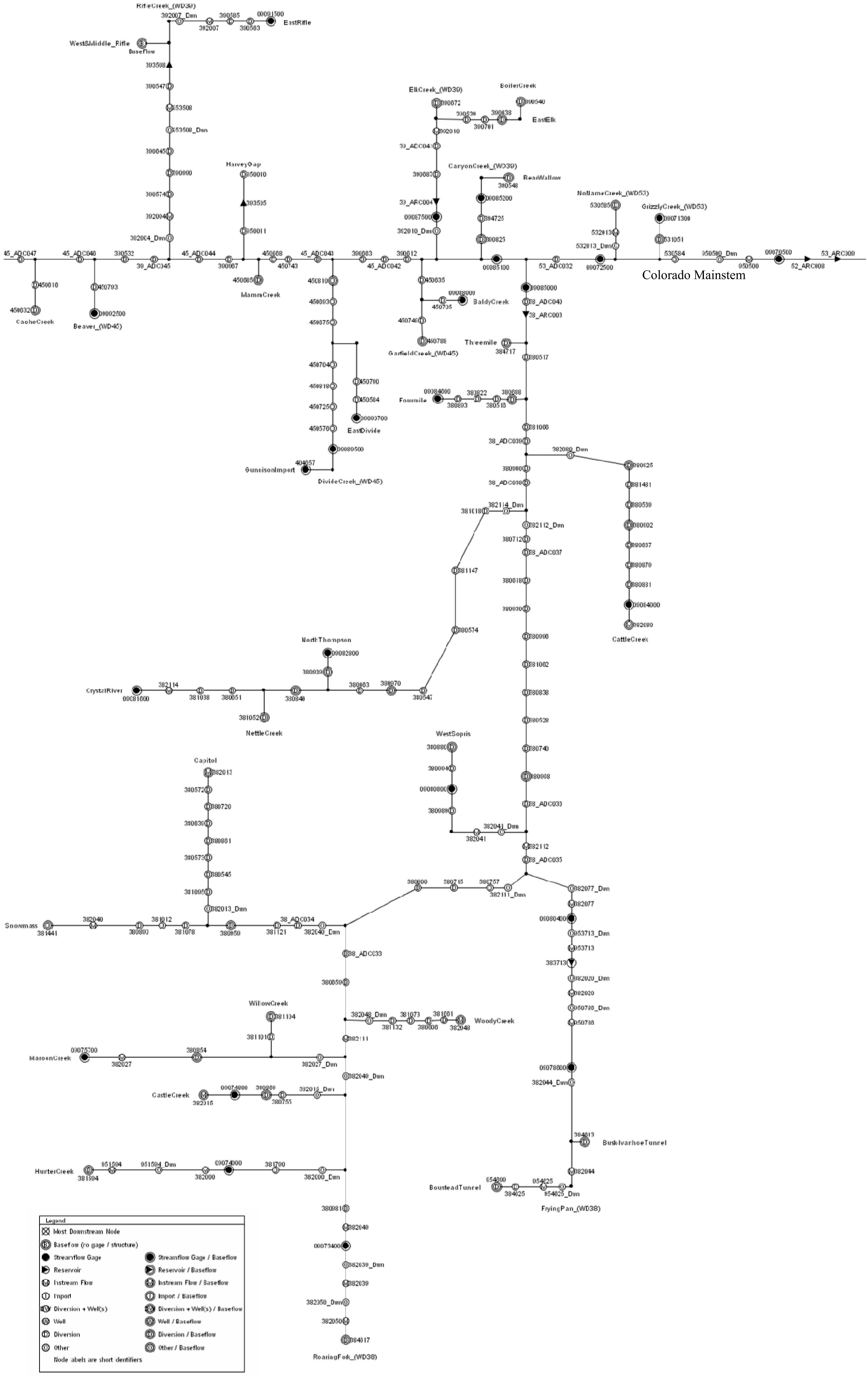


Figure 4.1c Network Diagram – Upper Colorado River Model from below Eagle River to below Rifle Creek

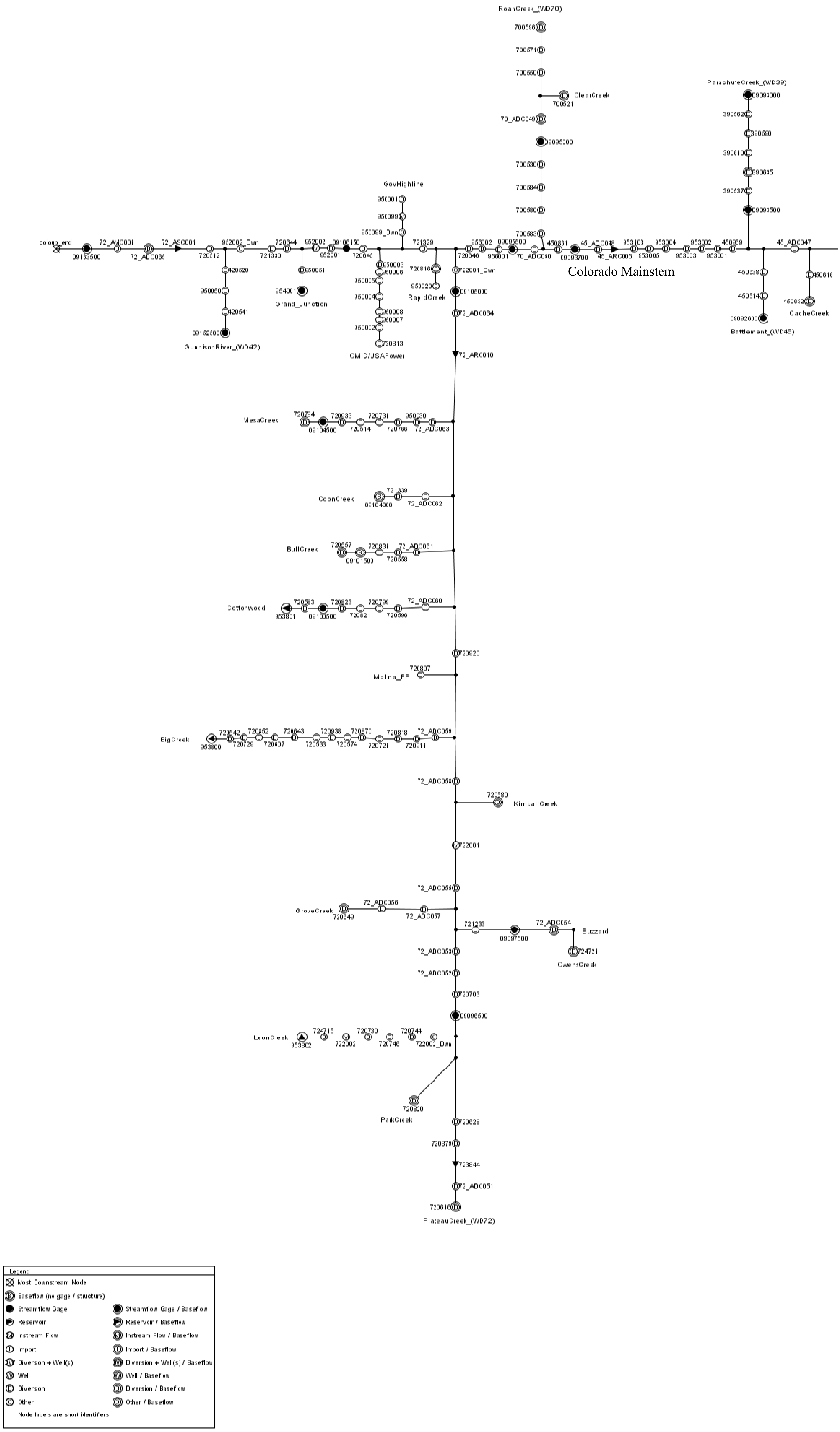


Figure 4.1d Network Diagram – Upper Colorado River Model from below Rifle Creek to the Colorado-Utah Border

4.2.2.2 Aggregation of Irrigation Structures

In general, the use associated with irrigation diversions having total absolute rights less than 11 cfs in the Upper Colorado River basin were included in the model at "aggregated nodes." These nodes represent the combined historical diversions, demand, and water rights of many small structures within a prescribed sub-basin. The aggregation boundaries were based generally on tributary boundaries, gage location, critical administrative reaches, and instream flow reaches. To the extent possible, aggregations were devised so that they represented no more than 2,200 irrigated acres. In the Upper Colorado River Model, 65 aggregated nodes were identified, representing around 75,000 acres of irrigated crops. These nodes were placed in the model at the most downstream position within the aggregated area.

Aggregated irrigation nodes were attributed the water rights associated with their constituent structures grouped into water right classes. Their historical diversions were developed by summing the historical diversions of the individual structures, and their irrigation water requirement is based on the total acreage associated with the aggregation.

Where to find more information

- Appendix A includes a memorandum describing the task in which irrigation structures were aggregated. It includes a table showing what diversion structures are included in each aggregation, and a description of where they are located in the model network. Appendix A also includes a memorandum describing the selection of water right classes for aggregate structures.

4.2.2.3 Municipal and Industrial Uses

One node in the model is a place-holder to represent the combined small diversions for municipal, industrial, and livestock use (M&I). Total non-irrigation consumptive use in the Upper Colorado River basin was estimated, as documented in the CDSS task memorandum "Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Upper Colorado River Basin."

The one aggregated M&I node in the Upper Colorado River Model represents approximately 0 acre-feet of consumptive use. The diversion has a priority of 1.0 (very senior) in the model, and a decreed amount equal to 0 cfs. In other words, this structure is not used but was retained for future scenarios.

Several diversions for municipal and industrial use are modeled explicitly in the Upper Colorado River Model. These explicitly modeled municipal diversions include the Town of Breckenridge, Town of Keystone, Dillon Valley Water and Sanitation District, Town of Dillon, Town of Vail, Upper Eagle Valley Water Authority, Town of Eagle, Town of Rifle, City of Glenwood Springs, Town of Snowmass, City of Aspen, Town of Carbondale, City of

Grand Junction, Town of Palisade, and the Ute Water Conservancy District. Five industrial diversions for power generation and mining are explicitly modeled including Molina Power Plant, Shoshone Power Plant (a.k.a. the Glenwood Power Canal), Redlands Power Canal, Climax Mine and Mill, and Henderson Mine.

Where to find more information

- Appendix B includes a memorandum describing the task in which municipal and industrial uses were aggregated.

4.2.3. Reservoirs

4.2.3.1 Key Reservoirs

Reservoirs with decreed capacities equal to or in excess of 4,000 acre-feet are considered key reservoirs, and are explicitly modeled. There are 18 key reservoirs with a combined total capacity of approximately 1,370,000 acre-feet, or 94 percent of the total modeled storage capacity of the basin. Two reservoirs with capacity of less than 4,000 acre-feet are included in the 18 key reservoirs and are explicitly modeled because they are key components in operational systems.

Two additional reservoirs were added as placeholders for future modeling efforts. Wolcott reservoir has not been constructed but has the potential to significantly impact basin operations and is likely to be analyzed in future “what-if” scenarios. Eagle Park reservoir is a small reservoir on the Eagle River used for augmentation.

4.2.3.2 Aggregation of Reservoirs

In keeping with CDSS’s objective of representing all consumptive use in the basin, the evaporation losses associated with small reservoirs and stock ponds were incorporated using 10 aggregated reservoir structures and 1 aggregated stock pond structure. Each aggregated reservoir and stock pond was assigned one account and an initial storage equal to its capacity. It was estimated to be 10 feet deep and was assigned a 3 point area-capacity curve. The first point is zero capacity and zero area. The second point is total capacity with the area equal to the total capacity divided by 10. The third point is a very large capacity with the area equal to the total capacity divided by 10.

Ten structures were used to represent the adjudicated, absolute storage rights in the database that are otherwise unaccounted for. Table 4.1 below summarizes storage capacity for the ten aggregated reservoirs.

Table 4.1
Aggregated Reservoirs

ID	WD	Name	Capacity (AF)	%
36_ARC001	36	36_ARC001	8,702	10
37_ARC002	37	37_ARC002	6,671	8
38_ARC003	38	38_ARC003	13,074	15
39_ARC004	39	39_ARC004	2,236	2
45_ARC005	45	45_ARC005	2,054	2
50_ARC006	50	50_ARC006	11,481	13
51_ARC007	51	51_ARC007	8,480	10
52_ARC008	52	52_ARC008	821	1
53_ARC009	53	53_ARC009	8,389	10
72_ARC010	72	72_ARC010	25,664	29
		Total	87,572	100

The one remaining reservoir represents stock pond use, as documented in CDSS Task 2.09-10 Memorandum "Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Upper Colorado River Basin". The total storage was aggregated into one stock pond as shown in Table 4.2.

Table 4.2
Aggregated Stock Ponds

ID	WD	Name	Capacity (AF)	%
72_ASC001	72	72_ASC001	2,261	100
		Total	2,261	100

Neither the aggregated reservoirs nor the stock pond release to the river in the model. However, they evaporate and fill to replace the evaporated amount. The effects of small reservoirs filling and releasing are left "in the gage" in the model, and are reflected in CDSS baseflow computations. The aggregated reservoirs are assigned storage rights with a priority of 1.0 (very senior) so that the evaporation use is not constrained by water rights.

> **Where to find more information**
>
> - Appendix B includes a memo describing the task in which small reservoir and stock ponds use was aggregated.

4.2.4. Instream Flow Structures

The model includes 105 instream flow reaches representing instream flow rights held by CWCB, minimum reservoir release agreements, filings by the U.S. Department of the Interior, and recreational instream channel diversions. These are a subset of the total CWCB tabulation of rights because many instream flow decrees are for stream reaches very high in the basin, above the model network.

4.3 Modeling Period

The Upper Colorado River Model data set extends from 1909 through 2005 and operates on USGS water year (October 1 through September 30). The calibration period was 1975 through 2005, a period selected because historical diversion data were readily available in electronic format for key structures. In addition, the period reflects most recent operations in the basin, and includes both drought (1977, 1989-1992, 2000-2003) and wet cycles (1983-1985).

As one goes back in time within the data set, more and more data are estimated. Before extending the data set, a feasibility study was done which included a survey of available data and methods for data extension. The scope of the study included the five western slope planning models.

> **Where to find more information**
>
> - The feasibility study for the data extension is documented in two task memos, which are collected in the CDSS Technical Papers:
>
>   -Data Extension Feasibility
>
>   -Evaluate Extension of Historical Data

4.4 Data Filling

In order to extend the data set to 1909, a substantial amount of reservoir content, diversion, demand, and baseflow time series data needed to be estimated. In many areas of the Upper Colorado River basin, HydroBase data begins in 1975, although for some structures there is additional, earlier historical data. Therefore, major structures were selected for additional investigation outside the database, or outside the standard CDSS data tables in the case of reservoir contents. CDSS tools were then developed to automate the estimation process for the remaining structures. This section describes data filling and extension for the Upper Colorado River Model.

4.4.1. Historical Data Extension For Major Structures

4.4.1.1 Historical Diversions

Thirteen major diversions in the Upper Colorado River basin were identified as warranting additional investigation to find actual diversion records prior to 1975, as shown in Table 4.3. Most of the structures had diversion records stored in HydroBase from November 1974 through the current year. Available records prior to 1975 were digitized from SEO, Denver Water, and USBR records to complete historic diversions

Table 4.3
Investigated and Extended Major Structures

WDID	Name	1909-2005 Annual Diversion
950050	Redlands Irrigation and Power (includes WDID 420541)	44,021
720646	Grand Valley Project – Roller Dam	758,491
514655	Moffat Tunnel	33,609
514634	Alva B. Adams Tunnel	212,982
514603	Gumlick Tunnel	3,331
511310	Vasquez Diversions	10,539
511309	St. Louis Diversions	4,578
511269	Denver Water Ranch Creek Diversions	4,085
510958	Willow Creek Feeder	15,857
510728	Englewood Ranch Creek Diversions	1,335
510639	Jim Creek Diversions	9,199
510529	Big Lake Ditch	25,516
380757	Home Supply Ditch	17,735

4.4.1.2 Historical Reservoir Contents

Historical reservoir content data is not complete in HydroBase. Therefore, some historical information for the major reservoirs was collected from several sources, including the U.S. Bureau of Reclamation and reservoir owners and operators. It was necessary to include data from sources other than HydroBase for some of the explicitly modeled reservoirs.

4.4.2. Automated Time Series Filling

An automated procedure was adopted to fill time series (i.e., historical diversions, demand, historical reservoir contents, reservoir targets, and irrigation water requirement) input to the model. It is a refinement over using an overall monthly average as the estimated value. Each month of the modeling period was categorized as an Average, Wet, or Dry month based on the gage flow at long-term "indicator" gages in the Upper Colorado River basin. A data point missing for a Wet March, for example, was filled with the average of other Wet Marches in the partial time series, rather than all Marches.

The process of developing the Average, Wet, and Dry designation for each month is referred to as "streamflow characterization". There are five streamflow characterizations in the Upper Colorado River basin, based on five indicator gages:

- 09034500 - Colorado River at Hot Sulphur Springs, CO
- 09037500 - Williams Fork River Near Parshall, CO
- 09085000 - Roaring Fork River at Glenwood Springs
- 09095500 - Colorado River Near Cameo
- 09152500 - Gunnison River Near Grand Junction

The characterization for the Hot Sulphur Springs gage is used when filling in time series for structures in Districts 50 and portions of 51. The Williams Fork gage characterization pertains to District 36 and portions of 51. The Roaring Fork gage characterization pertains to Districts 37, 38, 39, 52, and 53. The Cameo gage characterization pertains to Districts 45, 70, and 72. The Gunnison gage characterization pertains to District 42.

Months with gage flows at or below the 25^{th} percentile for that month are characterized as "Dry", while months at or above the 75^{th} percentile are characterized as "Wet", and months with flows in the middle are characterized as "Average".

- When historical diversion records are filled, a constraint is added to the estimation procedure. The estimated diversion may not exceed the water rights that were available to the diversion at the time. For example, if a ditch was enlarged and a junior right added to it in the 1950s, then a diversion estimate for 1935 cannot exceed the amount of the original right. The date of first use is derived from the administration number of the water right, which reflects the appropriation date.
- Crop irrigation water requirements for each diversion are calculated for the period 1975 through the current year, based on historical climate data and current irrigated acreage and crop type. Irrigation water requirements are filled back to 1909 using the wet/dry/average approach adopted for historic diversion.

Where to find more information

- A proof-of-concept effort with respect to the automated data filling process produced the following task memos, which are collected in the CDSS Technical Papers:

  -Data Extension Feasibility

  -Evaluate Extension of Historical Data

  -Characterize Streamflow Data

  -Verify Diversion Estimates

  These memos describe rationale for the data-filling approach, explore availability of basic gage data, explain the streamflow characterization procedure, and provide validation of the methods.
- **StateDMI** documentation describes the Streamflow Characterization Tool, a calculator for categorizing months as Average, Wet, or Dry
- **TSTool** documentation describes how to invoke the automated data filling procedure

4.4.3. Baseflow Filling

A typical approach to filling missing hydrologic sequences in the process of basin modeling is to develop regression models between historical stream gages. The best fitting model is then applied to estimate missing data points in the dependent gage's record. Once gage flow time series are complete, observed or estimated diversions, changes in storage, and so forth are added to or subtracted from the gage value to produce an estimated naturalized flow or baseflow.

The typical approach was deemed inadequate for a study period that extended over decades and greatly changed operating environments. Gage relationships derived from late-century gage records probably are not applicable to much earlier conditions, because the later gages reflect water use that may not have occurred at the earlier time. The CDSS approach is therefore to estimate baseflows at points where actual gage records are available, and then correlate between naturalized flows, as permitted by availability of data. Ideally, since baseflows do not reflect human activity, the relationship between two sets of baseflows is independent of the resource use and can be applied to any period.

Baseflow filling is carried out more or less automatically using the USGS Mixed Station Model, enhanced for this application under the CDSS project. The name refers to its ability to fill many series, using data from available stations. Many independent stations can be used to fill one time series, but only one station is used to fill each individual missing value. The Mixed Station Model fits each combination of dependent and independent variable with a linear regression relationship on log-transformed values, using the common period of record. For each point to be filled, the model then selects the regression that yields the least standard error of prediction

(SEP), among eligible correlations. Note that TSTool is being enhanced to include the functionality of the Mixed Station Model for use with future modeling updates.

The further one goes back in time, the fewer gage records exist to create baseflow series that can serve as independent variables. In 1920, there were 9 gages in the Upper Colorado River basin that have enough continuity in records to be used in the modeling effort. By 1950, the number of gages used in the model with data increased to 38. Approximately 58 percent of the gage site baseflows are filled.

Where to find more information

- The task memorandum documenting application of the Mixed Station Model to CDSS baseflows is entitled “Subtask 11.10 Fill Missing Baseflows” and is in the CDSS Technical Papers. It describes a sensitivity investigation of the use of historical gage data in lieu of baseflow estimates when the latter is unavailable.

4.5 Consumptive Use And Return Flow Amounts

The related values, consumptive use and return flow, are key components of both baseflow estimation and simulation in water resources modeling. StateMod’s baseflow estimating equation includes a term for return flows. Imports and reservoir releases aside, water that was in the gage historically is either natural runoff or delayed return flow. To estimate the natural runoff, or more generally, the baseflow, one must estimate return flow. During simulation, return flows affect availability of water in the stream in both the month of the diversion and subsequent months.

For non-irrigation uses, consumptive use is the depletive portion of a diversion, the amount that is taken from the stream and removed from the hydrologic system by virtue of the beneficial use. The difference between the diversion and the consumptive use constitutes the return flow to the stream.

For irrigation uses, the relationship between crop consumptive use and return flow is complicated by interactions with the water supply stored in the soil, i.e., the soil moisture reservoir, and losses not attributable to crop use. This is explained in greater detail below.

4.5.1. Variable Efficiency Of Irrigation Use

Generally, the efficiency of irrigation structures in the Upper Colorado River Model is allowed to vary through time, up to a specified maximum efficiency. Setting aside soil moisture dynamics for the moment, the predetermined crop irrigation water requirement is met out of the simulated headgate diversion, and efficiency (the ratio of consumed water to diverted water) falls where it may – up to the specified maximum efficiency. If the diversion is too small to meet the irrigation requirement at the maximum efficiency, maximum efficiency becomes the controlling parameter. Crop consumption is limited to the diverted amount multiplied by maximum efficiency, and the balance of the diversion, less 3 percent of the non-consumed water, returns to the stream.

The 3 percent of non-consumed water represents water lost to the hydrologic system altogether through, for example, non-crop consumptive use, deep groundwater storage, or evaporation. Note that for the Upper Colorado River Model, 3 percent of non-consumed water represents approximately 10 percent of basin-wide crop consumptive use. This value is recommended as an appropriate estimate of incidental use for the CRDSS basins, and is the same value used in the StateCU estimate of Consumptive Use and Losses in the Upper Colorado River Basin. (Consumptive Uses and Losses Report, Comparison between StateCU CU & Losses Report and the USBR CU & Losses Report (1998-1995), October 1999, Leonard Rice Engineers)

The model is supplied with time series of irrigation water requirements for each structure, based on its crop type and irrigated acreage. This information can be generated using the CDSS StateCU model. Maximum efficiency is also input to the model. For the Upper Colorado River basin, maximum efficiency is estimated to be 54 percent.

Headgate diversion is determined by the model, and is calculated in each time step as the minimum of 1) the water right, 2) available supply, 3) diversion capacity, and 4) headgate demand. Headgate demand is input as a time series for each structure. During calibration, headgate demand for each structure is simply its historical diversion time series. In the Baseline data set, headgate demand is set to the irrigation water requirement for the specific time step and structure, divided by the historical efficiency for that month of the year. Historical efficiency is defined as the smaller of 1) average historical diversion for the month, divided by average irrigation water requirement, and 2) maximum efficiency. In other words, if water supply is generally plentiful, the headgate demand reflects the water supply that has been typical in the past; and if water supply is generally limiting, it reflects the supply the crop needs in order to satisfy potential ET at the maximum efficiency.

StateMod also accounts for water supply available to the crop from the soil. Soil moisture capacity acts as a small reservoir, re-timing physical consumption of the water, and affecting the amount of return flow in any given month. Soil moisture capacity is input to the model for each irrigation structure, based on NRCS mapping. Formally, StateMod accounts for water supply to the crop as follows:

Let **DIV** be defined as the river diversion, $\boldsymbol{\eta_{max}}$ be defined as the maximum system efficiency, and let $\mathbf{CU_i}$ be defined as the crop irrigation water requirement.

Then, $SW = DIV * \eta_{max}$ (Max available water to crop)

when $SW \geq CU_i$ (Available water to crop is sufficient to meet crop demand)

$CU_w = CU_i$ (Water supply-limited CU = Crop irrigation water requirement)

$SS_f = SS_i + \min[(SS_m - SS_i),(SW - CU_w)]$ (Excess available water fills soil reservoir)

$SR = DIV - CU_w - (SS_f - SS_i)$ (Remaining diversion is "non-consumed")

$TR = 0.97 * SR$ (Non-consumed less incidental loss is total return flow)

when $SW < CU_i$ (Available water to Crop is not sufficient to meet crop demand)

$CU_w = SW + \min[(CU_i - SW), SS_i]$ (Water supply-limited CU = available water to crop + available soil storage)

$SS_f = SS_i - \min[(CU_i - SW), SS_i]$ (Soil storage used to meet unsatisfied crop demand)

$SR = DIV - SW$ (Remaining diversion is "non-consumed")

$TR = 0.97 * SR$ (Non-consumed less incidental loss is total return flow)

where **SW** is maximum water available to meet crop demand

CU_w is water supply limited consumptive use;

SS_m is the maximum soil moisture reservoir storage;

SS_i is the initial soil moisture reservoir storage;

SS_f is the final soil moisture reservoir storage;

SR is the diverted water in excess of crop requirement (non-consumed water);

TR is the total return to the stream attributable to this month's diversion.

For the following example, the maximum system efficiency is 60 percent; therefore a maximum of 60 percent of the diverted amount can be delivered and available to the crop. When this amount exceeds the irrigation water requirement, the balance goes to the soil moisture reservoir, up to its capacity. Additional non-consumed water returns to the stream, subject to 3 percent incidental loss. In this case, the crop needs are completely satisfied, and the water supply-limited consumptive use equals the irrigation water requirement.

When 60 percent of the diverted amount (the water delivered and available to meet crop demands) is less than the irrigation water requirement, the crop pulls water out of soil moisture storage, limited by the available soil moisture and the unsatisfied irrigation water requirement. Water supply-limited consumptive use is the sum of diverted water available to the crop and supply taken from soil moisture, and may be less than the crop water requirement. Total return flow is the 40 percent of the diversion deemed unable to reach the field (non-consumed), less 3 percent incidental loss.

With respect to consumptive use and return flow, aggregated irrigation structures are treated as described above, where the irrigation water requirement is based on total acreage for the aggregate.

4.5.2. Constant Efficiency For Other Uses And Special Cases

In specific cases, the Upper Colorado River Model applies an assumed, specified annual or monthly efficiency to a diversion in order to determine consumptive use and return flows. Although the efficiency may vary by month, the monthly pattern is the same in each simulation year. This approach is applied to municipal, industrial, transbasin users, and reservoir feeder canals. It can also apply to irrigation diversions for which irrigation water requirement has not been developed.

In the Upper Colorado River Model, irrigation water requirements were developed for irrigation diversions. The transbasin and industrial diversions in the Upper Colorado River Model were assigned a diversion efficiency of 1.00 in all months. During both baseflow estimation and simulation, the entire amount of the diversion is estimated to be removed from the hydrologic system. Diversions for the use of hydroelectric power generation were assigned a diversion efficiency of zero in all months. The explicitly modeled municipal systems were assigned monthly efficiencies representing municipal consumptive use patterns. The one aggregated municipal demand, used as a placeholder for future scenarios, was modeled using zero demand and efficiencies set to 0.60 in all months.

Reservoir feeders and other carriers that do not irrigate lands were assigned a diversion efficiency of zero in all months, reflecting that 100 percent of the diversions "return" to the reservoirs or other locations. These feeders include the following:

- Elliott Creek Feeder Canal
- Missouri Tunnel
- Wolcott Pumping Pipeline
- West Three Mile Ditch
- Grass Valley Canal
- Willow Creek Feeder Canal
- Windy Gap Pumping Plant Canal
- Bonham Branch Pipeline
- Cottonwood Branch Pipeline
- Leon Park Feeder Canal
- Park Creek Diversion System
- Southside Canal
- Grand Valley Project
- Orchard Mesa Check
- OMID Bypass
- Owens Creek Ditch

Where to find more information

- StateCU documentation describes different methods for estimating irrigation water requirement for structures, for input to the StateMod model.
- Section 7 of the StateMod documentation has subsections that describe "Variable Efficiency Considerations" and "Soil Moisture Accounting"
- Section 5 of this manual describes the input files where the parameters for computing consumptive use and return flow amounts are specified:
  - Irrigation water requirement in the Irrigation Water Requirement file (Section 5.5.3)
  - Headgate demand in the Direct Diversion Demand file (Section 5.4.4)
  - Historical efficiency in the Direct Diversion Station file (Section 5.4.1)
  - Maximum efficiency in the CU Irrigation Parameter Yearly file (Section 5.5.2)
  - Soil moisture capacity in the StateCU Structure file (Section 5.5.1)
  - Loss to the hydrologic system in the Return Flow Delay Table file (Section 5.4.2)

4.6 Disposition of Return Flows

4.6.1. Return Flow Timing

Return flow timing is specified to the model by specifying what percentage of the return flow accruing from a diversion reaches the stream in the same month as the diversion, and in each month following the diversion month. Four different return flow patterns are used in the Upper Colorado River Model. One pattern represents instantaneous (or within the same month as the diversion) returns and is applied to municipal and non-consumptive diversions. Another pattern represents return flows from snow-making activities.

The other patterns are generalized irrigation return patterns, applicable to irrigated lands "close" to the stream (center of acreage is approximately 1,000 feet from the stream), and "further" from the stream (center of acreage is approximately 2,000 feet from the stream). They were developed using the Glover analytical solution for parallel drain systems. The State's Analytical Stream Depletion Model (September, 1978), which is widely used in determining return flows for water rights transfers and augmentation plans, permits this option for determining accretion factors. The two irrigation patterns used in Colorado representing "close" and "further" include a 3 percent incidental loss.

The Glover analysis requires these input parameters:

T = Transmissivity in gallons per day per foot (gpd/ft). Transmissivity is the product of hydraulic conductivity (K) in feet per day, saturated thickness (b) in feet, and the appropriate conversion factor.

S = Specific Yield as a fraction

W = Distance from stream to impervious boundary in feet (ft)

x = Distance from point of recharge to stream in feet (ft)

Q = Recharge Rate in gallons per minute (gpm)

Regionalized values for the aquifer parameters were determined by selecting ten representative sites throughout the west slope, based partly on the ready availability of geologic data, and averaging them. The analysis estimated generalized transmissivity as 48,250 gpd/ft, specific yield as 0.13, and distance from the stream to the alluvial boundary as 3,500 ft. The Glover analysis was then executed for 1,000 feet from the recharge center to the stream and 2,000 feet from the recharge center to the stream.

It was estimated that the resulting pattern applies to half of the return flow, and that the other half returns within the month via the surface (tailwater returns, headgate losses, etc.). Combining surface water returns with groundwater returns resulted in the two irrigation return patterns shown in Table 4.4 and graphed in Figure 4.2. Month 1 is the month in which the diversion takes place. Note that Figure 4.2 reflects 100 percent of unused water returning to the river, both from surface runoff and subsurface flow. For each CDSS basin, the first month's return flow percent will be reduced to recognize incidental loss. As discussed above, incidental losses in the Upper Colorado River Model are estimated to be 3 percent of unused water, as shown in Table 4.4.

Where to find more information

- CDSS Memorandum "Upper Colorado River Basin Representative Irrigation Return Flow Patterns", Leonard Rice Engineers, January, 2003 in the CDSS Technical Papers

4.6.2. Return Flow Locations

Return flow locations were determined during the original data gathering, by examining irrigated lands mapping and USGS topographical maps, and confirming locations with Division 5 personnel. Some return flow locations were modified during calibration.

Table 4.4
Percent of Return Flow Entering Stream in Month n after Diversion (3% loss)

Month *n*	**For Lands "Close" to Stream (%)**	**For lands "Further" from Stream (%)**
1	75.6	57.4
2	11.3	14.5
3	3.2	7.2
4	2.2	5.0
5	1.6	3.7
6	1.2	2.7
7	0.8	2.0
8	0.6	1.5
9	0.5	1.1
10	0	0.8
11	0	0.6
12	0	0.5
13 - 14	0	0
15 - 36	0	0
Total	97	97

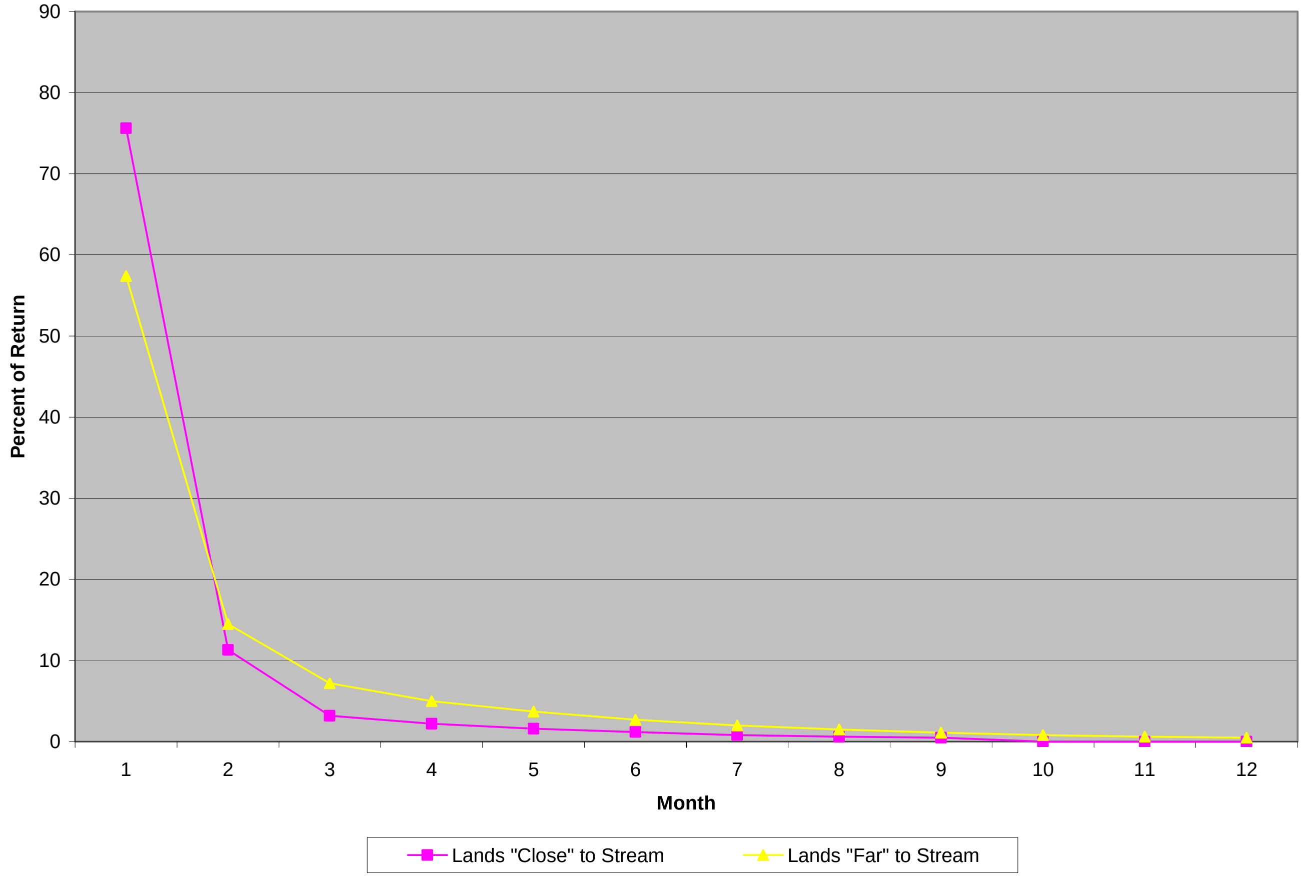


Figure 4.2 Percent of Return in Months After Division

4.7 Baseflow Estimation

In order to simulate river basin operations, the model must have the amount of water that would have been in the stream if none of the operations being modeled had taken place. These undepleted flows are called “baseflows”. The term is used in favor of “virgin flow” or “naturalized flow” because it recognizes that some historical operations can be left “in the gage”, with the estimation that those operations and impacts will not change in the hypothetical situation being simulated.

Given data on historical depletions and reservoir operations, StateMod can estimate baseflow time series at specified discrete inflow nodes. This process was executed prior to executing simulations, and the resulting baseflow file became part of the input data set for subsequent simulations. Baseflow estimation requires three steps: 1) adjust USGS stream gage flows using historical records of operations to get baseflow time series at gaged points, for the gage period of record; 2) fill the baseflow time series by regression against other baseflow time series; 3) distribute baseflow gains above and between gages to user-specified, ungaged inflow nodes. These three steps are described below.

4.7.1. Baseflow Computations At Gages

Baseflow at a site where historical gage data is available is computed by adding historical values of upstream depletive effects to the gaged value, and subtracting historical values of upstream augmenting effects from the gaged value:

$$Q_{baseflow} = Q_{gage} + Diversions - Returns - Imports +/- \Delta Storage + Evap +/- \Delta Soil\ Moisture$$

Historical diversions, imports, and reservoir contents are provided directly to StateMod to make this computation. Evaporation is computed by StateMod based on historical evaporation rates and reservoir contents. Return flows and soil storage are similarly computed based on diversions, crop water requirements, and/or efficiencies as described in Section 4.5, and return flow parameters as described in Section 4.6.

Where to find more information

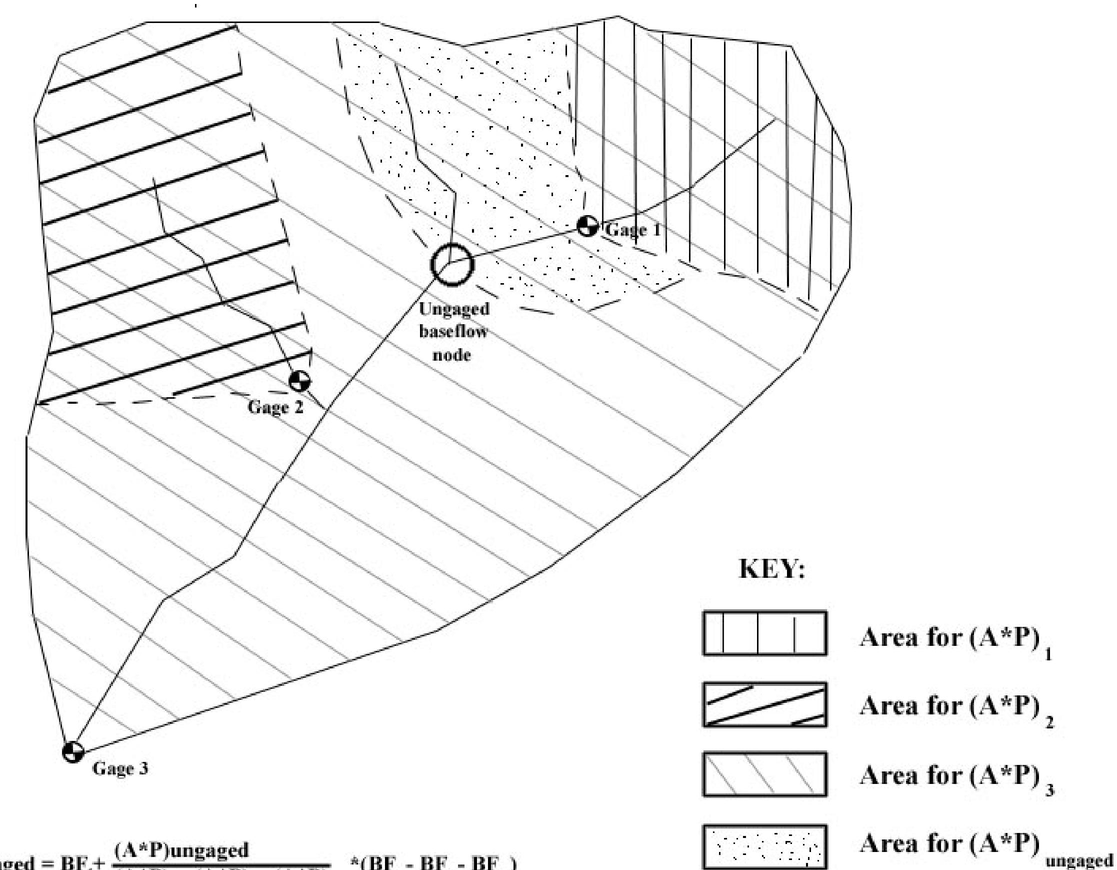
- When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file *(*.xbi)* that shows this computation for each gage and each month of the time step.

4.7.2. Baseflow Filling

Wherever gage records are missing, baseflows are estimated as described in Section 4.4.3 - Baseflow Filling.

4.7.3. Distribution Of Baseflow To Ungaged Points

In order for StateMod to have a water supply to allocate in tributary headwaters, baseflow must be estimated at all ungaged headwater nodes. In addition, baseflow gains between gages are modeled as entering the system at ungaged points, to better simulate the river's growth due to generalized groundwater contributions and unmodeled tributaries. As a matter of convention, key reservoir nodes were generally designated baseflow nodes in order for the model to "see" all the water supply estimated to be available at the site. During calibration, other ungaged nodes were sometimes made baseflow nodes to better simulate a water supply that would support historical operations.



$$BFungaged = BF_1 + \frac{(A^*P)ungaged}{(A^*P)_3 - (A^*P)_2 - (A^*P)_1} \;{}^*(BF_3 - BF_2 - BF_1)$$

Figure 4.3 Hypothetical Basin Illustration

StateMod has an operating mode in which, given baseflows at gaged sites and physical parameters of the gaged and ungaged sub-basins, it distributes baseflow gains spatially. The default method ("gain approach") for assigning baseflow to ungaged locations pro-rates baseflow gain above or between gages according to the product of drainage area and average annual precipitation. That is, each gage is assigned an "Area*Precipitation" (A*P) term, equal to the product of total area above the gage, and average annual precipitation over the gage's entire drainage area. Ungaged baseflow points are assigned an incremental "A*P", the product of the incremental drainage area above the ungaged baseflow point and below upstream gages, and the average annual precipitation over that area. Figure 4.3 illustrates a hypothetical basin and the areas associated with each of three gages and an ungaged location.

The portion of the baseflow gain below Gages 1 and 2 and above Gage 3, at the Ungaged location between the gages, is the gage-to-gage baseflow gain (BF_3 minus (BF_2 + BF_1)) times the ratio $(A*P)_{ungaged}/[(A*P)_{downstream\ gage} - \Sigma\ (A*P)_{upstream\ gage(s)}]$. Total baseflow at the ungaged location is equal to this term, plus the sum of baseflows at upstream gages. In the example there is only one upstream gage, having baseflow BF_1.

A second option for estimating headwater baseflows was sometimes invoked if the default method created results that did not seem credible. This method, referred to as the "neighboring gage approach", created a baseflow time series by multiplying the baseflow series at a specified gage by the ratio $(A*P)_{headwater}/(A*P)_{gage}$. This approach was effective, for example, for an ungaged tributary parallel and close to a gaged tributary.

Where to find more information

- Documentation for **StateDMI** describes computation of baseflow distribution parameters based on A*P, incremental A*P, and the network configuration.

4.8 Calibration Approach

Calibration is the process of simulating the river basin under historical conditions, and judiciously adjusting parameter estimates to achieve agreement between observed and simulated values of streamflow gages, reservoir levels, and diversions. The Upper Colorado River Model was calibrated in a two-step process described below. The issues encountered and results obtained are described in Section 7.

4.8.1. First Step Calibration

In the first calibration run, the model was executed with relatively little freedom with respect to operating rules. Headgate demand was simulated by historical diversions, and historical reservoir contents served as operational targets. The reservoirs would not fill beyond the historical content even if water was legally and physically available. Operating rules caused the reservoir to release to satisfy beneficiaries' demands, but if simulated reservoir content was higher than historical after all demand was satisfied, the reservoir released water to the river to achieve the historical end-of-month content. In addition, multiple-headgate collection systems would feature the historical diversion as the demand at each diversion point.

The objective of the first calibration run was to refine baseflow hydrology and return flow locations before introducing uncertainties related to rule-based operations. Diversion shortages, that is, the inability of a water right to divert what it diverted historically, indicated possible problems with the way baseflows were represented or with the location assigned to return flows back to the river. Baseflow issues were also evidenced by poor simulation of the historical gages. Generally, the parameters that were adjusted related to the distribution of baseflows (i.e., A*P parameters or the method for distributing baseflows to ungaged locations), and locations of return flows.

4.8.2. Second Step Calibration

In the second calibration run, constraints on reservoir operations were relaxed. As in the first calibration run, reservoirs were simulated for the period in which they were on-line historically. Reservoir storage was limited by water right and availability, and generally, reservoir releases were controlled by downstream demands. Exceptions were made for reservoirs known to operate by power or flood control curves, or other unmodeled considerations. In these cases, targets were developed to express the operation. For multi-structures in the Upper Colorado River Model, the centralized demand was placed at the final destination nodes, and priorities and legal availability govern diversions from the various headgates.

The objective of the second calibration step was to refine operational parameters. For example, poor calibration at a reservoir might indicate poor representation of administration or operating objectives. Calibration was evaluated by comparing simulated gage flows, reservoir contents, and diversions with historical observations of these parameters.

Where to find more information

- Section 7 of this document describes calibration of the Upper Colorado River Model.

4.9 Baseline Data Set

The Baseline data set is intended as a generic representation of recent conditions on the Upper Colorado Rivers, to be used for “what if” analyses. It represents one interpretation of current use, operating, and administrative conditions, as though they prevailed throughout the modeling period. Existing water resources systems are online and operational in the model from 1909 forward, as are junior rights and modern levels of demand. The data set is a starting point, which the user may choose to add to or adapt for a given application or interpretation of probable demands and near-term conditions. A particular example for scenario comparison would be the administration of the Blue River Decree. The Baseline data set models the Interim Agreement, other administration interpretations of the Blue River Decree could be developed and compared against current operations.

4.9.1. Calculated Irrigation Demand

In the Baseline data set, irrigation demand is set to a time series determined from crop irrigation water requirement and average irrigation efficiency for the structure. This “Calculated Demand” is an estimate of the amount of water the structure would have diverted absent physical or legal availability constraints. Thus if more water was to become available to the diverter under a proposed new regime, the model would show the irrigator with sufficient water rights diverting more than he did historically.

Calculated demands must account for both crop needs and irrigation practices. Monthly calculated demand for 1975 through 2005 is generated directly, by taking the maximum of crop irrigation water requirement divided by average monthly irrigation efficiency, and historic diversions. The irrigation efficiency may not exceed the defined maximum efficiency (54 percent), however, which represents a practical upper limit on efficiency for flood irrigation systems. Thus calculated demand for a perennially shorted diversion (irrigation water requirement divided by diversions is, on average, greater than 0.54) will be greater than the historical diversion for at least some months. By estimating demand to be the maximum of calculated demand and historical diversions, such irrigation practices as diverting to fill the soil moisture zone or diverting for stock watering can be mimicked more accurately.

Prior to 1975, calculated demands were filled using the automated time series filling technique described in Section 4.4.2. This is done because historical diversion records are generally not available until 1975 in the Upper Colorado River basin.

4.9.2. Municipal And Industrial Demand

Municipal and industrial demands were set to recent values or averages of recent records.

4.9.3. Transbasin Demand

Transbasin diversion demands for the Moffat System and Roberts Tunnel, representing current conditions over the 1950 through 2005 CRWAS modeling period, were provided by Denver Water Board. Transbasin diversion demands for Adams Tunnel and the Windy Gap Project representing current conditions over the 1950 through 2005 CRWAS modeling period were provided by Northern Colorado Water Conservancy District. Con-Hoosier transbasin diversion demands, representing current conditions over the 1950 through 2005 CRWAS modeling period, were provided by Colorado Springs. Demands for the period 1909 through 1049 were set to historical average monthly demands based on the provided data.

Other transbasin diversion demands for municipal use were set to historic average monthly diversions over the period 1998 through 2005 for the entire model period of 1909 through 2005. Transbasin diversion irrigation demands were filled from 1909 through 1974 and 1997 through 2005 using the “wet,” “dry,” and “average” patterns and previous baseline demands for the period 1975 through 1996.

4.9.4. Reservoirs

Reservoirs are represented as being on-line throughout the study period, at their current capacities. Initial reservoir contents were set to average September end-of-month contents over the period of record. During simulation, StateMod allows reservoir releases to satisfy unmet headgate demand, based on the reservoir being a supplemental supply to direct flow rights.

5. Baseline Data Set

This section describes each StateMod input file in the Baseline Data Set. The data set, described in more general terms in Section 4.9, is expected to be a starting point for users who want to apply the Upper Colorado River water resources planning model to a particular management issue. Typically, the investigator wants to understand how the river regime would change under a new use or different operations. The change needs to be quantified relative to how the river would look today absent the new use or different operation, which may be quite different from the historical record. The Baseline data set provides a basis against which to compare future scenarios. Users may opt to modify the Baseline data set for their own interpretation of current or near-future conditions. For instance, they may want to look at the effect of conditional water rights on available flow. The following detailed, file-by-file description is intended to provide enough detail that this can be done with confidence.

This section is divided into several subsections:

- Section 5.1 describes the response file, which lists names of the rest of the data files. The section tells briefly what is contained in each of the named files, so refer to it if you need to know where to find specific information.

- Section 5.2 describes the control file, which sets execution parameters for the run.

- Section 5.3 includes files that together specify the river system. These files express the model network and baseflow hydrology.

- Section 5.4 includes files that define characteristics of the diversion structures in the model: physical characteristics, irrigation parameters, historical diversions, demand, and water rights.

- Section 5.5 includes files that further define irrigation parameters for diversion structures.

- Section 5.6 includes files that define characteristics of the reservoir structures in the model: physical characteristics, evaporation parameters, historical contents, operational targets, and water rights.

- Section 5.7 includes files that define characteristics of instream flow structures in the model: location, demand, and water rights.

- Section 5.8 describes the characteristics of plan structures in the model: type, efficiency, return flow location, and failure criteria. The plan structures work in conjunction with operating rules.

- Section 5.9 describes the operating rights file, which specifies operations other than simple diversions, on-stream reservoir storage, and instream flow requirements. For example, the file specifies rules for reservoir releases to downstream users, diversions by exchange, and movement of water from one reservoir to another.

Where to find more information

- For generic information on every input file listed below, see the StateMod documentation. It describes how input parameters are used as well as format of the files.

5.1 Response File (*.rsp)

The response file was created by hand using a text editor, and lists other files in the data set. StateMod reads the response file first, and then "knows" what files to open to retrieve the remainder of the input data. The list of input files was slightly different depending on whether StateMod was being run to generate baseflows or to simulate. Since the "Baseline data set" refers to a particular simulation, the response file for the Baseline is presented first; it is followed by a description of the files used for baseflow generation.

5.1.1 For Baseline Simulation

The listing below shows the file names in *cm2009B.rsp*, describes contents of each file, and shows the subsection of this chapter where the file is described in more detail.

File Name	Description	Reference
cm2009.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 5.2
cm2009.rin	River Network file – lists every model node and specifies connectivity of network	Section 5.3.1
cm2009.ris	River Station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 5.3.2
cm2009.rib	Baseflow Parameter file – gives coefficients and related gage ID's for each baseflow node, with which StateMod computes baseflow gain at the node	Section 5.3.3
cm2009.rih	Historical Streamflow file – Monthly time series of streamflows at modeled gages	Section 5.3.4
cm2009x.xbm	Baseflow Data file – time series of undepleted flows at nodes listed in cm2009.ris	Section 5.3.5
cm2009.dds	Direct Diversion Station file – contains parameters for each diversion structure in the model, such as diversion capacity, return flow characteristics, and irrigated acreage served	Section 5.4.1
cm2009.dly	Delay Table file – contains several return flow patterns that express how much of the return flow accruing from diversions in	Section 5.4.2

File Name	Description	Reference
	one month reach the stream in each of the subsequent months, until the return is extinguished	
cm2009.ddh	Historical Diversions file – Monthly time series of historical diversions	Section 5.4.3
cm2009B.ddm	Monthly Demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
cm2009.ddr	Direct Diversion Rights file – lists water rights for direct diversion	Section 5.4.5
cm2009.str	StateCU Structure file – soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
cm2009.ipy	CU Irrigation Parameter Yearly file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
cm2009B.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3
cm2009B.res	Reservoir Station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1
cm2009.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
cm2009.eom	Reservoir End-of-Month Contents file – Monthly time series of historical reservoir contents	Section 5.6.3
cm2009B.tar	Reservoir Target file – monthly time series of maximum and minimum targets for each reservoir. A reservoir may not store above its maximum target, and may not release below the minimum target	Section 5.6.4
cm2009B.rer	Reservoir Rights file – lists storage rights for reservoirs	Section 5.6.5
cm2009.ifs	Instream Flow Station file – lists instream flow reaches	Section 5.7.1
cm2009.ifa	Instream Flow Annual Demand file – gives the decreed monthly instream flow demand rates	Section 5.7.2
cm2009B.ifm	Instream Flow Monthly Demand file – gives the decreed monthly instream flow demand rates that vary by year	Section 5.7.3
cm2009.ifr	Instream Flow Right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches	Section 5.7.4
cm2009.pln	Plan Data file – contains parameters for plan structures	Section 5.8
cm2009B.opr	Operational Rights file – specifies many different kinds of operations that were more complex than a direct diversion or an on-stream storage right. Operational rights could specify, for example, a reservoir release for delivery to a downstream	Section 5.9

File Name	Description	Reference
	diversion point, a reservoir release to allow diversion by exchange at a point which was not downstream, or a direct diversion to fill a reservoir via a feeder	

5.1.2 For Generating Baseflow

The baseflow file (*.xbm) that was part of the Baseline data set was created by StateMod and the Mixed Station Model in three steps described in Sections 4.7.1 through 4.7.3. In the first step, StateMod estimated baseflows at gaged locations, using the files listed in the response file cm2009.rsp. The baseflow response file calls for different diversion demands, reservoir station, reservoir targets, reservoir rights, instream flow demands, irrigation water requirement, and operational rights files from the Baseline response file; in these cases to reflect strictly historical data.

The baseflow time series created in the first run were partial series, because gage data was missing some of the time for most gages. The Mixed Station Model was used to fill the series, creating a complete series of baseflows at gages in a file named cm2009.xbf. The response file for the third step, in which StateMod distributed baseflow to ungaged points, was named cm2009x.rsp. The difference between the first-step response file cm2009.rsp and third-step response file cm2009x.rsp was that the cm2009.xbf file replaced the historical gage file cm2009.rih.

5.2 Control File (*.ctl)

The control file was hand-created using a text editor. It contains execution parameters for the model run, including the starting and ending year for the simulation, the number of entries in certain files, conversion factors, and operational switches. Many of the switches relate to either debugging output, or to integrated simulation of groundwater and surface water supply sources. The latter was developed for the Rio Grande basin and was not a feature of the Upper Colorado River Model. Control file switches are specifically described in the StateMod documentation. The simulation period parameters (starting and ending year) are the ones that users most typically adjust.

5.3 River System Files

5.3.1 River Network File (*.rin)

The river network file was created by StateDMI from the graphical network representation file created within StateDMI – StateMod Network interface (cm2009.net). The river network file describes the location and connectivity of each node in the model. Specifically, it is a list of each structure ID and name, along with the ID of the next structure downstream. It is an inherent characteristic of the network that, with the exception of the downstream terminal node, each node had exactly one downstream node.

Figures 4.1 and 4.2 in Section 4.2.1 illustrate the network, which starts at the major tributaries to the Upper Colorado River, including the Fraser River, Williams Fork River, Muddy Creek, Blue River, Eagle River, Roaring Fork River, Rifle Creek, and Plateau Creek. The last represented node on the Upper Colorado River is the Colorado River near Colorado-Utah State Line gage.

River gage nodes are labeled with United States Geological Survey (USGS) stream gaging station numbers (i.e., 09000000). In general, diversion and reservoir structure identification numbers are composed of Water District number followed by the State Engineer's four-digit structure ID. Instream flow water rights are also identified by the Water District number followed by the assigned State Engineer's four-digit identifier. Table 5.1 shows how many nodes of each type are in the Upper Colorado River Model.

Table 5.1
River Network Elements

Type	**Number**
Diversion	414
Instream Flow	105
Reservoirs	33
Stream Gages	84
Plan Structures	6
Other	93
Total	735

Where to find more information

- StateDMI documentation gives the file layout and format for the *.net* file.

5.3.2 River Station File (*.ris)

The river station file was created by StateDMI. It lists the model's baseflow nodes, both gaged and ungaged. These are the discrete locations where streamflow is added to the modeled system.

There are 84 gages in the model and 129 ungaged baseflow locations, for a total of 213 hydrologic inflows to the Upper Colorado River Model. Ungaged baseflow nodes include ungaged headwater nodes and other nodes where calibration revealed a need for additional baseflows. In the last case, a portion of the water that is simulated as entering the system further down (e.g., at the next gage) is moved up the system to the ungaged baseflow location.

5.3.3 Baseflow Parameter File (*.rib)

The baseflow parameter file contains an entry for each ungaged baseflow node in the model, specifying coefficients, or "proration factors", used to calculate the baseflow gain at that point. StateDMI computed proration factors based on the network structure and *area* multiplied by *precipitation* values supplied for both gages and ungaged baseflow nodes. This information is in the network file, which was input to StateDMI. Under the default “gain approach”, described in Section 4.7.3, the factors reflect the ratio of the product of incremental area and local average precipitation above the ungaged point to the product of incremental area and local average precipitation for the entire gage-to-gage reach.

At some locations, the hydrograph developed using the gain approach showed an attenuated shape that was not representative of a “natural” hydrograph. This occurred in headwater areas where the hydrograph was dominated by runoff from spring snowmelt. In these situations, baseflow was determined as a function of baseflow at a nearby stream gage, specified by the user. Ideally, this “neighboring gage” was from a drainage basin with similar physiographic characteristics. Baseflow at the ungaged site was estimated to be in the same proportion to baseflow at the nearby gage as the product of area and average precipitation at the two locations. This procedure, referred to as the “neighboring gage approach”, was applied to these structures:

Tributary Name	Baseflow WDID	Neighboring Gage
Elliot Creek	360645	09055300
Deep Creek	360801	09055300
Brush Creek	362002	09054000
Straight Creek	360829	09047500
Snowmass Creek	381441	09075700
Capitol Creek	382013	09075700
Snowmass Creek	380959	09075700
Willow Creek	381104	09075700
West & Middle Rifle Creeks	BaseFlow	09091500
Cache Creek	450632	09092600
Mamm Creek	450685	09089500
Divide Creek	450810	09089500
Garfield Creek	450788	09089500
Little Muddy Creek	500601	09041200
Pass Creek	500627	09041200
Crooked Creek	510594	09026500
Hamilton Creek	510728	09032000
Strawberry Creek	510941	09033500
Corral Creek	512061	09039000
Cottonwood Creek	520658	09060500
Sheephorn Creek	522006	09060500
Red Dirt Creek	530883	09060500
Lake Creek	530632	09071300
No Name Creek	530585	09085200
Grizzly Creek	531051	09085200
Grove Creek	720649	09097500
Kimball Creek	720580	09097500
Bull Creek	720557	09104500
Coon Creek	09104000	09104500
Bull Creek	09101500	09104500
Big Creek	953800	09097500
Rapid Creek	720764	09104500

In addition, a straight proration was used when an appropriate “neighboring gage” could not be identified due to unique characteristics of a structures’ drainage basin. For the structures in the following table, a percent of downstream baseflow to be applied at the structure location was directly set in StateDMI.

Tributary Name	Baseflow WDID	Baseflow Percent	Downstream Gage
Blue River	364512	100 %	09050700
Columbine Ditch	374641	20 %	09063000
Eagle River	374648	35 %	09063000
West Sopris Creek	380880	100 %	09080800
Hunter Creek	381594	80 %	09074000
Roaring Fork River	384617	70 %	09073400
Bobtail Creek	514603	80 %	09035500
Colorado River	514620	100 %	09019500
Hamilton Creek	510728	100 %	09032500
North Fork of Derby Creek	530555	18 %	09070500
South Fork of Derby Creek	530678	23 %	09070500
Egeria Creek	531082	100 %	09060700
Monte Cristo Creek	954683	40 %	09046600

Where to find more information

- Section 4.7.3 describes how baseflows were distributed spatially.

5.3.4 Historical Streamflow File (*.rih)

Created by TSTool, the historical streamflow file contains historical gage records from 1909 through 2005, for modeled gages. This file is used in stream baseflow generation and to create comparison output that is useful during model calibration. Records were taken directly from USGS tables in the database. In most cases, missing values, when the gage was not in operation, were denoted as such, using the value "-999." Table 5.2 lists the USGS gages used, their periods of record, and their average annual flows over the period of record. As footnoted in Table 5.2, some missing records were filled from other sources in the historical streamflow file. Large periods of missing data are specified, however, most gages listed had days, months, or years missing within the full period.

Table 5.2
Historical Average Annual Flows for Modeled Upper Colorado River Stream Gages

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09010500	Colorado R Below Baker Gulch, Nr Grand Lake, CO.	1954-2005	45,625
09011000	Colorado River Near Grand Lake, CO.	1905-1909 1911-1918 1934-1986	63,422
09019500	Colorado River Near Granby[1]	1909-1911 1935-2005	81,354
09021000	Willow Creek Below Willow Creek Reservoir[2]	1935-1982	32,550
09024000	Fraser River At Winter Park	1911-2005	17,930
09025000	Vasquez Creek At Winter Park, CO.	1935-2005	10,244
09026500	St. Louis Creek Near Fraser, CO.	1935-2005	18,471
09032000	Ranch Creek Near Fraser, CO.	1935-2005	10,159
09032499	Meadow Creek Reservoir Inflow[3]	1976-1992	8,064
09032500	Ranch Creek Near Tabernash, CO.	1935-1960	27,147
09033500	Strawberry Creek Near Granby, CO.	1937-1945	4,835
09034250	Colorado River At Windy Gap, Near Granby, CO.	1982-2005	183,828
09034500	Colorado River At Hot Sulphur Springs, CO.	1905-1909 1911-1912 1914-1924 1926-1928 1930-1994	312,568
09034800	Little Muddy Creek Near Parshall, CO.	1959-1965	2,140
09034900	Bobtail Creek Near Jones Pass, CO.	1966-2005	7,486
09035500	Williams Fork Below Steelman Creek, CO.	1934-1941 1966-2005	14,534
09036000	Williams Fork River Near Leal, Co	1934-2005	70,977
09037500	Williams Fork River Near Parshall, Co	1905-1924 1934-2005	90,883
09038500	Williams Fork River Below Williams Fork Reservoir	1949-1954 1959-2005	90,464
09039000	Troublesome Creek Near Pearmont, CO.	1954-1993	21,626
09040000	East Fork Troublesome C Near Troublesome, CO.	1937-1943 1954-1983	20,860
09041000	Muddy Creek Near Kremmling, CO.	1938-1943 1956-1971 1994-1999	40,495

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09041200	Red Dirt Creek Near Kremmling, CO.	1956-1974	13,741
09041500	Muddy Creek At Kremmling, CO.	1982-1995	66,565
09046600	Blue River Near Dillon, CO.	1958-2005	75,457
09047500	Snake River Near Montezuma, CO.	1943-1946 1952-2005	44,769
09050100	Tenmile Creek Below North Tenmile Creek At Frisco	1958-2005	72,206
09050700	Blue River Below Dillon Reservoir	1960-2005	148,763
09052800	Slate Creek At Upper Station, Near Dillon, CO.	1967-1994	18,652
09053500	Blue River Above Green Mountain Reservoir, CO.	1944-1971 1986-1987	292,702
09054000	Black Creek Below Black Lake, Near Dillon, CO.	1942-1949 1967-1994	22,993
09055300	Cataract Creek Near Kremmling, CO.	1967-1994	14,490
09057500	Blue River Below Green Mountain Reservoir	1943-2005	322,198
09058000	Colorado River Near Kremmling	1905-1918 1962-1970 1972-2005	842,653
09060500	Rock Creek Near Toponas, CO.	1953-1980	23,862
09060700	Egeria Creek Near Toponas, CO.	1966-1973	7,521
09063000	Eagle River At Red Cliff, CO.	1911-1925 1945-2005	32,950
09064000	Homestake Creek At Gold Park, CO.[4]	1948-2005	29,936
09065100	Cross Creek Near Minturn	1957-1963 1968-2005	37,602
09065500	Gore Creek At Upper Station, Near Minturn, CO.	1948-1956 1964-2005	21,494
09067300	Alkali Creek Near Wolcott, CO.	1959-1965	1,541
09068000	Brush Creek Near Eagle, CO.	1951-1972	31,966
09069500	Gypsum Creek Near Gypsum, CO.	1951-1955 1966-1972	23,470
09070000	Eagle River Below Gypsum	1947-2005	409,558
09070500	Colorado River Near Dotsero	1941-2005	1,495,720
09071300	Grizzly Creek Near Glenwood Springs, CO.	1977-1996	9,755
09072500	Colorado River At Glenwood Springs, CO.	1899-1966	1,929,298
09073400	Roaring Fork River Near Aspen[5]	1911-1921 1933-2005	84,130
09074000	Hunter Creek Near Aspen	1950-1956 1970-2005	32,330
09074800	Castle Creek Above Aspen, CO.	1970-1994	31,448
09075700	Maroon Creek Above Aspen, CO.	1970-1994	49,076
09078600	Fryingpan River Near Thomasville[6]	1976-1999 2002-2005	128,236
09080400	Fryingpan River Near Ruedi	1965-2005	131,229
09080800	West Sopris Creek Near Basalt, CO.	1964-1968	2,858
09081600	Crystal River Above Avalanche Creek Near Redstone	1956-2005	213,387
09082800	North Thompson Creek Near Carbondale, CO.	1964-1979	12,055
09084000	Cattle Creek Near Carbondale, CO.	1951-1955 1963-1972	11,069
09084600	Fourmile Creek Near Glenwood Springs, CO.	1958-1965	6,010
09085000	Roaring Fork River At Glenwood Springs	1906-1909 1911-2005	936,280
09085100	Colorado River Below Glenwood Springs	1967-2005	2,404,180

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09085200	Canyon Creek Above New Castle, CO.	1969-1986	39,853
09087500	Elk Creek At New Castle, CO.	1922-1924 1955-1960	68,366
09088000	Baldy Creek Near New Castle	1956-1961	3,842
09089500	West Divide Creek Near Raven[7]	1956-2005	27,061
09090700	East Divide Creek Near Silt, CO.	1960-1965	7,712
09091500	East Rifle Creek Near Rifle, CO.	1937-1943 1957-1964	27,742
09092500	Beaver Creek Near Rifle	1953-1982	3,369
09092600	Battlement Creek Near Parachute	1957-1965	6,032
09093000	Parachute Creek Near Parachute CO.	1949-1954 1965-1970 1975-1986	24,184
09093500	Parachute Creek At Parachute, CO.	1921-1927 1949-1954 1975-1982	22,385
09093700	Colorado River Near De Beque	1967-1997	2,795,201
09095000	Roan Creek Near De Beque, CO.	1921-1926 1963-1972 1975-1981	30,653
09095500	Colorado River Near Cameo	1934-2005	2,767,839
09096500	Plateau Creek Near Collbran, CO.	1922-1980	51,968
09097500	Buzzard Creek Near Collbran	1922-1980	33,775
09100500	Cottonwood Creek At Upper Sta, Near Molina, CO.	1945-1957	10,994
09104500	Mesa Creek Near Mesa, CO.	1941-1960	8,515
09105000	Plateau Creek Near Cameo[8]	1936-1995 1997-2005	143,458
09152500	Gunnison River Near Grand Junction	1897-1899 1902-1906 1917-2005	1,834,467
09163500	Colorado River Near Colorado-Utah State Line	1951-2005	4,427,224

1) Winter months, where missing, were set to the minimum bypass requirement of 20 cfs; ungaged preemptive reservoir releases were added; data from 1954 through 1960 was filled from gage 09019000 – Colorado River below Lake Granby.
2) Data from 1935 through 1953 was filled from gage 09020000 – Willow Creek Near Granby, CO.; missing data from 1983 through 2005 was filled from daily Willow Creek Reservoir operation data provided by the U.S. Bureau of Reclamation.
3) Data from 1975 through 1991 provided by the Denver Water Board.
4) Missing data filled by log regression from gage 09064500 – Homestake Creek near Red Cliff, CO.
5) Missing data in 1983 filled by log regression from gage 09073300 – Roaring Fork River above Difficult Creek near Aspen; data prior to 1965 filled from gage 09073500 – Roaring Fork River at Aspen, CO.
6) Data prior to 1976 filled by log regression from gage 09078000 – Fryingpan River Near Norrie, CO.
7) For the water years 2000 through 2004 the months of November through March had missing data.
8) Data for water years 1984 and 1985 were filled using recommendations from the Leonard Rice Colorado River Basin Physical Water Availability Study (1995).

5.3.5 Baseflow File (*.xbm)

The baseflow file contains estimates of base streamflows throughout the modeling period, at the locations listed in the river station file. Baseflows represent the conditions upon which simulated diversion, reservoir, and minimum streamflow demands were superimposed. StateMod estimates baseflows at stream gages during the gage's period of record from historical streamflows, diversions, end-of-month contents of modeled reservoirs, and estimated consumption and return flow patterns. It then distributes baseflow at gage sites to ungaged locations using proration factors representing the fraction of the reach gain estimated to be tributary to a baseflow point.

Table 5.3 compares historical gage flows with simulated baseflows for the 32 gages that operated continuously during the calibration period (1975-2005). The difference between the two represents estimated historical consumptive use upstream of the gage over this period.

Table 5.3
Baseflow Comparison
1975-2005 Average (acre-feet/yr)

Gage ID	Gage Name	Baseflow	Historical	Difference
09010500	Colorado R Below Baker Gulch, Nr Grand Lake, CO.	64,057	45,792	18,265
09019500	Colorado River Near Granby	271,179	39,532	231,648
09024000	Fraser River At Winter Park	26,116	13,309	12,807
09025000	Vasquez Creek At Winter Park, CO.	25,238	10,289	14,949
09026500	St. Louis Creek Near Fraser, CO.	24,973	15,221	9,752
09032000	Ranch Creek Near Fraser, CO.	16,803	8,860	7,943
09034900	Bobtail Creek Near Jones Pass, CO.	7,564	7,564	0
09035500	Williams Fork Below Steelman Creek, CO.	18,212	14,124	4,088
09036000	Williams Fork River Near Leal, Co	76,605	72,517	4,088
09037500	Williams Fork River Near Parshall, Co	112,429	79,248	33,181
09038500	Williams Fork River Below Williams Fork Reservoir	118,003	92,719	25,284
09046600	Blue River Near Dillon, CO.	78,713	69,345	9,368
09047500	Snake River Near Montezuma, CO.	45,970	45,449	521
09050100	Tenmile Creek Below North Tenmile Creek At Frisco	77,290	75,063	2,227
09050700	Blue River Below Dillon Reservoir	228,101	146,624	81,477
09057500	Blue River Below Green Mountain Reservoir	389,490	301,300	88,190

Gage ID	Gage Name	Baseflow	Historical	Difference
09058000	Colorado River Near Kremmling	1,222,566	718,265	504,301
09063000	Eagle River At Red Cliff, CO.	33,782	28,262	5,520
09064000	Homestake Creek At Gold Park, CO.	45,375	19,824	25,550
09065100	Cross Creek Near Minturn	37,802	37,802	0
09065500	Gore Creek At Upper Station, Near Minturn, CO.	22,232	22,232	0
09070000	Eagle River Below Gypsum	469,868	407,419	62,449
09070500	Colorado River Near Dotsero	2,052,728	1,455,699	597,029
09073400	Roaring Fork River Near Aspen	109,303	71,115	38,188
09074000	Hunter Creek Near Aspen	40,427	30,203	10,225
09080400	Fryingpan River Near Ruedi	169,008	123,912	45,096
09081600	Crystal River Above Avalanche Creek Near Redstone	215,575	215,575	0
09085000	Roaring Fork River At Glenwood Springs	1,037,512	860,603	176,909
09085100	Colorado River Below Glenwood Springs	3,150,273	2,370,982	779,290
09095500	Colorado River Near Cameo	3,596,485	2,726,209	870,275
09152500	Gunnison River Near Grand Junction	1,841,070	1,841,072	-2
09163500	Colorado River Near Colorado-Utah State Line	5,690,447	4,585,370	1,105,077

Where to find more information

- Sections 4.7.1 through 4.7.3 explain how StateMod and the Mixed Station Model were used to create baseflows.
- When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file *(*.xbi*) that shows this computation for each gage and each month of the time step.
- When the Mixed Station Model is used to fill baseflows, it creates two reports, cm2009.*sum* and cm2009.*sts*. The first indicates which stations were used to estimate each missing data point, and the second compares statistics of the unfilled time series with statistics of the filled series for each gage.

5.4 Diversion Files

5.4.1 Direct Diversion Station File (*.dds)

StateDMI was used in two steps to create the direct diversion station file.

The direct diversion station file describes the physical properties of each diversion simulated in the Upper Colorado River Model. Table 5.4 is a summary of the Upper Colorado River Model's diversion station file contents, including each structure's diversion capacity, irrigated acreage served in 1993, average annual system efficiency, and average annual headgate demand. The average annual headgate demand parameter was summarized from data in the diversion demand file rather than the diversion station file, but it was included here as an important characteristic of each diversion station. In addition to the tabulated parameters, the *.dds file also specifies return flow nodes and average monthly efficiencies. Table 5.4 identifies diversion systems, municipal and industrial, carrier, and other non-irrigation structures in the table notes.

Generally, the diversion station ID, name, diversion capacity, and irrigated acreage were gathered from HydroBase, by StateDMI. Return flow locations were specified to StateDMI in a hand-edited file cm2009.rtn. The return flow locations and distribution were based on physical location of irrigated lands, discussions with Division 5 personnel, as well as calibration efforts. StateCU computed monthly system efficiency for irrigation structures from historical diversions and historical crop irrigation requirements, and StateDMI wrote them into the final *.dds file.

For non-irrigation structures, monthly efficiency was specified by the user as input to StateDMI. Baseline irrigation demand was assigned to primary structures of multi-structure systems, therefore primary and secondary structures of multi-structure systems were assigned the average monthly efficiencies calculated for the irrigation system based on irrigation water requirements and water delivered from all sources. If efficiency was constant for each month, it could be specified in the hand-edited file cm2009.rtn.

Note that unknown capacity was set to 999 by StateDMI. This number was significantly large so as not to limit diversions.

Table 5.4
Direct Flow Diversion Summary Average
1975-2005

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
1	360606	ELLIOTT CREEK FEEDER[2]	90	0	0	0
2	360645	GUTHRIE THOMAS DITCH	37	402	43	5,062
3	360649	Hamilton Davidson Div Sy[8]	63	813	45	7,247
4	360660	HIGH MILLER DITCH	25	116	37	2,829
5	360662	Hoagland Div Sys[9]	84	1,010	50	9,670
6	360671	INDEPENDENT BLUE DITCH	26	242	40	2,905
7	360687	KIRKWOOD DITCH	17	68	15	1,339
8	360709	LOBACK DITCH	76	567	43	7,145
9	360725	MARY DITCH	14	11	15	578

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
10	360728	MAT NO 1 DITCH	16	21	15	955
11	360729	MAT NO 2 DITCH	17	25	15	1,063
12	360734	MCKAY DITCH	23	110	38	1,713
13	360765	PALMER-MCKINLEY DITCH	25	85	15	2,183
14	360780	PLUNGER DITCH	62	32	15	1,168
15	360784	RANKIN NO 1 DITCH[3]	4	0	36	1,109
16	360796	SAUMS DITCH	17	91	37	1,757
17	360800	SLATE CREEK DITCH	30	89	15	1,678
18	360801	SMITH DITCH	40	635	49	4,105
19	360829	STRAIGHT CREEK DITCH[3]	4	0	36	1,027
20	360841	TENMILE DIVERSION NO 1[3]	53	0	100	0
21	360868	WESTLAKE DITCH	20	171	37	2,555
22	360881	GREEN MTN HYDRO-ELECTRIC[3]	726	0	0	84,952
23	360908	KEYSTONE SNOWLINE DITCH[3]	5	0	30	627
24	360989	MAGGIE POND (SNOWMAKING) [3]	999	0	100	250
25	361008	BRECKENRIDGE PIPELINE[3]	5	0	36	2,185
26	361016	COPPER MTN SNOWMAKING[3]	3	0	30	332
27	364626	VIDLER TUNNEL COLL SYS[5]	27	0	100	422
28	364683	CON-HOOSIER SYS BLUE R D[2,5]	500	0	100	0
29	364684	BLUE RIVER DIVR PROJECT[5]	520	0	100	69,153
30	364685	BOREAS NO 2 DITCH[5]	16	0	100	140
31	364699	CON-HOOSIER TUNNEL[2,5]	77	0	100	0
32	36_ADC017	Upper Blue River	320	1,896	40	21,850
33	36_ADC018	Blue River abv Green Mou	80	632	38	9,014
34	36_ADC019	Blue River bl Green Moun	139	1,554	47	10,547
35	370519	BRAGG NO 1 DITCH	12	15	15	1,436
36	370539	CHATFIELD BARTHOLOMEW D	42	892	49	5,176
37	370548	C M STREMME GATES DITCH	28	351	38	4,018
38	370560	CREAMERY DITCH	23	124	38	2,328
39	370561	DAGGETT AND PARKER DITCH	23	472	46	3,449
40	370571	J M DODD DITCH	18	94	15	2,282
41	370635	HERNAGE DITCH	14	107	39	1,356
42	370642	HOLLINGSWORTH DITCH	51	236	33	5,053
43	370655	H O R DITCH	19	297	48	2,146
44	370658	HOWARD DITCH	17	226	41	2,603
45	370686	LOVE AND WHITE DITCH	20	282	45	2,219
46	370694	MATHEWS DITCH	19	326	44	3,029
47	370708	METCALF DITCH	29	0	36	2,323
48	370723	NEILSON SOUTH DITCH	10	45	15	1,010
49	370743	ONEILL AND HOLLAND DITCH	30	197	37	3,124
50	370823	STRATTON AND CO DITCH	49	620	40	7,270
51	370830	TERRELL AND FORD DITCH	32	166	48	2,273
52	370843	UPPER FROST DITCH	12	120	40	1,314
53	370848	WARREN DITCH	36	174	15	4,233
54	371091	EWING PLACER DITCH[5]	19	0	100	733
55	371146	WOLCOTT PUMPING PIPELINE[2,22]	500	0	0	0
56	374614	HOMESTAKE PROJ TUNNEL[5]	300	0	100	17,198
57	374641	COLUMBINE DITCH[,5]	30	0	100	1,449
58	374643	HOMESTAKE PROJ CONDUIT[2,5]	600	0	0	0

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
59	374648	WARREN E WURTS DITCH[5]	85	0	100	1,884
60	37_ADC029	Eagle River abv Brush Cr	189	2,851	51	19,507
61	37_ADC030	Brush Creek	141	2,605	47	19,224
62	37_ADC031	Eagle River bl Gypsum	115	1,583	44	11,223
63	380516	ATKINSON DITCH	17	315	46	2,163
64	380517	ATKINSON CANAL	26	83	31	3,361
65	380528	BASIN DITCH	45	373	15	8,956
66	380545	BORAM AND WHITE DITCH	17	145	42	1,821
67	380547	BOWLES AND HOLLAND DITCH	39	200	32	5,126
68	380569	C AND M DITCH	14	700	54	3,042
69	380572	CAPITOL FALLS DITCH	22	140	15	2,543
70	380573	CAPITOL PARK DITCH	11	75	34	1,529
71	380574	CARBONDALE DITCH	41	91	17	9,905
72	380606	COLLINS CREEK DITCH	16	81	47	1,180
73	380618	CRANE AND PEEBLES DITCH	29	131	24	6,252
74	380639	DESERT DITCH	17	347	57	1,900
75	380651	EAST MESA DITCH	42	550	29	12,821
76	380659	ELI CERISE DITCH	15	198	40	3,012
77	380663	ELLA DITCH	35	208	15	5,752
78	380667	EUREKA NO 1 DITCH	12	116	51	859
79	380688	FOUR MILE DITCH	13	158	49	1,008
80	380712	GLENWOOD DITCH	61	550	27	18,913
81	380715	GRACE AND SHEHI DITCH	34	83	20	7,361
82	380720	GREEN MEADOW DITCH	25	578	51	4,162
83	380740	HARRIS & REED DITCH	32	229	29	6,979
84	380755	HOLDEN DITCH	30	177	37	3,945
85	380757	HOME SUPPLY DITCH	91	1,171	34	21,232
86	380800	KESTER DITCH	17	244	33	4,782
87	380822	LIGNITE DITCH	15	71	48	501
88	380838	LOWER DITCH	13	106	28	2,198
89	380840	LOWLINE DITCH	53	444	20	13,311
90	380854	MAROON DITCH[3]	68	0	36	3,068
91	380861	MAURIN DITCH	13	165	56	1,416
92	380869	MIDLAND FLUME DITCH[3]	160	0	36	4,445
93	380879	MONARCH DITCH	10	441	53	2,001
94	380880	Mt. Sopris Div Sys[10]	46	915	59	4,405
95	380881	MOUNTAIN MEADOW DITCH	107	340	34	7,764
96	380890	MCKENZIE WILDCAT DITCH	30	268	50	1,810
97	380893	MCKOWN DITCH	26	513	53	3,034
98	380902	NEEDHAM DITCH	27	710	60	3,442
99	380925	PARK DITCH	25	547	48	3,872
100	380930	PATERSON D JACOB EXT	104	72	28	20,297
101	380939	PIONEER DITCH	29	125	15	2,884
102	380959	RED ROCK BLUFF DITCH	17	206	37	3,398
103	380966	ROBERTSON DITCH	21	319	27	5,952
104	380968	ROBINSON DITCH	55	552	27	18,076
105	380970	ROCKFORD DITCH	45	320	26	9,977
106	380981	SALVATION DITCH	110	547	36	8,893
107	380989	SHIPPEE DITCH	13	69	36	1,046

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
108	380994	SLOSS DITCH	13	420	62	1,599
109	380996	SLOUGH D AND BANNING LAT	49	269	15	7,581
110	381012	SNOWMASS DIVIDE DITCH	33	262	37	3,464
111	381018	SOUTHARD AND CAVANAUGH	26	181	29	6,702
112	381038	SWEET JESSUP CANAL	75	1,251	31	17,525
113	381052	CARBONDALE WTR SYS & PL[3]	9	0	36	997
114	381062	UNION DITCH	31	166	15	3,535
115	381066	VAN CLEVE NO 1 DITCH	1	429	68	1,432
116	381073	WACO DITCH	40	503	39	5,595
117	381078	WALKER WONDER DITCH	72	305	15	5,845
118	381095	WILLIAMS NO 1 D CAP CR	15	43	35	1,440
119	381101	WILLOW CREEK DITCH	40	134	36	2,985
120	381104	WILLOW AND OWL DITCH	13	290	52	1,391
121	381121	ALEXIS ARBANEY DITCH	10	30	39	1,332
122	381132	WALTHEN DITCH	18	89	34	1,834
123	381147	KAISER AND SIEVERS DITCH	29	527	27	6,897
124	381441	EAST SNOWMASS BRUSH C PL[3]	15	0	36	1,309
125	381481	VAN CLEVE-FISHER FDR D	26	462	56	1,901
126	381594	FRY ARK PR HUNTER TUNNEL[5]	332	0	100	0
127	381661	SALVATION DITCH VAGN EXT	15	542	55	2,241
128	381790	RED MOUNTAIN EXT DITCH	25	401	49	4,817
129	384613	IVANHOE RESERVOIR TUNNEL[5]	120	0	100	4,594
130	384617	IND P TM DVR TUNNEL NO 1[5]	625	0	100	55,784
131	384625	FRY ARK PR BOUSTEAD TUNL[5]	1,000	0	100	0
132	384717	WEST THREE MILE DITCH[2]	14	0	0	345
133	38_ADC033	Upper Roaring Fork	330	2,621	30	29,939
134	38_ADC034	Snowmass Creek	133	2,472	47	18,223
135	38_ADC035	Frying Pan River	81	750	32	12,313
136	38_ADC036	West Sopris Creek	93	1,195	32	13,647
137	38_ADC037	Roaring Fork abv Crystal	3,083	2,156	29	21,391
138	38_ADC038	Crystal River	91	1,601	30	13,826
139	38_ADC039	Cattle Creek	55	1,502	49	7,280
140	38_ADC040	Lower Roaring Fork	38	1,318	57	4,668
141	390532	CLOUGH NO 1 DITCH	23	163	21	3,340
142	390537	CORNELL DITCH	16	301	43	1,892
143	390539	CORYELL DITCH	17	101	24	2,188
144	390540	CORYELL JOINT STOCK IRRI	20	585	51	2,831
145	390547	DAVIE DITCH	18	615	53	2,578
146	390548	DEWEESE DITCH	35	109	33	2,224
147	390562	GRANLEE DITCH	18	169	35	2,376
148	390563	GRASS VALLEY CANAL[2]	124	0	0	0
149	390574	GRAND TUNNEL DITCH	27	761	33	6,963
150	390585	HIBSCHLE BENBOW DITCH	7	145	38	1,283
151	390590	JANGLE DITCH	16	176	30	2,085
152	390610	LOW COST DITCH	29	334	26	4,576
153	390612	LOWER CACTUS VALLEY D	55	1,338	29	17,311
154	390635	PARACHUTE DITCH	27	189	30	2,089
155	390638	PIERSON AND HARRIS DITCH	28	36	31	921
156	390645	RIFLE CREEK CANON DITCH	41	1,110	29	11,239

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
157	390663	SILT PUMP CANAL[2]	36	0	0	0
158	390672	THOMPKINS DITCH	27	374	25	7,084
159	390687	WARE AND HINDS DITCH	57	824	22	13,998
160	390701	RED ROCK DITCH	10	286	58	1,476
161	390825	WILLIAMS CANAL	37	594	28	8,876
162	390967	RIFLE TOWN OF PUMP & PL[3]	9	0	36	1,609
163	390990	WEST LAT RIFLE CR CANON	7	229	37	1,730
164	394725	Vulcan Ditch Div Sys[11]	10	35	24	1,586
165	39_ADC041	Elk Creek	275	1,480	32	18,454
166	39_ADC045	Rifle Creek	65	1,541	52	7,347
167	420520	GRAND JCT GUNNISON PL[3]	19	0	36	69
168	420541	REDLANDS POWER CANAL[3]	790	0	0	418,344
169	450514	BATTLEMENT DITCH	18	628	54	3,351
170	450576	DIVIDE CREEK HIGHLINE D	169	4,788	54	20,106
171	450584	EAST DIVIDE CREEK DITCH	25	377	49	2,423
172	450616	H AND S DITCH	12	367	50	2,090
173	450632	HOLMES DITCH	11	531	54	2,248
174	450635	HUDSON & SULLIVAN DITCH	13	174	53	972
175	450638	HUNTLEY DITCH	13	194	37	1,569
176	450668	LAST CHANCE DITCH	60	1,019	30	11,810
177	450675	LOUIS REYNOLDS DITCH	10	173	52	918
178	450685	MAMM CREEK DITCH	12	770	65	2,413
179	450693	MINEOTA DITCH	19	649	57	3,123
180	450704	MULTA-TRINA DITCH	59	1,311	52	7,396
181	450705	MURRAY AND YULE DITCH	21	385	54	1,823
182	450725	PORTER DITCH	63	1,239	53	6,675
183	450743	RISING SUN DITCH	58	229	25	7,052
184	450749	RODERICK DITCH	20	373	54	1,651
185	450788	SYKES AND ALVORD DITCH	12	515	54	2,059
186	450790	TALLMADGE AND GIBSON D	50	1,089	54	4,891
187	450793	TAUGHENBAUGH DITCH	49	905	57	3,805
188	450810	WARD AND REYNOLDS DITCH	10	147	48	1,000
189	450818	WEST DIVIDE CREEK DITCH	18	615	54	2,871
190	450861	LARKIN DITCH	43	274	17	9,545
191	450969	BLUESTONE VALLEY DITCH	106	1,773	21	34,021
192	45_ADC042	Colorado River bl Garfie	145	1,728	43	11,101
193	45_ADC043	Colorado River bl Divide	129	1,933	52	9,961
194	45_ADC044	Colorado R bl Mamm Creek	105	3,463	56	11,305
195	45_ADC046	Colorado River bl Beaver	58	1,120	51	5,877
196	45_ADC047	Colorado River bl Cache	71	1,420	53	7,683
197	45_ADC048	Colorado River nr De Beq	202	2,182	49	14,517
198	500526	BLICKLEY DITCH	19	164	45	1,619
199	500539	CLIFF DITCH	31	251	52	1,290
200	500574	HARDSCRABBLE DITCH	32	630	52	3,396
201	500576	HAYPARK CANAL HGT NO 1	75	925	49	6,327
202	500582	HERDE DITCH	23	518	54	2,286
203	500585	HOGBACK DITCH	27	284	53	1,348
204	500593	KIRTZ DITCH NO 2	77	2,133	53	9,177
205	500598	LANDSLIDE DITCH	16	60	42	934

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
206	500601	MARTIN NO 1 DITCH	31	609	54	2,226
207	500606	MISSOURI DITCH	98	643	49	5,056
208	500612	MCELROY NO 1 DITCH	12	148	46	1,262
209	500613	MCELROY NO 2 DITCH	12	170	51	1,034
210	500617	MCMAHON DITCH	72	418	47	4,010
211	500627	PASS CREEK DITCH	13	243	52	1,251
212	500628	PICKERING DITCH	27	291	52	1,588
213	500632	PLEASANT VIEW DITCH	11	117	48	946
214	500653	TOM ENNIS DITCH	60	707	52	3,560
215	500654	TROUBLESOME DITCH	30	334	37	3,510
216	500656	TYLER DITCH	18	239	52	1,290
217	500731	CLIFF DITCH HGT NO 2	999	408	54	1,566
218	500734	Deberard Div Sys[12]	83	1,064	49	8,202
219	50_ADC012	Troublesome Creek	112	1,238	48	9,526
220	50_ADC013	Upper Muddy Creek	90	1,713	53	8,038
221	50_ADC014	Muddy Creek abv Tyler Di	103	1,544	51	8,469
222	50_ADC015	Muddy Creek abv Red Dirt	67	1,350	53	5,919
223	50_ADC016	Lower Muddy Creek	1,032	1,470	54	5,264
224	50_ADC020	Colorado River bl Kremml	87	1,424	46	10,290
225	510529	Big Lake Div Sys[13]	261	3,396	44	30,302
226	510546	BUNTE HIGHLINE DITCH	50	661	39	7,716
227	510585	COFFEE MCQUEARY DITCH	30	464	45	4,114
228	510594	CROOKED CREEK DITCH NO 1	25	712	53	2,966
229	510629	FARRIS SOUTH SIDE DITCH	14	236	44	2,131
230	510639	Jim_Creek[2,5]	999	0	100	0
231	510660	GASKILL DITCH	9	350	54	1,267
232	510699	HAMMOND NO 1 DITCH	18	329	36	2,890
233	510700	HAMMOND NO 2 DITCH	11	327	52	1,378
234	510728	HAMILTON-CABIN CR DITCH[2,5]	70	0	100	0
235	510763	KINNEY BARRIGER DITCH	114	521	37	8,831
236	510788	LYMAN DITCH	26	240	41	2,556
237	510810	MUSGRAVE DITCH	25	360	45	3,195
238	510829	PEAVEY NO 2 DITCH	6	726	54	2,463
239	510831	PETERSON DITCH NO 1	13	435	54	1,712
240	510848	REDTOP VALLEY DITCH	150	1,920	49	14,823
241	510858	ROCK CREEK DITCH	14	32	45	372
242	510876	SCYBERT DITCH	12	327	44	2,562
243	510880	SELAK LARRABEE DITCH	24	307	50	2,093
244	510883	SHERIFF DITCH (156)	20	117	43	2,032
245	510893	SOPHRONIA DAY DITCH	39	751	47	4,985
246	510924	SYLVAN DITCH	77	421	49	3,083
247	510934	TRAIL CREEK DITCH	19	420	54	1,845
248	510939	UTE BILL NO 2 DITCH	15	62	25	2,054
249	510941	Vail Irr Div Sys[14]	64	915	54	6,590
250	510948	WALDON HOLLOW DITCH	20	131	46	1,745
251	510958	C-BT WILLOW CREEK FEEDER[2]	400	0	0	27,893
252	511070	HENDERSON MINE WTR SYS[3]	27	0	100	2,188
253	511149	THOMPSON PUMP NO 2	14	100	36	1,681
254	511231	Vail_Irr_Sys[2]	999	0	0	0

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
255	511237	WILLIAMS FORK POWER COND[3]	295	0	0	74,771
256	511269	Ranch_Creek[2,5]	999	0	100	0
257	511309	St_Louis_Cr[2,5, 7]	161	0	100	0
258	511310	Vasquez_Creek[2,5]	999	0	100	0
259	514601	GRAND RIVER DITCH[5]	525	0	100	18,265
260	514603	WILLIAMS FORK TUNNEL[5]	500	0	100	0
261	514625	BERTHOUD CANAL TUNNEL[5]	53	0	100	507
262	514634	C-BT ALVA B ADAMS TUNNEL[5]	550	0	100	234,018
263	514655	MOFFAT WATER TUNNEL[5]	928	0	100	60,116
264	514700	WINDY GAP PUMP PL CANAL[2]	600	0	0	35,756
265	51_ADC001	Colorado River nr Granby	32	547	47	3,533
266	51_ADC002	Willow Creek	36	501	52	2,734
267	51_ADC003	Ranch Creek	42	861	52	4,340
268	51_ADC004	Fraser River bl Crooked	121	1,170	52	6,204
269	51_ADC005	Tenmile Creek	53	1,862	54	6,851
270	51_ADC006	Fraser River at Granby	60	840	50	5,443
271	51_ADC007	Colorado River abv Hot S	94	1,373	49	9,394
272	51_ADC008	Colorado River abv Willi	58	1,284	52	6,680
273	51_ADC009	Upper Williams Fork	52	881	51	4,624
274	51_ADC010	Lower Williams Fork	58	1,075	53	5,068
275	51_ADC011	Colorado River abv Troub	55	753	43	6,308
276	520559	GUTZLER DITCH	13	135	44	1,288
277	520572	HOG EYE DITCH	13	25	35	977
278	520658	WILMOT DITCH	17	205	45	1,594
279	52_ADC021	Black Tail & Sheephorn C	192	2,734	47	20,958
280	52_ADC027	Colorado River abv Derby	91	1,072	47	7,240
281	530555	Derby Div Sys[15]	61	1,379	43	9,703
282	530584	SHOSHONE POWER PLANT[3]	1,408	0	0	19,349
283	530585	GLENWOOD L WATER CO SYS[3]	15	0	36	5,523
284	530621	HIGHWATER DITCH	16	434	54	1,577
285	530632	HORSE MEADOWS DITCH	7	17	30	633
286	530657	KAYSER DITCH	25	347	37	4,036
287	530678	LION BASIN DITCH	32	815	53	3,505
288	530780	ROGERS DITCH	21	74	28	2,964
289	530783	ROYAL FLUSH DITCH	5	468	54	1,603
290	530800	SOUTH DERBY DITCH	32	869	46	5,559
291	530883	WILSON AND DOLL DITCH	12	288	30	3,573
292	531051	GLENWOOD L WATER CO SYS[3]	11	0	36	0
293	531082	MACFARLANE DITCH	5	426	54	1,450
294	53_ADC022	Upper Egeria Creek	13	394	52	1,794
295	53_ADC023	King Creek	52	809	51	4,354
296	53_ADC024	Egeria Creek abv Toponas	40	2,450	54	8,574
297	53_ADC025	Toponas Creek	43	930	53	3,992
298	53_ADC026	Colorado River abv Alkal	107	932	41	9,149
299	53_ADC028	Derby Creek	61	1,330	44	9,171
300	53_ADC032	Colorado River abv Glenw	160	1,632	34	19,967
301	700521	CLEAR CREEK DITCH	50	865	47	5,112
302	700530	CREEK AND NEWMAN DITCH	33	505	40	4,312
303	700550	H V C AND S DITCH	16	173	39	2,206

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
304	700571	NEW HOBO DITCH	12	140	51	859
305	700580	RESERVOIR DITCH	37	978	40	6,886
306	700583	ROAN CREEK NO 2 DITCH	14	105	26	2,736
307	700584	ROAN CREEK NO 3 DITCH	16	205	30	2,166
308	700596	UPPER ROAN CREEK DITCH	14	155	36	1,419
309	70_ADC049	Upper Roan Creek	161	1,811	41	16,045
310	70_ADC050	Colorado River nr Cameo	57	1,313	53	5,480
311	720512	Arbogast Pump Div Sys[16]	20	330	41	2,084
312	720514	ARKANSAS DITCH	8	219	55	1,702
313	720533	BERTHOLF LANHAM UPDIKE D	62	1,098	58	4,558
314	720542	BONHAM BRANCH PIPELINE[2,3]	45	0	0	0
315	720557	BULL BASIN HIGHLINE D	13	137	53	734
316	720558	BULL CREEK DITCH	17	357	29	4,021
317	720574	COAKLEY KIGGINS DITCH	15	625	59	2,400
318	720580	COOK DITCH	14	457	53	1,862
319	720583	COTTONWOOD BRANCH PL[2,3]	28	0	0	0
320	720596	DAVENPORT D (COTTNWD)	9	615	53	2,604
321	720607	EAKIN-SMITH DITCH	8	140	51	896
322	720616	NEW ERIE CANAL	36	453	54	2,310
323	720628	GALBRAITH DITCH	16	429	62	1,827
324	720643	GOLDEN AGE DITCH	12	297	53	1,652
325	720644	GRAND JCT COLO R PL[3]	21	0	36	3,698
326	720645	GRAND VALLEY CANAL[2]	650	28,112	32	320,864
327	720646	GRAND VALLEY PROJECT	1,620	0	0	0
328	720649	GROVE CR DITCH CO NO 1 D	18	414	53	2,342
329	720703	HOOSIER DITCH	28	507	29	5,429
330	720721	JOHNSON AND STUART DITCH	10	475	54	1,608
331	720729	KIGGINS GOYN DITCH	10	243	53	1,214
332	720730	KIGGINS SALISBURY DITCH	31	152	45	1,919
333	720731	KING DITCH	19	387	41	3,267
334	720744	LEON DITCH	17	455	59	1,555
335	720746	LEON PARK FEEDER CANAL[2]	450	0	0	0
336	720764	MartinCrawford[3]	15	5	36	0
337	720766	Ute WCD Carver Ranch [3,19]	20	229	43	1,644
338	720784	MESA CREEK DITCH	24	728	33	6,488
339	720799	MORMON MESA DITCH	33	1,448	52	7,430
340	720807	MOLINA POWER PLANT	54	0	0	14,471
341	720813	ORCHARD MESA IRR DIS SYS	461	5,976	29	63,739
342	720816	PALISADE TOWN PL (RAPID) [3]	5	0	36	876
343	720818	PALMER DITCH	20	742	38	4,981
344	720820	Park Creek DivSys[2,21]	107	0	0	0
345	720821	PARKER DITCH	7	721	54	3,057
346	720823	PARK VIEW DITCH	12	279	53	1,528
347	720831	PIONEER OF PLATEAU DITCH	15	194	36	2,443
348	720852	RMG Div Sys[17]	19	630	54	2,671
349	720870	SILVER GAUGE DITCH	33	1,276	57	5,485
350	720879	SOUTHSIDE CANAL[2]	240	0	0	0
351	720911	TEMS DITCH	9	102	38	1,335
352	720920	UTE PIPELINE HGT NO 2[3]	50	0	36	0

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
353	720933	WEST SIDE DITCH	14	843	62	3,330
354	720938	WILDCAT DITCH (BIG CR)	28	493	40	4,938
355	721233	UPPER HIGHT DITCH	19	148	42	1,943
356	721329	Rapid Creek PP DivSys[3,20]	15	0	36	0
357	721330	COLORADO R PUMPING PLANT[1]	14	0	30	0
358	721339	COON CREEK PIPELINE[3]	4	0	36	0
359	721487	UTE PIPELINE HGT NO 1[3]	50	0	36	0
360	724715	LEON TUNNEL CANAL[5]	54	0	100	1,676
361	724721	OWENS CREEK DITCH[2.5]	19	0	0	0
362	72_ADC051	Plateau Creek abv Vega R	38	1,008	59	3,434
363	72_ADC052	Plateau Creek bl Vega Rs	22	894	61	3,442
364	72_ADC053	Salt Creek	45	1,641	49	8,513
365	72_ADC054	Upper Buzzard Creek	532	2,065	56	7,325
366	72_ADC055	Plateau Creek bl Buzzard	55	1,011	53	4,981
367	72_ADC056	Upper Grove Creek	45	1,226	54	4,838
368	72_ADC057	Lower Grove Creek	23	1,213	52	5,201
369	72_ADC058	Kimball Creek	36	722	41	5,025
370	72_ADC059	Big Creek	35	710	31	7,431
371	72_ADC060	Cottonwood Creek	14	631	46	3,640
372	72_ADC061	Bull Creek	36	751	37	6,401
373	72_ADC062	Coon Creek	406	1,615	55	5,993
374	72_ADC063	Mesa Creek	41	1,405	54	5,146
375	72_ADC064	Plateau Creek	62	794	51	3,757
376	72_ADC065	Colorado River nr State	400	1,809	43	13,658
377	72_AMC001	72_AMC001 Colorado River[3,22]	999	0	60	0
378	950001	Grand Valley Project	850	30,970	30	382,501
379	950002	USA Power Plant[3]	999	0	0	0
380	950003	Orchard Mesa Check[4]	1,072	0	0	200,000
381	950004	OMID Hydraulic Pump[3]	272	0	0	87,559
382	950005	OMID Pre-1985 Bypass [4]	1,072	0	0	0
383	950006	OMID Post-1985 Bypass [4]	1,072	0	0	720,000
384	950007	USA PP-Winter-OM Stip[3]	901	0	0	240,017
385	950008	USA PP-Summer-OM Stip[3]	850	0	0	213,924
386	950010	Dry Elk Valley Irr	45	1,536	63	5,766
387	950011	Farmers Irrigation Comp	90	3,823	56	14,625
388	950020	Ute Water Treatment[3]	34	0	36	9,950
389	950030	Mason Eddy-Ute[3]	7	0	36	0
390	950050	Redlands Power Canal Irr[18]	140	3,002	45	42,892
391	950051	Grand Junction Demands[3]	21	0	36	6,659
392	950060	Green_Mtn_Contract_Dem.	999	0	60	4,020
393	950061	Green_Mtn_Annual_Rep_Est2[3]	999	0	100	16,356
394	952001	15-Mile Fish Requirement[24]	999	0	0	0
395	953001	Ruedi Rnd 1-Muni Demand [3]	999	0	100	1,850
396	953002	Ruedi Rnd 1-Ind Demand[3]	999	0	100	6,000
397	953003	Ruedi Rnd 2-Muni Demand[3]	999	0	100	11,714
398	953004	Ruedi Rnd 2-Ind Demand[3]	999	0	100	5,440
399	953005	Ruedi Addl Demand[22]	999	0	60	0
400	953101	Wolford Fraser Demand	999	0	50	270
401	953102	Wolford MidPark Demand	999	0	50	1,056

#	Model ID #	Name	Cap (cfs)	1993 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
402	953103	Wolford Market Demand[22]	999	0	60	0
403	953668D	HUP Release Node[6]	99,999	0	0	0
404	953709D	HUP Release Node[6]	99,999	0	0	0
405	954512D	HUP Release Node[6]	99,999	0	0	0
406	954516D	HUP Release Node[6]	99,999	0	0	0
407	954683	Continental_Hoosier_Tunn[5]	500	0	100	10,257
408	954699	Boustead_Summary[5]	1,600	0	100	65,404
409	955001	Vail Valley Consolidated[3]	11	0	36	1,447
410	955002	Keystone Municipal[3]	2	0	36	399
411	955003	Vail Valley Consolidated[3]	13	0	36	1,333
412	956001	Future Depletion #1[22]	999	0	60	0
413	956002	Future Depletion #2[22]	999	0	60	0
414	MoffatBF	Moffat_Baseflow[25]	31	0	0	0

1) OMID Multi-Structure Irrigation System (720813 primary and 721330 secondary)
2) Reservoir Feeder or Carrier Ditch
3) Municipal/Industrial Diversion
4) Orchard Mesa Check Structure
5) Transbasin Diversion
6) Demand nodes that allow for release of excess HUP water in Williams Fork, Wolford, and Homestake Reservoirs
7) St. Louis Creek diversion system includes structures 511309 and 510593
8) Hamilton Davidson diversion system includes structures 360649 and 360541
9) Hoagland diversion system includes structures 360662, 360946, 361018, 361047, 361020, 361019, 360945, 361048, and 361049
10) Mt. Sopris diversion system includes structures 380880 and 381633
11) Vulcan Ditch diversion system includes structures 394725 and 390685
12) Deberard diversion system includes structures 500734 and 500548
13) Big Lake diversion system includes structures 510529 and 510584
14) Vail Irr diversion system includes structures 510941 and 511231
15) Derby diversion system includes structures 530555, 530519, and 530521
16) Arbogast Pump diversion system includes structures 720512 and 721072
17) RMG diversion system includes structures 720852 and 720555
18) Redlands Power Canal Irrigation diversion represents the irrigation portion of structure 420541 (Redlands Power Canal)
19) Ute WCD Carver Ranch diversion system includes structures 720766 and 721334
20) Rapid Creek PP diversion system includes structures 721329 and 721235
21) Park Creek diversion system includes carrier structures 720820 and 720819
22) Future Modeling Node (no demand in Baseline dataset)
23) Node can be used for modeling Green Mountain HUP Replacement Estimates
24) Fish demand node for historical releases from Ruedi Reservoir
25) Node used in baseflow generation diversion to Moffat Tunnel from Meadow Creek Reservoir

5.4.1.1 Key Structures

Key diversion structures were those modeled explicitly. The node associated with a key structure represents that single structure. In the Upper Colorado River Model, diversion structures with water rights totaling 11 cfs or more were generally designated key structures. They were identified by a six-digit number, which was a combination of water district number and structure ID from the State Engineer's structure and water rights tabulations.

The majority of the diversion structures in the Upper Colorado River basin were used for irrigation. Structures diverting for non-irrigation use were noted in Table 5.4 and include structures that carry water to reservoirs or other structure's irrigation demands, municipal and industrial structures, and transbasin export structures.

Average historical monthly efficiencies for each structure appear in the diversion station file; however, StateMod operates in the "variable efficiency" mode for most irrigation structures, in which case, the values are not used during simulation. Efficiency in a given month of the simulation is a function of the amount diverted that month, and the consumptive use, as limited by the water supply.

For municipal, industrial, carriers, and transbasin diverters, StateMod uses the efficiencies in the diversion station file directly during simulation to compute consumptive use and return flows. Diversion efficiency was set to values consistent with the type of use based on engineering judgment, or, if available, user information. Municipal structures were assigned efficiencies that varied by month to reflect indoor and outdoor use patterns. Reservoir feeders and other carriers were assigned an efficiency of 0 percent, allowing their diversions delivered without loss. Exports from the basin were assigned an efficiency of 100 percent because there were no return flows to the basin.

Diversion capacity is stored in HydroBase for most structures and was generally taken directly from the database. Capacities and irrigated acreage were accumulated by StateDMI for defined diversion systems. In preparing the direct diversion station file, however, StateDMI determined whether historical diversion records indicated diversions greater than the database capacity. If so, the diversion capacity was modified to reflect the recorded maximum diversion.

Return flow parameters in the diversion station file specify the nodes at which return flows will re-enter the stream, and divided the returns among several locations as appropriate. The locations were determined primarily case-by-case based on topography, locations of irrigated acreage, and conversations with water commissioners and users.

Where to find more information

- When StateMod is executed in the "data check" mode, it generates an *.xtb file which contains summary tables of input. One of these tables provides the return flow locations and percent of return flow to each location, for every diversion structure in the model. Another table provides the information shown in Table 5.4.
- Section 4.2.2.1 describes how key structures were selected.
- Section 4.5 describes the variable efficiency approach for irrigation structures, and describes how diversions, consumptive use, and efficiency interact in the model for different types of structures.

5.4.1.2 Aggregate Structures

Small structures within specific sub-basin were combined and represented at aggregated nodes. Aggregated irrigation structures were given the identifiers "WD_ADCxxx", where "WD" was the Water District number, and "ADC" stands for Aggregated Diversions Colorado; the "xxx" ranged from 001 to 065. Similarly, aggregated municipal and industrial structures were named "WD_AMCxxx" for Aggregated Municipal Colorado.

For the one aggregated M&I diversion, efficiency was not set because this structure was not used but had been retained for future scenarios.

Where to find more information

- Section 4.2.2.2 describes how small irrigation structures were aggregated into larger structures
- Appendix A – Task 10 Memorandum describes the Colorado aggregation, updated from the 2000 irrigated acreage assessment.

5.4.1.3 Special Structures

5.4.1.3.1 Grand Valley Area Water Demand (Cameo Call)

The Grand Valley Area is situated adjacent to the Upper Colorado River near the City of Grand Junction, extending a distance of about 35 miles from the diversion dam for the Government Highline Canal to the end of the irrigated area near West Salt Creek. Two large systems, the Grand Valley Irrigation Company and the Grand Valley Project, provide the majority of the irrigation water for the Grand Valley. These two major systems provide irrigation water to an estimated 65,500 acres in the valley. Because of the seniority of the water rights in these systems, and as a result of the operations of Green Mountain Reservoir, these systems generally receive a full supply of water. The amount of water available for diversion by these two systems is typically represented by the flow in the Colorado River at the Cameo stream gage (USGS Gage 09095500) and the flows of Plateau Creek; the cumulative demands are often referred to as the Cameo Demand.

There are two main structures that divert from the mainstem of the Colorado River; the Grand Valley Project (720646, Government Highline Canal) and the Grand Valley Canal (720645). The Grand Valley Project (720646, Grand Valley Irrigation Company) is modeled as a carrier structure, which delivers water to the following modeled diversion demand structures:

WDID	Name
720813	Orchard Mesa Irrigation District (OMID)
950001	Grand Valley Project
950002	USA Power Plant
950004	OMID Hydraulic Pump
950007	USA PP-Winter-Orchard Mesa Stipulation
950008	USA PP-Summer- Orchard Mesa Stipulation

Additional diversion structures associated with, but not receiving water directly from the Grand Valley Project are the OMID Bypass and Check structures:

WDID	Name
950003	Orchard Mesa Check
950005	OMID Pre-1985 Bypass
950006	OMID Post-1985 Bypass

The structures in the above two tables are non-consumptive structures except 720813 and 950001 which deliver water to irrigated acreage.

Through mutual agreements between the Grand Valley Canal (720645) and the Grand Valley Project (720646), the two irrigation systems can be operated in a manner to enhance the delivery of water at times when the total river flow (Upper Colorado River plus Plateau Creek) is insufficient to meet the cumulative Cameo demand of approximately 2,260 cfs. To avoid a situation in which the senior water rights of the Grand Valley Canal (720645) call out the more junior water rights of the upstream Grand Valley Project (720646), return flows from the power diversions at the USA Power Plant and the OMID Pump can be physically returned to the Upper Colorado River at a location upstream of the headgate of the Grand Valley Canal (720645). This is accomplished by utilizing a movable structure known as the Orchard Mesa Check (950003).

5.4.1.3.2 Continental-Hoosier Tunnel

The Continental-Hoosier Diversion System diverts water from several tributaries at the headwaters of the Blue River (near Hoosier Pass) and delivers it through the Hoosier Pass Tunnel into Montgomery Reservoir in the headwaters of the Middle Fork of the South Platte River (Division 1). The collection and diversion facilities and the pertinent water rights are owned by the City of Colorado Springs, which uses the diversions as a major source of municipal water supply. The demand sits at the Continental Hoosier Summary Node (954683) and water is carried to the demand from Continental Hoosier System Blue River Diversion (364683), Continental Hoosier Tunnel (364699), and from storage in Continental Hoosier Upper Blue Lakes (363570).

The approximate capacity of the Continental Hoosier Tunnel is 500 cfs. Transmountain diversions through the Tunnel are measured and recorded at the east portal of the tunnel. Records of the historical diversions were obtained from the Division of Water Resources database, supplemented by USGS records.

5.4.1.3.3 Boustead Tunnel

Charles H. Boustead Tunnel extends approximately 5.4 miles under the Continental Divide and is used to convey water collected at the project facilities in the headwaters of the Fryingpan River and Hunter Creek to Turquoise Lake in the Arkansas River drainage. The rated capacity of the 10.5 foot diameter tunnel is 945 cfs. Transmountain diversions through the Boustead Tunnel are measured and recorded at the east portal of the tunnel. Records of the historical diversions were obtained from the Division of Water Resources database, supplemented by USGS records.

The North Side Collection System is designed to divert, collect and transport an average of about 18,400 acre-feet of water annually through facilities at Mormon, Carter, Ivanhoe, Granite, Lily Pad, North Cunningham, Middle Cunningham and South Cunningham Creeks. This collection system consists of diversion structures on each of the major tributaries of the North Fork of the Fryingpan River and a series of tunnels (Carter Tunnel, Mormon Tunnel, Cunningham Tunnel and Nast Tunnel) to deliver the water to the west portal of the Boustead Tunnel. The diversions at each of the tributaries are measured and recorded by the division engineer in cooperation with the USBR and the Southeastern Colorado Water Conservancy District (SECWCD). The diversion locations are modeled by North & South Boustead Collection (384625).

The South Side Collection System is designed to transport an average of 50,800 acre-feet of water annually from the Fryingpan and Roaring Fork river basins. Facilities located on No Name, Midway and Hunter Creeks are used to collect water in the headwaters of the Hunter Creek basin for delivery via the Hunter Tunnel to the Fryingpan River basin, which in turn is delivered to the Boustead Tunnel. Additional facilities on Sawyer Creek, Chapman Creek, the South Fork of the Fryingpan River, and the mainstem of the Fryingpan are used to collect and transport water from the tributaries to the west portal of the Boustead Tunnel. The diversions at each of the tributaries are measured and recorded. The operating principles provide for minimum bypass requirements at each of the diversion structures on the South Side Collection System (except Sawyer Creek). The diversion locations are modeled by North & South Boustead Collection (384625) and Hunter Collection (381594).

The total Boustead Tunnel demand is located at Boustead Summary (954699). Water is carried to this demand from the two collection nodes North & South Boustead Collection (384625) and Hunter Collection (381594) along with reservoir water exchanged to the collection nodes from Ruedi Reservoir (383713).

5.4.1.3.4 Municipal Diversion Structures

In the historical and calibration simulations of the CRDSS Upper Colorado River Model, historical diversions for municipal uses are utilized and were generated using data from the State database and/or user-supplied data. For future operations under the CRDSS Baseline simulation, the monthly municipal demands were estimated to be equivalent to the monthly average values for the time period 1998 through 2005. The municipal structures included in the CRDSS Upper Colorado River Model are as follows:

WDID	Name
360784	Rankin No 1 Ditch
360829	Straight Creek Ditch
361008	Breckenridge Pipeline
370708	Metcalf Ditch
380854	Maroon Ditch
380869	Midland Flume Ditch
381052	Carbondale Wtr Sys & Pl
381441	East Snowmass Brush C Pl
390967	Rifle Town Of Pump & Pl
420520	Grand Jct Gunnison Pl
531051	Glenwood L Water Co Sys
720644	Grand Jct Colo R Pl
720764	Martin Crawford Ditch
720816	Palisade Town Pl (Rapid)
720920	Ute Pipeline Hgt No 2
721329	Rapid Creek Pp DivSys
721339	Coon Creek Pipeline
721487	UTE PIPELINE HGT NO 1
950020	Ute Water Treatment
950030	Mason Eddy-Ute
950051	Grand Junction Demands
955001	Vail Valley Consolidated
955002	Keystone Municipal
955003	Vail Valley Consolidated

Municipal water use does not constitute a significant depletion to the natural streamflow since much of the water returns to the stream as domestic wastewater and/or urban irrigation return flows.

Municipal Monthly Efficiencies (%)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10	12	14	44	55	62	61	56	44	26	0	10

Return flow patterns from municipal uses were based on the return flow analysis performed for the CRDSS. Locations of return flows were determined from inspection of topographic mapping and through interviews with the water users.

Operations of complex augmentation plans were not included in the CRDSS Upper Colorado River Model. Efforts have been made to simplify the municipal operations, including diversions. This was justified in that the municipal usage and depletions were relatively small.

5.4.1.3.5 Redlands Power Canal

The Redlands Canal physically diverts water from the Gunnison River (Division 4) and its diversions are not affected by administration of the more junior water rights on the mainstem of the Upper Colorado River (Division 5) downstream of Gunnison. However, the irrigated lands under the Redlands Canal are located in the Upper Colorado River basin and the return flows from irrigation and from hydroelectric power generation accrue to the Upper Colorado River downstream of Grand Junction. The canal serves about 4,500 acres and is owned and operated by the Redlands Water and Power Company.

During the summer irrigation season, the Redlands Canal is normally operated to divert about 610 cfs for power generation and about 60 cfs for irrigation use. During the non-irrigation season, the system is operated to divert up to 750 cfs solely for hydroelectric power generation. Hydroelectric and irrigation demands are modeled separately due to differences in consumptive use, return flow patterns, and return flow locations. The hydroelectric demands are modeled at node 420541 and irrigation demands at 950050.

5.4.1.3.6 Silt Project

The Silt Project is located in west-central Colorado near the Towns of Rifle and Silt. The Project was authorized in 1956 in accordance with the Colorado River Storage Project Act and was constructed by the USBR from 1964 to 1967. The Project is operated to provide a supplemental supply of irrigation water for approximately 4,628 acres and a full service supply to 2,416 acres on the north side of the Upper Colorado River.

The main features of the Silt Project include Rifle Gap Dam and Reservoir on Rifle Creek and the Silt Pump Plant on the mainstem of the Upper Colorado River. The project enhances the use of existing irrigation facilities owned by the Farmers Irrigation Company, including the Grass Valley Canal, Harvey Gap Reservoir, the East Lateral and the West Lateral.

Project acreage and demands are located at Dry Elk Valley Irr (950010) and Farmers Irrigation Comp (950011). The carrier structure Grass Valley Canal (390563) delivers water from East Rifle Creek and water exchanged from Rifle Gap Reservoir to both demand locations and Harvey Gap Reservoir. Farmers Irrigation Comp (950011) receives additional water from Harvey Gap Reservoir and from the Colorado River via the carrier structure Silt Pump (390663).

5.4.1.3.7 15-Mile Endangered Fish Reach

The reach of the Upper Colorado River between the headgate of the Grand Valley Irrigation Canal (GVIC) and the confluence of the Upper Colorado River and the Gunnison River is often referred to as the 15-Mile Reach. This reach is considered a critical flow reach for the protection of endangered fish species because the river can be physically dried up at the GVIC headgate. The USFWS recommended flows for the months of July through October are 1630 cfs, 1240 cfs, and 810 cfs under wet, average, and dry hydrologic conditions. In 1997, the Recovery Implementation Program – Recovery Action Plan (RIPRAP) was developed and set aside storage within the Upper Colorado River Basin to be released to the 15-Mile Reach during times of low flows.

During the period August 1991 through September 1996, releases were made from the Colorado Water Conservation Board’s contract water in the regulatory capacity of Ruedi Reservoir to provide supplemental flows to the 15-Mile Reach. In the Historic simulation, releases from Ruedi Reservoir are modeled using the 15-Mile Fish Requirement (952001) diversion node from August 1991 through September 1996.

The fish requirements are modeled by an instream flow node (see section 5.7) USFWS Recommended Fish Flow (952002) for water years 1997 through 2005 and for the entire model period in the Baseline data set. The instream flow demand is met from several fish pools in reservoirs throughout the basin (see section 5.9.19).

5.4.1.3.8 Excess HUP Demand Structures

The operations of the Blue River Decree and supplemental agreements allow Denver and Colorado Springs to replace water stored out-of-priority to Green Mountain Reservoir from Wolford Mountain Reservoir and Williams Fork Reservoir. Future agreements and/or decrees may allow Colorado Springs to replace water from Homestake Reservoir. Obligated water is released from these reservoirs to make replacements to all uses of Green Mountain Reservoir in lieu of releasing water from Green Mountain Reservoir. Historic and future operations of these alternate sources of replacement water requires replacements be made in the current year. To ensure that complete replacement is made in the current year from these reservoirs, four additional structures were added, one for each reservoir, Wolford HUP Release Node (953668D), Williams Fork HUP Release Node (953709D), Homestake HUP Release Node (954516D), and Dillon HUP Release Node (954512D). These nodes are non-consumptive (consumptive use = 0%) and return water to the next downstream node acting as a release to target for a specific reservoir account.

5.4.1.3.9 Future Reservoir Demand Structures

Several diversion structures in the network are "placeholders" for modeling future anticipated reservoir demands in the Upper Colorado River basin. Strictly speaking, they are not part of the Baseline data set because their demands are set to zero or their rights are either absent or decree limits are set to zero. The diversion structures that fall into this category include:

WDID	Name
950061	Green Mtn Annual Rep Est.
953005	Ruedi Addl Demand
953103	Wolford Market Demand

5.4.1.3.10 Future Depletions

Several diversion structures in the network are "placeholders" for modeling future anticipated demands in the Upper Colorado River basin. Strictly speaking, they are not part of the Baseline data set because their demands are set to zero or their rights are either absent or decree limits are set to zero. The diversion structures that fall into this category include:

WDID	Name
72_AMC001	72_AMC001 Colorado River
956001	Future Depletion #1
956002	Future Depletion #2

5.4.2 Return Flow Delay Tables (*.dly)

The cm2009.dly file, which was hand-built with a text editor, describes the estimated re-entry of return flows into the river system. The irrigation return patterns are based on Glover analysis for generalized characteristics of the alluvium, and have been applied in other west slope basin models. The return flow patterns also account for surface water returns. Percent return flow in the first month for the Glover-derived patterns are adjusted to reflect 3 percent loss of returns due to non-crop consumption or evaporation, termed "incidental losses." In all cases, these lag times represent the combined impact of surface and subsurface returns.

The 3 percent of non-consumed water, used to represent incidental loss, is based on a recommendation used in the Upper Colorado River Consumptive Uses and Losses Report, developed for the Colorado Water Conservation Board (Consumptive Uses and Losses Report, Comparison between StateCU CU & Losses Report and the USBR CU & Losses Report (1998-1995), October 1999, Leonard Rice Engineers). In the CU and Losses Report, incidental losses were estimated to be 10 percent of basin-wide crop consumptive use. However, StateMod applied a loss factor to unused diverted water, not crop consumptive use. Therefore, an equivalent loss factor was developed for non-consumed diverted water from the results of the StateCU consumptive use analyses performed in support of the Upper Colorado River Model as follows:

StateCU Total Basin Crop Consumptive Use (Ave 1975 – 2004) = 453,940 acre-feet

Incidental loss = 10% of Total Crop CU = 45,394 acre-feet

StateCU Unused Water (Ave 1975 – 2004) = 1,472,033

Incidental Loss as percent of Unused Water = 45,394 / 1,472,033 = 3%

Four of the seven patterns available in this file are used in the Upper Colorado River Model, as shown in Table 5.5. Pattern 1 represents returns from irrigated lands relatively close to a live stream or drain (<1200 feet). Pattern 2 is used for irrigation further from a live stream (>1200 feet). Pattern 3 represents ground water returns to Long Hollow from irrigation on Red Mesa in the San Juan River Basin (not used in the Upper Colorado River Model). Pattern 4 represents immediate returns, as for municipal and industrial uses. Pattern 5 is applicable to snowmaking diversions. Pattern 6 and 7 are previous patterns 1 and 2 without consideration of incidental losses (not used in the Upper Colorado River Model).

Table 5.5
Percent of Return Flow Entering Stream in Months Following Diversion

Month n	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6	Pattern 7
1	75.6	57.4	53.8	100	0	78.6	60.4
2	11.3	14.5	5.6	0	0	11.3	14.5
3	3.2	7.2	3.6	0	0	3.2	7.2
4	2.2	5.0	2.9	0	0	2.2	5.0
5	1.6	3.7	2.5	0	100	1.6	3.7
6	1.2	2.7	2.2	0	0	1.2	2.7
7	0.8	2.0	2.0	0	0	0.8	2
8	0.6	1.5	1.8	0	0	0.6	1.5
9	0.5	1.1	1.8	0	0	0.5	1.1
10	0	0.8	1.6	0	0	0	0.8
11	0	0.6	1.6	0	0	0	0.6
12	0	0.5	1.5	0	0	0	0.5
13 – 14	0	0	2.8	0	0	0	0
15 - 36	0	0	13.3	0	0	0	0
Total	97	97	97	100	100	100	100
Note: Month 1 is the same month as diversion							

Where to find more information

- Section 4.6.1 describes how irrigation return flow delay patterns were developed.

5.4.3 Historical Diversion File (*.ddh)

The historical diversion file contains time series of diversions for each structure. The file was created by StateDMI, which filled missing records as described in Section 4.4.2. StateMod uses the file for baseflow estimations at stream gage locations, and for comparison output during calibration.

The file was referenced by StateDMI when developing the headgate demand time series for the diversion demand file.

5.4.3.1 Key Structures

For most explicitly modeled irrigation and M&I structures, StateDMI accessed HydroBase for historical diversion records. Historical diversions were accumulated by StateDMI for defined diversion systems. For certain structures, the data was assembled from other sources or developed from database data into a time-series file which StateDMI read. These included the Moffat Tunnel and Fraser River Diversion Project plus other larger diverters as follows:

WDID	Name
360784	RANKIN NO 1 DITCH
360829	STRAIGHT CREEK DITCH
360841	TENMILE DIVERSION NO 1
360908	KEYSTONE SNOWLINE DITCH
361008	BRECKENRIDGE PIPELINE
361016	COPPER MTN SNOWMAKING
370708	METCALF DITCH
380757	HOME SUPPLY DITCH
380869	MIDLAND FLUME DITCH
381052	CARBONDALE WTR SYS & PL
381441	EAST SNOWMASS BRUSH C PL
381594	FRY ARK PR HUNTER TUNNEL
384625	FRY ARK PR BOUSTEAD TUNL
390563	GRASS VALLEY CANAL
420520	GRAND JCT GUNNISON PL
420541	REDLANDS POWER CANAL
450969	BLUESTONE VALLEY DITCH
510529	Big Lake Div Sys
510639	FRASER RIVER DIVR PROJ
510728	HAMILTON-CABIN CR DITCH
510941	Vail Irr Div Sys
510958	C-BT WILLOW CREEK FEEDER
511070	HENDERSON MINE WTR SYS
511269	FRASER RIVER DIVR PROJ
511309	FRASER RIVER DIVR PROJ
511310	FRASER RIVER DIVR PROJ
514603	WILLIAMS FORK TUNNEL
514634	C-BT ALVA B ADAMS TUNNEL

WDID	Name
514655	MOFFAT WATER TUNNEL
514700	WINDY GAP PUMP PL CANAL
530584	SHOSHONE POWER PLANT
720542	BONHAM BRANCH PIPELINE
720583	COTTONWOOD BRANCH PL
720628	GALBRAITH DITCH
720644	GRAND JCT COLO R PL
720646	GRAND VALLEY PROJECT
720746	LEON PARK FEEDER CANAL
720766	Ute WCD Carver Ranch
720813	ORCHARD MESA IRR DIS SYS
720816	PALISADE TOWN PL (RAPID)
720820	Park Creek DivSys
720852	RMG Div Sys
720879	SOUTHSIDE CANAL
720920	UTE PIPELINE HGT NO 2
721339	COON CREEK PIPELINE
724715	LEON TUNNEL CANAL
950001	Grand Valley Project
950002	USA Power Plant
950003	Orchard Mesa Check
950004	OMID Hydraulic Pump
950010	Dry Elk Valley Irr
950011	Farmers Irrigation Comp
950030	Mason Eddy-Ute
950050	Redlands Power Canal Irr
950051	Grand Junction Demands
952001	15-Mile Fish Requirement
955001	Vail Valley Consolidated
955002	Keystone Municipal
955003	Vail Valley Consolidated

The following carrier and summary structures have their historical use represented at other nodes, therefore diversions were set to zero. In addition, future use structures have historical diversions set to zero because they did not divert historically.

WDID	Name
360881	GREEN MTN HYDRO-ELECTRIC
360989	MAGGIE POND (SNOWMAKING)
364683	CON-HOOSIER SYS BLUE R D
364699	CON-HOOSIER TUNNEL
371146	WOLCOTT PUMPING PIPELINE
374643	HOMESTAKE PROJ CONDUIT
390563	GRASS VALLEY CANAL
390663	SILT PUMP CANAL
511237	WILLIAMS FORK POWER COND
531051	GLENWOOD L WATER CO SYS
720646	GRAND VALLEY PROJECT
720807	MOLINA POWER PLANT
721330	COLORADO R PUMPING PLANT
72_AMC001	72_AMC001 Colorado River
950005	OMID Pre-1985 Bypass
950006	OMID Post-1985 Bypass
950007	USA PP-Winter-OM Stip
950008	USA PP-Summer-OM Stip
950020	Ute Water Treatment
950061	Green_Mtn_Annual_Rep_Est.
953002	Ruedi Rnd 1-Ind Demand
953003	Ruedi Rnd 2-Muni Demand
953004	Ruedi Rnd 2-Ind Demand
953005	Ruedi Addl Demand
953101	Wolford Fraser Demand
953102	Wolford MidPark Demand
953103	Wolford Market Demand
953668D	HUP Release Node
953709D	HUP Release Node
954516D	HUP Release Node
954699	Boustead_Summary
956001	Future Depletion #1
956002	Future Depletion #2

Historical diversions for the following transbasin structures were extracted from USGS or DNR streamflow records in HydroBase, as shown, which are more complete than records stored in HydroBase under the WDID.

WDID	Name	USGS or DNR Streamflow Gage
364626	VIDLER TUNNEL COLL SYS	09047300
364684	BLUE RIVER DIVR PROJECT	09050590
364685	BOREAS NO 2 DITCH	09046000
371091	EWING PLACER DITCH	09062000
374614	HOMESTAKE PROJ TUNNEL	09063700
374641	COLUMBINE DITCH	09061500
374648	WARREN E WURTS DITCH	09062500
384613	IVANHOE RESERVOIR TUNNEL	09077500
384617	IND P TM DVR TUNNEL NO 1	09073000
514601	GRAND RIVER DITCH	09010000
514603	WILLIAMS FORK TUNNEL[1]	APGTUNCO
514625	BERTHOUD CANAL TUNNEL	09021500
514634	C-BT ALVA B ADAMS TUNNEL[2]	09013000
514634	C-BT ALVA B ADAMS TUNNEL[2]	ADANETCO
514655	MOFFAT WATER TUNNEL[1]	09022500
954683	Continental_Hoosier_Tunn	HSPTUNCO

1) Streamflow gage data used in calculations for the Moffat System
2) Streamflow gage ID for the Adams Tunnel changed in October 1996 from 09013000 to ADANETCO

5.4.3.2 Aggregate Structures

Aggregated irrigation structures were assigned the sum of the constituent structures' historical diversion records from HydroBase.

Where to find more information

- The feasibility study for the data extension is documented in two task memos, which were collected in the CDSS *(Technical Papers)*:

  -Data Extension Feasibility *(Appendix E.1)*

  -Evaluate Extension of Historical Data *(Appendix E.2)*

5.4.4 Direct Diversion Demand File (*.ddm)

Created by StateDMI, this file contains time series of demand for each structure in the model. Demand is the amount of water the structure "wanted" to divert during simulation. Thus demand differs from historical diversions, as it represents what the structure would divert in order to get a full water supply. Table 5.4 in Section 5.4.1 lists average annual demand for each diversion structure. Note that the Baseline demands do not include demands associated with conditional water rights.

5.4.4.1 Key Structures

Irrigation demand was computed as the maximum of crop irrigation water requirement divided by average monthly efficiency for the structure or historical diversions, as described in Section 4.9.1. Note that the irrigation water requirement is based on actual climate data beginning in 1975. Prior to that, it was filled using the automatic data filling algorithm described in Section 4.4.2. Monthly efficiency is the average system (combined conveyance and application) efficiency over the efficiency period (1975 through 2005) but capped at 0.54.

Transbasin and municipal and industrial demands were set to recent values or averages of recent records for the entire simulation period.

5.4.4.2 Aggregate Structures

Aggregated irrigation structure demand was computed as for key irrigation structures. The only difference is that the irrigated acreage, which was the basis of irrigation water requirement, is the sum of irrigated acreage for constituent structures. Similarly, filled diversions are summed across all constituent structures, and average efficiency is based on efficiency of the aggregation as a unit. As discussed above, there is no demand assigned to the aggregated M&I structure.

5.4.4.3 Special Structures

5.4.4.3.1 Grand Valley Area Water Demand (Cameo Call)

Total demands for the Grand Valley Project, Orchard Mesa Irrigation District, and USA Power are located at their individual "demand" nodes and the carrier structure Grand Valley Project (720646) was set to zero. Grand Valley Project (950001) irrigation demand was calculated based on irrigation water requirement extending throughout the study period. OMID Pump (950004) and USA Power Plant Summer Orchard Mesa Stipulation (950008) demands were filled using the dry, average, and wet demands determined for the period 1975 through 1991, and extended to the entire model period of 1909 through 2005. Orchard Mesa Check (950003) demand was set to 100,000 af/month. OMID Post- 1985 Bypass (950006) was set to 6,000 af/month. USA Power Plant Winter Orchard Mesa Stipulation (950008) was set to 800 cfs continuous demand for November through March. OMID Power (950002) and OMID Pre- 1985 Bypass (950005) were set to zero.

5.4.4.3.2 Transbasin Demands

The techniques used to fill the transbasin diversion demands are based on what was done previously for each individual transbasin diversion during the last model update. The following transbasin diversion demands were set to average monthly diversions over the period 1998 through 2005 for the entire model period of 1909 through 2005.

WDID	Name
364626	VIDLER TUNNEL COLL SYS
364685	BOREAS NO 2 DITCH
371091	EWING PLACER DITCH
374641	COLUMBINE DITCH
374648	WARREN E WURTS DITCH
384613	IVANHOE RESERVOIR TUNNEL
514625	BERTHOUD CANAL TUNNEL

The following transbasin diversion demands were filled using the dry, average, and wet demands determined for the period 1975 through 1991, and extended to the entire model period of 1909 through 2005.

WDID	Name
384617	IND P TM DVR TUNNEL NO 1
954699	Boustead_Summary

The Homestake Proj Tunnel (374614) was filled with the estimate of a continuous 300 cfs diversion schedule.

The Blue River Diversion Project (364684, aka Roberts Tunnel) and the Moffat Water Tunnel (514655) demands for 1947 through 1991 were provided by the Denver Water Board. Demands from 1992 through 2005 were filled using historical diversions and demands from 1909 through 1946 were filled using the dry, average, and wet demands determined for the period 1947 through 1991.

The Continental Hoosier Tunnel (954483) demand for 1952 through 2005 was provided by Colorado Springs. Demand from 1998 through 1951 were filled using the dry, average, and wet demands determined for the period 1947 through 1991.

The C-BT Alva B Adams Tunnel (514634) and Windy Gap (514700) demands for 1950 through 1996 were provided by the Northern Colorado Water Conservancy District. Demands from 1997 through 2005 were filled using historical diversions and demands from 1909 through 1946 were filled using the dry, average, and wet demands determined for the period 1950 through 1996.

5.4.4.3.3 Municipalities and Industrial Demands

Municipal demands in the baseline dataset were based on average monthly diversions over the recent period 1998 through 2005 for the entire model period of 1909 through 2005.

WDID	Name
360784	RANKIN NO 1 DITCH
360829	STRAIGHT CREEK DITCH
361008	BRECKENRIDGE PIPELINE
370708	METCALF DITCH
381052	CARBONDALE WTR SYS & PL
381441	EAST SNOWMASS BRUSH C PL
390967	RIFLE TOWN OF PUMP & PL
420520	GRAND JCT GUNNISON PL
530585	GLENWOOD L WATER CO SYS
720644	GRAND JCT COLO R PL
720816	PALISADE TOWN PL (RAPID)
950051	Grand Junction Demands
955001	Vail Valley Consolidated
955002	Keystone Municipal
955003	Vail Valley Consolidated

Industrial demands were filled on an individual basis based on previously used techniques. Henderson Mine (511070) was set to the 1975 through 1991 average depletion. Shoshone Power Plant (530584) was set to the decree limits of its associated water rights. Molina Power Plant (720807) and Redlands Power Canal (420541) were set to their average demand over the period 1975 through 1991. Maggie Pond (360989), used for snowmaking at Breckenridge Ski Area, was filled with zeros. There were three exceptions where new methods were used due to additional information becoming available since the last model update. Tenmile Diversion No. 1 (Climax) (360841) was filled with zeros because the mine was no longer in operation. Snowmaking demands at Keystone (360908) and Copper Mountain (361016) were set to the average monthly values for the most recent six years (2000 through 2005). Demands for Ute Water Treatment (950020) were provided by the Ute Water Conservancy District.

5.4.4.3.4 Silt Project

Project demands are located at Dry Elk Valley Irr (950010) and Farmers Irrigation Comp (950011) and were calculated based on acreage and crop demand. Demands for the carrier structures Grass Valley Canal (390563) and Silt Pump (390663) were set to zero and operating rules pull water through these structures to the demand locations.

5.4.4.3.5 15-Mile Endangered Fish Reach

The 15-Mile Fish Requirement (952001) demand was set to zero and the Baseline demand was modeled by an instream flow node USFWS_Recomm._Fish_Flow (952002).

5.4.4.3.6 Excess HUP Demand Structures

The four excess HUP demand structures Wolford HUP Release Node (953668D), Williams fork HUP Release Node (953709D), Homestake HUP Release Node (954516D), and Dillon HUP Release Node (954512D) all have constant demands of 999999 af. These high demands ensure that excess water is released from the reservoirs based on operating rules.

5.4.4.3.7 Reservoir Demand Structures

Green Mountain Hydro-Electric (360881) and Williams Fork Power Conduit (511237) have baseline demands based on their average use from 1975 through 1991. Green Mountain Contract Water (950060) demand is based on the 2006 monthly user release schedule and an annual demand of 4020 af.

Wolford Mountain Reservoir demands from Fraser Basin (953101) and Middle Park (953102) are based on an analysis over the period of 1953 through 1994 from "Wolford Mountain Reservoir - Assessment of Reservoir Operations and Hydrologic Impacts", February 1997, provided by CRWCD. A Market (953103) demand was added based on the C1 version 5 dataset. These demands were filled using the dry, average, and wet patterns and extended to the entire model period of 1909 through 2005.

Ruedi Reservoir demands, which include Round 1 Municipal (953001), Round 1 Industrial (953002), Round 2 Municipal (953003), Round 2 Industrial (953004), and Additional Demand (953005), were filled with constant annual demands. Round 1 and Round 2 demands are based on the C1 version 5 dataset. Additional Demand was set to zero and can be modified for future scenarios.

5.4.4.3.8 *Future Depletions*

Demands for future depletion nodes (956001 and 956002) were set to zero, as they were not active in the Baseline data set. These nodes can be used for future scenarios.

5.4.4.3.9 *Carrier Structures and Multistructures*

Most demands for carrier structures and secondary components of multistructures were set to zero in the Baseline dataset. Operating rules are used to carry water from these structures to satisfy demands at destination structures or reservoirs. There are two carriers that have demands in the Baseline dataset. Windy Gap Pump (514700) and Willow Creek Feeder (510958); both deliver water to Granby Reservoir using the Type 14 operating rule that requires demands at the diverting structure.

WDID	Name
360606	ELLIOTT CREEK FEEDER
374643	HOMESTAKE PROJ CONDUIT
381594	FRY ARK PR HUNTER TUNNEL
384625	FRY ARK PR BOUSTEAD TUNL
390563	GRASS VALLEY CANAL
390663	SILT PUMP CANAL
510639	FRASER RIVER DIVR PROJ
510728	HAMILTON-CABIN CR DITCH
511231	VAIL IRRIGATION SYSTEM – MEADOW
511269	FRASER RIVER DIVR PROJ
511309	FRASER RIVER DIVR PROJ
511310	FRASER RIVER DIVR PROJ
514603	WILLIAMS FORK TUNNEL
720542	BONHAM BRANCH PIPELINE
720583	COTTONWOOD BRANCH PL
720646	GRAND VALLEY PROJECT
720746	MARTIN CRAWFORD DITCH
720746	LEON PARK FEEDER CANAL
720820	Park Creek DivSys
720879	SOUTHSIDE CANAL
720920	UTE PIPELINE HGT NO 2
721329	Rapid Creek PP DivSys
721330	COLORADO R PUMPING PLANT

WDID	Name
721339	COON CREEK PIPELINE
721487	UTE PIPELINE HGT NO 1
724721	OWENS CREEK DITCH
950030	MASON EDDY-UTE

5.4.5 Direct Diversion Right File (*.ddr)

The direct diversion right file contains water rights information for each diversion structure in the model. StateDMI created the diversion right file based on the structure list in the diversion station file. Note that the Baseline direct diversion right file does not include conditional water rights. It is recommended for future updates that the StateDMI commands be run initially without the “set” commands. This allows the modeler to view any changes to water rights (transfers, conditional to absolute, abandonment, etc.) reflected in updated versions of HydroBase and modify the “set” commands as necessary.

The information in this file is used during simulation to allocate water in the right sequence or priority and to limit the allocation by decreed amount. The file is also an input to StateDMI when filling historical diversion time series. Based on the appropriation dates expressed in the administration number located in the rights file, StateDMI determines the total amount of the water right during the time of the missing data in the Historical dataset, and constrains the diversion estimates accordingly. For example, suppose a ditch has two decrees, one for 2.5 cfs with an appropriation date of 1886, and the other for 6 cfs with an appropriation data of 1932. When StateDMI estimates diversions prior to 1932, it limits them to a maximum rate of 2.5 cfs for the month, regardless of the average from available diversion records. This approach was adopted so the water development of the historical study period could be simulated. The Baseline dataset is not limited to the historic diversion rights but rather incorporates the current right regime of the river.

All diversion rights were set “on” in the Upper Colorado River Model. Operating rules and/or demands are used to limit direct diversion rights for some structures, for example structures that only carry water to demands at other structures.

5.4.5.1 Key Structures

Water rights for explicitly modeled structures were taken from HydroBase and match the State Engineer’s official water rights tabulation. Water rights for each individual structure in a diversion system are included under the defined diversion system identifier. In addition, many structures that historically diverted more than their decreed water rights were assigned a “free river right”, with an extremely junior administration number of 99999.99999 and a decreed amount of 999.0 cfs. These rights allow structures to divert more than their decreed water rights under free river conditions; provided their demand is unsatisfied and water is legally available.

5.4.5.2 Aggregate Structures

In the Upper Colorado River Model, aggregated structures include, in some cases, more than 70 individual structures each having multiple water rights. Therefore, aggregated irrigation structures were assigned up to 11 water rights, one for each of 11 water right (administration) classes. Appendix A describes the procedure and results for determining appropriate water right classes for the basin. The decreed amount for a given water right class was set to the sum of all water rights that 1) were associated with individual structures included in the aggregated irrigation structure, and 2) had an administration number that fell within the water right class. The administration number for each right was calculated to be the weighted average by summing the product of each administration number and decree and dividing by the total decree within the water right class. For example, given 2 water rights; one for 10 cfs at an administration number of 1 and one for 2 cfs at an administration number of 4, the weighted administration number would be (10 x 1 + 2 x 4) / (10 + 2) = 1.5.

The aggregated M&I (72_AMC001) node was assigned a water right with an administration number of 1.00000 and a decree limit of 0.0 cfs because the structure was a placeholder for future depletions and was not used in the Baseline dataset.

5.4.5.3 Special Diversion Rights

5.4.5.3.10 Grand Valley Area Water Demand (Cameo Call)

Total demands for the Grand Valley Project, Orchard Mesa Irrigation District, and USA Power are located at their individual demand structures and the demand for carrier structure Grand Valley Project (720646) was set to zero. Water rights are assigned to the Grand Valley Project structure and operating rules are used to deliver water to the demand structures in this system. All the structures in this system with WDIDs starting with 95 were assigned junior or free river rights because StateMod expects rights in the diversion right file for each structure in the diversion station file.

Water Right ID	Name	Administration No.	Rate
720646.02	Orchard Mesa Irr Dist Sy	22729.18536	10.2
720646.03	Orchard Mesa Irr Dist Sy	22729.21116	450
720646.05	USA Power Plant	30895.21241	800
720646.07	Grand Valley Proj	22729.19544	40
720646.08	USA_PP_Winter	30895.21241	800
720646.09	USA_PP_SummerSR_OM-Stip	99999.99999	400
720646.10	USA_PP_Winter_OM-Stip	100000.10000	999
720813.01	Orchard Mesa Irr Dist Sy	99999.99999	999
950001.01	Grand Valley Proj - Irr	99999.99999	999
950002.01	USA Power Plant	99999.99999	999

Water Right ID	Name	Administration No.	Rate
950003.01	Orchard Mesa Check	999999.00000	640
950004.01	OMID Hydraulic Pump	99999.99999	999
950005.01	OMID Pre-1985 Bypass	999998.00000	1100
950006.01	OMID Post-1985 Bypass	30895.23492	1100
950007.01	USA PP Winter OM-Stip	99999.90009	999
950008.01	USA PP Summer OM-Stip	100000.10000	999

5.4.5.3.11 Transbasin Demands

Many transbasin collection system rights are consolidated at one or more structures within the model; therefore water rights were assigned specifically. The rights associated with the Bunte Highline Ditch were set senior to the C-BT rights at Willow Creek Reservoir to simplify reservoir operations. Egeria Creek Above Toponas aggregate structure receives transbasin water from the Stillwater Ditch and was assigned a senior water right and a sufficient decree rate to ensure its diversion.

Water Right ID	Name	Administration No.	Rate
364683.01	Con-Hoosier Modif 1929 W	35927.00000	540
364699.01	Con-Hoosier Blue R Div	30184.29071	77
381594.01	Hunter Tunnel Collection	39291.00001	1262
384613.02	Ivanhoe Reservoir Tunnel	28394.27306	25
384613.03	Ivanhoe Reservoir Tunnel	28394.27299	50
384613.04	Ivanhoe Reservoir Tunnel	28394.28365	70
510639.01	Jim Creek Div	30870.26117	75
511309.02	St Louis Creek Div	30870.26117	214
511310.01	Vasquez Creek Div	30870.26117	105
511269.01	Den Ranch Creek Div	30870.26117	180
514655.01	Fraser River Div Proj	30870.26117	928
364626.01	Vidler Tunnel Collection	15829.00000	4.5
364626.02	Vidler Tunnel Collection	19875.00000	4
364626.03	Vidler Tunnel Collection	23296.22400	4
364626.04	Vidler Tunnel Collection	30184.16801	5.48
364626.05	Vidler Tunnel Collection	30184.23561	10
364626.06	Vidler Tunnel Collection	30951.00000	3
364626.07	Vidler Tunnel Collection	32075.18444	2.72
364626.08	Vidler Tunnel Collection	32075.23561	10

Water Right ID	Name	Administration No.	Rate
364626.09	Vidler Tunnel Collection	33289.00000	13
364626.1	Vidler Tunnel Collection	40020.00000	31.8
514700.01	Windy Gap Pump PL Canal	47671.00001	300
514700.02	Windy Gap Pump PL Canal	47671.00002	100
514700.03	Windy Gap Pump PL Canal	47671.00003	200
510958.01	C-BT WILLOW CREEK FEEDER	31258.00000	400
510546.02	Bunte Highline Ditch	31257.99998	14.1
510546.03	Bunte Highline Ditch	31257.99999	8.04
53_ADC024.02	Stillwater Ditch	1.00000	9.87

5.4.5.3.12 Municipalities and Industrial Demands

Many municipal and industrial system demands are consolidated at one or more structures within the model, therefore individual water rights were assigned as follows:

Water Right ID	Name	Administration No.	Rate
360841.01	TenMile Diversion No.1	31566.00000	35
360989.01	Maggie Pond Snowmaking	99999.99999	999
361016.01	Copper Mtn Snowmaking	99999.99999	999
530585.02	Glenwood L Water Sys Co	33023.31607	3
531051.03	GLENWOOD L WATER CO SYS	19573.13680	12
720807.01	Molina Power Plant	99999.99999	999
720816.01	Palisade Town Pipeline	12797.00000	1.44
720816.02	Palisade Town Pipeline	14222.00000	3.55
720920.01	Ute Pipeline Hdg No.2	38847.00000	20
720920.02	Ute Pipeline Hdg No.2	40013.39608	30
721487.01	Ute Pipeline Hdg No.1	38846.99999	20.0
721487.02	Ute Pipeline Hdg No.1	40013.39607	30.0
950020.01	Ute Water Treatment Plan	12753.00000	4.03
950020.02	Ute Water Treatment Plan	30895.12724	1.95
950020.03	Ute Water Treatment Plan	30895.24260	0.74
950020.04	Ute Water Treatment Plan	32811.00000	2.12
950020.05	Ute Water Treatment Plan	38847.00000	20

Water Right ID	Name	Administration No.	Rate
950020.06	Ute Water Treatment Plan	46751.46599	11
950020.07	Ute Water Treatment Plan	46995.00000	4.1
950020.08	Ute Water Treatment Plan	41791.00000	15
950030.01	Mason Eddy Ditch-Ute	12753.00000	4.03
950030.02	Mason Eddy Ditch-Ute	30895.12724	1.95
950030.03	Mason Eddy Ditch-Ute	30895.24260	0.74
950030.04	Mason Eddy Ditch-Ute	32811.00000	2.12
950030.05	Carver Ranch PL-Ute	46751.46599	11
950051.01	City of Grand Jnct	1.00000	999
955001.01	Vail Valley Water - Irr	15646.00000	11.2
955002.01	Snake R Water Dist Well	18181.00000	0.03
955002.02	Snake R Water Dist Well	32075.25333	0.12
955002.03	Snake R Water Dist Well	44741.00000	1.23
955003.01	Vail Valley Water - NonI	42420.41366	13

5.4.5.3.13 Redlands Power Canal

Redlands Power Canal rights are assigned to two structures that model the power demand (420541) and the irrigation demand (950050). The original first right is divided into its proportionate amounts based on use.

Water Right ID	Name	Administration No.	Rate
420541.01	Redlands Power Canal	22283.20300	610
950050.01	Redlands Power Canal-Irr	22283.20300	60
950050.02	Redlands Power Canal-Irr	34419.33414	80

5.4.5.3.14 Silt Project

The Silt Project demand is met through operating rules, therefore free water rights were assigned to the two diversion demand structures because StateMod expects rights in the diversion right file for each structure in the diversion station file.

Water Right ID	Name	Administration No.	Rate
950010.01	Dry Elk Valley Irr	99999.99999	0
950011.01	Farmers Irrigation Comp	99999.99999	0

5.4.5.3.15 15-Mile Endangered Fish Reach

The 15-Mile Endangered Fish Reach demand is met by operating rules that release water from Ruedi Reservoir in the Historic and Calculated simulations and have zero demand in the Baseline simulation. A free water right was assigned because StateMod expects rights in the diversion right file for each structure in the diversion station file.

Water Right ID	Name	Administration No.	Rate
952001.01	15-Mile Fish Require	99999.91000	0

5.4.5.3.16 Excess HUP Demand Structures

Demands at the Excess HUP Demand Structures are met by operating rules. Water rights for these structures were included in the *.ddr file as placeholders because StateMod expects rights in the diversion right file for each structure in the diversion station file.

Water Right ID	Name	Administration No.	Rate
954516D.01	HUP Release Node	99999.99999	0
953709D.01	HUP Release Node	99999.99999	0
953668D.01	HUP Release Node	99999.99999	0

5.4.5.3.17 Reservoir Demand Structures

Demands located at the Reservoir Demand Structures are exclusively met by operating rules or the structures are used as placeholders for alternate future scenarios. The water rights associated with these structures have a decreed rate of diversion of 0 cfs. The one exception is the Wolcott Pumping Plant where the demand was set to zero in the *.ddm file and the decreed rate of diversion was set by values located in HydroBase.

Water Right ID	Name	Administration No.	Rate
953101.01	Wolford_Fraser_Dem	99999.00000	0
953102.01	Wolford_MidPark_Dem	99999.00000	0
953103.01	Wolford_Market_Dem	99999.00000	0
371146.01	Wolcott_Pumping_Plant	42485.00000	500
953001.01	Ruedi_Rnd_1-Mun.Demand	99999.00000	0
953002.01	Ruedi_Rnd_1-Ind.Demand	99999.00000	0
953003.01	Ruedi_Rnd_2-Mun.Demand	99999.00000	0

Water Right ID	Name	Administration No.	Rate
953004.01	Ruedi_Rnd_2-Ind.Demand	99999.00000	0
953005.01	Ruedi_Addl_Dem	99999.00000	0
950060.01	Grn_Mtn_Contract_Dem	99999.00000	0
950061.01	Grn_Mtn_Annual_Rep_Est.	99999.00000	0

5.4.5.3.18 Future Depletions

Future Depletion structures are included as placeholders for alternate future scenarios and therefore the decreed rate of diversion was set to 0 cfs.

Water Right ID	Name	Administration No.	Rate
956001.01	Future_Depletion_#1	99999.00000	0
956002.01	Future_Depletion_#2	99999.00000	0

5.4.5.3.19 Cliff Ditch Water Rights

Cliff Ditch has two headgates that are represented in the model network, structure 500539 – Cliff Ditch and 500731 – Cliff Ditch Headgate No. 2. Structure 500539 has two water rights and the second water right can be diverted at the alternate point 500731. Structure 500731 does not have a water right. Based on their locations, with a gaged tributary entering the mainstem of Troublesome Creek between the two structures, and inspection of the water rights and historic diversions, it was determined that the shared water right could be divided equally between the two structures.

Water Right ID	Name	Administration No.	Rate
500731.01	Cliff Ditch Hdg No 2	20676.19665	12
500539.02	Cliff Ditch	20676.19665	12

5.4.5.3.20 Free Water Rights

Free water rights, with a junior administration number 99999.99999 and decreed rate of diversion of 999 cfs, were added during calibration for those structures whose historical demands were observed to exceed the water rights for the structure.

Water Right ID	Name	Administration No.	Rate
360662.99	HOAGLAND CANAL SPRUCE	99999.99999	999
360729.99	MAT NO 2 DITCH	99999.99999	999
360734.99	MCKAY DITCH	99999.99999	999

Water Right ID	Name	Administration No.	Rate
360765.99	PALMER-MCKINLEY DITCH	99999.99999	999
360780.99	PLUNGER DITCH	99999.99999	999
360800.99	SLATE CREEK DITCH	99999.99999	999
360801.99	SMITH DITCH	99999.99999	999
360841.99	TenMile Diversion No.1	99999.99999	999
360868.99	WESTLAKE DITCH	99999.99999	999
364626.99	Vidler Tunnel Collection	99999.99999	999
370519.99	BRAGG NO 1 DITCH	99999.99999	999
370548.99	C M STREMME GATES DITCH	99999.99999	999
370571.99	J M DODD DITCH	99999.99999	999
370655.99	H O R DITCH	99999.99999	999
370723.99	NEILSON SOUTH DITCH	99999.99999	999
370743.99	ONEILL AND HOLLAND DITCH	99999.99999	999
370823.99	STRATTON AND CO DITCH	99999.99999	999
370830.99	TERRELL AND FORD DITCH	99999.99999	999
370848.99	WARREN DITCH	99999.99999	999
371091.99	EWING PLACER DITCH	99999.99999	999
380517.99	ATKINSON CANAL	99999.99999	999
380547.99	BOWLES AND HOLLAND DITCH	99999.99999	999
380573.99	CAPITOL PARK DITCH	99999.99999	999
380618.99	CRANE AND PEEBLES DITCH	99999.99999	999
380663.99	ELLA DITCH	99999.99999	999
380667.99	EUREKA NO 1 DITCH	99999.99999	999
380688.99	FOUR MILE DITCH	99999.99999	999
380712.99	GLENWOOD DITCH	99999.99999	999
380715.99	GRACE AND SHEHI DITCH	99999.99999	999
380720.99	GREEN MEADOW DITCH	99999.99999	999
380740.99	HARRIS & REED DITCH	99999.99999	999
380757.99	HOME SUPPLY DITCH	99999.99999	999
380838.99	LOWER DITCH	99999.99999	999
380840.99	LOWLINE DITCH	99999.99999	999
380854.99	MAROON DITCH	99999.99999	999
380881.99	MOUNTAIN MEADOW DITCH	99999.99999	999
380890.99	MCKENZIE WILDCAT DITCH	99999.99999	999

Water Right ID	Name	Administration No.	Rate
380893.99	MCKOWN DITCH	99999.99999	999
380925.99	PARK DITCH	99999.99999	999
380930.99	PATERSON D JACOB EXT	99999.99999	999
380939.99	PIONEER DITCH	99999.99999	999
380959.99	RED ROCK BLUFF DITCH	99999.99999	999
380968.99	ROBINSON DITCH	99999.99999	999
380970.99	ROCKFORD DITCH	99999.99999	999
380981.99	SALVATION DITCH	99999.99999	999
381018.99	SOUTHARD AND CAVANAUGH D	99999.99999	999
381038.99	SWEET JESSUP CANAL	99999.99999	999
381073.99	WACO DITCH	99999.99999	999
381101.99	WILLOW CREEK DITCH	99999.99999	999
381121.99	ALEXIS ARBANEY DITCH	99999.99999	999
381132.99	WALTHEN DITCH	99999.99999	999
381147.99	KAISER AND SIEVERS DITCH	99999.99999	999
384613.99	IVANHOE RESERVOIR TUNNEL	99999.99999	999
390532.99	CLOUGH NO 1 DITCH	99999.99999	999
390537.99	CORNELL DITCH	99999.99999	999
390540.99	CORYELL JOINT STOCK IRRI	99999.99999	999
390562.99	GRANLEE DITCH	99999.99999	999
390590.99	JANGLE DITCH	99999.99999	999
390610.99	LOW COST DITCH	99999.99999	999
390612.99	LOWER CACTUS VALLEY D	99999.99999	999
390635.99	PARACHUTE DITCH	99999.99999	999
390638.99	PIERSON AND HARRIS DITCH	99999.99999	999
390645.99	RIFLE CREEK CANON DITCH	99999.99999	999
390672.99	THOMPKINS DITCH	99999.99999	999
390687.99	WARE AND HINDS DITCH	99999.99999	999
390825.99	WILLIAMS CANAL	99999.99999	999
450616.99	H AND S DITCH	99999.99999	999
450668.99	LAST CHANCE DITCH	99999.99999	999
450685.99	MAMM CREEK DITCH	99999.99999	999
450704.99	MULTA-TRINA DITCH	99999.99999	999
450743.99	RISING SUN DITCH	99999.99999	999

Water Right ID	Name	Administration No.	Rate
450788.99	SYKES AND ALVORD DITCH	99999.99999	999
450793.99	TAUGHENBAUGH DITCH	99999.99999	999
450818.99	WEST DIVIDE CREEK DITCH	99999.99999	999
450861.99	LARKIN DITCH	99999.99999	999
500539.99	CLIFF DITCH	99999.99999	999
500582.99	HERDE DITCH	99999.99999	999
500627.99	PASS CREEK DITCH	99999.99999	999
500628.99	PICKERING DITCH	99999.99999	999
500654.99	TROUBLESOME DITCH	99999.99999	999
500656.99	TYLER DITCH	99999.99999	999
500731.99	Cliff Ditch Hdg No 2	99999.99999	999
500734.99	DEBERARD DITCH	99999.99999	999
510546.99	BUNTE HIGHLINE DITCH	99999.99999	999
510585.99	COFFEE MCQUEARY DITCH	99999.99999	999
510639.99	Jim Creek Div	99999.99999	999
510660.99	GASKILL DITCH	99999.99999	999
510699.99	HAMMOND NO 1 DITCH	99999.99999	999
510763.99	KINNEY BARRIGER DITCH	99999.99999	999
510829.99	PEAVEY NO 2 DITCH	99999.99999	999
510831.99	PETERSON DITCH NO 1	99999.99999	999
510876.99	SCYBERT DITCH	99999.99999	999
510880.99	SELAK LARRABEE DITCH	99999.99999	999
510883.99	SHERIFF DITCH 156	99999.99999	999
510893.99	SOPHRONIA DAY DITCH	99999.99999	999
510934.99	TRAIL CREEK DITCH	99999.99999	999
510939.99	UTE BILL NO 2 DITCH	99999.99999	999
510958.99	C-BT WILLOW CREEK FEEDER	99999.99999	999
511070.99	HENDERSON MINE WTR SYS	99999.99999	999
511310.99	Vasquez Creek Div	99999.99999	999
520559.99	GUTZLER DITCH	99999.99999	999
520658.99	WILMOT DITCH	99999.99999	999
530555.99	CABIN CREEK DITCH	99999.99999	999
530632.99	HORSE MEADOWS DITCH	99999.99999	999
530783.99	ROYAL FLUSH DITCH	99999.99999	999

Water Right ID	Name	Administration No.	Rate
700550.99	H V C AND S DITCH	99999.99999	999
700584.99	ROAN CREEK NO 3 DITCH	99999.99999	999
720533.99	BERTHOLF LANHAM UPDIKE D	99999.99999	999
720580.99	COOK DITCH	99999.99999	999
720645.99	GRAND VALLEY CANAL	99999.99999	999
720911.99	TEMS DITCH	99999.99999	999
950050.99	Redlands Power Canal-Irr	99999.99999	999
38_ADC035.99	Frying Pan River	99999.99999	999
38_ADC036.99	West Sopris Creek	99999.99999	999
45_ADC047.99	Colorado River bl Cache	99999.99999	999
50_ADC012.99	Troublesome Creek	99999.99999	999
50_ADC016.99	Lower Muddy Creek	99999.99999	999
51_ADC001.99	Colorado River nr Granby	99999.99999	999
51_ADC002.99	Willow Creek	99999.99999	999
51_ADC003.99	Ranch Creek	99999.99999	999
51_ADC006.99	Fraser River at Granby	99999.99999	999
51_ADC007.99	Colorado River abv Hot S	99999.99999	999
51_ADC008.99	Colorado River abv Willi	99999.99999	999
51_ADC011.99	Colorado River abv Troub	99999.99999	999
53_ADC024.99	Egeria Creek abv Toponas	99999.99999	999
53_ADC028.99	Derby Creek	99999.99999	999
53_ADC032.99	Colorado River abv Glenw	99999.99999	999

5.5 Irrigation Files

The irrigation files provide parameters used during simulation to compute on-farm consumptive use and return flow volumes related to a given month's diversion.

5.5.1 StateCU Structure File (*.str)

This file contains the soil moisture capacity of each irrigation structure in inches per inch of soil depth. It is required for StateMod's soil moisture accounting in both baseflow and simulation modes. Soil moisture capacity values were gathered from Natural Resources Conservation Service (NRCS) mapping. The file was created by StateDMI.

5.5.2 Irrigation Parameter Yearly (*.ipy)

This file contains conveyance efficiency and maximum application efficiency by irrigation type for each irrigation structure for each year of the study period. The file also contains acreage by irrigation type – either flood or sprinkler. In the Upper Colorado River basin, all acreage was assigned flood irrigation type. Maximum system efficiency (includes both conveyance and application efficiencies) was estimated to be 54 percent for Colorado structures. Because overall system efficiency was considered, conveyance efficiency was set to 1.0 and maximum flood application efficiency was set to the system efficiencies outlined here. This file was created by StateDMI.

5.5.3 Irrigation Water Requirement File (*.iwr)

Data for the irrigation water requirement file was generated by StateCU for the period 1975 through 2005, then extended back to 1909 using TSTool. StateCU was executed using the SCS modified Blaney-Criddle monthly evapotranspiration option with TR-21 crop parameters for lands irrigated below elevation 6500 feet. A standard elevation adjustment was applied to TR-21 crop coefficients. For structures irrigating pasture grass above 6500 feet, StateCU was executed using the original Blaney-Criddle method with high-altitude crop coefficients, as described in the SPDSS 59.2 Task Memorandum *Develop Locally Calibrated Blaney-Criddle Crop Coefficients*, March 2005. Acreage for each structure was set to the acreage defined in 1993 for the entire study period. The irrigation water requirement file contains the time series of monthly irrigation water requirements for structures whose efficiency varied through the simulation.

5.6 Reservoir Files

5.6.1 Reservoir Station File (*.res)

This file describes physical properties and some administrative characteristics of each reservoir simulated in the Upper Colorado River basin. It was assembled by StateDMI, using considerable amount of information provided in the commands file. Twenty-two key reservoirs are modeled explicitly. Eleven aggregated reservoirs and stock ponds account for evaporation from numerous small storage facilities.

The modeled reservoirs are listed below with their capacity and their number of accounts or pools.

#	ID #	Name	Capacity (af)	# of Accounts
1	363543	Green Mountain Reservoir	154,645	6
2	363570	Cont Hoosier Blue Res	2,113	2
3	363575	Clinton Gulch Reservoir	4,300	9
4	364512	Dillon Reservoir	257,000	5
5	36_ARC001	36_Arc001	8,702	1
6	373639	Wolcott Reservoir	65,975	1
7	373699	Eagle Park Reservoir	3,148	4
8	374516	Homestake Proj Reservoir	43,600	3
9	37_ARC002	37_Arc002	6,671	1
10	383713	Ruedi Reservoir	102,373	6
11	38_ARC003	38_Arc003	13,074	1
12	393505	Grass Valley Reservoir	5,920	1
13	393508	Rifle Gap Reservoir	13,602	2
14	39_ARC004	39_Arc004	2,236	1
15	45_ARC005	45_Arc005	2,054	1
16	503668	Wolford Mountain Res	65,985	9
17	50_ARC006	50_Arc006	11,481	1
18	513686	Meadow Creek Reservoir	5,930	3
19	513695	C-BT Shadow Mtn Grand L	18,369	2
20	513709	Williams Fork Reservoir	96,822	5
21	513710	C-BT Willow Creek Res	10,553	2
22	514620	C-BT Granby Reservoir	539,758	2
23	51_ARC007	51_Arc007	8,480	1
24	52_ARC008	52_Arc008	821	1
25	53_ARC009	53_Arc009	8,389	1
26	723839	Leon Lake Aggreg Res	2,904	1
27	723842	Monument Aggreg Res	987	1
28	723844	Vega Reservoir	34,131	3
29	723961	Jerry Creek Aggreg Res	8,623	1
30	72_ARC010	72_Arc010	25,664	1
31	72_ASC001	72_Asc001	2,261	1
32	953800	Bonham Creek Aggregated Res	6,778	1
33	953801	Cottonwood Creek Aggreg Res	3,812	1

Leon Lake Aggregate Reservoir includes Leon Lake and Colby Horse Reservoir. Monument Aggregate Reservoir includes Monument Reservoir 1 (aka Hunter Reservoir), Monument Reservoir 2, and Big Park Reservoir. Cottonwood Creek Aggregate Reservoir includes Cottonwood Reservoirs 1, 2, 4 and 5, Never Sweet Reservoir, Little Meadows Reservoir, and Big Meadows Reservoir. Bonham Creek Aggregate Reservoir includes Bohnam Resevoir, Big Creek Reservoir, Atkinson Reservoir, Forty-acre Reservoir, Silver Lake, and Dawson Reservoir.

5.6.1.1 Key Reservoirs

Parameters related to the physical attributes of key reservoirs include inactive storage, where applicable, total storage, area-capacity data, applicable evaporation/precipitation stations, and initial reservoir contents. For explicitly modeled reservoirs, storage and area-capacity information were obtained from either the Division Engineer or the reservoir owners. Initial contents for all reservoirs were set to average September end-of-month contents over the period 1975 through 2005. After filling dead pools, initial contents were prorated to reservoir accounts based on account size.

Administrative information includes reservoir account ownership, administrative fill date, and evaporation charge specifications. This information was obtained from interviews with the Division Engineer, local water commissioners, and the owner/operator of the individual reservoirs.

5.6.1.2 Aggregate Reservoirs

The amount of storage for aggregate reservoirs and stock ponds is based on storage decrees and the CDSS Task 2.09-10 Memorandum "Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Upper Colorado River basin" (see Appendix B). Surface area for the aggregate reservoirs and stock ponds were developed based on the estimates of straight-sided pits with a depth of 10 feet. Initial contents were set to capacity.

5.6.1.3 Reservoir Accounts

Except as noted below, Upper Colorado River Model reservoirs are modeled with one active account and possibly a dead pool.

5.6.1.3.21 Green Mountain Reservoir

This reservoir was constructed as an integral part of the C-BT Project with the primary objective of providing replacement water to Western Slope water users and providing water that could be exchanged up to Granby Reservoir. Additional uses of the reservoir include contract users, a supply source for the Silt Project, and deliveries to meet the 15-Mile Endangered Fish Reach instream flow requirement. Hydroelectric power generation is driven by power demand and releases for other uses, therefore difficult to model. The reservoir is modeled with the following six accounts:

Account	Storage Amount (af)
Historic Users	66,000
C-BT Pool	52,000
Contract	20,000
Silt Project	5,000
Inactive	11,645
Surplus Fish	66,000

5.6.1.3.22 Continental Hoosier – Upper Blue Lakes

The Upper Blue Lakes are an integral part of the Continental Hoosier transbasin diversion for the City of Colorado Springs. The reservoir stores water that is later taken through the Continental Hoosier tunnel and/or used as a replacement source for diversions out-of-priority to Green Mountain Reservoir in accordance with the Blue River Decree and subsequent agreements. The combined reservoir is modeled with two accounts, Active (2140 af) and Colorado Springs Out-of-priority (2100 af).

5.6.1.3.23 Clinton Gulch Reservoir

Clinton Gulch Reservoir was initially used in the operations of the Climax Mine. Around 1992 the reservoir was acquired by west slope users to firm additional yield for Summit County and Grand County users by way of an agreement with Denver, known as the Clinton Agreement. Due to the numerous entities involved in the agreement eight accounts are modeled:

Account	Storage Amount (af)
Town of Breckenridge	390
Town of Dillon	60
Town of Silverthorne	165
Breckenridge Ski Area	455
Copper Mountain Ski Area	490
Keystone Ski Area	1,305
Winter Park Ski Area	270
Summit County	465
Dead Pool	700

5.6.1.3.24 Dillon Reservoir

The Denver Board of Water Commissioners (Denver) operates Dillon Reservoir and the Harold D. Roberts Tunnel as primary features of its raw water collection and transmountain diversion system. Water diverted pursuant to the direct flow decree of Roberts Tunnel, together with releases from storage in Dillon Reservoir, are conveyed under the Continental Divide to the headwaters of the North Fork of the South Platte River on Colorado's Eastern Slope. Beyond Denver's direct use of the reservoir, Denver has entered into additional agreements with west slope users - two notable agreements are the Blue River Decree and the Clinton Agreement. Dillon Reservoir is modeled with five accounts:

Account	Storage Amount (af)
Denver	252,015
Summit County	1,021
Dead Pool	3,269
1000 ac-ft minimum stream flow	1,000
Denver out-of-priority	154,645

5.6.1.3.25 Eagle Park Reservoir

Eagle Park Reservoir is used to provide augmentation water for multiple entities on the Eagle River. The reservoir is not operated in the baseline data set, but is setup as a placeholder for future modeling. The reservoir is modeled with four accounts:

Account	Storage Amount (af)
Eagle River Water & Sanitation	330
Upper Eagle River Regional Water Authority	383
Vail Valley Association	1,100
River District	200

5.6.1.3.26 Homestake Reservoir

Homestake Reservoir is owned and operated by the City of Aurora and the City of Colorado Springs as part of the Homestake transbasin project. The City of Colorado Springs is in the process of evaluating the use of the reservoir as a replacement source for their out-of-priority diversions associated with the Continental Hoosier transbasin project. The reservoir is modeled with three accounts:

Account	Storage Amount (af)
Colorado Springs and Aurora	42,881
Dead Pool	211
Homestake – Green Mountain Replacement	21,440

5.6.1.3.27 Ruedi Reservoir

Ruedi Reservoir is used to provide replacement storage for out-of-priority diversions at the North Side and South Side collection systems of the Fryingpan – Arkansas transbasin diversion project. Additional storage is available for contract sale to meet irrigation, municipal, and industrial water needs in western Colorado and is a source of supply for instream flow benefits on the lower Upper Colorado River, including the 15-Mile Reach, critical to habitat for endangered fish species. The reservoir is modeled with the following six accounts:

Account	Storage Amount (af)
Round 1 and 2 Contracts	24,850
Replacement	28,000
Dead Pool / Unallocated	28,698
CWCB Fish	10,825
Unallocated 5k	5,000
USFWS 5k 4/5	5,000

5.6.1.3.28 Wolford Mountain Reservoir

Wolford Mountain Reservoir is used to provide additional contracted water to west slope users, a supplemental replacement source for out-of-priority diversions to Green Mountain Reservoir, and for supplemental flows in the 15-Mile Reach for endangered fish species. The reservoir is modeled with nine accounts:

Account	Storage Amount (af)
West Slope	34,383
Denver	25,610
Fish Account	6,000
Wolford Mountain Fish Temp	5,413
Denver Replacement 1	5,000
Denver Replacement 2	20,610
Colorado Springs	1,750
Colorado Springs Book-over	250
Colorado Springs Replacement	1,750

5.6.1.3.29 Meadow Creek Reservoir

Meadow Creek Reservoir is one of the structures included in an agreement between Denver, Englewood, and Climax – Henderson Mill. A majority of the water stored in the reservoir is diverted through the Moffat Tunnel for use on the east slope. A small portion of the reservoir is reserved for the use in the Vail Ditch (Grand County Irrigation Company). The reservoir is modeled as having three accounts:

Account	Storage Amount (af)
Denver-Englewood	4,780
Vail Ditch	850
Dead Pool	300

5.6.1.3.30 Williams Fork Reservoir

Denver's Williams Fork Reservoir is an integral part of their transbasin projects. Water is exchanged to the Moffat collection system (Fraser River), Gumlick Tunnel (Williams Fork River), and Dillon Reservoir and Roberts Tunnel (Blue River), and is used for replacement in agreements with Climax – Henderson Mill and the Blue River Decree, as well as a supplemental source for the fish flows in the 15-Mile Reach. There are five accounts modeled:

Account	Storage Amount (af)
Denver	94,622
Henderson	2,200
Williams Fork Fish Temp	5,413
Williams Fork – Green Mountain Replacement 1	10,000
Williams Fork – Green Mountain Replacement 2	25,000

5.6.2 Net Evaporation File (*.eva)

The evaporation file contains monthly average evaporation data (12 values that are applied in every year). The annual net reservoir evaporation was estimated by subtracting the weighted average effective monthly precipitation from the estimated gross monthly free water surface evaporation. Annual estimates of gross free water surface evaporation were taken from the National Oceanic and Atmospheric Administration (NOAA) Technical Report NWS 33. The annual estimates of evaporation were distributed to monthly values based on elevation through the distributions listed in Table 5.6. These monthly distributions are used by the State Engineer's Office.

Table 5.6
Monthly Distribution of Evaporation as a Function of Elevation (percent)

Month	Greater than 6,500 feet	Less than 6,500 feet
Jan	3.0	1.0
Feb	3.5	3.0
Mar	5.5	6.0
Apr	9.0	9.0
May	12.0	12.5
Jun	14.5	15.5
Jul	15.0	16.0
Aug	13.5	13.0
Sep	10.0	11.0
Oct	7.0	7.5
Nov	4.0	4.0
Dec	3.0	1.5

Four evaporation stations are used in the calculation of annual net evaporation in the Upper Colorado River Model:

1. Rifle (10005) is used to calculate evaporation for the following reservoirs: Grass Valley, Rifle Gap, 39_ARC004, and 45_ARC005.
2. Glenwood Springs 1 N and Aspen (10006) are used to calculate evaporation for the following reservoirs: Wolcott, Homestake, 37_ARC002, Ruedi, 38_ARC003, 52_ARC008, 53_ARC009, Vega, 72_ARC010, 72_ASC001, Bonham Aggregated, Cottonwood Aggregated, Leon Creek Aggregated, Monument Aggregated, and Jerry Creek Aggregated.
3. Green Mountain Dam and Dillon 1 E (10008) are used to calculate evaporation for the following reservoirs: Green Mountain, Continental Hoosier Upper Blue Lakes, Clinton Gulch, Dillon, 36_ARC001, Wolford Mountain, 50_ARC006, and Williams Fork.
4. Shadow Mountain Reservoir (10009) is used to calculate evaporation for the following reservoirs: Meadow Creek, Grand Lake/Shadow Mountain, Willow Creek, Granby, and 51_ARC007.

The resulting net monthly free water surface evaporation estimates, in feet, used in the Upper Colorado River Model are as follows:

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
10005	0.13	0.06	0.02	0.03	0.06	0.11	0.22	0.32	0.42	0.41	0.35	0.24	2.37
10006	0.13	0.02	-0.09	-0.1	-0.02	0.07	0.17	0.32	0.41	0.42	0.29	0.24	1.86
10008	0.14	0.03	-0.05	-0.05	0.01	0.06	0.16	0.25	0.35	0.32	0.26	0.22	1.70
10009	0.03	0.01	-0.06	-0.06	0.01	0.05	0.07	0.29	0.38	0.32	0.22	0.08	1.34

5.6.3 End-Of-Month Content File (*.eom)

The end-of-month content file contains historical end-of-month storage contents for reservoirs in the reservoir station file. The historical EOM reservoir contents in this file are used by StateMod when estimating baseflow to reverse the effects of reservoir storage and evaporation on gaged streamflows, and to produce comparison output useful for calibration. The file was created by TSTool, which reads data from HydroBase and filled missing data with a variety of user-specified algorithms.

5.6.3.1 Key Reservoirs

Data for the Upper Colorado River Model key reservoirs was primarily generated by converting daily observations stored in HydroBase to month-end data, supplemented by USBR data. Missing end-of-month contents were filled with the average of available values for months with the same hydrologic condition and remaining missing values were filled with average monthly values. For reservoirs with little or no historical data available end-of-month contents were set to reservoir capacity. Table 5.7 presents the on-line date for each reservoir and the primary data source for end-of-month contents. Historical contents in the *.eom file were set to zero prior to the on-line date.

Table 5.7
Reservoir On-line Dates and EOM Contents Data Source

WDID	Reservoir Name	On-Line Date	Primary Data Source
363543	Green Mountain Reservoir	1943	HydroBase Daily
363570	Cont Hoosier Blue Res	1962	HydroBase Daily
363575	Clinton Gulch Reservoir	1977	HydroBase Daily
364512	Dillon Reservoir	1963	HydroBase Daily
373639	Wolcott Reservoir	N/A	N/A
373699	Eagle Park Reservoir	1990	N/A
374516	Homestake Proj Reservoir	1967	HydroBase Daily
383713	Ruedi Reservoir	1968	HydroBase Daily
393505	Grass Valley Reservoir	1890	HydroBase Daily
393508	Rifle Gap Reservoir	1967	HydroBase Daily
503668	Wolford Mountain Res	1995	HydroBase Daily
513686	Meadow Creek Reservoir	1956	HydroBase Daily
513695	C-BT Shadow Mtn Grand L	1946	HydroBase Daily
513709	Williams Fork Reservoir	1939	HydroBase Daily
513710	C-BT Willow Creek Res	1953	HydroBase Daily
514620	C-BT Granby Reservoir	1949	HydroBase Daily
723844	Vega Reservoir	1960	USBR

723961	Jerry Creek Aggreg	1980	HydroBase Daily

5.6.3.2 Aggregate Reservoirs

Aggregated reservoirs were assigned contents equal to their capacity, because actual data was not available. Aggregated reservoirs are modeled as though in operation throughout the study period.

5.6.4 Reservoir Target File (*.tar)

The reservoir target file contains minimum and maximum target storage limits for reservoirs in the reservoir station file. The reservoir may not store more than the maximum target, or release to the extent that storage falls below the minimum target. In the Baseline data set, the minimum targets were set to zero, and the maximum targets were set to capacity for reservoirs that operated primarily for agricultural and municipal diversion storage. Maximum targets were set to operational targets according to rule curves provided by USBR for Ruedi, Green Mountain, and Willow Creek reservoirs and rule curves provided by Denver Water for Williams Fork reservoir. The file was created by TSTool.

5.6.5 Reservoir Right File (*.rer)

The reservoir right file contains water rights associated with each reservoir in the reservoir station file. Specifically, the parameters for each storage right include the reservoir, administration number, decreed amount, the account(s) to which exercise of the right accrues, and whether the right was used as a first or second fill. It is recommended for future updates that the StateDMI commands be run initially without the "set" commands. This allows the modeler to view any changes to water rights (transfers, conditional to absolute, abandonment, etc.) reflected in updated versions of HydroBase and modify the "set" commands as necessary.

5.6.5.1 Key Reservoirs

In general, water rights for explicitly modeled reservoirs were taken from HydroBase and correspond to the State Engineer's official water rights tabulation. In addition, many key reservoirs were assigned a "free water right", with an extremely junior administration number to allow storage under free river conditions.

5.6.5.2 Aggregate Reservoirs

Aggregated reservoirs and stock ponds were assigned a decreed amount equal to their capacity, and an administration number 1.00000.

5.6.5.3 Special Reservoir Rights

5.6.5.3.31 Green Mountain Reservoir

Green Mountain Reservoir (363543) has two senior rights with the same administration number that are combined in HydroBase. It was necessary to split these rights because their combined decreed volumes exceeded the reservoir's capacity. Additionally, there was an understanding between Colorado Springs, Denver, and the USBR that the senior refill right would not be exercised to call out upstream junior storage rights. The senior first fill right has an administration number of 31258.00000 and volume of 154,645 af. The senior refill right was assigned an administration number of 38628.00001 and volume of 6316 af. Additionally, the junior refill right was set to include the conditional portion of the right with an administration number of 50403.49309 and a volume of 154,645.

5.6.5.3.32 Clinton Gulch Reservoir

Clinton Gulch Reservoir (363575) has two rights, a senior first fill and a junior refill. Pursuant to the Clinton Reservoir Agreement with Denver, 3650 af can be stored in Clinton Gulch Reservoir prior to Denver exercising its Roberts Tunnel and Dillon Reservoir rights. The first fill right was broken into two rights with volumes of 3,650 af and 600 af and administration numbers of 31257.99999 and 45290.35239, respectively. The junior refill right has a volume of 4,250 and an administration number of 51864.51194.

5.6.5.3.33 Dillon Reservoir

Dillon Reservoir (364512) has two water rights, a modified senior first fill right and a junior refill right. The senior first fill right was modified to be junior to Colorado Springs' Continental Hoosier Tunnel diversions and Cont Hoosier Blue Reservoir storage based on an agreement between Colorado Springs and Denver. The first fill reservoir right was also set slightly junior to the Roberts Tunnel diversion right. The senior first fill right has a storage volume of 252,678 af and an administration number set to 35927.00004. The junior refill right has a volume of 252,678 af and an administration number set to 50038.49309.

5.6.5.3.34 Cont Hoosier Blue Reservoir

Continental Hoosier Blue Reservoir (363570) a.k.a. Upper Blue Lakes, is part of Colorado Springs' Continental Hoosier project. The senior first fill right was modified so that it was slightly junior to the Continental Hoosier Tunnel diversion right with a modified administration number of 35927.00001.

5.6.5.3.35 Ruedi Reservoir

Ruedi Reservoir (383713) has a conditional portion to its refill right that was included in the modeled right. The junior refill right was set to a volume of 101,280 af.

5.6.5.3.36 Free Reservoir Rights

There are a few reservoirs in the Upper Colorado River ModelNP2008 that are assigned a free river fill right. These free river rights allow the reservoirs to fill when unappropriated water is available and there was available capacity in the reservoir.

Water Right ID	Name	Administration No.	Volume	On/Off
363570.02	CON_HOOSIER_RES-free	99999.99999	10,000	On
374516.02	HOMESTAKE_RES-refill	99999.99999	43,505	On
393505.03	GRASS_VALLEY_RES-refill	99999.99999	5,920	On
393508.02	RIFLE_GAP_RES-refill	99999.99999	13,601	On
503668.03	WOLFORD_MOUNTAIN-refill	99999.99999	30,000	On
513686.02	MEADOW_CREEK_RES-refill	99999.99999	5,100	On
513695.02	SHADOW_MTN_RES-refill	99999.99999	19,669	On
513710.02	WILLOW_CREEK_RES-refill	99999.99999	10,553	On
514620.02	GRANBY_RESERVOIR-refill	99999.99999	543,758	On
723844.02	VEGA_RESERVOIR_refill	99999.99999	33,500	On

5.7 Instream Flow Files

5.7.1 Instream Station File (*.ifs)

Eighty-nine instream flow reaches are defined in this file, which was created in StateDMI. The file specifies an instream flow station and downstream terminus node for each reach, through which instream flow rights can exert a demand in priority. Table 5.8 lists each instream flow station included in the Upper Colorado River Model, along with their location and maximum daily demand. These rights represent decrees acquired by CWCB, with the exception of instream flow stations listed under the following section.

5.7.1.1 Special Instream Flow Stations

Several reservoir bypass agreements, bypass agreements associated with transbasin diversions, and other operations are represented as instream flow reaches as follows:

Reservoir Bypass Agreements:

- Rifle Gap Reservoir Bypass (953508)
- Green Mountain Reservoir Bypass (953543)
- Wolford Mountain Reservoir Bypass (953668)
- Shadow Mountain Reservoir and Grand Lake Bypass (953695)
- Williams Fork Reservoir Bypass (953709)
- Willow Creek Reservoir Bypass (953710)
- Ruedi Reservoir Bypass (953713)
- Dillon Reservoir Bypass (954512)
- Granby Reservoir Bypass (954620)
- Wolcott Reservoir Pumping Pipeline Bypass (951146)

Transbasin Diversion Bypass Agreements:

- Ranch Creek below the Moffat Tunnel project diversion (951269)
- St. Louis Creek below the Moffat Tunnel project diversion (951309)
- Vasquez Creek below the Moffat Tunnel project diversion (951310)
- Hunter Creek below the Moffat Tunnel project diversion (951594)
- Jim Creek below the Moffat Tunnel project diversion (950639)
- Below the Thomasville Gage on the Fryingpan River for the Fryingpan-Arkansas project (950786)
- Homestake Creek downstream of the Gold Park Gage for the Homestake project (954516)
- Bobtail Creek downstream of the Gumlick Tunnel for the Williams Fork River portion of the Moffat Tunnel project (954603)
- Fryingpan River downstream of the Boustead Tunnel for the Fryingpan-Arkansas project (954625)

Other Instream Flow Reaches:

- An instream flow node was added to continue the Eagle River instream flow section below the minimum bypass at the proposed Wolcott Reservoir Pumping Pipeline diversion location (372059_2). StateMod does not allow an instream flow within an instream flow.
- An instream flow node was added to reflect bypasses for the Grand Valley Project (950099). This node can be used to analyze future scenarios where the Grand Valley Project bypasses water for endangered fish flows.
- An instream flow node was added to reflect minimum flow requirements at the Shoshone power plant (950500). This node was used in the Historic simulation to reflect releases from Green Mountain to satisfy Shoshone's demand prior to 1984.
- An instream flow node was added on the mainstem of the Colorado to simulate the USFWS recommended endangered fish flows through the critical 15-Mile Reach (952002).
- An instream flow node was added to reflect the minimum bypass flow requirement for Ute Water Conservancy District Plateau Creek diversions (950920).

Recreational Instream Channel Diversions:

- An instream flow node was added represent the Blue River Whitewater Course (361123). This conditional water right is turned off in the baseline dataset.
- An instream flow node was added represent the Town of Vail Whitewater Course (371412). This conditional water right is turned off in the baseline dataset.

- An instream flow node was added represent the Avon Whitewater Course (371416). This conditional water right is turned off in the baseline dataset.
- An instream flow node was added represent the Aspen Whitewater Course (381418).

5.7.2 Instream Flow Annual Annual File (*.ifa)

Instream flow demands were developed from decreed amounts and comments in the State Engineer's water rights tabulation or from agreements as listed in Section 5.7.1. Twelve monthly instream flow demands are used and repeated for each year of the simulation. The file contains monthly demands for each instream flow structure included in the Upper Colorado River Model, except for structures included in the Instream Demand Monthly File (*.ifm), see below.

5.7.3 Instream Flow Monthly Demand File (*.ifm)

There are two instream flow structures with variable demands. Structures 952002 - USFWS Recommended Fish Flow and 954620 - Granby Res Min Release demands are based on hydrologic conditions (dry, average, wet conditions). Twelve monthly instream flow demands were developed for each of the years in the study period.

5.7.4 Instream Right File (*.ifr)

Water rights for each instream flow reach modeled in the Upper Colorado River Model are contained in the instream flow right file, and shown in Table 5.8. Note that the decree represents the maximum demand, which may vary throughout the year. These data were obtained from HydroBase with the exception of instream flow reaches listed under section 5.7.4.1. It is recommended for future updates that the StateDMI commands be run initially without the "set" commands. This allows the modeler to view changes to water rights (transfers, conditional to absolute, abandonment, etc.) reflected in updated versions of HydroBase and modify the "set" commands as necessary.

Table 5.8
Instream Flow Summary

#	ID	Name	Decree (cfs)
1	361123	BLUE RIVER WHITEWATER CO	0.00
2	362000	MIN FLOW CATARACT CR LOW	6.00
3	362002	MIN FLOW BRUSH CREEK	3.00
4	362012	MIN FLOW SLATE CREEK	7.00
5	362030	MIN FLOW BLUE RIVER 3	20.00
6	362033	MIN FLOW SNAKE RIVER LOW	12.00
7	362037	MIN FLOW BLUE RIVER 4	32.00
8	362043	MIN FLOW BLUE RIVER 5	50.00
9	362044	MIN FLOW BLUE RIVER 6	55.00
10	362045	MIN FLOW BLUE RIVER 7	75.00
11	362046	MIN FLOW BLUE RIVER 8	115.00
12	362047	MIN FLOW BLUE RIVER 9	125.00
13	362048	MIN FLOW BLUE RIVER 10	125.00
14	362049	MIN FLOW BLUE RIVER 11	60.00
15	371412	TOWN OF VAIL WHITEWATER	0.00

#	ID	Name	Decree (cfs)
16	371416	AVON WHITEWATER COURSE R	0.00
17	372000	MIN FLOW GYPSUM CREEK LO	6.00
18	372012	MIN FLOW EAGLE RIVER	130.00
19	372028	MIN FLOW EAGLE RIVER	25.00
20	372034	MIN FLOW EAGLE RIVER	15.00
21	372041	MIN FLOW EAGLE RIVER	35.00
22	372042	MIN FLOW EAGLE RIVER	50.00
23	372043	MIN FLOW BRUSH CREEK	12.00
24	372046	MIN FLOW EAGLE RIVER	12.00
25	372056	MIN FLOW GORE CR LOWER	36.00
26	372057	MIN FLOW GORE CR MIDDLE	26.00
27	372059	MIN FLOW EAGLE RIVER	45.00
28	372059_2	MIN_FLOW_EAGLE_RIVER_2	155.00
29	381418	ASPEN WHITEWATER COURSE	653.00
30	382000	MIN FLOW HUNTER CR LOWER	30.00
31	382013	MIN FLOW CAPITOL CREEK	10.00
32	382015	MIN FLOW CASTLE CREEK	12.00
33	382020	MIN FLOW FRYINGPAN R MID	200.00
34	382027	MIN FLOW MAROON CREEK	14.00
35	382039	MIN FLOW ROARING FORK 2	15.00
36	382040	MIN FLOW SNOWMASS CR LWR	15.00
37	382041	MIN FLOW SOPRIS CREEK	5.00
38	382044	MIN FLOW FRYINGPAN R UP	12.00
39	382048	MIN FLOW WOODY CREEK	6.00
40	382049	MIN FLOW ROARING FORK 3	32.00
41	382050	MIN FLOW ROARING FORK 1	10.00
42	382077	MIN FLOW FRYINGPAN R LOW	110.00
43	382080	MIN FLOW CATTLE CREEK	6.00
44	382111	MIN FLOW ROARING FORK 4	55.00
45	382112	MIN FLOW ROARING FORK 5	75.00
46	382114	MIN FLOW CRYSTAL R LOWER	100.00
47	392004	MIN FLOW RIFLE CREEK	5.00
48	392007	MIN FLOW EAST RIFLE CR L	6.00
49	392010	MIN FLOW ELK CREEK LOWER	8.00
50	512014	MIN FLOW WILLIAMS FORK R	32.00
51	512016	MIN FLOW WILLIAMS FORK R	28.00
52	512027	MIN FLOW WILLIAMS FORK R	12.00
53	512028	MIN FLOW WILLIAMS FORK R	15.00
54	512035	MIN FLOW WILLIAMS FORK R	25.00
55	512036	MIN FLOW COLORADO R LOW	150.00
56	512037	MIN FLOW COLORADO R MID2	135.00
57	512038	MIN FLOW COLORADO R MID1	90.00
58	512039	MIN FLOW WILLIAMS FORK R	38.00
59	512061	MIN FLOW CORRAL CREEK	1.50
60	512068	MIN FLOW N FK COLORADO R	18.00
61	512069	MIN FLOW COLORADO R UP 1	50.00
62	512076	MIN FLOW CROOKED CR LOW	8.00
63	512084	MIN FLOW FRASER RIVER	6.00
64	512089	MIN FLOW COLORADO R UP 2	40.00
65	512096	MIN FLOW FRASER R FRASER	11.00
66	512097	MIN FLOW HAMILTON CR LOW	1.50
67	512101	MIN FLOW RANCH CREEK HUR	7.00

#	ID	Name	Decree (cfs)
68	512102	MIN FLOW RANCH CREEK LOW	8.00
69	512104	MIN FLOW ST LOUIS CR LOW	6.00
70	512108	MIN FLOW FRASER RIVER 1	8.00
71	512109	MIN FLOW FRASER RIVER 2	17.00
72	512110	MIN FLOW MEADOW CREEK 1	3.50
73	512114	MIN FLOW FRASER R RANCH	30.00
74	522006	MIN FLOW SHEEPHORN CREEK	4.50
75	522009	MIN FLOW COTTONWOOD CR	2.00
76	532002	MIN FLOW ROCK CREEK	10.00
77	532006	MIN FLOW SWEETWATER CR	18.00
78	532013	MIN FLOW NO NAME CREEK	2.00
79	532014	MIN FLOW DERBY CREEK	7.50
80	722001	MIN FLOW PLATEAU CREEK L	16.00
81	722001_2	MIN_FLOW_PLATEAU_2	16.00
82	722002	MIN FLOW LEON CREEK	3.50
83	950099	GVWM_Bypass	0.00
84	950500	Shoshone_Call_Flows	1250.00
85	950639	Jim_Creek_Bypass	10.00
86	950786	Thomasville_Gage_Bypass	200.00
87	950920	UWCD_PLATEAU_BYPASS	20.00
88	951146	Wolcott_PP_Bypass	110.00
89	951269	Den_Ranch_Crk_Bypass	4.00
90	951309	St_Louis_Crk_Bypass	10.00
91	951310	Vasquez_Crk_Bypass	8.00
92	951594	Hunter_Crk_Bypass	21.00
93	952002	USFWS_Recomm._Fish_Flow	16000.00
94	953508	Rifle_Gap_Res_Bypass	5.00
95	953543	Green_Mtn_Res_Bypass	85.00
96	953668	Wolford_Res_Bypass	13.00
97	953695	Shadow_Mtn_Res_Bypass	50.00
98	953709	Williams_Fork_Res_Bypass	15.00
99	953710	Willow_Crk_Res_Bypass	7.00
100	953713	Ruedi_Res_Bypass	110.00
101	954512	Dillon_Res_Min_Rel	50.00
102	954516	Gold_Park_Gage_Min_Flow	24.00
103	954603	Gumlick_Tunnel_Bypass	1.00
104	954620	Granby_Res_Min_Rel	75.00
105	954625	Boustead_Tunnel_Bypass	30.00

5.7.4.1 Special Instream Flow rights

Several reservoir bypass agreements, bypass agreements associated with transbasin diversions, and other operations represented as instream flows have water rights set as follows:

Reservoir Bypass Rights:

- Rifle Gap Reservoir Bypass (953508) was set to 5.00 cfs with an administration number of 37503.36898
- Green Mountain Reservoir Bypass (953543) was set to 85.00 cfs with an administration number of 31257.99994

- Wolford Mountain Reservoir Bypass (953668) was set to 13.00 cfs with an administration number of 50385.99999
- Shadow Mountain Reservoir and Grand Lake Bypass (953695) was set to 50.00 cfs with an administration number of 31257.99999
- Williams Fork Reservoir Bypass (953709) was set to 15.00 cfs with an administration number of 31358.99999
- Willow Creek Reservoir Bypass (953710) was set to 7.00 cfs with an administration number of 31257.99999
- Ruedi Reservoir Bypass (953713) was set to 110.00 cfs with an administration number of 39290.99999
- Dillon Reservoir Bypass (954512) was set to 50.00 cfs with an administration number of 31257.99997
- Granby Reservoir Bypass (954620) was set to 75.00 cfs with an administration number of 31257.99999
- Wolcott Reservoir Pumping Pipeline Bypass (951146) was set to 110.00 cfs with an administration number of 42484.99999

Transbasin Diversion Bypass Agreement Rights:

- Ranch Creek below the Moffat Tunnel project diversion (951269) was set to 4.00 cfs with an administration number of 30870.26116
- St. Louis Creek below the Moffat Tunnel project diversion (951309) was set to 10.00 cfs with an administration number of 30870.26116
- Vasquez Creek below the Moffat Tunnel project diversion (951310) was set to 8.00 cfs with an administration number of 30870.26116
- Hunter Creek below the Moffat Tunnel project diversion (951594) was set to 21.00 cfs with an administration number of 39290.99999
- Jim Creek below the Moffat Tunnel project diversion (950639) was set to 10.00 cfs with an administration number of 30870.26116
- Fraser River downstream of the Moffat Tunnel diversion (954655) was set to 3.9 cfs with an administration number of 30870.26116
- Fryingpan River below the Thomasville Gage (950786) was set to 200.00 cfs with an administration number of 39290.99999
- Homestake Creek below the Gold Park Gage (954516) was set to 24.00 cfs with an administration number of 39650.37519
- Bobtail Creek downstream of the Gumlick Tunnel diversion (954603) was set to 1.00 cfs with an administration number of 30870.26116
- Fryingpan River downstream of the Boustead Tunnel diversion (954625) was set to 30.00 cfs with an administration number of 39290.99999

Other Instream Flow Reach Rights:

- Eagle River Instream Flow (372059_2) was set to 155.00 cfs with an administration number of 47558.00000
- Grand Valley Project Bypass (950099) was set to 0.00 cfs with an administration number of 99999.00000. Operating rules trigger this instream flow, which have a constant demand of 50 cfs.
- Shoshone Power Plant instream flow (950500) was set to 1250.00 cfs with an administration number of 99999.80000.

- 15-Mile Reach instream flow (952002) was set to 16000.00 cfs with an administration number of 99999.92000.
- The Ute Water Conservancy District Plateau Creek bypass (950920) was set to 20 cfs with an administration number of 38846.99999, just senior to the Ute Water Conservancy District Plateau Creek diversion.

5.8 Plan Data File (*.pln)

The plan data file can contain information related to operating terms and conditions, well augmentation, water reuse, recharge, and out-of-priority plans. Plan structures are accounting tools used in coordination with operating rights to model complicated systems. In the Upper Colorado River Model, out-of-priority plan structures are used to model the Blue River Decree. The first four plan structures track the amount of water Denver and Colorado Springs divert out-of-priority and corresponding replacements made to Green Mountain Reservoir under Blue River Decree operating rules. Numerous operating rules work in conjunction with the plan structures to model the complexities of the Blue River Decree, see section 5.9.18.

The HUP Replacement Limit plan limits the annual volume of water released to historical users to 66,000 acre-feet. The CSU Replacement Limit plan limits the annual volume of water that the Continental Hoosier Project can divert or store out of priority to 2,100 acre-feet.

Name	Structure ID	Plan ID
Continental Hoosier Tunnel	954683	954683OOPPLN
Upper Blue Lakes	363570	363570OOPPLN
Roberts Tunnel	364684	364684OOPPLN
Dillon Reservoir	364512	364512OOPPLN
HUP Replacement Limit	HUPLimitPLN	HUPLimitPLN
CSU Replacement Limit	CSULimitPLN	CSULimitPLN

5.9 Operating Rights File (*.opr)

The operating rights file specifies operations that are more complicated than a direct diversion or direct storage in an on-stream reservoir. Typically, these are reservoir operations involving two or more structures, such as a release from a reservoir to a diversion structure, a release from one reservoir to a second reservoir, or a diversion to an off-stream reservoir. The file was created by hand. Each operating right was assigned an administration number consistent with the structures' other rights and operations.

In the Upper Colorado River Model, seventeen different types of operating rights are used:

- **Type 1 –** a release from storage to the stream to satisfy an instream flow demand. In the Upper Colorado River Model, this rule is used to satisfy minimum reservoir release requirements at Granby and Dillon Reservoirs, historic demands at Shoshone Power Plant, and USFWS recommended endangered fish flows through the critical 15-Mile Reach.

- **Type 2 –** a release from storage to the stream, for shepherded delivery to a downstream diversion or carrier. Typically, the reservoir supply is supplemental, and its release was given an administration number junior to direct flow rights at the destination structure. A release is made only if demand at the diversion structure is not satisfied after direct flow rights have diverted. Releases to irrigation structures are made only if there is remaining crop irrigation requirement.
- **Type 3 –** a release from storage directly to a carrier (a ditch or canal as opposed to the river), for delivery to a diversion station. Typically, the reservoir supply is supplemental, and its release is given an administration number junior to direct flow rights at the destination structure. A release is made only if demand at the diversion structure is not satisfied after direct flow rights have diverted. Releases to irrigation structures are made only if there is remaining crop irrigation requirement.
- **Type 4 –** a release from storage in exchange for a direct diversion elsewhere in the system. The release can occur only to the extent that there is legally available water in the exchange reach. Typically, the storage water is supplemental, and is given an administration number junior to direct flow rights at the diverting structure.
- **Type 5 –** a release from storage in exchange for reservoir storage elsewhere in the system. The release can occur only to the extent that there is legally available water in the exchange reach. Typically, the storage water is supplemental, and is given an administration number junior to storage rights at the storing reservoir.
- **Type 6 –** a reservoir to reservoir transfer (book-over). The book-over is commonly used to transfer water from one reservoir storage account to another in a particular month. It can also transfer water from one storage account to another based on the amount of water diverted by an operating rule. For example, in the Upper Colorado River Model, water is transferred from the Wolford Mountain Reservoir West Slope account to the Wolford Mountain Reservoir Temporary Fish account on June 30.
- **Type 7 –** a release from storage in exchange for diversion by a carrier elsewhere in the system. The release can occur only to the extent that there is legally available water in the exchange reach. Typically, the storage water is supplemental, and is given an administration number junior to carrier's operating right. Releases to irrigation structures are made only if there is remaining crop irrigation requirement.
- **Type 9 –** a release from storage to the river to meet a reservoir target. This operation is used in the Upper Colorado Baseline simulation at reservoirs with forecasting operations (Green Mountain, Upper Blue Lakes, Ruedi, Williams Fork, and Willow Creek). Targets allow maximum storage control of reservoir levels by storage rights and releases to meet demands.
- **Type 10 –** a general replacement release from storage for a diversion by river direct or by exchange elsewhere in the system. This rule is used to supply Historic Users in the basin supplemental water for diversions made by the Colorado Big Thompson Project.
- **Type 11 –** a direct flow diversion to another diversion or reservoir through an intervening carrier. This rule type uses the administration number and decreed amount of the direct flow right associated with the carrier, regardless of the administration number assigned to the operating right itself. In the Upper Colorado River Model, the Type 11 operating rule is used both as a direct flow diversion to another diversion and as a direct flow diversion to a reservoir. For example, this rule type is used to deliver water from St. Louis Creek to meet Moffat Tunnel demands on the Fraser River. This rule type is also used to deliver water to Vega Reservoir through the Leon Creek Feeder Canal where the demand is Vega Reservoir's storage target.

- **Type 14 –** a direct flow diversion to another diversion or reservoir through an intervening carrier limited by the demand at the carrier. This rule type uses the administration number and decreed amount of the direct flow right associated with the carrier, regardless of the administration number assigned to the operating rule itself. In the Upper Colorado River Model, the Type 14 operating rule is used to limit the amount and timing of water diverted through the Willow Creek Feeder and Windy Gap diversions into Granby Reservoir.
- **Type 22 –** The type 22 operating rule directs StateMod to consider soil moisture in the variable efficiency accounting. For structures with crop irrigation water requirements, excess diverted water not required by the crops during the month of diversion is stored in the soil reservoir zone, up to the soil reservoir's available capacity. If diversions are not adequate to meet crop irrigation water requirements during the month of diversion, water is withdrawn from the soil reservoir to meet unsatisfied demands. The depth of the soil zone is defined in the control file (*.ctl). For the Upper Colorado River Model, the effective soil depth or root zone was set to 3 feet. As discussed in section 5.5.1, the available water content, in inches per inch, was defined for each irrigating structure in the StateCU structure file (*.str).
- **Type 27 –** a release from storage tied to a reuse plan to a diversion or reservoir and corresponding plan structure directly via the river or a carrier. This rule type is used to release water stored out-of-priority in Upper Blue Lakes and Dillon Reservoir to Green Mountain Reservoir pursuant to the Blue River Decree.
- **Type 34 –** a reservoir to reservoir transfer, which could be used to book-over water from one account to another within a reservoir or transfer water from one reservoir to another reservoir via a pipeline or carrier. This rule type can also limit the amount of the book-over or transfer based on another operating rule or amount within a plan structure. In the Upper Colorado River Model this rule type is used to book-over water within a reservoir and transfer water from one reservoir to another to repay obligations owed from out-of-priority operations pursuant to the Blue River Decree.
- **Type 38 –** the out-of-priority diversion rule provides a method to divert to a reservoir or diversion based on the upstream storage statute (out-of-priority). This rule works in coordination with the subordinating water right and a plan structure to track the volume of water diverted and subsequently owed to the subordinating water right. In the Upper Colorado River Model the rule is used to allow Denver and Colorado Springs to operate their systems under the guidelines set forth in the Blue River Decree.
- **Type 41 –** reservoir storage with special limits allows a reservoir to store water via a reservoir right up to the volume of water stored in out-of-priority plans. The rule also reduces more than one out-of-priority plans pro rata by the amount stored under this rule. In the Upper Colorado River Model the rule is used to allow Green Mountain Reservoir to fill after the paper fill of its subordinating right has been reached. The amount that can be filled under this right is limited to the amount of water stored and diverted out-of-priority to Green Mountain Reservoir by Denver and Colorado Springs as allowed by the Blue River Decree. Additionally, the amount owed to Green Mountain Reservoir by Denver and Colorado Springs due to out-of-priority operations is reduced by the amount stored under this rule.
- **Type 42 –** the plan demand reset rule provides a method to reset a plan demand at a given time. In the Upper Colorado River Model this rule is used to reset Denver's and Colorado Springs' out-of-priority plan demands remaining at the end of the administration year. This allows the "books to be clear" going into a new administration year and eases the user's ability to track the complicated accounting of the out-of-priority operations under the Blue River Decree. Note: in

years this rule triggers, Denver and/or Colorado Springs are not able to repay in full their obligations to Green Mountain Reservoir under the Blue River Decree.

The presentation of operating rights for the Upper Colorado River Model is generally organized by project:

Section	**Description**
5.9.1	Colorado-Big Thompson (C-BT) Project
5.9.2	Green Mountain Reservoir Operations
5.9.3	Denver – Dillon Operations
5.9.4	Continental-Hoosier Project
5.9.5	Wolford Mountain Reservoir Operations
5.9.6	Williams Fork Reservoir and Moffat Tunnel
5.9.7	Fryingpan-Arkansas Project
5.9.8	Ruedi Reservoir
5.9.9	Grand Valley Operations
5.9.10	Homestake Project
5.9.11	Silt Project
5.9.12	Glenwood Springs Operations
5.9.13	Owens Creek Ditch Transbasin
5.9.14	Ute Water Conservancy District Operations
5.9.15	Collbran Project and Vega Reservoir
5.9.16	Leon Creek Transbasin Operations
5.9.17	Soil Moisture Operations
5.9.18	Blue River Decree Operations
5.9.19	15-Mile Reach Endangered Fish Flow Operations

Where to find more information

- StateMod documentation describes the different types of operating rights that could be specified in this file, and describes the required format for the file.
- The section “Colorado River Projects and Special Operations” in the document “Upper Colorado River Basin Information” describes each reservoir’s typical operations.

5.9.1 Colorado-Big Thompson Project and Windy Gap Project

The Colorado-Big Thompson (C-BT) Project diverts water from the Upper Colorado River basin via the Alva B. Adams Tunnel (550 cfs capacity) for irrigation and municipal use in the South Platte River basin. This system is operated through the use of carrier ditches, exchange agreements, and four reservoirs (Willow Creek, Granby, Green Mountain, and Shadow Mountain/Grand Lake modeled as one storage facility). The Windy Gap Project, located on the Colorado River below the confluence with the Fraser River, was added to this system in 1985 to help acquire additional water.

Shadow Mountain/Grand Lake (18,369 acre-feet capacity) receives water from its local drainage as well as from Granby Reservoir through the use of the Granby Pumping Plant. This reservoir and natural lake is the source from which the Adams Tunnel diverted. Granby Reservoir (539,758 acre-feet capacity) serves as the primary storage facility for the C-BT Project. Willow Creek Reservoir (10,553 acre-feet capacity) stores flows from the Willow Creek drainage and provides water to Granby Reservoir through the Willow Creek Feeder Canal (400 cfs capacity). Green Mountain Reservoir (154,645 acre-feet capacity) serves as the replacement reservoir for the C-BT system (see section 5.9.2).

Reservoir	Acct	Account Name	Capacity (acre-feet)
Granby	1	C-BT Pool	465,568
Granby	2	Dead Pool	74,190
Shadow Mountain/Grand Lake	1	Account	1,839
Shadow Mountain/Grand Lake	2	Dead Pool	16,530
Willow Creek	1	C-BT Pool	3,329
Willow Creek	2	Dead Pool	7,224

Eleven operating rules are used to simulate the C-BT Project and Windy Gap Project operations. Operations are split into four sections below.

Granby Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Adams Tunnel	1	31258.00004	3	Release to direct diversion via pipeline
2	Granby Reservoir Bypass	1	31258.00001	1	Release to instream flow
3	Shadow Mtn/Grand Lake	1	31258.00003	3	Release to reservoir via pipeline
4	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 simulates the Granby Pumping Plant, moving water from Granby Reservoir through Shadow Mountain/Grand Lake and ultimately Adams Tunnel. The administration number was set junior to Granby Reservoir's storage right and Adams Tunnel's direct right. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 2 is a minimum release from Granby Reservoir to ensure instream flows below the dam of the following quantities: September through April – 20 cfs; May through July – 53, 56, or 75 cfs; August – 28, 30, or 40 cfs. Flows are based on dry, average, and wet monthly patterns. The administration number was set junior to the instream flow right. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 3 moves water from Granby Reservoir to Shadow Mountain/Grand Lake Reservoir. The rule transfers water to the C-BT and Dead Pool accounts in Shadow Mountain/Grand Lake Reservoir to replace evaporation losses. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 4 releases water from all accounts proportionally to meet the end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Shadow Mountain/Grand Lake Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 releases water from all accounts proportionally to meet the historical end-of-month target values at Shadow Mountain/Grand Lake Reservoir. The junior administration number ensures this is the last operating rule to fire at the reservoir. Shadow Mountain/Grand Lake Reservoir is a flow through structure and is maintained year round with a pool height variation of no more than 1 ft. Targets reflect historic operation in the Historic, Calculated, and Baseline simulations because of the strict water level requirements that were maintained over the historical period of the reservoir.

Willow Creek Reservoir and Feeder Canal Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Granby Reservoir	Willow Creek Feeder	31258.00000	14	Carrier with constrained demand
2	Granby Reservoir	1, Willow Creek Feeder	31258.00002	2	Release to river to carrier
3	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 simulates the Willow Creek Feeder Canal direct diversions from Willow Creek to Granby Reservoir. The administration number is set equal to the direct diversion right for Willow Creek Feeder Canal. This rule turns off the direct diversion right for the Willow Creek Feeder Canal. Information provided in the direct diversion structure (*.dds), right (*.ddr), and demand (*.ddm) files and reservoir demand located at Granby Reservoir limits the amount of water diverted. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 2 simulates releases from Willow Creek Reservoir to Willow Creek Feeder Canal, which carries water to Granby Reservoir. This rule is set junior to operating rule 1 to allow the direct diversion to meet the demand before water is released from storage. Willow Creek Feeder Canal has the added variable of pumping costs that are not simulated directly within StateMod.

The demand for the Baseline simulation is filled Historic data and can be adjusted to model different future scenarios. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 3 releases water from all accounts proportionally to meet the historical end-of-month target values at Willow Creek Reservoir. The junior administration number ensures this is the last operating rule to fire at the reservoir. In the Historic simulation, targets are set to historic end-of-month storage. In the Baseline simulation targets are set to simulate the seasonal operational water levels. This rule is on in the Historic, Calculated, and Baseline simulations.

Windy Gap Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Granby Reservoir	Windy Gap Pipeline	47671.00001	14	Carrier with constrained demand
2	Granby Reservoir	Windy Gap Pipeline	47671.00002	14	Carrier with constrained demand
3	Granby Reservoir	Windy Gap Pipeline	47671.00003	14	Carrier with constrained demand

Operating rules 1 through 3 simulates the Windy Gap direct diversions from the Colorado River to Granby Reservoir. The administration numbers correspond to the direct diversion rights for Windy Gap, which are set junior to the Colorado River instream flow downstream of the diversion (512038). These rules turn off the direct diversion rights for Windy Gap. Information provided in the direct diversion structure (*.dds), right (*.ddr), and demand (*.ddm) files and reservoir demand located at Granby Reservoir limit the amount of water diverted. Windy Gap has the added variable of pumping costs that are not simulated directly within StateMod. The demands for the Baseline simulation are projected depletions provided by Northern Colorado Water Conservancy District. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.2 Green Mountain Reservoir Operations

Green Mountain Reservoir (154,645 acre-feet capacity) serves as the replacement reservoir for the C-BT system. In addition to the C-BT replacement account, Green Mountain has a Historic Users Pool (HUP) western slope account for agriculture and municipal users; a Contract account for diverters other than the C-BT and HUP beneficiaries; a Silt Project account, which stores water for demand met by the Silt Pump Canal; and a Surplus Fish account for future applications of the Upper Colorado Model.

From the time construction of Green Mountain Reservoir was completed (1948) until 1984, the reservoir was operated in strict accordance with provisions laid out in Senate Document 80. During this time period, if the flow at the Shoshone Diversion Dam (WDID 530584), as measured at the Dotsero stream gage (09070500), was less than 1,250 cfs, the division engineer would first curtail all transmountain diversions (other than C-BT) before making a release from Green Mountain Reservoir. As a result of this method of administration, Green Mountain typically remained reasonably full during the summer irrigation season and was drawn down beginning in September, reaching its low point in storage by the end of April of the following year. A significant portion of the water was being released for power generation without the additional benefit of supplementing existing Western Slope irrigation uses.

In 1985, the division engineer began to administer the river in accordance with the priority system, with the result that many of the transmountain diversions that historically had been curtailed by the division engineer (Denver and Colorado Springs) were actually in priority and entitled to divert. The junior rights that would be called out by the Shoshone Call and/or the Cameo Call were more likely to be junior Western Slope water users. Green Mountain Reservoir provided general depletion replacement releases from the HUP account to historical irrigation and municipal diverters who had water rights that were senior to January 24, 1984.

In 1997, the division engineer revised the administration of the HUP account in Green Mountain Reservoir as a result of the litigation in Case No. 91CW247 (Orchard Mesa Check Case). Green Mountain Reservoir continues to provide general depletion replacement releases from the Historic Users Pool (HUP) account to historical irrigation and municipal diverters who have water rights that are senior to October 15, 1977.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Green Mountain	1	Historic Users Pool	66,000
Green Mountain	2	C-BT Pool	52,000
Green Mountain	3	Contract	20,000
Green Mountain	4	Silt Project	5,000
Green Mountain	5	Inactive	11,645
Green Mountain	6	Surplus Fish	66,000

Twenty-eight operating rules are used to simulate the operations associated with Green Mountain Reservoir. Operations are split into seven sections below.

Elliot Feeder Canal Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Green Mountain Reservoir	Elliot Creek Feeder	31258.00000	11	Carrier to reservoir
2	Green Mountain Hydroelectric	Elliot Creek Feeder	31258.00000	11	Carrier to diversion

Operating rules 1 and 2 simulate the Elliot Creek Feeder Canal transporting water from Elliot Creek to demands at Green Mountain Reservoir for storage and hydroelectric power generation. The administration number for Elliot Creek Feeder Canal diversion right, Green Mountain Reservoir first fill right, and Green Mountain Reservoir Hydroelectric Power diversion right are the same – 31258.00000. Because of the same administration number, rule 1 uses Green

Mountain Reservoir's fill right, and rule 2 uses Green Mountain Reservoir Hydroelectric Power's right, both at the Elliot Creek Feeder Canal location. The diversions are limited to times of demand at the reservoir and power plant and to the physical limitations of the Elliot Creek Feeder Canal. These rules are on in the Historic, Calculated, and Baseline simulations.

C-BT Project Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Granby Reservoir	2	31258.00011	5	Release to river exch to storage
2	Willow Creek Reservoir	2	31258.00018	5	Release to river exch to storage
3	Shadow Mtn/Grand Lake	2	31258.00025	5	Release to river exch to storage
4	Granby Reservoir	2, Willow Creek Feeder	31258.00032	7	Release to river exch to carrier

Operating rules 1 through 3 deliver water by exchange from the C-BT account in Green Mountain Reservoir to both the C-BT and Dead Pool accounts in the associated reservoirs. The administration numbers were set junior to the fill rights of the associated reservoirs and are part of a sequence of replacements associated with the Blue River Decree (see Section 5.9.18). These rules are modeled because Green Mountain Reservoir was built as a replacement source for the C-BT Project. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 4 exchanges water from the C-BT account in Green Mountain Reservoir to the Willow Creek Feeder Canal. This rule is linked with rule 1 of section 5.9.1 Colorado-Big Thompson Project – Willow Creek Reservoir and Feeder Canal Operations, above; see this section for more details. The administration number is set junior to the carrier operation right and is part of a sequence of replacements associated with the Blue River Decree (see Section 5.9.18). This rule is on in the Historic, Calculated, and Baseline simulations.

Silt Project Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Farmers Irrigation Company	4, Silt Pump Canal	39041.00007	2	Release to river to carrier

Operating rule 1 releases water from the Green Mountain's Silt project account when the Farmers Irrigation Company (950011) demand can not be met by its local sources. Water is delivered via the Silt Pump Canal. The administration number was set junior to the operation right of the Silt Pump Canal (see section 5.9.11) and is part of a sequence of replacements associated with the Blue River Decree (see section 5.9.18). This rule is on in the Historic, Calculated, and Baseline simulations.

Historic Users Replacement Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Shoshone Call Flows	1	99999.90000	1	Release to instream flow demand
2	Historic Users	1	48966.00000	10	Release to general replace demand
3	Government Highline	1, Grand Valley Project	48966.00000	2	Release to river to carrier

4	OMID Irrigation	1, Grand Valley Project	48966.00000	2	Release to river to carrier
5	OMID Pump	1, Grand Valley Project	48966.00000	2	Release to river to carrier
6	Historic Users	1	46674.00000	10	Release to general replace demand
7	Government Highline	1, Grand Valley Project	46674.00000	2	Release to river to carrier
8	OMID Irrigation	1, Grand Valley Project	46674.00000	2	Release to river to carrier
9	OMID Pump	1, Grand Valley Project	46674.00000	2	Release to river to carrier

Operating rule 1 provides water from the HUP account to an instream flow reach upstream of Shoshone Power Plant. The junior administration number ensures this rule is operated when Shoshone can not achieve its demand from the natural flow in the river. The instream flow is used to limit the amount of water released to Shoshone's senior right, which is 1250 cfs. This rule is on in the Historical and Calculated simulations from the start of the study period through 1984. This rule is off in the Baseline simulation.

Operating rule 2 provides general replacement releases from Green Mountain to historical irrigation and municipal diverters. Water rights that are senior to January 24, 1984, receive water from this operating rule, except for industrial uses, transmountain diversions, and carrier systems. This rule is operational from 1985 through 1996, allowing historical Green Mountain reservoir operations to be simulated. This rule is on for the Historical and Calculated simulations and off in the Baseline simulation.

Operating rules 3 through 5 are extensions of rule 2, which provide replacement water to the Grand Valley Project roller dam (720646). These rules are operational from 1985 through 1996. The general replacement rule (Right Type 10) does not provide replacement water to structures that receive water via a carrier, and therefore these rules are required to deliver replacement water to the Grand Valley demands. These rules are on for the Historical and Calculated simulations and off in the Baseline simulation.

Operating rules 6 through 9 replace the functions of rules 2 through 5, respectively, within the Historic and Calculated simulations starting in 1997 and are on throughout the Baseline simulation. These rules use a date of October 15, 1977, which represents the adjudication date for the HUP pool in Senate Document 80.

Contract Demands Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Vail Valley Consolidated	3	42420.41373	4	Exchange to direct diversion
2	Atkinson Ditch	3	49308.48667	4	Exchange to direct diversion
3	Needham Ditch	3	46751.42648	4	Exchange to direct diversion
4	Derby Diversion System	3	47481.12662	4	Exchange to direct diversion
5	Coon Creek Pipeline	3	46995.00007	4	Exchange to direct diversion
6	Green Mountain Contract Demand	3	48966.00007	2	Release to direct diversion
7	Reservoir to Target	1	99999.99999	9	Release to river by target

8	Reservoir to Target	3	99999.99999	9	Release to river by target
9	Reservoir to Target	4	99999.99999	9	Release to river by target
10	Reservoir to Target	2	100000.00000	9	Release to river by target

Operating rules 1 through 5 release water from the contract pool, by exchange, to the individual Contract pool users. The administration numbers were set junior to the direct diversion rights and are part of a sequence of replacements associated with the Blue River Decree (see Section 5.9.18). These rules are operational from 1985 on for the Historic and Calculated simulations to reflect the change in Green Mountain Reservoir HUP operations, and are on for the entire Baseline simulation.

Operating rule 6 is similar to rules 1 through 5 except that releases are made directly to the demand rather than by exchange.

Operating rules 7 through 10 release water from the historic user pool, contract, Silt project, and C-BT accounts, respectively, to meet the historical end-of-month target values at Green Mountain Reservoir. These releases represent releases not explicitly modeled in the Historic and Calculated simulations, and are set so the C-BT account releases last. In the Baseline simulation these rules are used to release to a reservoir forecasting operating curve.

15-Mile Reach Fish Flows Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Surplus Fish Account	1 to 6	99999.99999	6	Reservoir account book-over
2	Fish Instream Flow	6	99999.93011	1	Release to instream flow demand
3	Historic User Account	6 to 1	99999.96000	6	Reservoir account book-over
4	Fish Instream Flow	1	99999.93011	1	Release to instream flow demand

Operating rules 1 through 3 are not used in the current update of the Upper Colorado River Model but were retained for use in future alternate simulations.

Operating rule 4 allows water from the historic user pool in Green Mountain Reservoir to supplement the endangered fish demands in the 15-mile reach (see section 5.9.19). This rule is turned on in 1997 for Historical and Calculated simulations and is on for the entire Baseline simulation for the months of July through October.

Blue River Decree Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Green Mountain Reservoir	First 5	38628.00000	41	Reservoir storage with special limits

Operating rule 1 simulates Green Mountain Reservoir’s 1955 Blue River Decree Exchange storage right. This operating rule allows Green Mountain to store under a 1955 right the amount of water that was diverted and stored out-of-priority to Green Mountain’s senior first fill right by Denver and Colorado Springs. When water is stored under this right it reduces the out-of-priority obligation owed by Denver and Colorado Springs proportionately (see Section 5.9.18 for additional information).

5.9.3 Continental-Hoosier Project

The Continental-Hoosier (Con-Hoosier) Project, sometimes called the Blue River Project, diverts water from the headwaters of the Blue River and its tributaries into the South Platte River Basin for municipal water supply. The collection, diversion facilities, and associated water rights are owned by the City of Colorado Springs. Water collected from two structures (364683 and 364699) and stored in Upper Blue Lakes (363570, capacity 2,113 acre-feet) is exported through the Con-Hoosier Tunnel (954683, 500 cfs capacity).

Reservoir	Acct	Account Name	Capacity (acre-feet)
Upper Blue	1	Active	2,140
Upper Blue	2	Colorado Springs – Out-Of-Priority	2,100
Upper Blue	3	MOA Releases	250

Twenty-two operating rules are used to simulate the operations associated with the Con-Hoosier Project. Operations are split below into four sections.

Continental-Hoosier Tunnel Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Continental-Hoosier Summary Node	364699, 1929 Right	30184.29071	11	Carrier to diversion
2	Continental-Hoosier Summary Node	364683, 1948 Right	35927.00000	11	Carrier to diversion

Operating rules 1 and 2 carry water from collection nodes (364699 and 364683) to demand at the summary node (954683). The administration numbers of these rules were set equal to the administration numbers of the direct diversion rights associated with the carrier structures. These two rules are turned on in the Historic, Calculated, and Baseline simulations.

Con-Hoosier Tunnel Out-Of-Priority Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Continental-Hoosier Summary	364683, 1948 Right	31257.99995	38	Out-of-priority diversion
2	Continental-Hoosier Plan	NA	99999.99999	42	Plan demand reset

Operating rule 1 simulates Colorado Springs' diversions through the Con-Hoosier Tunnel out-of-priority to Green Mountain Reservoir. This is the only right needed to represent out-of-priority diversions because the 1929 water right, associated with structure 364699, is senior to Green Mountain Reservoir's first fill right. The administration number was set senior to Green Mountain Reservoir's first fill right and is the first out-of-priority operation associated with the Blue River Decree (see Section 5.9.18 for additional information). Out-of-priority diversion accounting is simulated at plan structure 954683OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations, with diversions limited to months of April through July.

Operating rule 2 resets accounting to zero at plan structure 954683OOPPLN. The administration number was set junior and operates on the last day of March. This operating rule is used to simplify review of plan accounting and to highlight years when out-of-priority diversions are not replaced. This rule is on in the Historic, Calculated, and Baseline simulations.

Upper Blue Lakes Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Continental-Hoosier Summary Node	1	35927.00002	3	Release to demand via pipeline
2	Continental-Hoosier Summary Node	2	35927.00003	3	Release to demand via pipeline
3	Reservoir to Target	1	1.00000	9	Release to river by target
4	Reservoir to Target	2	1.00001	9	Release to river by target

Operating rules 1 and 2 release water from Upper Blue Lakes to the Con-Hoosier demand located at the summary node (954683). The administration number was set junior to the direct diversion rights and the reservoir fill right, which maximizes the amount of water available to meet the demand. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 3 and 4 release water from Upper Blue Lakes on the first day of August to simulate the trade of 250 acre-feet of water to the West Slope users in the Blue River Basin for 250 acre-feet of water in Wolford Mountain Reservoir. This is a simplified operation to mimic the trade of water in the Blue River Basin and is used because the amount of water is minimal and the individual beneficiary demands are not modeled (see Section 5.9.18 for additional information). In the Historic and Calculated simulations the rule is turned on from 2004 forward and in the Baseline simulation the rule is on for the entire study period.

Reservoir Out-Of-Priority Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Upper Blue out-of-priority account	NA	31257.99996	38	Out-of-priority storage
2	Upper Blue Plan	NA	99999.99999	42	Plan demand reset
3	Dillon Reservoir out-of-priority account	2	1.00002	34	Reservoir exchange with plan
4	Dillon Reservoir out-of-priority account	2	1.00003	34	Reservoir exchange with plan
5	Green Mountain Reservoir first 5 accounts	2	1.00004	27	Release to reservoir with plan
6	Green Mountain Reservoir first 5 accounts	2	1.00005	27	Release to reservoir with plan
7	Dillon Reservoir out-of-priority account	1	1.00006	34	Reservoir exchange with plan
8	Dillon Reservoir out-of-priority account	1	1.00007	34	Reservoir exchange with plan
9	Green Mountain Reservoir first 5 accounts	1	1.00008	27	Release to reservoir with plan
10	Green Mountain Reservoir first 5 accounts	1	1.00009	27	Release to reservoir with plan
11	MOA Release account	1 to 3	1.00000	6	Reservoir account book-over
12	MOA Release account	2 to 3	1.00001	6	Reservoir account book-over

13	Maggie Pond	3	1.00002	2	Release to direct diversion
14	Upper Blue Active account	2 to 1	1.00015	6	Reservoir account book-over

Operating rule 1 simulates Colorado Springs' storage in Upper Blue Lakes out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the second out-of-priority operation associated with the Blue River Decree (see Section 5.9.18 for additional information). Out-of-priority storage from this rule is accounted for with the plan structure 363570OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations and storage is limited to the months of April through July.

Operating rule 2 resets accounting to zero at plan structure 363570OOPPLN. The administration number was set junior and operates on the last day of March. This operating rule is used to simplify the review of the plan accounting and to highlight years when the out-of-priority storage is not replaced. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 3 through 10 release water from the Upper Blue Reservoir to either Dillon or Green Mountain reservoirs to replace remaining out-of-priority obligations on August 1st. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step. Releases to Dillon reservoir decrease Colorado Springs' out-of-priority obligation while increasing Denver's out-of-priority obligation. Releases to Green Mountain Reservoir reduce Colorado Springs' out-of-priority obligation. These operating rules are tied to either the out-of-priority diversion plan (954683OOPPLN) or to the out-of-priority storage plan (363570OOPPLN) for accounting of replacements. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 11 and 12 transfer water from Colorado Springs' active and OOP accounts to the 250 acre-feet MOA Release account in Upper Blue Lakes in June and July to reflect the delivery to Upper Blue River water users per the 2003 MOA. Operating rule 13 release the water in the MOA Release account to Maggie Pond (360989) in November. Operating Rule 13 transfers water from Colorado Springs' out-of-priority storage account to the active account in Upper Blue Lakes. This rule empties the out-of-priority storage account and makes the water available for Colorado Springs to use through the Con-Hoosier Tunnel or other uses. The administration number was set junior to the replacement rules to ensure Green Mountain is satisfied before Colorado Springs can claim the water. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.4 Denver – Dillon Operations

The city of Denver uses two facilities to draw water from the Upper Colorado River basin into the South Platte River basin: Moffat Tunnel (see Section 5.9.6) and the Harold D. Roberts Tunnel (Roberts Tunnel). Roberts Tunnel is located in District 36 on the Blue River. Dillon Reservoir, which is owned by the City of Denver and has a capacity of 257,000 acre-feet, provides water to Roberts Tunnel when the tunnel's direct diversion right is not in priority. Both Roberts Tunnel and Dillon Reservoir operate out-of-priority to Green Mountain Reservoir as part of the Blue River Decree (see Section 5.9.18).

In addition to serving Denver's needs, Dillon Reservoir stores water for several other users. The Summit County account stores water for the beneficiaries of the original Summit County Agreement and the Clinton Reservoir Agreement (see the Colorado River Basin Information Report for more information). The 1,000 acre-foot pool, in substitution years, supplies water for the 50 cfs instream flow below Dillon Reservoir. The final account in Dillon is used to store out-of-priority water.

Clinton Gulch Reservoir (capacity 4,300 acre-feet) was purchased by Summit County Agreement beneficiaries to obtain additional storage water to satisfy their demands. Operational rules assigned to Clinton Gulch Reservoir in the Upper Colorado Model are related to Climax mine operations. Since the Summit County and Clinton Reservoir-Fraser River agreements are not explicitly modeled, some operations were omitted. This reservoir is included in the model to facilitate the inclusion of these agreements in future model enhancements. Clinton Gulch Reservoir is divided into eight accounts, one for each of the shareholders of the Clinton Ditch and Reservoir Company, and one Dead Pool.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Dillon	1	Denver / Roberts Tunnel	252,015
Dillon	2	Summit County	1,021
Dillon	3	Dead Pool	3,269
Dillon	4	1000 acre-feet	1,000
Dillon	5	Denver – Out-Of-Priority	154,645
Clinton Gulch	1	Town of Breckenridge	390
Clinton Gulch	2	Town of Dillon	60
Clinton Gulch	3	Town of Silverthorne	165
Clinton Gulch	4	Breckenridge Ski Area	455
Clinton Gulch	5	Cooper Mountain Ski Area	490
Clinton Gulch	6	Keystone Ski Area	1,305
Clinton Gulch	7	Winter Park Ski Area	270
Clinton Gulch	8	Summit County	465
Clinton Gulch	9	Dead Pool	700

Forty-one operating rules are used to simulate the operations associated with Roberts Tunnel, Dillon Reservoir, and Clinton Gulch Reservoir. Operations are split below into five sections.

Roberts Tunnel Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Roberts Tunnel	NA	31257.99998	38	Out-of-priority diversion
2	Roberts Tunnel Plan	NA	99999.99999	42	Plan demand reset

Operating rule 1 simulates Denver's diversion through the Roberts Tunnel out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the third out-of-priority operation associated with the Blue River Decree (see Section 5.9.18 for additional information). Out-of-priority diversions from this rule are accounted for with the plan structure 364684OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations and the diversions are limited to the months of April through July.

Operating rule 2 resets accounting to zero at plan structure 364684OOPPLN. The administration number was set junior and operates on the last day of March. This operating rule is used to simplify the review of the plan accounting and to highlight years when the out-of-priority diversions are not replaced. This rule is on in the Historic, Calculated, and Baseline simulations.

Dillon Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Roberts Tunnel	1	35927.00008	2	Release to river to direct diversion
2	Roberts Tunnel	5	35927.00009	2	Release to river to direct diversion
3	Green Mountain Reservoir	4	99999.00000	2	Release to river to reservoir
4	Excess HUP Release	4	100000.00000	2	Release to river to direct diversion
5	Below Dillon Minimum Stream Flow	4	31257.99998	1	Release to instream flow demand
6	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rules 1 and 2 release water to Roberts Tunnel from Dillon Reservoir. Through agreements with Colorado Springs, Denver subordinates their operations of Dillon Reservoir and Roberts Tunnel to the operations of the Continental Hoosier Project. Therefore, the administration numbers were set, in sequence, junior to Colorado Springs' operations, Roberts Tunnel direct diversion right, Dillon Reservoir direct storage right, and exchanges from Williams Fork Reservoir to both Roberts Tunnel and Dillon Reservoir. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 3 through 5 release water from the 1000 acre-feet account in substitution years to replace Denver's out-of-priority operation obligations. Releases to the minimum stream flow between Dillon Reservoir and Green Mountain Reservoir (954512) occur when there is water in the account and a demand exists at the instream flow node. Releases are then made in March to Green Mountain Reservoir and the Excess HUP Release node (954512D) to ensure all replacement water is released within the same administration year. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 6 releases water from all accounts in Dillon Reservoir to meet the end-of-month target values. The administration number was set junior so that it was the last reservoir operation. This rule is on in the Historic, Calculated, and Baseline simulations.

Dillon Reservoir Out-Of-Priority Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Dillon: Denver – Out-Of-Priority	NA	31257.99999	38	Out-of-priority storage
2	Dillon Reservoir Plan	NA	99999.99999	42	Plan demand reset
3	1000 acre-feet account	5 to 4	1.00016	34	Reservoir exchange with plan

4	Green Mountain Reservoir	5	1.00025	27	Release to reservoir with plan
5	Green Mountain Reservoir	5	1.00026	27	Release to reservoir with plan
6	Green Mountain Reservoir	1	1.00027	27	Release to reservoir with plan
7	Green Mountain Reservoir	1	1.00028	27	Release to reservoir with plan
8	Dillon: Denver / Roberts Tunnel	5 to 1	1.00029	6	Reservoir account book-over
9	Green Mountain Reservoir	5	1.00025	27	Release to reservoir with plan
10	Green Mountain Reservoir	5	1.00026	27	Release to reservoir with plan
11	Green Mountain Reservoir	1	1.00027	27	Release to reservoir with plan
12	Green Mountain Reservoir	1	1.00028	27	Release to reservoir with plan

Operating rule 1 simulates Denver's storage in Dillon Reservoir out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the fourth and final out-of-priority operation associated with the Blue River Decree (see Section 5.9.18 for additional information). Out-of-priority storage from this rule is accounted for with the plan structure 364512OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations and storage is limited to the months of April through July.

Operating rule 2 resets accounting to zero at plan structure 364512OOPPLN. The administration number was set junior and operates on the last day of March. This operating rule is used to simplify the review of the plan accounting and to highlight years when the out-of-priority storage is not replaced. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 3 books-over water to the 1000 acre-feet account from the out-of-priority account. The administration number was set senior so that operations occur at the beginning of the August 1st time step. Water booked-over reduces Denver's out-of-priority obligation and is tied to the out-of-priority storage plan (364512OOPPLN) for accounting of replacements. The water books-over into the 1000 acre-feet account is used as described above in the Dillon Reservoir Operations section. The rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 4 through 7 release water from Dillon to Green Mountain reservoirs to replace remaining out-of-priority obligations on August 1st. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step, but junior to replacement releases from Williams Fork and Wolford Mountain Reservoirs. Releases to Green Mountain Reservoir reduce Denver's out-of-priority obligation. These operating rules are tied to the out-of-priority diversion plan (364684OOPPLN) and to the out-of-priority storage plan (364512OOPPLN) for accounting of replacements. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 8 transfers water from Denver's out-of-priority storage account to the Denver / Roberts Tunnel account in Dillon Reservoir. This rule empties the out-of-priority storage account and makes the water available for Denver to use through the Roberts Tunnel or other uses. The administration number was set junior to the replacement rules to ensure Green Mountain is satisfied before Denver could claim the water. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 9 through 12 release water from Dillon to Green Mountain reservoirs to replace remaining out-of-priority Colorado Springs obligations on August 1st. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step, but junior to replacement releases from Williams Fork and Wolford Mountain Reservoirs. Releases to Green Mountain Reservoir reduce Colorado Spring's out-of-priority obligation. These operating rules are tied to the out-of-priority diversion plan (363570OOPPLN) and to the out-of-priority storage plan (363570OOPPLN) for accounting of replacements. These rules are on in the Historic, Calculated, and Baseline simulations.

Clinton Gulch Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Climax-Ten Mile Creek Div No.1	1	100000.00000	3	Release to direct diversion via pipeline
2	Climax-Ten Mile Creek Div No.1	2	100000.00000	3	Release to direct diversion via pipeline
3	Climax-Ten Mile Creek Div No.1	3	100000.00000	3	Release to direct diversion via pipeline
4	Climax-Ten Mile Creek Div No.1	4	100000.00000	3	Release to direct diversion via pipeline
5	Climax-Ten Mile Creek Div No.1	5	100000.00000	3	Release to direct diversion via pipeline
6	Climax-Ten Mile Creek Div No.1	6	100000.00000	3	Release to direct diversion via pipeline
7	Climax-Ten Mile Creek Div No.1	7	100000.00000	3	Release to direct diversion via pipeline
8	Climax-Ten Mile Creek Div No.1	8	100000.00000	3	Release to direct diversion via pipeline
9	Reservoir to target	All	100000.00000	9	Release to River by target

Operating rules 1 through 8 release water from Clinton Gulch Reservoir to Climax's Ten Mile Creek Diversion No.1. The administration numbers were set junior to Climax's Ten Mile Creek Diversion No.1 direct diversion right. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 9 releases water from all accounts in Dillon Reservoir to meet the end-of-month target values. The administration number was set junior so that it is the last reservoir operation. This rule is on in the Historic, Calculated, and Baseline simulations.

Clinton Gulch Agreement Dillon Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Town of Breckenridge	2	47483.00001	4	Exchange to direct diversion
2	Town of Breckenridge	1	47483.00002	4	Exchange to direct diversion
3	Town of Dillon	2	18005.00001	4	Exchange to direct diversion
4	Town of Dillon	1	18005.00002	4	Exchange to direct diversion

5	Breckenridge Ski Area	2	100000.00000	4	Exchange to direct diversion
6	Breckenridge Ski Area	1	100000.00001	4	Exchange to direct diversion
7	Copper Mountain Ski Area	2	100000.00000	4	Exchange to direct diversion
8	Copper Mountain Ski Area	1	100000.00001	4	Exchange to direct diversion
9	Keystone Ski Area	2	47968.00001	4	Exchange to direct diversion
10	Keystone Ski Area	1	47968.00002	4	Exchange to direct diversion
11	Town of Keystone	2	44741.00001	4	Exchange to direct diversion
12	Town of Keystone	1	44741.00002	4	Exchange to direct diversion

Operating rules 1 through 12 release water from Dillon Reservoir to beneficiaries of the Summit County and Clinton Reservoir-Fraser River agreements. The administration numbers were set junior to direct diversion right for each of the individual structures. These rules are included to represent a simplification of the two agreements and a starting point for future model updates of the two agreements. These rules are on in the Historic and Calculated simulations from 1992 forward and on the entire study period in the Baseline simulation.

5.9.5 Wolford Mountain Reservoir Operations

Wolford Mountain Reservoir (capacity 65,985 acre-feet) was constructed and is operated by the Colorado River Water Conservation District. The reservoir began storing water during 1995 and filled over two seasons. In the Historical and Calculated data sets, many operating rules are turned on in 1997, since Wolford Mountain did not follow normal operations during the filling sequence.

Wolford Mountain Reservoir was divided into nine accounts, including a general West Slope account; a Denver account that serves as a general replacement in lieu of Green Mountain; two 15-mile reach endangered fish accounts; two Denver Replacement accounts that receive water from Denver’s reserve account and then releases to Green Mountain demands or for fish flows; a Colorado Springs account that serves for general replacement in lieu of Green Mountain; a Colorado Springs account used to book-over 250 acre-feet per year to their reserve account from the West Slope account; and a Colorado Springs Replacement account that receives water from Colorado Springs’ reserve account and then releases to Green Mountain demands or for fish flows. Many of the reservoir’s accounts are used to ensure proper accounting of the Blue River Decree and the Interim Policy along with proper release schedules between the many accounts throughout the basin that are used to replace in lieu of Green Mountain.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Wolford Mountain	1	West Slope	34,383
Wolford Mountain	2	Denver	25,610
Wolford Mountain	3	Fish Account	6,000
Wolford Mountain	4	Temporary Fish	5,413
Wolford Mountain	5	Denver Replacement 1	5,000
Wolford Mountain	6	Denver Replacement 2	20,610
Wolford Mountain	7	Colorado Springs	1,750
Wolford Mountain	8	Colorado Springs Book-over	250
Wolford Mountain	9	Colorado Springs Replacement	1,750

Eighty operating rules are used to simulate the operations associated with Wolford Mountain Reservoir. Operations are split below into six sections.

15-Mile Reach Fish Flow Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Fish Instream Flow	3	99999.93014	1	Release to instream flow demand
2	Temporary Fish Account	1 to 4	99999.95000	6	Reservoir account book-over
3	Fish Instream Flow	4	99999.93003	1	Release to instream flow demand

Operating rules 1 and 3 releases water from the Fish and Temporary Fish accounts, respectively, to the USFWS fish flow demand in the 15-Mile reach. The administration numbers were set junior to the instream flow right and are part of the fish release sequence described below in Section 5.9.19. These rules operate in the months of July through October. These rules are on in the Historic and Calculated simulations starting in 1997 and are on for the entire study period in the Baseline simulation.

Operating rule 2 transfers water from the West Slope account to the Temporary Fish account. The administration number was set junior and operates on June 30th. This rule is on in the Historic and Calculated simulations starting in 1997 and is on for the entire study period in the Baseline simulation.

Wolford Contract Demands Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Fraser Contract Demand	1	99999.00000	4	Exchange to direct diversion
2	Middle Park Contract Demand	1	99999.00000	4	Exchange to direct diversion

Operating rules 1 and 2 releases water from the West Slope account to the two contract demands. The administration numbers were set junior to most diversions and operations. The demands for both the Fraser and Middle Park nodes are satisfied solely by releases from Wolford Mountain Reservoir. These rules are on in the Historic, Calculated, and Baseline simulations.

A third Wolford Mountain Contract demand node exists – Market Demand (953103). This node does not have a demand in the Historic, Calculated, or Baseline simulations and is a placeholder for future scenarios. Operating rules will need to be added for this node in the future.

Other General Wolford Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Reservoir to target	All	99999.99999	9	Release to River by target

Operating rule 1 releases water from all accounts in Wolford Mountain Reservoir to meet the end-of-month target values. The administration number was set junior so that it is the last reservoir operation. This rule is on in the Historic, Calculated, and Baseline simulations.

Colorado Springs Replacement Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Colorado Springs Replacement acct	7 to 9	1.00010	34	Reservoir exchange with plan
2	Colorado Springs Replacement acct	7 to 9	1.00011	34	Reservoir exchange with plan
3	Colorado Springs Book-over acct	1 to 8	1.00014	6	Reservoir account book-over
4	Colorado Springs account	8 to 7	999999.9998	6	Reservoir account book-over
5	West Slope account	8 to 1	999999.9999	6	Reservoir account book-over

Operating rules 1 and 2 book-over water to the Colorado Springs Replacement account from the Colorado Springs account. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step. Water booked-over reduces Colorado Springs' out-of-priority obligations and are tied to the out-of-priority diversion and storage plans, 954683OOPPLN and 363570OOPPLN, respectively, for accounting of replacements. The water booked-over into the Colorado Springs Replacement account is used to meet Green Mountain Reservoir obligations, as described below in the Green Mountain Operations from Alternate Replacement Pools section. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 3 through 5 book-over water between the West Slope, Colorado Springs Book-over, and Colorado Springs accounts. The administration number for rule 3 was set senior so that operations occur at the beginning of the August 1st time step. The administration number for rules 4 and 5 were set to the last two rights in the Upper Colorado River Model so that operations occur at the end of the August 1st time step. It is critical that these two rules do not repeat with rule 3 when StateMod iterates. These rules are part of the Blue River Decree and Interim Policy operations; see section 5.9.18 for additional information. These rules are on in the Historic and Calculated simulations starting in 2004 and the entire study period for the Baseline simulation.

Denver Replacement Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Denver Replacement 1 account	2 to 5	1.00017	34	Reservoir exchange with plan
2	Denver Replacement 1 account	2 to 5	1.00018	34	Reservoir exchange with plan
3	Denver Replacement 2 account	2 to 6	1.00021	34	Reservoir exchange with plan
4	Denver Replacement 2 account	2 to 6	1.00022	34	Reservoir exchange with plan
5	Denver Replacement 2 account	2 to 2	1.00030	34	Reservoir exchange with plan
6	Denver Replacement 2 account	2 to 2	1.00031	34	Reservoir exchange with plan

Operating rules 1 through 4 book-over water to the two Denver Replacement accounts from the Denver account. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step. Water booked-over reduces Denver's out-of-priority obligations and are tied to the out-of-priority diversion and storage plans, 364684OOPPLN and 364512OOPPLN, respectively, for accounting of replacements. Operating rules 5 and 6 book-over water to the Denver Replacement Account from the Denver Replacement Account, increasing Denver's out of priority plan obligation by the remaining amount in Colorado Spring's out-of-priority plan. Water booked-over reduces Colorado Springs' out-of-priority obligations and are tied to the out-of-priority diversion and storage plans, 363570OOPPLN and 954683OPPLN, respectively, for accounting of replacements, and subject to CSULimit obligations. The water booked-over into the Denver Replacement accounts are used to meet Green Mountain Reservoir obligations, as described below in the Green Mountain Operations from Alternate Replacement Pools section. The rules are on in the Historic, Calculated, and Baseline simulations.

Green Mountain Operations from Alternate Replacement Pools

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Granby Reservoir	5	31258.00005	5	Release to river exch to storage
2	Granby Reservoir	9	31258.00007	5	Release to river exch to storage
3	Granby Reservoir	6	31258.00008	5	Release to river exch to storage
4	Willow Creek Reservoir	5	31258.00012	5	Release to river exch to storage
5	Willow Creek Reservoir	9	31258.00014	5	Release to river exch to storage
6	Willow Creek Reservoir	6	31258.00015	5	Release to river exch to storage
7	Shadow Mtn/Grand Lake	5	31258.00019	5	Release to river exch to storage
8	Shadow Mtn/Grand Lake	9	31258.00021	5	Release to river exch to storage
9	Shadow Mtn/Grand Lake	6	31258.00022	5	Release to river exch to storage
10	Granby Reservoir	5, Willow Creek Feeder	31258.00026	7	Release to river exch to carrier
11	Granby Reservoir	9, Willow Creek Feeder	31258.00028	7	Release to river exch to carrier
12	Granby Reservoir	6, Willow Creek Feeder	31258.00029	7	Release to river exch to carrier

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
13	Farmers Irrigation Co	5, Silt Pump Canal	39041.00001	2	Release to river to carrier
14	Farmers Irrigation Co	9, Silt Pump Canal	39041.00003	2	Release to river to carrier
15	Farmers Irrigation Co	6, Silt Pump Canal	39041.00004	2	Release to river to carrier
16	Historic Users	5	48965.99994	10	Release to general replace dem
17	Historic Users	9	48965.99996	10	Release to general replace dem
18	Historic Users	6	48965.99997	10	Release to general replace dem
19	Government Highline	5, Grand Valley Project	48965.99994	2	Release to river to carrier
20	Government Highline	9, Grand Valley Project	48965.99996	2	Release to river to carrier
21	Government Highline	6, Grand Valley Project	48965.99997	2	Release to river to carrier
22	OMID Irrigation	5, Grand Valley Project	48965.99994	2	Release to river to carrier
23	OMID Irrigation	9, Grand Valley Project	48965.99996	2	Release to river to carrier
24	OMID Irrigation	6, Grand Valley Project	48965.99997	2	Release to river to carrier
25	OMID Pump	5, Grand Valley Project	48965.99994	2	Release to river to carrier
26	OMID Pump	9, Grand Valley Project	48965.99996	2	Release to river to carrier
27	OMID Pump	6, Grand Valley Project	48965.99997	2	Release to river to carrier
28	Historic Users	5	46673.99994	10	Release to general replace dem
29	Historic Users	9	46673.99996	10	Release to general replace dem
30	Historic Users	6	46673.99997	10	Release to general replace dem
31	Government Highline	5, Grand Valley Project	46673.99994	2	Release to river to carrier
32	Government Highline	9, Grand Valley Project	46673.99996	2	Release to river to carrier
33	Government Highline	6, Grand Valley Project	46673.99997	2	Release to river to carrier
34	OMID Irrigation	5, Grand Valley Project	46673.99994	2	Release to river to carrier
35	OMID Irrigation	9, Grand Valley Project	46673.99996	2	Release to river to carrier
36	OMID Irrigation	6, Grand Valley Project	46673.99997	2	Release to river to carrier
37	OMID Pump	5, Grand Valley Project	46673.99994	2	Release to river to carrier
38	OMID Pump	9, Grand Valley Project	46673.99996	2	Release to river to carrier
39	OMID Pump	6, Grand Valley Project	46673.99997	2	Release to river to carrier
40	Vail Valley Consolidated	5	42420.41367	4	Exchange to direct diversion
41	Vail Valley Consolidated	9	42420.41369	4	Exchange to direct diversion
42	Vail Valley Consolidated	6	42420.41370	4	Exchange to direct diversion
43	Atkinson Ditch	5	49308.48661	4	Exchange to direct diversion
44	Atkinson Ditch	9	49308.48663	4	Exchange to direct diversion
45	Atkinson Ditch	6	49308.48664	4	Exchange to direct diversion
46	Needham Ditch	5	46751.42642	4	Exchange to direct diversion

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
47	Needham Ditch	9	46751.42644	4	Exchange to direct diversion
48	Needham Ditch	6	46751.42645	4	Exchange to direct diversion
49	Derby Diversion System	5	47481.12656	4	Exchange to direct diversion
50	Derby Diversion System	9	47481.12658	4	Exchange to direct diversion
51	Derby Diversion System	6	47481.12659	4	Exchange to direct diversion
52	Coon Creek Pipeline	5	46995.00001	4	Exchange to direct diversion
53	Coon Creek Pipeline	9	46995.00003	4	Exchange to direct diversion
54	Coon Creek Pipeline	6	46995.00004	4	Exchange to direct diversion
55	Green Mtn Contract Dem	5	48966.00001	4	Exchange to direct diversion
56	Green Mtn Contract Dem	9	48966.00003	4	Exchange to direct diversion
57	Green Mtn Contract Dem	6	48966.00004	4	Exchange to direct diversion
58	Fish Instream Flow	6	99999.93008	1	Release to instream flow demand
59	Fish Instream Flow	5	99999.93005	1	Release to instream flow demand
60	Fish Instream Flow	9	99999.93007	1	Release to instream flow demand
61	Excess HUP Release	5	100000.00000	2	Release to direct diversion
62	Excess HUP Release	9	100000.00000	2	Release to direct diversion
63	Excess HUP Release	6	100000.00000	2	Release to direct diversion

Operating rules 1 through 12 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – C-BT Project Operations, above.

Operating rules 13 through 15 correspond with the rule outlined in Section 5.9.2 Green Mountain Reservoir Operations – Silt Project Operations, above.

Operating rules 16 through 39 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – Historic Users Replacement Operations, above. Wolford Mountain Reservoir was not online when Green Mountain Reservoir was releasing to the Shoshone Call Flows, therefore this rule is not modeled.

Operating rules 39 through 57 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – Contract Demands Operations, above. Operating rules 55 through 57 are *exchanges* to direct diversion while the corresponding operating rules at Green Mountain Reservoir are *releases* to direct diversion.

Operating rules 58 through 60 correspond with rule 4 outlined in Section 5.9.2 Green Mountain Reservoir Operations – 15-Mile Reach Fish Flows Operations.

Operating rules 61 through 63 release water from the replacement accounts, in March, to the Excess HUP Release node (953668D) so replacement water is released within the same administration year. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.6 Williams Fork Reservoir and Moffat Tunnel

The city of Denver uses two facilities to draw water from the Upper Colorado River basin into the South Platte River basin: Moffat Tunnel and the Harold D. Roberts Tunnel (see Section 5.9.4). The city of Englewood developed the Englewood Cabin-Meadow Creek Project to divert water from the Fraser River basin and export it through the Moffat Tunnel to its facilities.

Two primary reservoirs are associated with the Moffat and Englewood systems. Williams Fork Reservoir stores water for exchange by the city of Denver and the Henderson Mine and Mill. This reservoir is located on the Williams Fork River, in District 51, and has a capacity of 96,822 acre-feet. Meadow Creek Reservoir stores water for Denver, Englewood, and the Vail Ditch Company on Meadow Creek, a tributary to the Fraser River, and has a capacity of 5,930 acre-feet.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Williams Fork	1	Denver	94,622
Williams Fork	2	Henderson	2,200
Williams Fork	3	Temporary Fish	5,413
Williams Fork	4	Green Mountain Replacement 1	10,000
Williams Fork	5	Green Mountain Replacement 2	25,000
Meadow Creek	1	Denver / Englewood	4,780
Meadow Creek	2	Vail Ditch	850
Meadow Creek	3	Dead Pool	300

Seventy-eight operating rules are used to simulate the operations associated with Williams Fork Reservoir and Moffat Tunnel. Operations are split below into six sections.

Meadow Creek Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Vail Irrigation Diversion System	2	31259.30134	4	Exchange to direct diversion
2	Hamilton-Cabin Creek Ditch	1	31259.30134	3	Release to direct diversion via pipeline
3	Moffat Summary Node	1	31259.30134	3	Release to direct diversion via pipeline
4	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 releases water from the Vail Ditch account in Meadow Creek Reservoir by exchange to the Vail Ditch Diversion System demand. The administration number was set just junior to the reservoir's first fill right. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 2 and 3 releases water from the Denver / Englewood account in Meadow Creek Reservoir to Moffat Tunnel Collection points. The administration numbers were set just junior to the reservoir's first fill right. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 4 releases water from all accounts proportionally to meet the end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Fraser River Moffat Carrier Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Moffat Summary Node	Jim Creek Collection	30870.26117	11	Carrier to diversion
2	Moffat Summary Node	Vasquez Creek Collection	30870.26117	11	Carrier to diversion
3	Moffat Summary Node	St. Louis Creek Collection	20676.16801	11	Carrier to diversion
4	Moffat Summary Node	St. Louis Creek Collection	30870.26117	11	Carrier to diversion
5	Moffat Summary Node	Ranch Creek Collection	30870.26117	11	Carrier to diversion
6	Moffat Summary Node	Gumlick (Jones Pass) Tunnel	30870.26117	11	Carrier to diversion
7	Moffat Summary Node	Englewood Ranch Crk Collection	20676.16801	11	Carrier to diversion

Operating rules 1 through 7 carry water from their respective tributaries to the Moffat Tunnel summary node. The administration numbers were set identical to the direct diversion rights of the carrier structures. The direct diversion rights are turned off through the use of these rules. These rules are off in the Historic and on in the Calculated and Baseline simulations.

Williams Fork Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Henderson Mine	2	31359.00002	4	Exchange to direct diversion
2	Roberts Tunnel	1	35927.00006	4	Exchange to direct diversion
3	Dillon Reservoir	1	35927.00007	5	Release to river exch to storage
4	Jim Creek Collection	1	30870.26118	4	Exchange to direct diversion
5	Vasquez Creek Collection	1	30870.26118	4	Exchange to direct diversion
6	St. Louis Creek Collection	1	30870.26118	4	Exchange to direct diversion
7	Ranch Creek Collection	1	30870.26118	4	Exchange to direct diversion
8	Gumlick (Jones Pass) Tunnel	1	30870.26118	4	Exchange to direct diversion
9	Jim Creek Collection	1	30870.26118	7	Release to river exch to carrier
10	Vasquez Creek Collection	1	30870.26118	7	Release to river exch to carrier
11	St. Louis Creek Collection	1	20676.16802	7	Release to river exch to carrier
12	St. Louis Creek Collection	1	30870.26118	7	Release to river exch to carrier
13	Ranch Creek Collection	1	30870.26118	7	Release to river exch to carrier
14	Gumlick (Jones Pass) Tunnel	1	30870.26118	7	Release to river exch to carrier
15	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 releases water from the Henderson account in Williams Fork Reservoir in exchange to Henderson Mine and Mill demands. The administration number was set junior to the reservoirs first fill right. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 2 and 3 allow Roberts Tunnel and Dillon Reservoir, respectively, to divert or store water by exchange from Williams Fork Reservoir. These rules are part of the Blue River Decree operations and their administration numbers were set junior to the direct diversion and storage rights (see Section 5.9.18). These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 4 through 8 release water from Williams Fork Reservoir in exchange for diversions at the collection points for the Moffat Tunnel. The administration numbers were set junior to the direct diversion rights of these structures. These rules are on in the Historic simulation and off in the Calculated and Baseline simulations.

Operating rules 9 through 14 release water from Williams Fork Reservoir in exchange for diversions at the collection points for the Moffat Tunnel. The administration numbers were set junior to the direct diversion rights of these structures. These rules are tied back to operating rules 1 through 6 of Section 5.9.6 Williams Fork Reservoir and Moffat Tunnel – Fraser River Moffat Carrier Operations, above. These rules are off in the Historic simulation and on in the Calculated and Baseline simulations.

Operating rule 15 releases water from all accounts proportionally to meet the end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

15-Mile Reach Fish Flow Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Temporary Fish Account	1 to 3	99999.95000	6	Reservoir account book-over
2	Fish Instream Flow	3	99999.93002	1	Release to instream flow demand

Operating rule 1 transfers water from the Denver account to the Temporary Fish account. The administration number was set junior and operated on June 30th. This rule is on in the Historic and Calculated simulations starting in 1997 and is on for the entire study period in the Baseline simulation.

Operating rule 2 releases water from the Temporary Fish account to the USFWS fish flow demand in the 15-Mile reach. The administration number was set junior to the instream flow right and is part of the fish release sequence described below in Section 5.9.19. These rules operate in the months of July through October. These rules are on in the Historic and Calculated simulations starting in 1997 and on for the entire study period in the Baseline simulation.

Denver Replacement Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Denver Replacement 1 account	1 to 4	1.00019	34	Reservoir exchange with plan
2	Denver Replacement 1 account	1 to 4	1.00020	34	Reservoir exchange with plan
3	Denver Replacement 2 account	1 to 5	1.00023	34	Reservoir exchange with plan
4	Denver Replacement 2 account	1 to 5	1.00024	34	Reservoir exchange with plan
5	Denver Replacement 2 account	1 to 1	1.00032	34	Reservoir exchange with plan
6	Denver Replacement 2 account	1 to 1	1.00033	34	Reservoir exchange with plan

Operating rules 1 through 4 book-over water to the two Denver Replacement accounts from the Denver account. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step. Water booked-over reduces Denver's out-of-priority obligations and are tied to the out-of-priority diversion and storage plans, 364684OOPPLN and 364512OOPPLN, respectively, for accounting of replacements. Operating rules 5 and 6 book-over water to the Denver Replacement Account from the Denver Replacement Account, increasing Denver's out of priority plan obligation by the remaining amount in Colorado Spring's out-of-priority plan. Water booked-over reduces Colorado Springs' out-of-priority obligations and are tied to the out-of-priority diversion and storage plans, 363570OOPPLN and 954683OPPLN, respectively, for accounting of replacements, and subject to CSULimit obligations. The water booked-over into the Denver Replacement accounts is used to meet Green Mountain Reservoir obligations, as described below in the Green Mountain Operations from Alternate Replacement Pools section. The rules are on in the Historic, Calculated, and Baseline simulations.

Green Mountain Operations from Alternate Replacement Pools

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Granby Reservoir	4	31258.00006	5	Release to river exch to storage
2	Granby Reservoir	5	31258.00009	5	Release to river exch to storage
3	Willow Creek Reservoir	4	31258.00013	5	Release to river exch to storage
4	Willow Creek Reservoir	5	31258.00016	5	Release to river exch to storage
5	Shadow Mtn/Grand Lake	4	31258.00020	5	Release to river exch to storage
6	Shadow Mtn/Grand Lake	5	31258.00023	5	Release to river exch to storage
7	Granby Reservoir	4, Willow Creek Feeder	31258.00027	7	Release to river exch to carrier
8	Granby Reservoir	5, Willow Creek Feeder	31258.00030	7	Release to river exch to carrier
9	Farmers Irrigation Co	4, Silt Pump Canal	39041.00002	2	Release to river to carrier
10	Farmers Irrigation Co	5, Silt Pump Canal	39041.00005	2	Release to river to carrier
11	Shoshone Call Flows	4	99999.89998	1	Release to instream flow dem
12	Shoshone Call Flows	5	99999.89999	1	Release to instream flow dem
13	Historic Users	4	48965.99995	10	Release to general replace dem

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
14	Historic Users	5	48965.99998	10	Release to general replace dem
15	Government Highline	4, Grand Valley Project	48965.99995	2	Release to river to carrier
16	Government Highline	5, Grand Valley Project	48965.99998	2	Release to river to carrier
17	OMID Irrigation	4, Grand Valley Project	48965.99995	2	Release to river to carrier
18	OMID Irrigation	5, Grand Valley Project	48965.99998	2	Release to river to carrier
19	OMID Pump	4, Grand Valley Project	48965.99995	2	Release to river to carrier
20	OMID Pump	5, Grand Valley Project	48965.99998	2	Release to river to carrier
21	Historic Users	4	46673.99995	10	Release to general replace dem
22	Historic Users	5	46673.99998	10	Release to general replace dem
23	Government Highline	4, Grand Valley Project	46673.99995	2	Release to river to carrier
24	Government Highline	5, Grand Valley Project	46673.99998	2	Release to river to carrier
25	OMID Irrigation	4, Grand Valley Project	46673.99995	2	Release to river to carrier
26	OMID Irrigation	5, Grand Valley Project	46673.99998	2	Release to river to carrier
27	OMID Pump	4, Grand Valley Project	46673.99995	2	Release to river to carrier
28	OMID Pump	5, Grand Valley Project	46673.99998	2	Release to river to carrier
29	Vail Valley Consolidated	4	42420.41368	4	Exchange to direct diversion
30	Vail Valley Consolidated	5	42420.41371	4	Exchange to direct diversion
31	Atkinson Ditch	4	49308.48662	4	Exchange to direct diversion
32	Atkinson Ditch	5	49308.48665	4	Exchange to direct diversion
33	Needham Ditch	4	46751.42643	4	Exchange to direct diversion
34	Needham Ditch	5	46751.42646	4	Exchange to direct diversion
35	Derby Diversion System	4	47481.12657	4	Exchange to direct diversion
36	Derby Diversion System	5	47481.12660	4	Exchange to direct diversion
37	Coon Creek Pipeline	4	46995.00002	4	Exchange to direct diversion
38	Coon Creek Pipeline	5	46995.00005	4	Exchange to direct diversion
39	Green Mtn Contract Dem	4	48966.00002	4	Exchange to direct diversion
40	Green Mtn Contract Dem	5	48966.00005	4	Exchange to direct diversion
41	Fish Instream Flow	5	99999.93009	1	Release to instream flow dem
42	Fish Instream Flow	4	99999.93006	1	Release to instream flow dem
43	Excess HUP Release	4	100000.00000	2	Release to direct diversion
44	Excess HUP Release	5	100000.00000	2	Release to direct diversion

Operating rules 1 through 8 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – C-BT Project Operations, above.

Operating rules 9 and 10 correspond with the rule outlined in Section 5.9.2 Green Mountain Reservoir Operations – Silt Project Operations, above.

Operating rules 11 through 28 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – Historic Users Replacement Operations, above.

Operating rules 29 through 40 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – Contract Demands Operations, above. Operating rules 39 and 40 are *exchanges* to direct diversions while the operating rules at Green Mountain Reservoir are *releases* to direct diversions.

Operating rules 41 and 42 correspond with rule 4 outlined in Section 5.9.2 Green Mountain Reservoir Operations – 15-Mile Reach Fish Flows Operations, above.

Operating rules 43 and 44 release water from the replacement accounts, in March, to the Excess HUP Release node (953709D) so replacement water is released within the same administration year. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.7 Fryingpan-Arkansas Project

The Fryingpan-Arkansas (Fry-Ark) Project diverts water from the Fryingpan River and Hunter Creek basins into the Arkansas River basin for use on the Front Range. Water is exported from the Upper Colorado River basin through the Charles H. Boustead Tunnel, which has a rated capacity of approximately 1,000 cfs. Because the project was completed in phases, it is modeled as two collection areas, Fryingpan and Hunter, and one replacement reservoir, Ruedi Reservoir. The Fryingpan collection area obtains water from tributaries to the Fryingpan River basin, including 100% of the North Side collection system and a significant portion of the South Side collection system (see Upper Colorado River Basin Information Report). The Hunter collection area diverts water from the Hunter Creek basin through the use of the Hunter Tunnel (approximately 300 cfs capacity), and a portion of the South Side collection system.

Fryingpan-Arkansas Project Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Boustead Summary Node	Hunter Tunnel	39291.00001	11	Carrier to diversion
2	Boustead Summary Node	Boustead Tunnel	39291.00000	11	Carrier to diversion
3	Boustead Summary Node	Boustead Tunnel	48577.39291	11	Carrier to diversion

Operating rule 1 diverts water from the Hunter Creek collection area and carries it to the Boustead summary node. The administration number for this rule was set to the administration number of Hunter Creek’s direct diversion right. The Hunter Creek collection area was not online until 1981. In the Historic simulation, the demand is met by the direct diversion right; therefore this rule is turned off. In the Calculated simulation this rule is turned on starting in 1981. This rule is on for the entire study period in the Baseline simulation.

Operating rules 2 and 3 divert water from the Fryingpan collection area and carry it to the Boustead summary node. The administration numbers for these rules were set to the administration numbers of Boustead Tunnel's direct diversion rights. In the Historic simulation, the demand is met by the direct diversion rights, therefore these rules are turned off. These rules are on for the entire study period in the Calculated and Baseline simulations.

5.9.8 Ruedi Reservoir

Ruedi Reservoir, in the Fryingpan River basin, has a capacity of 102,373 acre-feet. It provides replacement water for out-of-priority diversions for the Fry-Ark Project. In addition, it provides water for contract sales as well as instream flow demands in the 15-Mile Reach of the Colorado River below the Grand Valley Project.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Ruedi	1	Round 1 & 2 Contract	24,850
Ruedi	2	Replacement	28,000
Ruedi	3	Unallocated / Dead Pool	28,698
Ruedi	4	CWCB Fish	10,825
Ruedi	5	Unallocated / 5,000 acre-feet	5,000
Ruedi	6	USFWS 5,000 acre-feet 4/5	5,000

Eighteen operating rules are used to simulate the operations associated with Ruedi Reservoir. Operations are split below into four sections.

Fryingpan-Arkansas Project Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Hunter Tunnel	2	39291.00002	4	Exchange to direct diversion
2	Boustead Tunnel	2	48577.39292	4	Exchange to direct diversion
3	Boustead Summary Node	2, Hunter Tunnel	48577.39293	7	Release to river exch to carrier
4	Boustead Summary Node	2, Boustead Tunnel	48577.39292	7	Release to river exch to carrier
5	Boustead Summary Node	2, Boustead Tunnel	48577.39294	7	Release to river exch to carrier

Operating rules 1 and 2 release water from Ruedi's Replacement account in exchange for the out-of-priority diversions made at the Hunter Creek Tunnel and Boustead Tunnel. The administration numbers for these rules were set just junior to the direct diversion rights. Rule 1 is on from 1981 on, while rule 2 is on the entire study period in the Historic simulation. Both rules are off in the Calculated and Baseline simulations.

Operating rules 3 through 5 release water from Ruedi's Replacement account in exchange for the out-of-priority diversions made at the Hunter Creek Tunnel and Boustead Tunnel carriers to the Boustead summary node. The administration numbers were set junior to the most junior direct diversion right for the two carrier structures. These rules are off in the Historic simulation. Rule 3 is on starting in 1981 while rules 4 and 5 are on the entire study period in the Calculated simulation. In the Baseline simulation, these rules are on the entire study period.

15-Mile Reach Fish Flow Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Fish Flow Diversion	5	99999.91002	2	Release to direct diversion
2	Fish Flow Diversion	4	99999.91001	2	Release to direct diversion
3	Fish Flow Diversion	6	99999.91003	2	Release to direct diversion
4	Fish Instream Flow	5	99999.93001	1	Release to instream flow dem
5	Fish Instream Flow	4	99999.93004	1	Release to instream flow dem
6	Fish Instream Flow	6	99999.93012	1	Release to instream flow dem
7	Unallocated / 5,000 acre-feet account	6 to 5	99999.93013	6	Reservoir account book-over

Operating rules 1 through 3 release water from the Unallocated / 5,000 acre-feet, CWCB Fish, and USFWS 5,000 acre-feet 4/5 accounts in Ruedi Reservoir, respectively, to the Fish Flow diversion node. The administration numbers were set junior to the reservoir first fill right. These rules model the pre-1997 fish releases that were made from Ruedi Reservoir (see Section 5.9.19). These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 4 through 6 release water from the Unallocated / 5,000 acre-feet, CWCB Fish, and USFWS 5,000 acre-feet 4/5 accounts in Ruedi Reservoir, respectively, to the Fish Instream Flow. The administration numbers were set junior to the reservoir first fill right and are part of a release series from reservoirs throughout the basin. These rules model the post-1997 fish releases that are made from Ruedi Reservoir (see Section 5.9.19). These rules are on in the Historic and Calculated simulations starting in1997 and on the entire study period in the Baseline simulation, operating July through October.

Operating rule 7 transfers water from the USFWS 5,000 acre-feet 4/5 account to the Unallocated / 5,000 acre-feet account. The administration number was set junior and operates on March 31st. This rule is on in the Historic and Calculated simulations starting in 1997 and on for the entire study period in the Baseline simulation.

Contract Demands Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Round 1 Municipal Demand	1	39291.00003	2	Release to direct diversion
2	Round 1 Industrial Demand	1	39291.00004	2	Release to direct diversion
3	Round 2 Municipal Demand	1	39291.00005	2	Release to direct diversion
4	Round 2 Industrial Demand	1	39291.00006	2	Release to direct diversion
5	Ruedi Additional Depletions	3	99999.92500	2	Release to direct diversion

Operating rules 1 through 4 releases water from the Round 1 & 2 Contract account in Ruedi Reservoir to aggregated contract demands. The administration numbers for these rules were set just junior to Ruedi Reservoir’s first fill right. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 5 releases water from the Unallocated / Dead Pool account in Ruedi Reservoir. This rule was retained from previous modeling efforts that focused on potential future depletion scenarios. It is recommended that this rule be revisited, in particular the reservoir account and the administration number, if similar modeling efforts are conducted in the future. This rule is turned off in the Historic, Calculated, and Baseline simulations.

Other Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 releases water from all accounts proportionally to meet the end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

5.9.9 Grand Valley Operations

The Grand Valley Project (GVP) is modeled in the Upper Colorado Model as twelve nodes to represent the various uses and return flows from the project's Government Highline Canal, Orchard Mesa Irrigation District (OMID) irrigation, OMID hydraulic pump, and the Grand Valley Power Plant (USA Power Plant). These structures receive water by a series of operational rules that pull water from the GVP roller dam (720646), which is modeled as a carrier structure. The Orchard Mesa Check structure, when operating, allows return flows from power diversions at the USA Power Plant and the OMID pump to be returned to the Colorado River upstream of the Grand Valley Irrigation Canal headgate (see Upper Colorado River Basin Information Report). The demand breakdown for the four GVP nodes is based on the historical operation of the Orchard Mesa Check structure.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Government Highline Canal	GVP roller dam	22729.14519	11	Carrier to diversion
2	Government Highline Canal	GVP roller dam	22729.19544	11	Carrier to diversion
3	Government Highline Canal	GVP roller dam	22729.21241	11	Carrier to diversion
4	Government Highline Canal	GVP roller dam	30895.24988	11	Carrier to diversion
5	OMID Irrigation	GVP roller dam	22729.18536	11	Carrier to diversion
6	OMID Irrigation	GVP roller dam	22729.21116	11	Carrier to diversion
7	OMID Pump	GVP roller dam	22729.18536	11	Carrier to diversion
8	OMID Pump	GVP roller dam	22729.21116	11	Carrier to diversion
9	USA Power	GVP roller dam	30895.21241	11	Carrier to diversion
10	USA Power – Winter	GVP roller dam	30895.21241	11	Carrier to diversion
11	USA Power – Summer Senior	GVP roller dam	30895.21241	11	Carrier to diversion
12	USA Power – Summer Junior	GVP roller dam	100000.10000	11	Carrier to diversion

13	OMID Irrigation	Colorado R Pumping Plt	41791.00000	11	Carrier to diversion
14	Government Highline Canal Bypass	GVP roller dam	22729.14518	11	Carrier to diversion
15	Government Highline Canal Bypass	GVP roller dam	22729.19543	11	Carrier to diversion
16	Government Highline Canal Bypass	GVP roller dam	22729.21240	11	Carrier to diversion
17	Government Highline Canal Bypass	GVP roller dam	30895.24987	11	Carrier to diversion

Operating rules 1 through 12 divert water from the GVP roller dam to the individual demands. The administration numbers were set equal to the ten direct diversion rights that divert at the GVP roller dam. See Section 2.4 Grand Valley Area Water Demand (Cameo Call) of the Upper Colorado River Basin Information Report for further details concerning this complex diversion system. Rules 1 through 8 are on in the Historic, Calculated, and Baseline simulations. Rule 9 is on in the Historic and Calculated simulations through 1996 and off in the Baseline. Rules 10 through 12 replace rule 9 starting in 1997 in the Historic and Calculated simulations and are on the entire study period in the Baseline simulation.

Operating rule 13 diverts water at the Colorado River Pumping Plant and delivers it to OMID Irrigation. The Colorado River Pumping Plant did not historically operate, but was include in previous modeling efforts and was retained in this update. It is recommended that this rule be revisited in the future. This rule is turned off in the Historic, Calculated, and Baseline simulations.

Operating rules 14 through 17 deliver water to the Government Highline Canal Bypass from the GVP roller dam. These rules were retained from previous modeling efforts that focused on potential future depletion scenarios. It is recommended that these rules be revisited if similar modeling efforts are conducted in the future. This rule is turned off in the Historic, Calculated, and Baseline simulations.

5.9.10 Homestake Project

The Homestake Diversion Project exports water from Homestake Creek, a tributary of the Eagle River, into the Arkansas River basin for the cities of Colorado Springs and Aurora. This project has one reservoir, Homestake, one transmountain diversion with its own decree, Homestake Project Tunnel, and two modeled collection areas, the Missouri Tunnel system and the Homestake Reservoir system. Homestake Reservoir is the primary western slope storage facility for this project, storing water from Homestake Creek, Hunter Creek, and several neighboring tributaries. The Homestake Project Tunnel (300 cfs capacity) conveys water diverted under its direct flow and storage decrees to the Arkansas River basin. The Missouri Tunnel system (600 cfs capacity) conveys water from four nearby drainages to Homestake Reservoir. The Homestake Reservoir collection system includes the reservoir on Middle Fork Homestake Creek and a diversion from East Fork Homestake Creek.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Homestake	1	Colorado Springs & Aurora	42,881
Homestake	2	Dead Pool	211
Homestake	3	Homestake Reservoir Green Mountain Replacement	21,440

Twenty-one operating rules are used to simulate the operations associated with the Homestake Project. Operations are split below into four sections.

Homestake Project Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Homestake Reservoir	Missouri Tunnel	39650.37520	11	Carrier to reservoir

Operating rule 1 delivers water from the Missouri Tunnel collection system to Homestake Reservoir. The administration number was set equal to the direct diversion right of the Missouri Tunnel. This operating rule turns off the direct diversion right for the Missouri Tunnel and is used to limit the diversions at the Missouri Tunnel to times when Homestake Reservoir has a demand and there is physical supply at the Missouri Tunnel. This rule is on in the Historic, Calculated, and Baseline simulations.

Homestake Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Homestake Tunnel	1	39650.37521	2	Release to direct diversion
2	Reservoir to Target	All	99999.99999	9	Release to river by target

Operating rule 1 releases water from the Colorado Springs & Aurora account to the Homestake Tunnel. The administration number associated with this rule was set junior to the Homestake Tunnel direct diversion right and Missouri Tunnel operating rule, discussed above. This rule is used to meet remaining Homestake Tunnel demands with releases from Homestake Reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 2 releases water from all accounts proportionally to meet the end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Colorado Springs Replacement Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Homestake Reservoir Green Mtn Replacement account	1 to 3	1.00012	34	Reservoir exch with plan
2	Homestake Reservoir Green Mtn Replacement account	1 to 3	1.00013	34	Reservoir exch with plan

Operating rules 1 and 2 book-over water to the Homestake Reservoir Green Mountain Replacement account from the Colorado Springs & Aurora account. The administration numbers were set senior so that operations occur at the beginning of the August 1st time step. Water booked-over reduces Colorado Springs' out-of-priority obligations and are tied to the out-of-priority diversion and storage plans, 954683OOPPLN and 363570OOPPLN, respectively. The water booked over into the Homestake Reservoir Green Mountain Replacement account is used to meet Green Mountain Reservoir obligations, as described below in the Green Mountain Operations from Alternate Replacement Pools section. These operations are currently going through the process to be decreed. It is recommended that these rules be reviewed and updated once the decree is final. These rules are off in the Historic, Calculated, and Baseline simulations.

Green Mountain Operations from Alternate Replacement Pools

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Granby Reservoir	3	31258.00010	5	Release to river exch to storage
2	Willow Creek Reservoir	3	31258.00017	5	Release to river exch to storage
3	Shadow Mtn/Grand Lake	3	31258.00024	5	Release to river exch to storage
4	Granby Reservoir	3, Willow Creek Feed	31258.00031	7	Release to river exch to carrier
5	Farmers Irrigation Co	3, Silt Pump Canal	39041.00006	2	Release to river to carrier
6	Historic Users	3	46673.99999	10	Release to general repl demand
7	Government Highline	3, Grand Valley Proj	46673.99999	2	Release to river to carrier
8	OMID Irrigation	3, Grand Valley Proj	46673.99999	2	Release to river to carrier
9	OMID Pump	3, Grand Valley Proj	46673.99999	2	Release to river to carrier
10	Vail Valley Consolidated	3	42420.41372	4	Exchange to direct diversion
11	Atkinson Ditch	3	49308.48666	4	Exchange to direct diversion
12	Needham Ditch	3	46751.42647	4	Exchange to direct diversion
13	Derby Diversion System	3	47481.12661	4	Exchange to direct diversion
14	Coon Creek Pipeline	3	46995.00006	4	Exchange to direct diversion
15	Green Mtn Contract Dem	3	48966.00006	4	Exchange to direct diversion
16	Fish Instream Flow	3	99999.93010	1	Release to instream flow demand
17	Excess HUP Release	3	100000.00000	2	Release to direct diversion

Operating rules 1 through 17 are off in the Historic, Calculated, and Baseline simulations. At the time of this model update, Colorado Springs is in the process of decreeing alternate replacement sources to Green Mountain Reservoir for operations under the Blue River Decree. Agreements allow for Colorado Springs to use Wolford Mountain Reservoir as an alternate replacement source to Green Mountain Reservoir based on previous decrees that allow Denver the use of Wolford Mountain Reservoir as an alternate replacement source. Agreements do not grant Colorado Springs the use of Homestake Reservoir as an alternate replacement source and therefore the rules are included but turned off.

Operating rules 1 through 4 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – C-BT Project Operations, above.

Operating rule 5 corresponds with the rule outlined in Section 5.9.2 Green Mountain Reservoir Operations – Silt Project Operations, above.

Operating rules 6 through 9 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – Historic Users Replacement Operations, above. Homestake Reservoir was not decreed as an alternate replacement source for Green Mountain Reservoir when releases were made to the Shoshone Call Flows and water rights that were senior to January 24, 1984; therefore these rules are not modeled.

Operating rules 10 through 15 correspond with the rules outlined in Section 5.9.2 Green Mountain Reservoir Operations – Contract Demands Operations, above. Operating rule 15 allows *exchange* to direct diversions, while the operating rule at Green Mountain Reservoir allows *releases* to direct diversions.

Operating rule 16 corresponds with rule 4 outlined in Section 5.9.2 Green Mountain Reservoir Operations – 15-Mile Reach Fish Flows Operations, above.

Operating rule 17 releases water from the replacement accounts, in March, to the Excess HUP Release node (954516D) to ensure replacement water is released within the same administration year.

5.9.11 Silt Project

The Silt Project was authorized in 1956 under the Colorado River Storage Project Act and provides supplemental water for irrigation use in the general vicinity of Rifle Creek. The two primary facilities of the project include Rifle Gap Reservoir on Rifle Creek and the Silt Pump Plant, located on the mainstem of the Colorado River. In addition, it uses existing facilities such as Grass Valley Canal, East Lateral, West Lateral, and Grass Valley Reservoir (a.k.a. Harvey Gap Reservoir), owned by the Farmers Irrigation Company.

Rifle Gap Reservoir stores water for the Davie Ditch and the facilities owned by the Farmers Irrigation Company. While most irrigated acreage is in the Rifle Creek basin and an unnamed basin containing the Grass Valley Reservoir, some of the water diverted from the Grass Valley Canal is used to irrigate lands in the adjacent Elk Creek basin. The three basins are tributary to the mainstem of the Colorado River. As briefly discussed above in Section 5.9.2 Green Mountain Reservoir Operations – Silt Project Operations, the Silt Project owns storage water in Green Mountain Reservoir, which provides supplemental water to the Silt Pump Plant to satisfy irrigation demands. In the Upper Colorado Model, the irrigated lands associated with this project are divided into the following three demands:

- Davie Ditch receives water from Rifle Creek and stored water in Rifle Gap Reservoir
- Dry Elk Valley receives water from the East Rifle Creek and water by exchange from Rifle Gap Reservoir
- Farmers Irrigation Company irrigates lands downstream of Grass Valley Reservoir, which receive water from Grass Valley Reservoir, the Colorado River, and storage water in Green Mountain's Silt Project account via the Silt Pump Plant.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Rifle Gap	1	Silt Pool	12,168
Rifle Gap	2	Dead Pool	1,434
Grass Valley (a.k.a. Harvey Gap)	1	Farmers	5,920

Twelve operating rules are used to simulate the operations associated with the Silt Project.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Dry Elk Valley Irrigation	Grass Valley Canal	15458.13715	11	Carrier to diversion
2	Harvey Gap Reservoir	Grass Valley Canal	15458.13715	11	Carrier to reservoir
3	Dry Elk Valley Irrigation	Grass Valley Canal	37503.15066	11	Carrier to diversion
4	Harvey Gap Reservoir	Grass Valley Canal	37503.15066	11	Carrier to reservoir
5	Dry Elk Valley Irrigation	1, Grass Valley Canal	37503.36902	7	Release to river exch to carrier
6	Harvey Gap Reservoir	1, Grass Valley Canal	37503.36902	7	Release to river exch to carrier
7	Dry Elk Valley Irrigation	1, Grass Valley Canal	37503.36903	7	Release to river exch to carrier
8	Harvey Gap Reservoir	1, Grass Valley Canal	37503.36903	7	Release to river exch to carrier
9	Davie Ditch	1	37503.36901	2	Release to direct diversion
10	Reservoir to Target	All	99999.99999	9	Release to river by target
11	Farmers Irrigation Co	Silt Pump Plant	39041.00000	11	Carrier to reservoir
12	Farmers Irrigation Co	1	37503.35322	2	Release to direct diversion

Operating rules 1 through 4 divert water through the Grass Valley Canal to Dry Elk Valley Irrigation demand or to Harvey Gap Reservoir. The administration numbers for these rules were set equal to the direct diversion rights associated with the Grass Valley Canal. These rules are used because the demands are not located at the Grass Valley Canal. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 5 through 8 release water from the Silt Pool account in Rifle Gap Reservoir in exchange for diversions at the Grass Valley Canal for demands at Dry Elk Valley Irrigation and Harvey Gap Reservoir. The administration numbers for these rules were set just junior to Rifle Gap Reservoir’s first fill right. These rules are directly related to rules 1 through 4. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 9 releases water from the Silt Pool account in Rifle Gap Reservoir to the Davie Ditch. The administration number for this rule was set just junior to Rifle Gap Reservoir’s first fill right. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 10 releases water from all accounts proportionally in Rifle Gap Reservoir to meet end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 11 diverts water at the Silt Pump Plant and delivers it to the Farmers Irrigation Company. The administration number was set equal to the direct diversion right of the Silt Pump Plant. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 12 releases water from the Farmers account in Harvey Gap Reservoir to the Farmers Irrigation Company. The administration number was set junior to the deliveries from Grass Valley Canal to Harvey Gap Reservoir and senior to exchanges from Rifle Gap Reservoir to Harvey Gap Reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

5.9.12 Glenwood Springs Operations

The town of Glenwood Springs obtains the majority of its municipal water supply from surface diversions on Grizzly Creek via the Glenwood Water Co. System (WDID 531051) and from No Name Creek, also through the Glenwood Water Co. System (WDID 530585) - both of which are tributaries of the Upper Colorado River. In the Upper Colorado River Model the demands for the town of Glenwood Springs are modeled at structure located on No Name Creek.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Structure 530585	Structure 531051	20427.19858	11	Carrier to diversion
2	Structure 530585	Structure 531051	33023.31607	11	Carrier to diversion
3	Structure 530585	Structure 531051	19573.13680	11	Carrier to diversion

Operating rules 1 through 3 carry water from Grizzly Creek (WDID 531051) to No Name Creek (WDID 530585) to meet the town of Glenwood Springs municipal demand. The administration numbers were set equal to the direct diversion rights located at Structure 531051. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.13 Owens Creek Ditch Transbasin

Divide Creek Highline Ditch (WDID 450576) receives imported water from Clear Fork Feeder/Divide Creek Feeder (WDID 404657) in Water Division 4 and from Owens Creek Ditch (WDID 724721). Clear Fork Feeder/Divide Creek Feeder (WDID 404657) is modeled as an import into Divide Creek and does not require additional operating rules. Owens Creek Ditch (WDID 724721) is modeled as a diversion structure on Owens Creek, tributary to Buzzard Creek, and requires two operating rules to model the deliveries to Divide Creek Highline Ditch.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Divide Creek Highline Ditch	Owens Creek Ditch	22995.20976	11	Carrier to diversion
2	Divide Creek Highline Ditch	Owens Creek Ditch	23177.00000	11	Carrier to diversion

Operating rules 1 and 2 carry water from the Owens Creek Feeder to the Divide Creek Highline Ditch. The administration numbers for these rules were set equal to the direct diversion rights of Owens Creek Ditch. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.14 Ute Water Conservancy District Operations

The Ute Water Conservancy District (Ute WCD) is the largest rural water provider in the Upper Colorado River basin, with a service area that extends from near Cameo to the northwest including the town of Fruita. The service area includes most of the rural land on both sides of the Upper Colorado River, but excludes the towns of Palisade, Clifton, Whitewater and Grand Junction, which have their own municipal supplies. Raw water diversions for the Ute WCD are made through six main structures: (1) the Ute Pipeline Headgate No. 2 (WDID 720920) on Plateau Creek; (2) the Ute Pipeline Headgate No. 1 (721487) diverting from the tailrace of the Molina Power Plan; (3) the Mason Eddy Ditch (WDID 950030) on Mesa Creek; (4) the Coon Creek Pipeline (WDID 721339); (5) Rapid Creek Pumping Plant (WDID 721329) on the Colorado River; and (6) the Martin Crawford Ditch (720764) on Rapid Creek. Water is delivered from Plateau Creek and its tributaries to the Rapid Creek Ute Water Treatment Plant (950020) where it is treated and distributed to users.

Ute WCD stores and releases water from Jerry Creek Reservoir 1 and 2, operated and modeled as a single reservoir (723961) with 8,360 acre-feet capacity.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Jerry Creek Agg Res	1	Active	8,460

Seventeen operating rules are used to simulate the operations associated with the Silt Project.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Rapid Creek Ute WTP	Ute Pipeline Hdgt 1	38846.99999	11	Carrier to diversion
2	Rapid Creek Ute WTP	Ute Pipeline Hdgt 1	40013.39607	11	Carrier to diversion
3	Rapid Creek Ute WTP	Ute Pipeline Hdgt 2	38847.00000	11	Carrier to diversion
4	Rapid Creek Ute WTP	Ute Pipeline Hdgt 2	40013.39608	11	Carrier to diversion
5	Rapid Creek Ute WTP	Mason Eddy Ditch	12753.00000	11	Carrier to diversion
6	Rapid Creek Ute WTP	Mason Eddy Ditch	30895.12724	11	Carrier to diversion
7	Rapid Creek Ute WTP	Mason Eddy Ditch	30895.24260	11	Carrier to diversion
8	Rapid Creek Ute WTP	Mason Eddy Ditch	32811.00000	11	Carrier to diversion
9	Rapid Creek Ute WTP	Mason Eddy-Carver Ranch	46751.46599	11	Carrier to diversion
10	Rapid Creek Ute WTP	Coon Creek Pipeline	46995.00000	11	Carrier to diversion
11	Rapid Creek Ute WTP	Martin Crawford D	48942.48333	11	Carrier to diversion
12	Rapid Creek Ute WTP	Rapid Creek Pumping Plant	41791.00000	11	Carrier to diversion
13	Rapid Creek Ute WTP	Jerry Creek Aggreg Res	46995.00001	3	Reservoir to demand
14	Jerry Creek Aggreg Res	Ute Pipeline Hdgt 1	40013.39607	11	Carrier to reservoir
15	Jerry Creek Aggreg Res	Ute Pipeline Hdgt 2	40013.39608	11	Carrier to reservoir
16	Ute Pipeline Hdgt 2	Jerry Creek Aggreg Res	46995.00001	3	Release to demand

Operating rules 1 through 12 divert water from Plateau Creek and its tributaries and deliver it to the Rapid Creek Ute Water Treatment Plant. The administration numbers were set equal to the direct diversion rights of the carrier structures. These rules are off in the Historic simulation because the demands are modeled at the carrier locations. In the Calculated and Baseline simulations these rules are turned on and the demand is modeled at the Rapid Creek Ute Water Treatment Plant.

Operating rule 13 releases water from Jerry Creek Aggregated Reservoir to Rapid Creek Ute Water Treatment Plant. This rule is turned off in the Historical simulation, because the demands are modeled at the carrier locations. Operating rules 14 and 15 divert from Ute Pipeline Headgates 1 and 2 for storage in Jerry Creek Aggregated Reservoir. These rules are on in all simulations. Rule 16 releases water from Jerry Creek Aggregated Reservoir to meet Ute Pipeline Headgate 2 demand in the Historical simulation only.

5.9.15 Collbran Project and Vega Reservoir

The Collbran Project was built by the USBR between 1957 and 1962. The project provides supplemental irrigation water for diverters in the Plateau Creek basin and generates hydroelectric power through the Molina Power Plant. The primary features of this project are Vega Reservoir, the Southside Canal, and the Molina Power Plant. Vega Reservoir is the main storage facility for the project providing irrigation water and replacement water for out-of-priority diversions used to generate hydropower.

The Southside Canal originates from Vega Reservoir and crosses nine sub-basins of Plateau Creek - the canal has a 240 cfs capacity at the reservoir and a 50 cfs capacity by the time it reaches the final stream, Mesa Creek. This carrier ditch conveys water from Vega Reservoir to ditches downstream of the canal-stream crossing. In addition, the Southside Canal provides exchange water to diverters that cannot be served by the canal directly.

The Molina Power Plant is served by two carrier ditches, Bonham Branch Pipeline and Cottonwood Branch Pipeline, on Big and Cottonwood Creeks, respectively. As part of the Collbran Project, the USBR rehabilitated several small reservoirs on the Grand Mesa above Big and Cottonwood Creeks. This additional storage water supplemented the available water in Big and Cottonwood Creeks to satisfy the hydropower demand at the Molina Power Plant. In the Upper Colorado Model, the multiple reservoirs on the Grand Mesa were aggregated into two reservoirs, one at each of the headwaters of Big and Cottonwood Creeks. The Bonham Aggregated Reservoir and Cottonwood Aggregated Reservoir each have one active account to supply storage water to the Molina Power Plant.

Vega Reservoir stores water by natural streamflow and from feeder canals originating on Park and Leon Creeks. Vega Reservoir (34,131 acre-feet capacity) is divided into two accounts: project irrigation and dead storage. The project irrigation pool provides water for irrigation use on the Plateau Creek tributaries, which are crossed by the Southside Canal.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Vega	1	Project Irrigation	33,311
Vega	2	Dead Pool	820
Bonham Aggregated	1	Active	6,778
Cottonwood Aggregated	1	Active	3,812

Eighty-four operating rules are used to simulate the operations associated with the Collbran Project.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Vega Reservoir	Leon Park Feeder Canal	37486.00000	11	Carrier to diversion
2	Vega Reservoir	Leon Park Feeder Canal	44194.43247	11	Carrier to diversion
3	Vega Reservoir	Park Creek Feeder Canal	30895.23492	11	Carrier to diversion
4	Vega Reservoir	Park Creek Feeder Canal	41500.00000	11	Carrier to diversion
5	Molina Power Plant	Bonham Branch Pipeline	37486.00000	11	Carrier to diversion
6	Molina Power Plant	Bonham Branch Pipeline	37486.00001	2	Release to river to carrier
7	Reservoir to target	N/A	99999.99999	9	Release to river by target
8	Molina Power Plant	Cottonwood Branch Pipeline	37486.00000	11	Carrier to diversion
9	Molina Power Plant	Cottonwood Branch Pipeline	37486.00001	2	Release to river to carrier
10	Reservoir to target	N/A	99999.99999	9	Release to river by target
11	Galbraith Ditch	Southside Canal	37486.00004	11	Carrier to diversion
12	Grove Cr Ditch Co No 1	Southside Canal	37486.00004	11	Carrier to diversion
13	Golden Age Ditch	Southside Canal	37486.00004	11	Carrier to diversion
14	Kiggins Goyn Ditch	Southside Canal	37486.00004	11	Carrier to diversion
15	Eakin-Smith Ditch	Southside Canal	37486.00004	11	Carrier to diversion
16	Bertholf Lanham Updike	Southside Canal	37486.00004	11	Carrier to diversion
17	Silver Gauge Ditch	Southside Canal	37486.00004	11	Carrier to diversion
18	Wildcat Ditch (Big Cr)	Southside Canal	37486.00004	11	Carrier to diversion
19	Coakley Kiggins Ditch	Southside Canal	37486.00004	11	Carrier to diversion
20	Park View Ditch	Southside Canal	37486.00004	11	Carrier to diversion
21	Mormon Mesa Ditch	Southside Canal	37486.00004	11	Carrier to diversion
22	Pioneer Of Plateau Ditch	Southside Canal	37486.00004	11	Carrier to diversion
23	Bull Creek Ditch	Southside Canal	37486.00004	11	Carrier to diversion
24	Mesa Creek Ditch	Southside Canal	37486.00004	11	Carrier to diversion
25	West Side Ditch	Southside Canal	37486.00004	11	Carrier to diversion
26	Arkansas Ditch	Southside Canal	37486.00004	11	Carrier to diversion
27	King Ditch	Southside Canal	37486.00004	11	Carrier to diversion

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
28	Galbraith Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
29	Grove Cr Ditch Co No 1	1,Southside Canal	37486.00004	2	Release to river to carrier
30	Golden Age Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
31	Kiggins Goyn Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
32	Eakin-Smith Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
33	Bertholf Lanham Updike	1,Southside Canal	37486.00004	2	Release to river to carrier
34	Silver Gauge Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
35	Wildcat Ditch (Big Cr)	1,Southside Canal	37486.00004	2	Release to river to carrier
36	Coakley Kiggins Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
37	Park View Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
38	Mormon Mesa Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
39	Pioneer Of Plateau Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
40	Bull Creek Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
41	Mesa Creek Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
42	West Side Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
43	Arkansas Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
44	King Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
45	Mason Eddy D (Irr)	1,Southside Canal	37486.00004	2	Release to river to carrier
46	Bull Basin Highline D	1,Southside Canal	37486.00004	2	Release to river to carrier
47	RMG (Mel) Div Sys	1,Southside Canal	37486.00004	2	Release to river to carrier
48	Johnson And Stuart D	1,Southside Canal	37486.00004	2	Release to river to carrier
49	Parker Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
50	Davenport D (Cottnwd)	1,Southside Canal	37486.00004	2	Release to river to carrier
51	Palmer Ditch	1,Southside Canal	37486.00004	2	Release to river to carrier
52	New Erie Canal	1	37486.00004	4	Exch to direct diversion
53	Plateau Abv Vega Agg	1	37486.00005	4	Exch to direct diversion
54	Plateau Bl Vega Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
55	Salt Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
56	Upper Grove Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
57	Lower Grove Crk Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
58	Big Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
59	Cottonwood Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
60	Bull Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
61	Coon Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
62	Mesa Creek Agg	1,Southside Canal	37486.00005	2	Release to river to carrier
63	Reservoir to target	All	99999.99999	9	Release to river by target

Operating rules 1 through 4 allow Vega Reservoir to pull water from the Leon Creek Feeder (720746) and the Park Creek Ditch (720820) to supplement the natural inflows into the reservoir. Both of these structures are carrier ditches and are subject to the 350 cfs capacity of the Leon Creek Feeder. The administration numbers were set equal to the direct diversion rights for the two structures. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 5 and 6 allow the Molina Power Plant to pull available streamflow on Big Creek from the Bonham Branch Pipeline and storage water from the Bonham Aggregated Reservoir, respectively. Both operations are subject to the 45 cfs capacity of the Bonham Branch Pipeline. The administration number for rule 5 was set equal to the direct diversion right for the Bonham Branch Pipeline, while rule 6 was set just junior. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 7 releases water from all accounts proportionally in Bonham Reservoir to meet end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 8 and 9 allow the Molina Power Plant to pull available streamflow on Cottonwood Creek from the Cottonwood Branch Pipeline and storage water from the Cottonwood Aggregated Reservoir, respectively. Both operations are subject to the 28 cfs capacity of the Cottonwood Branch pipeline. The administration number for rule 8 was set equal to the direct diversion right for the Cottonwood Branch Pipeline, while rule 9 was set just junior. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 10 releases water from all accounts proportionally in Cottonwood Reservoir to meet end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 11 through 27 divert direct flow water through Southside Canal to ditches on Plateau Creek tributaries. The administration number for these rules corresponds to Southside Canal’s direct flow right. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 28 through 51 provide Vega Reservoir storage water to ditches served by Southside Canal. Operating rule 52 provides water from Vega Reservoir, by exchange, to the New Erie Canal. The administration number for these rules ensures their direct flow rights are used before their storage rights. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rule 53 provides water from Vega Reservoir, by exchange, to the aggregated irrigation structure with lands located on Plateau Creek above Vega Reservoir. The administration number was set junior to the structure's direct diversion rights. This rule supplements the structure's direct flow rights. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rules 54 through 62 carry water from Vega Reservoir through the Southside Canal to the aggregated irrigation structures located on the Plateau Creek tributaries. The administration numbers were set junior to the structures' direct diversion rights. This rule supplements the structures' direct flow rights. This rule is on in the Historic, Calculated, and Baseline simulations.

Operating rule 63 releases water from Vega Reservoir to meet end-of-month target values. The junior administration number ensures this is the last operating rule to fire at the reservoir. This rule is on in the Historic, Calculated, and Baseline simulations.

5.9.16 Leon Creek Aggregated Reservoir Operations

Reservoirs on Leon Creek are aggregated into two reservoirs – one that stores and delivers water to the Leon Tunnel for use in the Gunnison Basin, and one that delivers water to irrigation demands on Leon Creek.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Leon Lake Agg Reservoir	1	Active	2,904
Monument Agg Reservoir	1	Active	987

Five operating rules are used to simulate the operations associated with the Leon Lake and Monument Aggregated Reservoirs.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Leon Tunnel	1 (Leon Lake Agg)	22995.18426	2	Release to direct diversion
2	Kiggins Salisbury Ditch	1 (Monument Agg)	37037.00001	2	Release to direct diversion
3	Leon Ditch	1 (Monument Agg)	32811.00001	2	Release to direct diversion
4	Leon Lake to Target	1	99999.99999	9	Release to river by target
5	Monument to Target	1	99999.99999	9	Release to river by target

Operating rule 1 releases water from Leon Lake Aggregate Reservoir directly to Leon Tunnel Canal. Operating rules 2 and 3 release water from Monument Aggregate Reservoir directly to Kiggins Salisbury Ditch, and Leon Ditch, respectively. The administration numbers for these rules were set just junior to the direct diversion rights for these structures. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 4 and 5 releases water in Leon Lake Aggregated Reservoir and Monument Aggregate Reservoir to meet end-of-month target values. The junior administration numbers ensures these are the last operating rule to fire at the reservoir. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.17 Soil Moisture Operations

A type 22 operating rule is also used to allow soil moisture accounts for irrigation structures.

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Operate Soil Moisture	N/A	90000.00000	22	Soil moisture reservoir accounting

Operating rule 1 directs StateMod to consider soil moisture in the variable efficiency accounting. The administration number was set junior to allow for most operations at irrigation structures to occur. This operating rule allows structures with crop irrigation water requirements to store excess diverted water not required by the crops during the month of diversion in the soil reservoir zone. It also allows releases from the soil reservoir to meet unsatisfied demands if diversions are not adequate to meet crop irrigation water requirements during the month of diversion. This rule is on in the Historic, Calculated, and Baseline simulations.

5.9.18 Blue River Decree Operations

Consolidated Case Nos. 2782, 5016 and 5017 (the Blue River Decree). In this 1955 adjudication, the relative priorities of the storage rights and hydroelectric rights for Green Mountain Reservoir and the upstream rights at Dillon Reservoir and the Continental-Hoosier System (Colorado Springs) were specified as follows:

Continental Hoosier System	77 cfs	August 5, 1929
Green Mountain Reservoir	154,645 acre-feet	August 1, 1935
Green Mountain Hydro	1,726 cfs	August 1, 1935
Green Mountain Senior Refill	6,315 acre-feet	August 1, 1935
Montezuma Tunnel (Roberts Tunnel)	788 cfs	June 24, 1946
Dillon Reservoir	252,678 acre-feet	June 24, 1946
Continental-Hoosier System	400 cfs	May 13, 1948
Continental-Hoosier Storage	5,306 acre-feet	May 13, 1948

In this decree, Colorado Springs and Denver obtained the right to divert and store water at their upstream facilities on an out-of-priority basis against Green Mountain Reservoir's first fill right. Because the cities have storage in the upper Blue River basin, they were in a position to repay Green Mountain in the event the latter does not fill. This agreement allows out-of-priority upstream diversions against the senior storage decree at Green Mountain Reservoir. The cities have agreed to pay power interference charges to offset impacts, if any, to the Green Mountain Hydroelectric direct right.

When Denver incurs an obligation to repay Green Mountain Reservoir for water stored out-of-priority at Dillon Reservoir, provisions of the Blue River Decree, as more specifically described in a 1964 Stipulation and Agreement, allow Denver to replace the water owed by substituting releases from its Williams Fork Reservoir. In 1991, the agreements were again modified and allowed use of Wolford Mountain Reservoir as an additional source of substitution supply for water owed to Green Mountain Reservoir by Denver. These agreements also make reference to a requirement for Denver to maintain a pool of 1,000 acre-feet in Dillon Reservoir, which releases to Green Mountain Reservoir to the extent necessary to maintain flow in the Blue River below Dillon Dam at 50 cfs.

The Interim Policy was adopted by the State Engineer "to give water users certainty about administrative and accounting principles concerning Green Mountain Reservoir" and is, at the time of this update, the current administration of the Blue River Decree. The Interim Policy specifically outlines the components to the Paper Fill of Green Mountain Reservoir under its August 1, 1935, first fill right. The Paper Fill is defined to be met when 154,645 acre-feet is equal to the sum of:

1. Initial storage in Green Mountain Reservoir at the beginning of the administration year,
2. Stored water in Green Mountain Reservoir after the administration date,
3. Bypassed water in excess of 60 cfs or the demand of a downstream call senior to August 1, 1935,
4. Out-of-priority depletions from HUP and Contract beneficiaries upstream of Green Mountain Reservoir, and
5. Out-of-priority diversions and storage made by Denver and Colorado Springs.

After a paper fill has been met Green Mountain Reservoir stores under the October 10, 1955, "exchange" right up to the amount of water stored and diverted out-of-priority to its 1935 storage right by Denver and Colorado Springs. According to Alan Martellaro, Division 5 Engineer, the Blue River Decree has been administered under the Interim Policy from 2003 to the time of this update (2006). Operations for out-of-priority depletions from HUP and Contract beneficiaries upstream of Green Mountain Reservoir are considered minor and are not explicitly modeled. Operations for the Interim Policy, detailed below, are used exclusively throughout the model simulations.

In this update of the Upper Colorado River Model, the Interim Policy is modeled to represent the current administration of the Blue River Decree. On April 1st, Green Mountain Reservoir is administered and the first fill volume is determined. The Paper Fill, under the Interim Policy, is satisfied when the administered first fill volume is equal to the sum of the:

1. Initial storage in Green Mountain Reservoir at the beginning of the administration year,
2. Stored water in Green Mountain Reservoir after the administration date,
3. Bypassed water in excess of 60 cfs or the demand of a downstream call senior to August 1, 1935, and
4. Out-of-priority diversions and storage made by Denver and Colorado Springs.

Once the Paper Fill has been reached, the 1935 priority storage water right is satisfied and can no longer call.

Below is an outline of the Blue River Decree operations through an administration year under the Interim Policy as modeled in this update of the Upper Colorado River Model:

April 1st through July 31st Prior to a Paper Fill

Right #	Description	Account or Carrier	Admin #	Right Type	Plan Structure
1	Divert at Con-Hoosier - senior right	364699	30184.29071	11	
2	Green Mountain Reservoir Instream Flow	NA	31257.99994	*.ifr	
3	Divert at Con-Hoosier OOP - junior right	364683	31257.99995	38	954683OOPPLN
4	Store in Upper Blue Lakes OOP	NA	31257.99996	38	363570OOPPLN
5	Dillon Reservoir Instream Flow	NA	31257.99997	*.ifr	
6	Divert at Roberts Tunnel OOP	NA	31257.99998	38	364684OOPPLN
7	Store in Dillon OOP	NA	31257.99999	38	364512OOPPLN
8	Store in Green Mountain - senior right	First 5	31258.00000	*.rer	

Operating rule 1 carries water from the Con-Hoosier collection node 364699 to demand at the summary node 954683. The administration number was set equal to the administration number of the direct diversion right associated with the carrier. This rule is turned on in the Historic, Calculated, and Baseline simulations.

Right 2 is the instream flow requirement below Green Mountain Reservoir (note, not an operating rule). The administration number was set senior to Green Mountain and the upstream out-of-priority operations. This right is on in the Historic, Calculated, and Baseline simulations.

Operating rule 3 simulates Colorado Springs' diversions through the Con-Hoosier Tunnel out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the first out-of-priority operation. Out-of-priority diversion accounting is simulated at plan structure 954683OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations with diversions limited to months of April through July.

Operating rule 4 simulates Colorado Springs' storage in Upper Blue Lakes out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the second out-of-priority operation. Out-of-priority storage from this rule is accounted for with the plan structure 363570OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations and storage was limited to the months of April through July.

Right 5 is the instream flow requirement below Dillon Reservoir (note, not an operating rule). The administration number was set senior to Green Mountain and Denver's out-of-priority operations. This right is on in the Historic, Calculated, and Baseline simulations.

Operating rule 6 simulates Denver's diversions through the Roberts Tunnel out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the third out-of-priority operation. Out-of-priority diversions from this rule are accounted for with plan structure 364684OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations and the diversions were limited to the months of

April through July.

Operating rule 7 simulates Denver's storage in Dillon Reservoir out-of-priority to Green Mountain Reservoir. The administration number was set senior to Green Mountain Reservoir's first fill right and is the fourth and final out-of-priority operation. Out-of-priority storage from this rule is accounted for with plan structure 364512OOPPLN. This rule is on in the Historic, Calculated, and Baseline simulations and storage was limited to the months of April through July.

Right 8 is Green Mountain Reservoir's senior first fill right. The administration number was set by StateDMI and information located in HydroBase. This right is on in the Historic and Calculated simulations starting in1943. The date is based on the first year diversions to storage occurred at Green Mountain Reservoir. The date is required due to accounting of bypassed water against the first fill right by setting the on/off switch for Green Mountain Reservoir to 3 in the *.res file. In the Baseline simulations, the right is on for the entire study period.

April 1st through July 31st after Paper Fill was met

Right #	Description	Account or Carrier	Admin #	Right Type	Plan Structure
1	Divert at Con-Hoosier - junior right	364683	35927.00000	11	
2	Store in Upper Blue Lakes - original right	1	35927.00001	*.rer	
3	Release from Upper Blue Lakes to Con-Hoosier Tunnel Demand	1	35927.00002	3	
4	Release from Upper Blue Lakes to Con-Hoosier Tunnel Demand	2	35927.00003	3	
5	Divert at Roberts Tunnel - original right	NA	35927.00004	*.ddr	
6	Store in Dillon - modified original right	First 3	35927.00005	*.rer	
7	Exchange from Williams Fork to Roberts Tunnel	1	35927.00006	4	
8	Exchange from Williams Fork to Dillon	1	35927.00007	5	
9	Release from Dillon to Roberts Tunnel	1	35927.00008	2	
10	Release from Dillon to Roberts Tunnel	5	35927.00009	2	
11	Store in Green Mountain - 1955 Exchange Right	First 5	38628.00000	41	954683OOPPLN 363570OOPPLN 364684OOPPLN 364512OOPPLN
12	Store in Green Mountain - senior refill right	First 5	38628.00001	*.rer	
13	Store in Dillon - junior refill right	First 3	50038.49309	*.rer	
14	Store in Green Mountain - junior refill right	First 5	50403.49309	*.rer	
15	Store in Upper Blue Lakes – free river refill right	1	99999.99999	*.rer	

Rights 1 through 10 and 12 through 15 represent normal operations of diversions, storage, and exchanges in the Blue River Basin. Denver's operations (rights 5 through 10) were set junior to Colorado Spring's operations (rights 1 through 4) based on agreements between the two municipalities. Administration numbers were modified slightly to allow for the correct order of operation within each entity's system.

Operating rule 11 simulates Green Mountain Reservoir's 1955 Blue River Decree Exchange storage right. This operating rule allows Green Mountain to store, under a 1955 right, the amount of water that was diverted and stored out-of-priority to Green Mountain's senior first fill right by Denver and Colorado Springs. When water is stored under this right, it reduces the out-of-priority obligation owed by Denver and Colorado Springs proportional to their out-of-priority operations. This rule operates after the out-of-priority operations are complete which allows for a pro rata amount to be credited to each of the four out-of-priority plans. When the amount stored under this right equals out-of-priority operations by both cities, the right is satisfied.

August 1st Substitution Bill Repayment

Right #	Description	Account or Carrier	Admin #	Right Type	Plan Structure
1	Upper Blue lakes release 250 af to the river for West Slope use	1	1.00000	9	
2	Upper Blue lakes release 250 af to the river for West Slope use	2	1.00001	9	
3	Upper Blue release from OOP account to Dillon OOP account	2	1.00002	34	363570OOPPLN 364512OOPPLN
4	Upper Blue release from OOP account to Dillon OOP account	2	1.00003	34	954683OOPPLN 364512OOPPLN
5	Upper Blue release from OOP account to GM	2	1.00004	27	363570OOPPLN
6	Upper Blue release from OOP account to GM	2	1.00005	27	954683OOPPLN
7	Upper Blue release from C. Springs account to Dillon OOP account	1	1.00006	34	363570OOPPLN 364512OOPPLN
8	Upper Blue release from C. Springs account to Dillon OOP account	1	1.00007	34	954683OOPPLN 364512OOPPLN
9	Upper Blue release from C. Springs account to GM	1	1.00008	27	363570OOPPLN
10	Upper Blue release from C. Springs account to GM	1	1.00009	27	954683OOPPLN
11	Wolford transfer C. Springs account to C. Springs R account	7 to 9	1.00010	34	954683OOPPLN
12	Wolford transfer C. Springs account to C. Springs R account	7 to 9	1.00011	34	363570OOPPLN
13	Homestake transfer C. Springs & Aurora account to HR GMR account	1 to 3	1.00012	34	954683OOPPLN
14	Homestake transfer C. Springs & Aurora account to HR GMR account	1 to 3	1.00013	34	363570OOPPLN
15	Wolford transfer 250 af from West Slope account to Book-over account	1 to 8	1.00014	6	
16	Upper Blue transfer from OOP account to C. Springs account	2	1.00015	6	
17	Dillon transfer from OOP account to 1000 af account	5 to 4	1.00016	34	364512OOPPLN
18	Wolford transfer from Denver account to Denver R1 account	2 to 5	1.00017	34	364684OOPPLN
19	Wolford transfer from Denver account to Denver R1 account	2 to 5	1.00018	34	364512OOPPLN

20	William Fork transfer from Denver account to WF GMR1 account	2 to 5	1.00019	34	364684OOPPLN
21	William Fork transfer from Denver account to WF GMR1 account	2 to 5	1.00020	34	364512OOPPLN
22	Wolford transfer from Denver account to Denver R2 account	2 to 6	1.00021	34	364684OOPPLN
23	Wolford transfer from Denver account to Denver R2 account	2 to 6	1.00022	34	364512OOPPLN
24	William Fork transfer from Denver account to WF GMR2 account	2 to 6	1.00023	34	364684OOPPLN
25	William Fork transfer from Denver account to WF GMR2 account	2 to 6	1.00024	34	364512OOPPLN
26	Dillon release from OOP account to Green Mountain	5	1.00025	27	364684OOPPLN
27	Dillon release from OOP account to Green Mountain	5	1.00026	27	364512OOPPLN
28	Dillon release from Denver account to Green Mountain	1	1.00027	27	364684OOPPLN
29	Dillon release from Denver account to Green Mountain	1	1.00028	27	364512OOPPLN
30	Dillon transfer remaining OOP water to Denver account	5 to 1	1.00029	6	
31	Wolford transfer Book-over account to C. Springs account	8 to 7	999999.9998	6	
32	Wolford transfer remaining Book-over account to West Slope account	8 to 1	999999.9999	6	

Operating rules 1, 2, 11, 12, 15, 16, 31, and 32 were incorporated in the model based on a May 15, 2003, *Memorandum of Agreement Regarding Colorado Springs Substitution Operations*. This agreement outlines the use of a 1,750 acre-feet pool in Wolford Mountain Reservoir, the transfer of 250 acre-feet per year from the West Slope pool to Colorado Spring's pool in Wolford Reservoir, and 250 acre-feet per year available in Upper Blue Lakes to West Slope users in the Blue River Basin. The agreement also outlines the use of the 1,750 acre-feet pool in Wolford Mountain Reservoir as an alternate replacement source to Green Mountain Reservoir operations. The 1,750 acre-feet account is used to replace out-of-priority operations by Colorado Springs in the Blue River Basin. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 13 and 14 transfer water from Colorado Spring's account to the Green Mountain Replacement account in Homestake Reservoir. At the time of this model update, Colorado Springs was in the process of obtaining a decree for alternate replacement sources to Green Mountain Reservoir. These rules are off in the Historic, Calculated, and Baseline simulations.

Operating rules 3 through 10 release water from the Upper Blue Reservoir to either Dillon or Green Mountain reservoirs to replace remaining out-of-priority obligations on August 1st. Releases to Dillon reservoir decrease Colorado Springs' out-of-priority obligation while increasing Denver's out-of-priority obligation. Releases to Green Mountain Reservoir reduce Colorado Springs' out-of-priority obligation. These operating rules are tied to either the out-of-priority diversion plan (954683OOPPLN) or to the out-of-priority storage plan (363570OOPPLN) for accounting of replacements. These rules are on in the Historic, Calculated, and Baseline simulations.

Operating rules 17 through 30 represent Denver's out-of-priority obligation replacement operations. Denver has the ability to repay out-of-priority obligations from three reservoirs - Dillon, Wolford Mountain, and Williams Fork. Wolford Mountain Reservoir and Williams Fork Reservoir each have two accounts to which Denver can transfer water for replacement. These accounts, and the order in which they are used, were established based on Denver's operations at the time of this model update. These rules are on in the Historic, Calculated, and Baseline simulations.

Replacement Reservoir Operations

Green Mountain Reservoir demands are met from alternate replacement accounts throughout the basin. In substitution years, when Denver and Colorado Springs make water available in reservoirs other than Green Mountain, releases are made from the alternate replacement accounts before Green Mountain Reservoir. As noted previously, Homestake Reservoir operations are included but turned off. The USBR provided the current release order from the different accounts in the basin as follows:

Release Order	Reservoir	Account
1	Wolford Mountain	Denver R1
2	Williams Fork	WF GMR1
3	Wolford Mountain	C. Springs R
4	Wolford Mountain	Denver R2
5	Williams Fork	WF GMR2
6	Homestake	HR GMR
7	Green Mountain	First 4 accounts

One hundred thirty nine operating rules are used to model Green Mountain Reservoir operations at the alternate replacement reservoirs. Some of Green Mountain Reservoir's operations are limited to specific time periods in the Historic simulation that do not overlap with the operational periods of some of the replacement reservoirs. For these cases (i.e. Shoshone Call Flows pre-1985 and Wolford Mountain Reservoir) operating rules were not developed for the replacement reservoir's account(s). See Section 5.9.2 for details on Green Mountain Reservoir release operations.

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
1	Granby Reservoir	5	31258.00005	5	Wolford Mountain
2	Granby Reservoir	4	31258.00006	5	Williams Fork
3	Granby Reservoir	9	31258.00007	5	Wolford Mountain
4	Granby Reservoir	6	31258.00008	5	Wolford Mountain
5	Granby Reservoir	5	31258.00009	5	Williams Fork
6	Granby Reservoir	3	31258.00010	5	Homestake
7	Granby Reservoir	2	31258.00011	5	Green Mountain
8	Willow Creek Reservoir	5	31258.00012	5	Wolford Mountain
9	Willow Creek Reservoir	4	31258.00013	5	Williams Fork

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
10	Willow Creek Reservoir	9	31258.00014	5	Wolford Mountain
11	Willow Creek Reservoir	6	31258.00015	5	Wolford Mountain
12	Willow Creek Reservoir	5	31258.00016	5	Williams Fork
13	Willow Creek Reservoir	3	31258.00017	5	Homestake
14	Willow Creek Reservoir	2	31258.00018	5	Green Mountain
15	Shadow Mountain/Grand Lake	5	31258.00019	5	Wolford Mountain
16	Shadow Mountain/Grand Lake	4	31258.00020	5	Williams Fork
17	Shadow Mountain/Grand Lake	9	31258.00021	5	Wolford Mountain
18	Shadow Mountain/Grand Lake	6	31258.00022	5	Wolford Mountain
19	Shadow Mountain/Grand Lake	5	31258.00023	5	Williams Fork
20	Shadow Mountain/Grand Lake	3	31258.00024	5	Homestake
21	Shadow Mountain/Grand Lake	2	31258.00025	5	Green Mountain
22	Granby Reservoir	5, Willow Creek Feeder	31258.00026	7	Wolford Mountain
23	Granby Reservoir	4, Willow Creek Feeder	31258.00027	7	Williams Fork
24	Granby Reservoir	9, Willow Creek Feeder	31258.00028	7	Wolford Mountain
25	Granby Reservoir	6, Willow Creek Feeder	31258.00029	7	Wolford Mountain
26	Granby Reservoir	5, Willow Creek Feeder	31258.00030	7	Williams Fork
27	Granby Reservoir	3, Willow Creek Feeder	31258.00031	7	Homestake
28	Granby Reservoir	2, Willow Creek Feeder	31258.00032	7	Green Mountain
29	Farmers Irrigation Company	5, Silt Pump Canal	39041.00001	2	Wolford Mountain
30	Farmers Irrigation Company	4, Silt Pump Canal	39041.00002	2	Williams Fork
31	Farmers Irrigation Company	9, Silt Pump Canal	39041.00003	2	Wolford Mountain
32	Farmers Irrigation Company	6, Silt Pump Canal	39041.00004	2	Wolford Mountain
33	Farmers Irrigation Company	5, Silt Pump Canal	39041.00005	2	Williams Fork
34	Farmers Irrigation Company	3, Silt Pump Canal	39041.00006	2	Homestake
35	Farmers Irrigation Company	4, Silt Pump Canal	39041.00007	2	Green Mountain
36	Vail Valley Consolidated	5	42420.41367	4	Wolford Mountain
37	Vail Valley Consolidated	4	42420.41368	4	Williams Fork
38	Vail Valley Consolidated	9	42420.41369	4	Wolford Mountain
39	Vail Valley Consolidated	6	42420.41370	4	Wolford Mountain
40	Vail Valley Consolidated	5	42420.41371	4	Williams Fork
41	Vail Valley Consolidated	3	42420.41372	4	Homestake
42	Vail Valley Consolidated	3	42420.41373	4	Green Mountain
43	Historic Users	5	46673.99994	10	Wolford Mountain

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
44	Government Highline	5, Grand Valley Project	46673.99994	2	Wolford Mountain
45	OMID Irrigation	5, Grand Valley Project	46673.99994	2	Wolford Mountain
46	OMID Pump	5, Grand Valley Project	46673.99994	2	Wolford Mountain
47	Historic Users	4	46673.99995	10	Williams Fork
48	Government Highline	4, Grand Valley Project	46673.99995	2	Williams Fork
49	OMID Irrigation	4, Grand Valley Project	46673.99995	2	Williams Fork
50	OMID Pump	4, Grand Valley Project	46673.99995	2	Williams Fork
51	Historic Users	9	46673.99996	10	Wolford Mountain
52	Government Highline	9, Grand Valley Project	46673.99996	2	Wolford Mountain
53	OMID Irrigation	9, Grand Valley Project	46673.99996	2	Wolford Mountain
54	OMID Pump	9, Grand Valley Project	46673.99996	2	Wolford Mountain
55	Historic Users	6	46673.99997	10	Wolford Mountain
56	Government Highline	6, Grand Valley Project	46673.99997	2	Wolford Mountain
57	OMID Irrigation	6, Grand Valley Project	46673.99997	2	Wolford Mountain
58	OMID Pump	6, Grand Valley Project	46673.99997	2	Wolford Mountain
59	Historic Users	5	46673.99998	10	Williams Fork
60	Government Highline	5, Grand Valley Project	46673.99998	2	Williams Fork
61	OMID Irrigation	5, Grand Valley Project	46673.99998	2	Williams Fork
62	OMID Pump	5, Grand Valley Project	46673.99998	2	Williams Fork
63	Historic Users	3	46673.99999	10	Homestake
64	Government Highline	3, Grand Valley Project	46673.99999	2	Homestake
65	OMID Irrigation	3, Grand Valley Project	46673.99999	2	Homestake
66	OMID Pump	3, Grand Valley Project	46673.99999	2	Homestake
67	Historic Users	1	46674.00000	10	Green Mountain
68	Government Highline	1, Grand Valley Project	46674.00000	2	Green Mountain
69	OMID Irrigation	1, Grand Valley Project	46674.00000	2	Green Mountain
70	OMID Pump	1, Grand Valley Project	46674.00000	2	Green Mountain
71	Needham Ditch	5	46751.42642	4	Wolford Mountain
72	Needham Ditch	4	46751.42643	4	Williams Fork
73	Needham Ditch	9	46751.42644	4	Wolford Mountain
74	Needham Ditch	6	46751.42645	4	Wolford Mountain
75	Needham Ditch	5	46751.42646	4	Williams Fork
76	Needham Ditch	3	46751.42647	4	Homestake
77	Needham Ditch	3	46751.42648	4	Green Mountain

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
78	Coon Creek Pipeline	5	46995.00001	4	Wolford Mountain
79	Coon Creek Pipeline	4	46995.00002	4	Williams Fork
80	Coon Creek Pipeline	9	46995.00003	4	Wolford Mountain
81	Coon Creek Pipeline	6	46995.00004	4	Wolford Mountain
82	Coon Creek Pipeline	5	46995.00005	4	Williams Fork
83	Coon Creek Pipeline	3	46995.00006	4	Homestake
84	Coon Creek Pipeline	3	46995.00007	4	Green Mountain
85	Derby Diversion System	5	47481.12656	4	Wolford Mountain
86	Derby Diversion System	4	47481.12657	4	Williams Fork
87	Derby Diversion System	9	47481.12658	4	Wolford Mountain
88	Derby Diversion System	6	47481.12659	4	Wolford Mountain
89	Derby Diversion System	5	47481.12660	4	Williams Fork
90	Derby Diversion System	3	47481.12661	4	Homestake
91	Derby Diversion System	3	47481.12662	4	Green Mountain
92	Historic Users	5	48965.99994	10	Wolford Mountain
93	Government Highline	5, Grand Valley Project	48965.99994	2	Wolford Mountain
94	OMID Irrigation	5, Grand Valley Project	48965.99994	2	Wolford Mountain
95	OMID Pump	5, Grand Valley Project	48965.99994	2	Wolford Mountain
96	Historic Users	4	48965.99995	10	Williams Fork
97	Government Highline	4, Grand Valley Project	48965.99995	2	Williams Fork
98	OMID Irrigation	4, Grand Valley Project	48965.99995	2	Williams Fork
99	OMID Pump	4, Grand Valley Project	48965.99995	2	Williams Fork
100	Historic Users	9	48965.99996	10	Wolford Mountain
101	Government Highline	9, Grand Valley Project	48965.99996	2	Wolford Mountain
102	OMID Irrigation	9, Grand Valley Project	48965.99996	2	Wolford Mountain
103	OMID Pump	9, Grand Valley Project	48965.99996	2	Wolford Mountain
104	Historic Users	6	48965.99997	10	Wolford Mountain
105	Government Highline	6, Grand Valley Project	48965.99997	2	Wolford Mountain
106	OMID Irrigation	6, Grand Valley Project	48965.99997	2	Wolford Mountain
107	OMID Pump	6, Grand Valley Project	48965.99997	2	Wolford Mountain
108	Historic Users	5	48965.99998	10	Williams Fork
109	Government Highline	5, Grand Valley Project	48965.99998	2	Williams Fork
110	OMID Irrigation	5, Grand Valley Project	48965.99998	2	Williams Fork
111	OMID Pump	5, Grand Valley Project	48965.99998	2	Williams Fork

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
112	Historic Users	1	48966.00000	10	Green Mountain
113	Government Highline	1, Grand Valley Project	48966.00000	2	Green Mountain
114	OMID Irrigation	1, Grand Valley Project	48966.00000	2	Green Mountain
115	OMID Pump	1, Grand Valley Project	48966.00000	2	Green Mountain
116	Green Mountain Contract Demand	5	48966.00001	4	Wolford Mountain
117	Green Mountain Contract Demand	4	48966.00002	4	Williams Fork
118	Green Mountain Contract Demand	9	48966.00003	4	Wolford Mountain
119	Green Mountain Contract Demand	6	48966.00004	4	Wolford Mountain
120	Green Mountain Contract Demand	5	48966.00005	4	Williams Fork
121	Green Mountain Contract Demand	3	48966.00006	4	Homestake
122	Green Mountain Contract Demand	3	48966.00007	2	Green Mountain
123	Atkinson Ditch	5	49308.48661	4	Wolford Mountain
124	Atkinson Ditch	4	49308.48662	4	Williams Fork
125	Atkinson Ditch	9	49308.48663	4	Wolford Mountain
126	Atkinson Ditch	6	49308.48664	4	Wolford Mountain
127	Atkinson Ditch	5	49308.48665	4	Williams Fork
128	Atkinson Ditch	3	49308.48666	4	Homestake
129	Atkinson Ditch	3	49308.48667	4	Green Mountain
130	Shoshone Call Flows	4	99999.89998	1	Williams Fork
131	Shoshone Call Flows	5	99999.89999	1	Williams Fork
132	Shoshone Call Flows	1	99999.90000	1	Green Mountain
133	Fish Instream Flow	5	99999.93005	1	Wolford Mountain
134	Fish Instream Flow	4	99999.93006	1	Williams Fork
135	Fish Instream Flow	9	99999.93007	1	Wolford Mountain
136	Fish Instream Flow	6	99999.93008	1	Wolford Mountain
137	Fish Instream Flow	5	99999.93009	1	Williams Fork
138	Fish Instream Flow	3	99999.93010	1	Homestake
139	Fish Instream Flow	1	99999.93011	1	Green Mountain

End of Year (March) Remaining Replacement Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
1	Green Mountain Reservoir	4	99999.00000	2	Dillon
2	Excess HUP Release	4	100000.00000	2	Dillon
3	Excess HUP Release	5	100000.00000	2	Wolford Mountain
4	Excess HUP Release	9	100000.00000	2	Wolford Mountain
5	Excess HUP Release	6	100000.00000	2	Wolford Mountain
6	Excess HUP Release	4	100000.00000	2	Williams Fork
7	Excess HUP Release	5	100000.00000	2	Williams Fork
8	Excess HUP Release	3	100000.00000	2	Homestake

Operating rules 1 through 8 release unused replacement water from alternate reservoir accounts based on USBR and Denver reservoir operations. Water owed to Green Mountain Reservoir due to out-of-priority operations is replaced within the same administration year and is not carried over in alternate replacement reservoirs. These rules are on in the Historic, Calculated, and Baseline simulations.

End of Year (March 31st) Remaining Obligation Operations

Right #	Description	Account or Carrier	Admin #	Right Type	Plan Structure
1	Continental-Hoosier Plan Accounting Reset	NA	99999.99999	42	954683OOPPLN
2	Upper Blue Lakes Plan Accounting Reset	NA	99999.99999	42	363570OOPPLN
3	Roberts Tunnel Plan Accounting Reset	NA	99999.99999	42	364684OOPPLN
4	Dillon Reservoir Plan Accounting Reset	NA	99999.99999	42	364512OOPPLN

Operating rules 1 through 4 are used to reset accounting of out-of-priority operations every administration year. These rules are used to simplify the review of the plan accounting and to highlight years when the out-of-priority storage is not replaced. These rules are on in the Historic, Calculated, and Baseline simulations.

5.9.19 15-Mile Reach Endangered Fish Flow Operations

The reach of the Upper Colorado River between the headgate of the Grand Valley Irrigation Canal (GVIC) and the confluence of the Upper Colorado River and the Gunnison River is often referred to as the 15-Mile Reach. This reach is considered a critical flow reach for the protection of endangered fish species because the river can be physically dried up at the GVIC headgate. The USFWS recommended flows for the months of July through October are 1630 cfs, 1240 cfs, and 810 cfs under wet, average, and dry hydrologic conditions. In 1997, the Recovery Implementation Program – Recovery Action Plan (RIPRAP) was developed and set aside storage within the Upper Colorado River Basin to be released to the 15-Mile Reach during times of low flows. Weekly phone conferences are held from July through October to determine the quantity and source of releases required to meet the fish demands. Although there is not a set sequence of reservoir releases, the USBR and CWCB provided the following general reservoir account and release order for modeling purposes.

Reservoir	Acct	Account Name	Capacity (acre-feet)
Ruedi	5	Unallocated / 5,000 acre-feet	5,000
Williams Fork	3	Temporary Fish	5,413
Wolford Mountain	4	Temporary Fish	5,413
Ruedi	4	CWCB Fish	10,825
HUP Surplus			
Wolford Mountain	5	Denver Replacement 1	5,000
Williams Fork	4	Green Mountain Replacement 1	10,000
Wolford Mountain	9	Colorado Springs Replacement	1,750
Wolford Mountain	6	Denver Replacement 2	20,610
Williams Fork	5	Green Mountain Replacement 2	25,000
Homestake	3	Homestake Reservoir Green Mountain Replacement	21,440
Green Mountain	1	Historic Users Pool	66,000
Ruedi	6	USFWS 5,000 acre-feet 4/5	5,000
Wolford Mountain	3	Fish Account	6,000

Operational releases from Green Mountain's HUP account for 15-Mile Reach instream flows are determined based on an Operating Criteria Curve. If HUP storage is above the curve band, releases can be made from the HUP account to the 15-Mile reach while ensuring the HUP recipients' demand can continue to be met. If storage is below the curve band, fish releases are not made. StateMod does not currently have a feature to model operating curves or end-of-month targets for individual reservoir accounts.

Beyond supplementing low flows in the late summer through RIPRAP, the Recovery Program also investigated enhancing peak flows through the Coordinated Reservoir Operations Study (CROS). This study recommended participating reservoirs bypass legally storable water during a ten day period to allow enhanced peak flows in the 15-Mile Reach. This ten day period is determined based on prediction of the peak runoff through a coordinated effort of the Water Division 5 Engineer, U.S. Fish and Wildlife Service, and the National Weather Service. CROS operations are not specifically modeled due to the dynamic time period and StateMod forecasting limitations.

Nineteen operating rules were used to represent the releases to the 15-Mile Reach.

15-Mile Reach Endangered Fish Flow Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
1	Fish Flow Diversion	4	99999.91001	2	Ruedi
2	Fish Flow Diversion	5	99999.91002	2	Ruedi
3	Fish Flow Diversion	6	99999.91003	2	Ruedi
4	Fish Instream Flow	5	99999.93001	1	Ruedi
5	Fish Instream Flow	3	99999.93002	1	Williams Fork
6	Fish Instream Flow	4	99999.93003	1	Wolford Mountain

Right #	Destination	Account or Carrier	Admin #	Right Type	Reservoir Water Released From
7	Fish Instream Flow	4	99999.93004	1	Ruedi
8	Fish Instream Flow	5	99999.93005	1	Wolford Mountain
9	Fish Instream Flow	4	99999.93006	1	Williams Fork
10	Fish Instream Flow	9	99999.93007	1	Wolford Mountain
11	Fish Instream Flow	6	99999.93008	1	Wolford Mountain
12	Fish Instream Flow	5	99999.93009	1	Williams Fork
13	Fish Instream Flow	3	99999.93010	1	Homestake
14	Fish Instream Flow	1	99999.93011	1	Green Mountain
15	Fish Instream Flow	6	99999.93012	1	Ruedi
16	Unallocated/5,000 acre-feet acct	6 to 5	99999.93013	6	Ruedi
17	Fish Instream Flow	3	99999.93014	1	Wolford Mountain
18	Temporary Fish Account	1 to 4	99999.95000	6	Wolford Mountain
19	Temporary Fish Account	1 to 3	99999.95000	6	Williams Fork

Operating rules 1 through 3 releases water from the CWCB Fish, Unallocated / 5,000 acre-feet, and USFWS 5,000 acre-feet 4/5 accounts in Ruedi Reservoir, respectively, to the Fish Flow diversion node. The administration numbers were set junior to the reservoir first fill right. These rights were created to model the pre-1997 fish releases that were made exclusively from Ruedi Reservoir. These rights are on in the Historic, Calculated, and Baseline simulations. The demand at the Fish Flow Diversion node determines when the rules operate because the direct diversion right is set to a rate of 0 cfs. Therefore, the demand is only satisfied by the releases from these rules. In the Historic and Calculated simulations demand is non-zero while in the Baseline simulation the demand is set to zero.

Operating rules 4 through 19 release water from the reservoir accounts to the Fish Instream Flow. The administration numbers were set junior to the reservoir’s first fill rights and set to mimic the general sequence of releases provided by the USBR and the CWCB. These rights were created to model the post-1997 fish releases. These rights are on in the Historic and Calculated simulations from 1997 on and on the entire study period in the Baseline simulation. They operate in the months of July through October.

6. Baseline Results

The “Baseline” data set simulates current demands, current infrastructure and projects, and the current administrative environment, as though they had been in place throughout the modeled period. This section summarizes the state of the river as the Upper Colorado River Model characterizes it, under these assumptions.

6.1 Baseline Streamflows

Table 6.1 shows the average annual flow from the Baseline simulation for each gage, based on a 1950 through 2005 simulation period. In general, this value is lower than the historical average, because demand has risen and the development of storage has re-timed the supply so that more of the demand can be met. The second value in the table is the average annual available flow, as identified by the model. Available flow at a point is water that is not needed to satisfy instream flows or downstream diversion demand; it represents the water that could be diverted by a new water right. The available flow is always less than the total simulated flow.

The Baseline data set, and corresponding results, does not include any consideration for Colorado River Compact obligations, nor are conditional water rights represented in the Baseline data set. Variations of the Baseline data set could include conditional rights within the Upper Colorado River basin, and would likely result in less available flow than presented here.

Temporal variability of the historical and Baseline simulated flows is illustrated in Figures 6.1 through 6.14 for selected gages. Each figure shows two graphs: overlain hydrographs of historical gage flow, simulated gage flow, and simulated available flow for 1975 through 2005; and an average annual hydrograph based on the longer 1950 through 2004 period. The annual hydrograph is a plot of monthly average flow values, for the three parameters. The gages selected for these figures have a fairly complete record between 1975 and 2005.

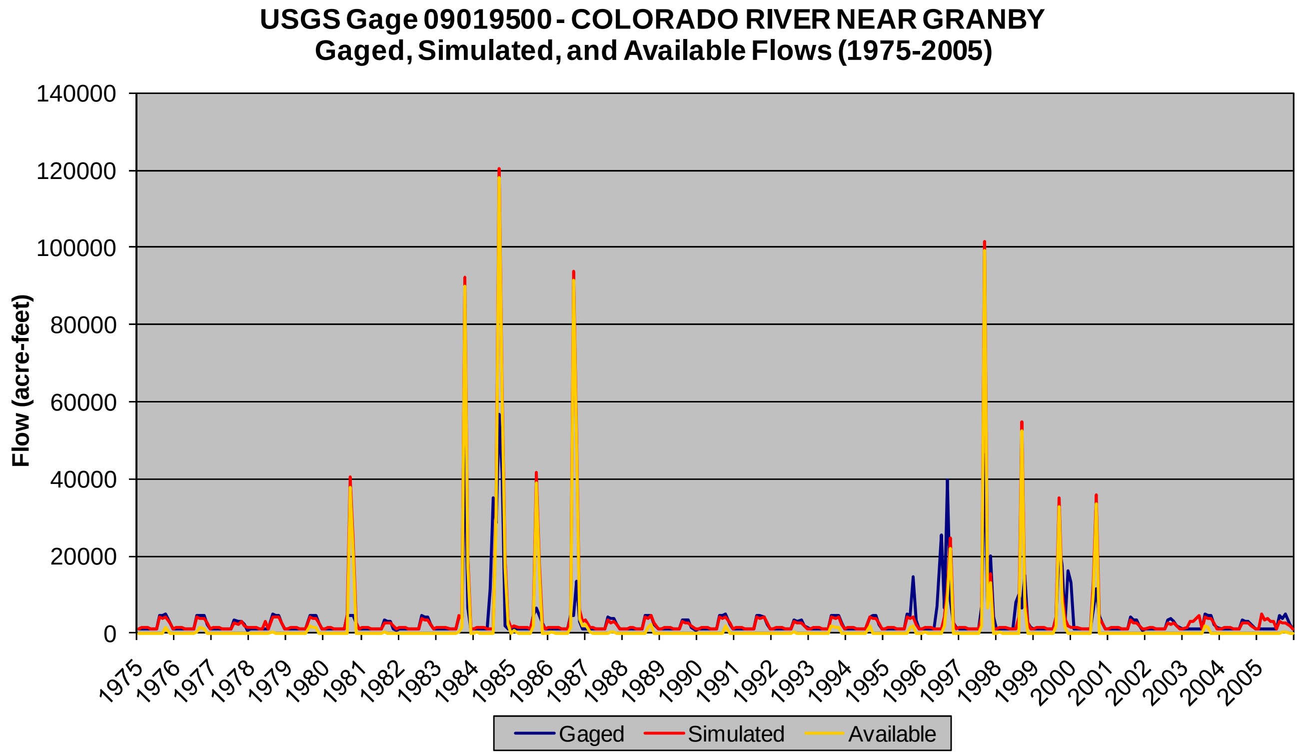
Baseline flows are generally higher than historical flows during the irrigation season on tributaries with significant storage and on tributary gages upstream of senior diverters. This is, in part, due to increased reservoir releases and bypassed flow required to meet the higher Baseline demands. In addition, many of the reservoirs included in the Upper Colorado River Model came on-line during the simulation period. Their ability to re-regulate natural flow and provide supplemental water during the late irrigation season is not represented in the historical gage record for much of the study period, therefore not fully represented in the 1950 through 2005 graphs. Additionally, many of the gages presented in the 1950 through 2005 graphs were not online for the entire study period historically; therefore their average gaged flow presented is not representative of their average simulated flows presented.

Table 6.1
Simulated and Available Baseline Average Annual Flows for Upper Colorado River Model Gages (1950-2005)

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
09010500	Colorado R Below Baker Gulch, Nr Grand Lake, CO.	45,196	7,750
09011000	Colorado River Near Grand Lake, CO.	51,329	9,480
09019500	Colorado River Near Granby	52,126	29,762
09021000	Willow Creek Below Willow Creek Reservoir	26,486	15,198
09024000	Fraser River At Winter Park	12,201	5,631
09025000	Vasquez Creek At Winter Park, CO.	11,217	6,509
09026500	St. Louis Creek Near Fraser, CO.	5,712	1,696
09032000	Ranch Creek Near Fraser, CO.	11,179	4,963
09032499	Meadow Creek Reservoir Inflow	8,398	2,191
09032500	Ranch Creek Near Tabernash, CO.	24,830	11,319
09033500	Strawberry Creek Near Granby, CO.	5,236	1,803
09034000	Fraser River at Granby	90,360	35,692
09034250	Colorado River At Windy Gap, Near Granby, CO.	149,253	73,730
09034500	Colorado River At Hot Sulphur Springs, CO.	153,072	82,635
09034800	Little Muddy Creek Near Parshall, CO.	2,447	572
09034900	Bobtail Creek Near Jones Pass, CO.	7,421	1,563
09035500	Williams Fork Below Steelman Creek, CO.	12,777	3,083
09036000	Williams Fork River Near Leal, Co	68,300	9,654
09037500	Williams Fork River Near Parshall, Co	72,731	10,312
09038500	Williams Fork River Below Williams Fork Reservoir	88,458	26,195
09039000	Troublesome Creek Near Pearmont, CO.	21,675	4,750
09040000	East Fork Troublesome C Near Troublesome, CO.	19,244	14,916
09041000	Muddy Creek Near Kremmling, CO.	40,049	19,839
09041200	Red Dirt Creek Near Kremmling, CO.	13,390	3,242
09041500	Muddy Creek At Kremmling, CO.	61,430	36,858
09046600	Blue River Near Dillon, CO.	67,233	24,890
09047500	Snake River Near Montezuma, CO.	45,010	19,664
09050100	Tenmile Creek Below North Tenmile Creek At Frisco	74,417	31,757
09050700	Blue River Below Dillon Reservoir	134,254	62,976

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
09052800	Slate Creek At Upper Station, Near Dillon, CO.	18,256	7,625
09053500	Blue River Above Green Mountain Reservoir, CO.	234,866	87,414
09054000	Black Creek Below Black Lake, Near Dillon, CO.	22,443	10,195
09055300	Cataract Creek Near Kremmling, CO.	13,917	5,299
09057500	Blue River Below Green Mountain Reservoir	283,690	103,422
09058000	Colorado River Near Kremmling	667,605	297,693
09060500	Rock Creek Near Toponas, CO.	24,022	15,687
09060700	Egeria Creek Near Toponas, CO.	8,494	1,188
09063000	Eagle River At Red Cliff, CO.	29,461	19,488
09064000	Homestake Creek At Gold Park, CO.	16,573	5,985
09065100	Cross Creek Near Minturn	36,921	30,260
09065500	Gore Creek At Upper Station, Near Minturn, CO.	21,438	16,809
09067300	Alkali Creek Near Wolcott, CO.	1,719	1,278
09068000	Brush Creek Near Eagle, CO.	31,944	16,388
09069500	Gypsum Creek Near Gypsum, CO.	23,564	8,145
09070000	Eagle River Below Gypsum	395,681	240,163
09070500	Colorado River Near Dotsero	1,391,006	530,855
09071300	Grizzly Creek Near Glenwood Springs, CO.	8,339	8,099
09072500	Colorado River At Glenwood Springs, CO.	1,498,662	1,101,750
09073400	Roaring Fork River Near Aspen	55,459	15,357
09074000	Hunter Creek Near Aspen	32,031	20,662
09074800	Castle Creek Above Aspen, CO.	30,110	19,530
09075700	Maroon Creek Above Aspen, CO.	46,877	30,496
09078600	Fryingpan River Near Thomasville	84,982	12,852
09080400	Fryingpan River Near Ruedi	109,938	39,349
09080800	West Sopris Creek Near Basalt, CO.	5,035	2,561
09081600	Crystal River Above Avalanche Creek Near Redstone	210,691	135,427
09082800	North Thompson Creek Near Carbondale, CO.	12,277	11,861
09084000	Cattle Creek Near Carbondale, CO.	11,576	898
09084600	Fourmile Creek Near Glenwood Springs, CO.	6,963	4,228
09085000	Roaring Fork River At Glenwood Springs	811,951	649,321
09085100	Colorado River Below Glenwood Springs	2,271,076	1,365,441

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
09085200	Canyon Creek Above New Castle, CO.	35,317	29,649
09087500	Elk Creek At New Castle, CO.	61,720	56,178
09088000	Baldy Creek Near New Castle	3,833	2,896
09089500	West Divide Creek Near Raven	25,074	9,665
09090700	East Divide Creek Near Silt, CO.	9,806	6,139
09091500	East Rifle Creek Near Rifle, CO.	26,712	4,162
09092500	Beaver Creek Near Rifle	3,403	1,067
09092600	Battlement Creek Near Parachute	5,733	1,774
09093000	Parachute Creek Near Parachute CO.	21,091	12,532
09093500	Parachute Creek At Parachute, CO.	21,477	20,242
09093700	Colorado River Near De Beque	2,458,109	1,405,252
09095000	Roan Creek Near De Beque, CO.	28,002	18,837
09095500	Colorado River Near Cameo	2,546,197	1,405,252
09096500	Plateau Creek Near Collbran, CO.	24,509	14,900
09097500	Buzzard Creek Near Collbran	34,114	30,528
09105000	Plateau Creek Near Cameo	130,538	108,323
09152500	Gunnison River Near Grand Junction	1,733,528	1,276,078
09163500	Colorado River Near Colorado-Utah State Line	4,235,824	4,235,824



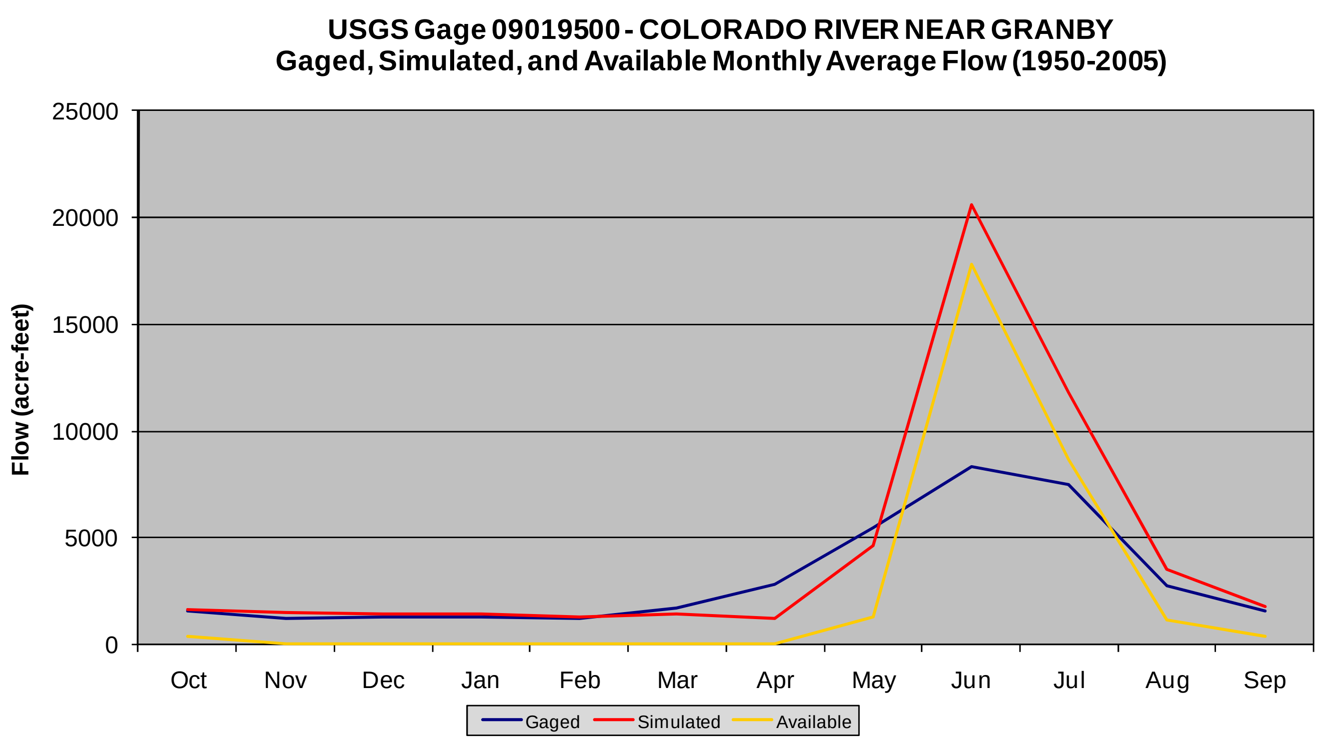
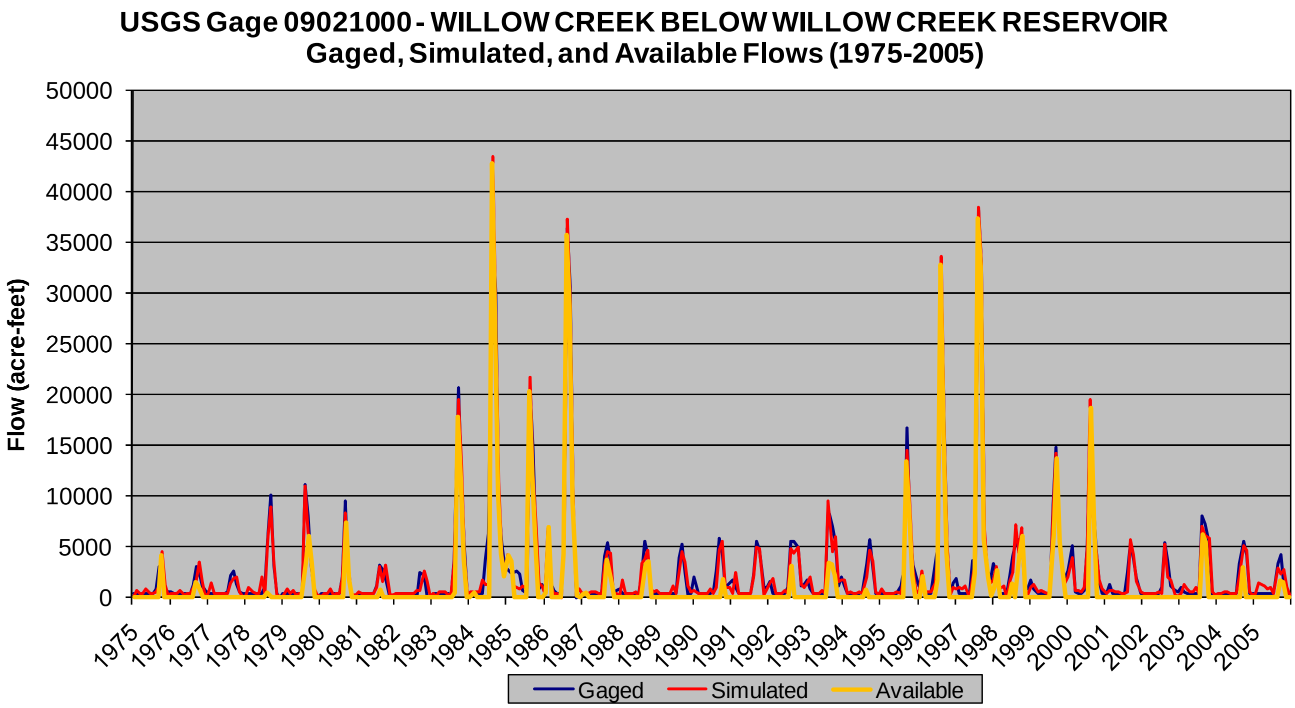


Figure 6.1 Baseline Results – Colorado River near Granby



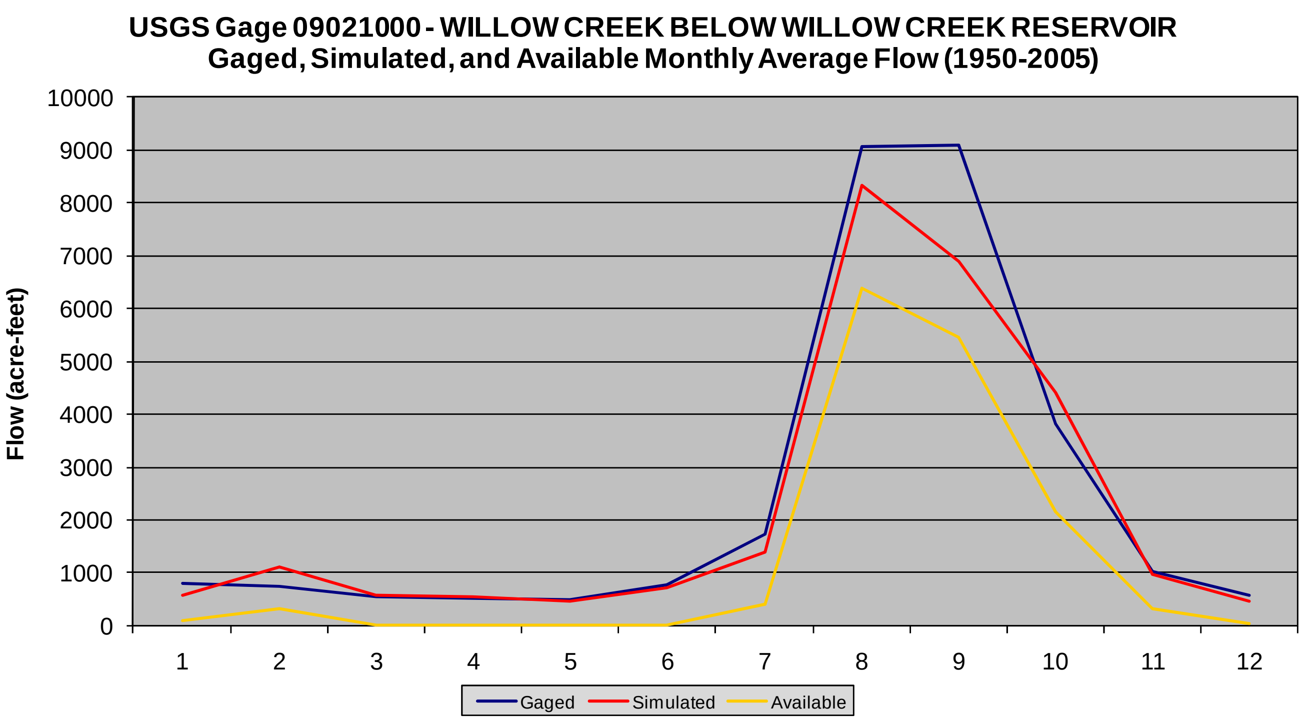
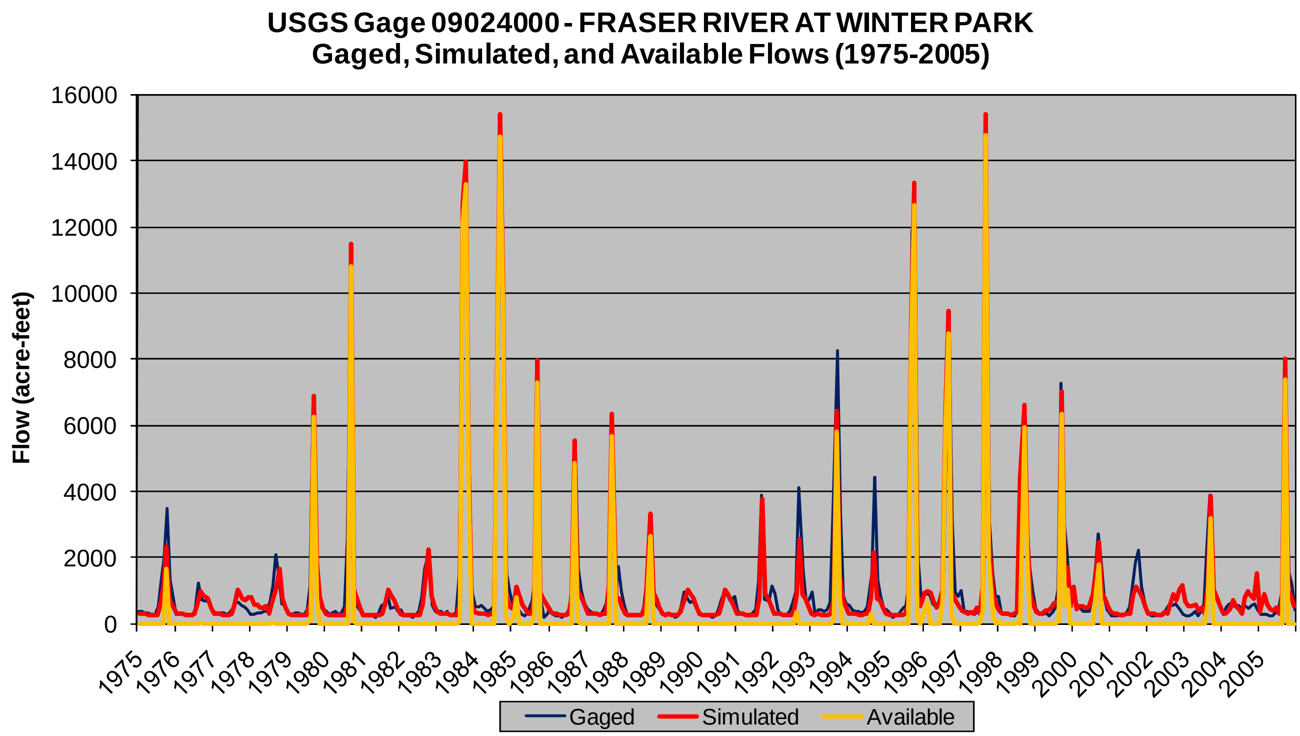


Figure 6.2 Baseline Results – Willow Creek below Willow Creek Reservoir



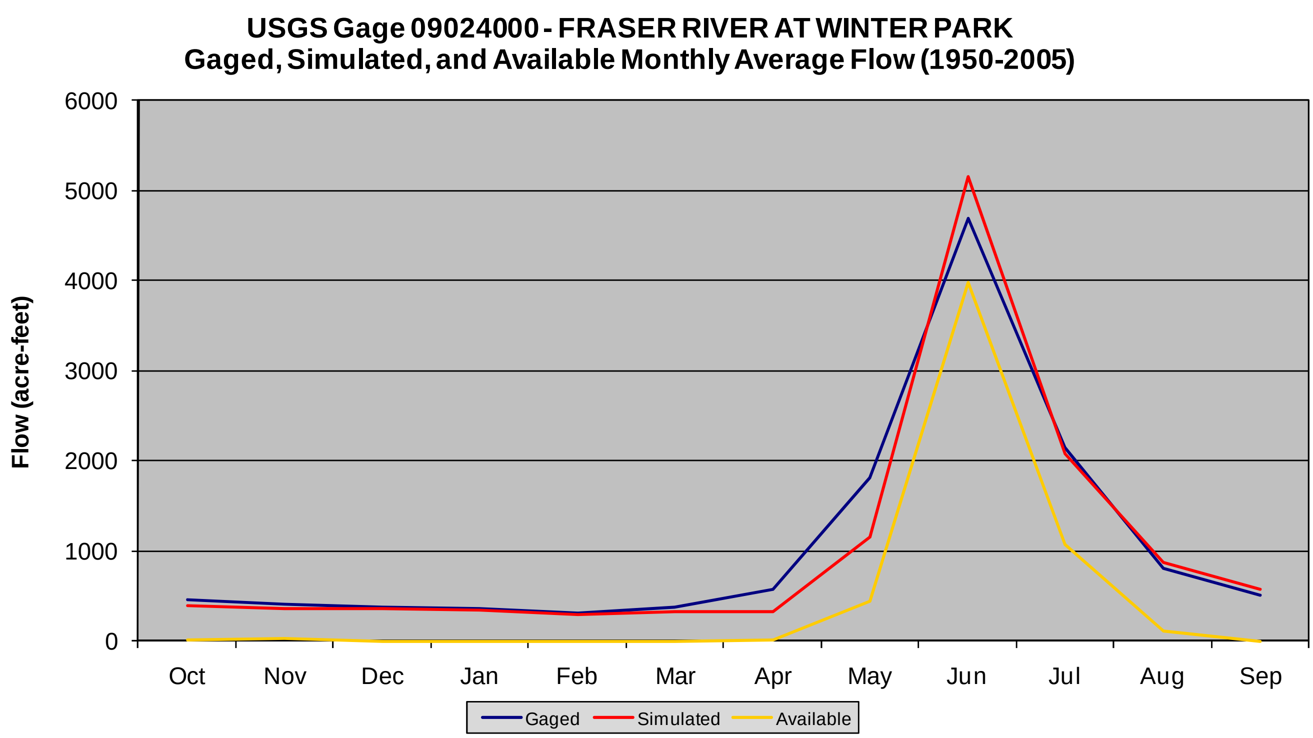
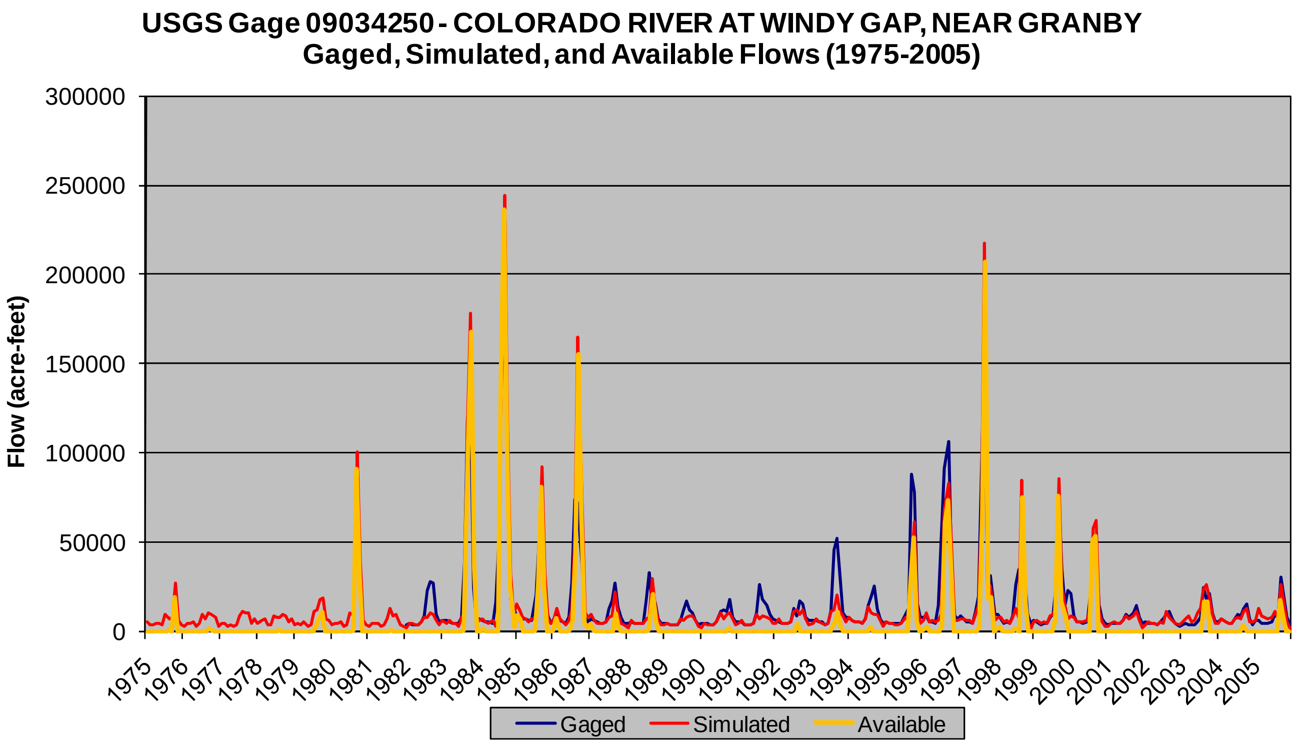


Figure 6.3 Baseline Results – Fraser River at Winter Park



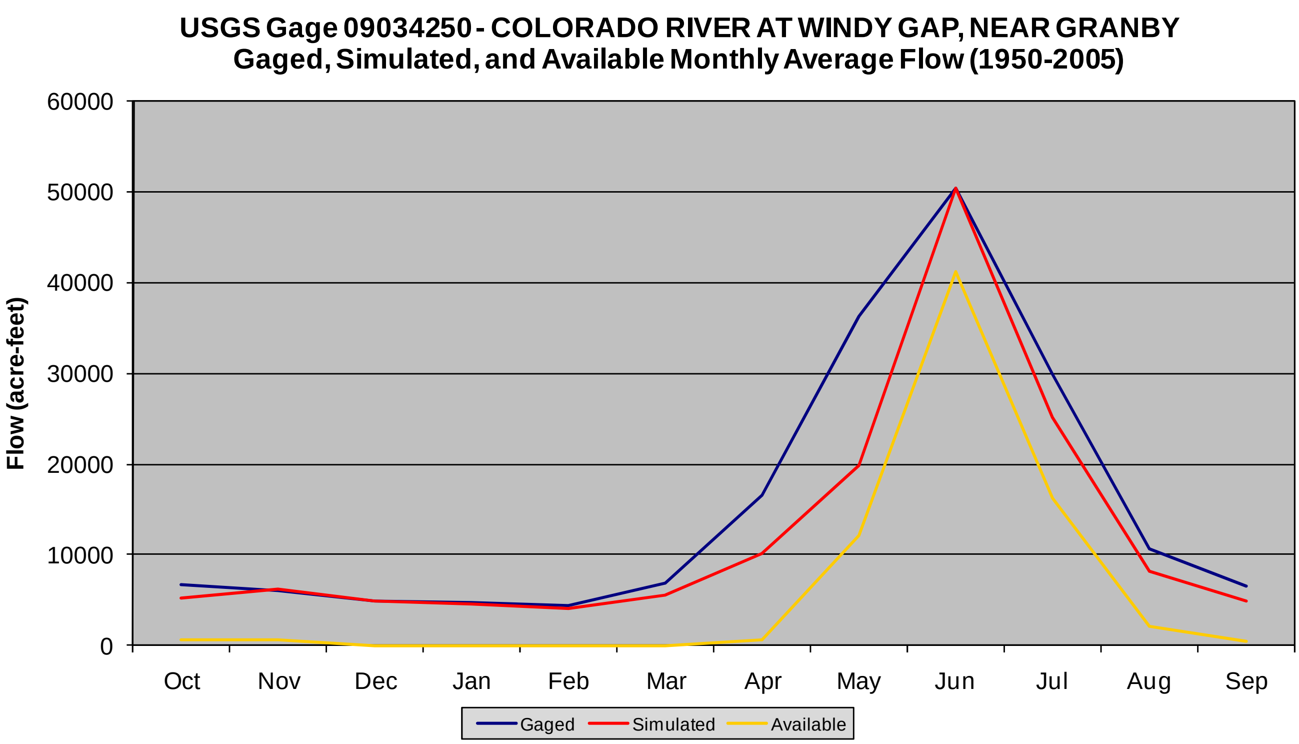
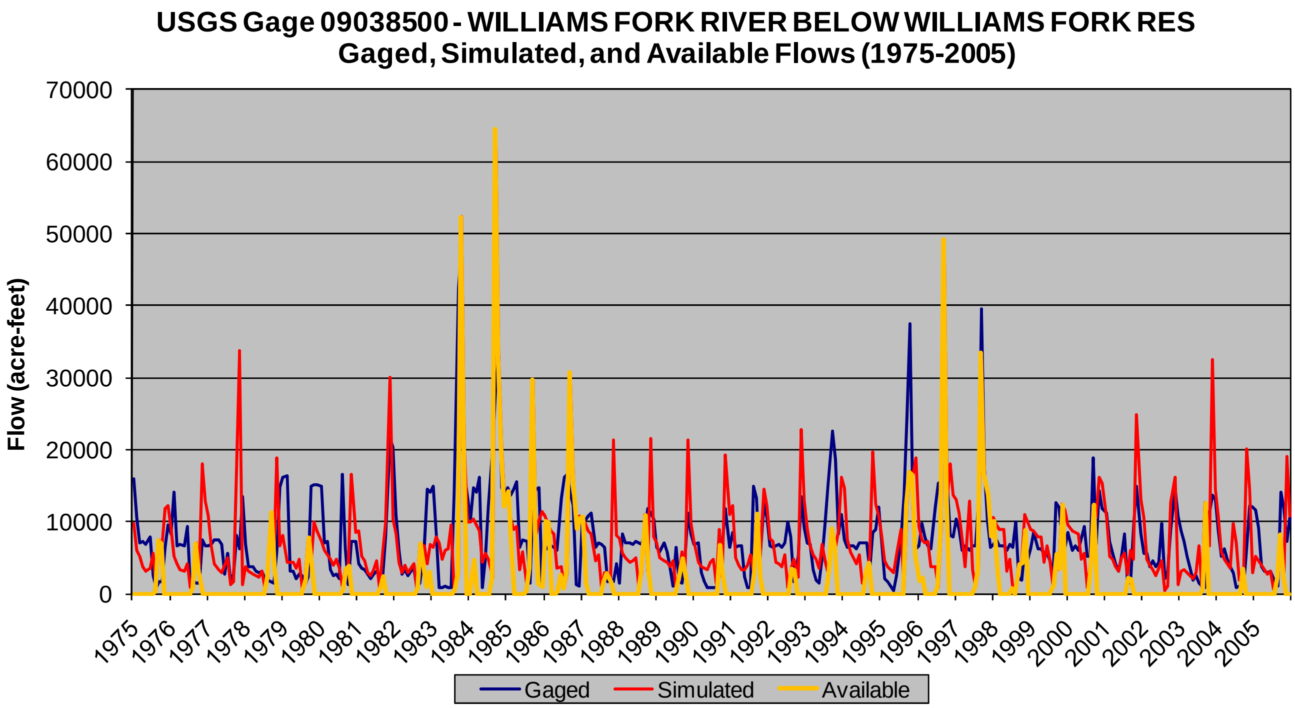


Figure 6.4 Baseline Results – Colorado River at Windy Gap, near Granby, CO



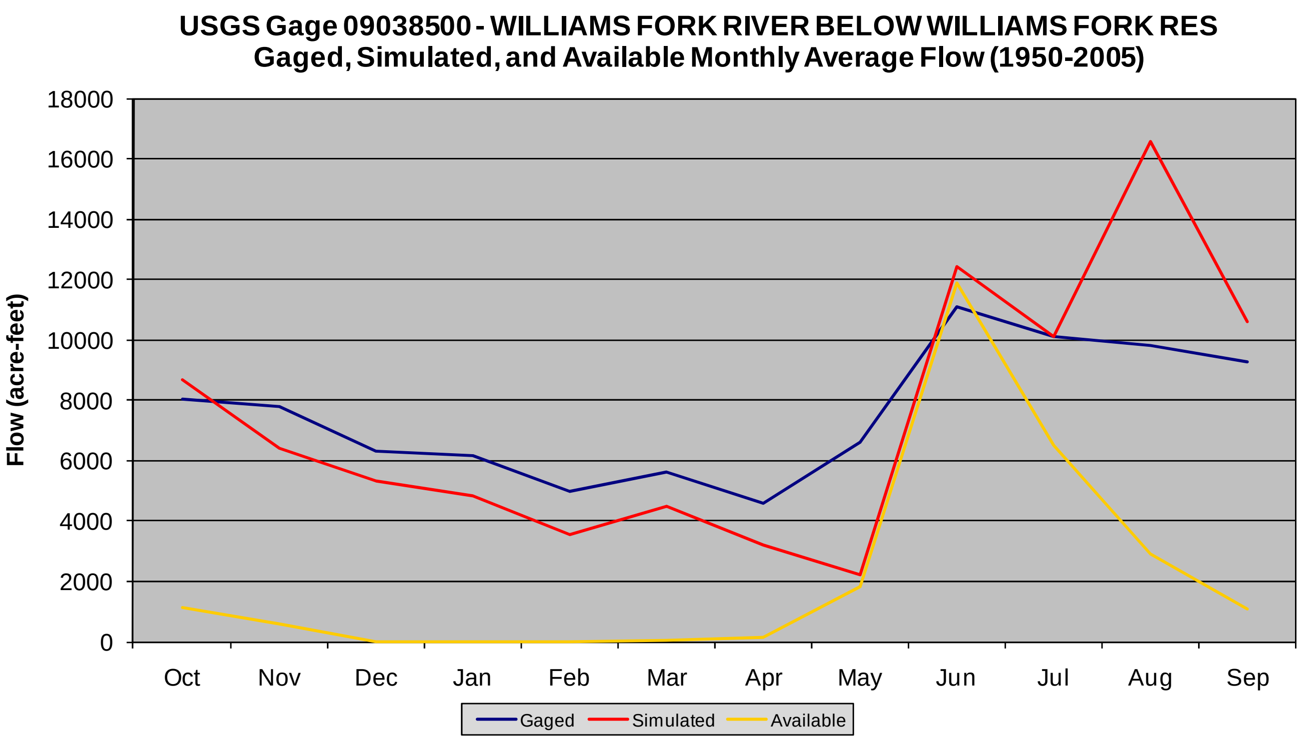
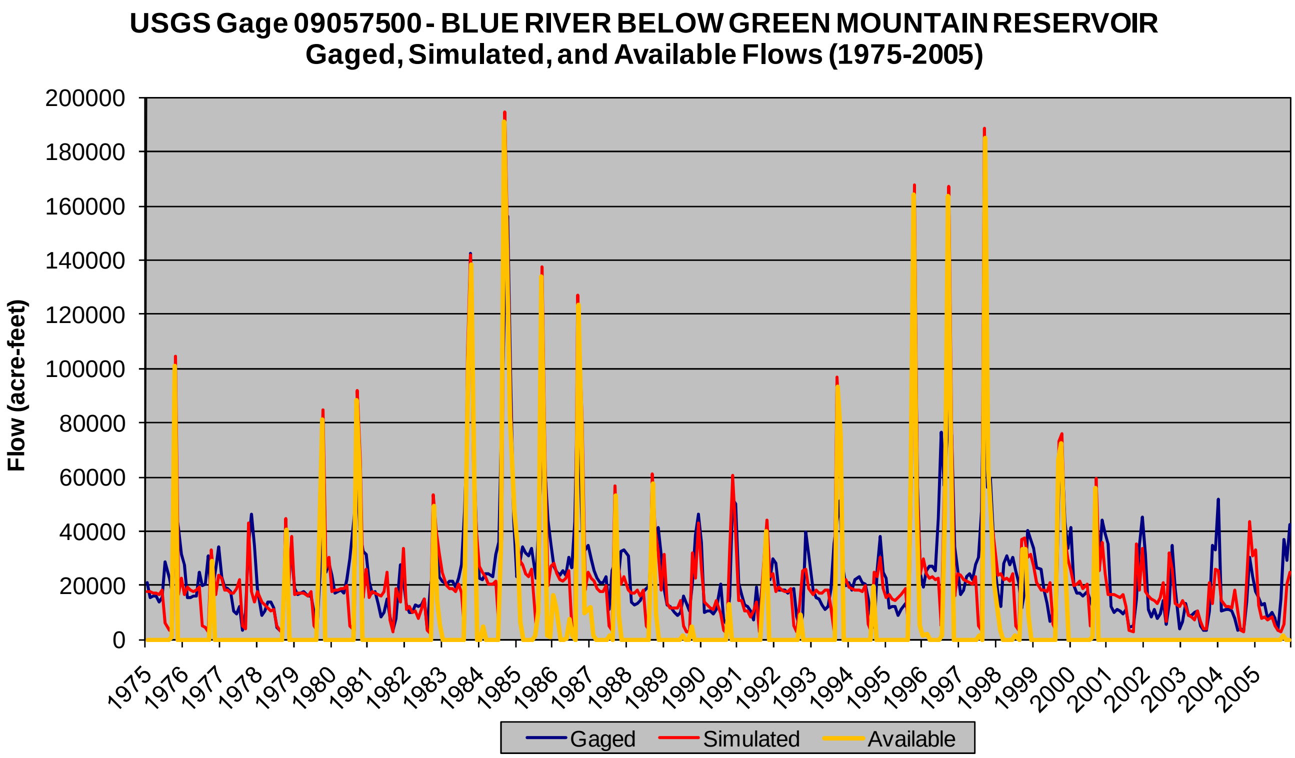


Figure 6.5 Baseline Results – Williams Fork River below Williams Fork Reservoir



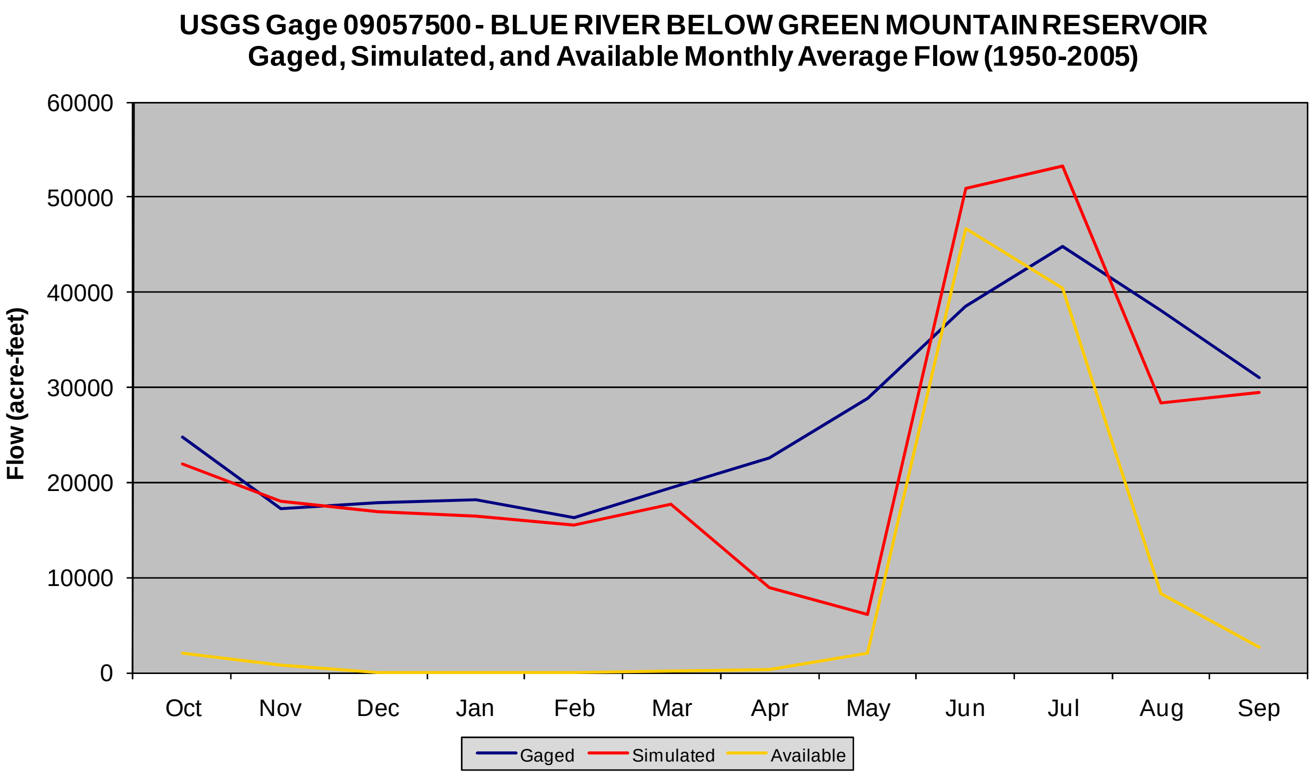
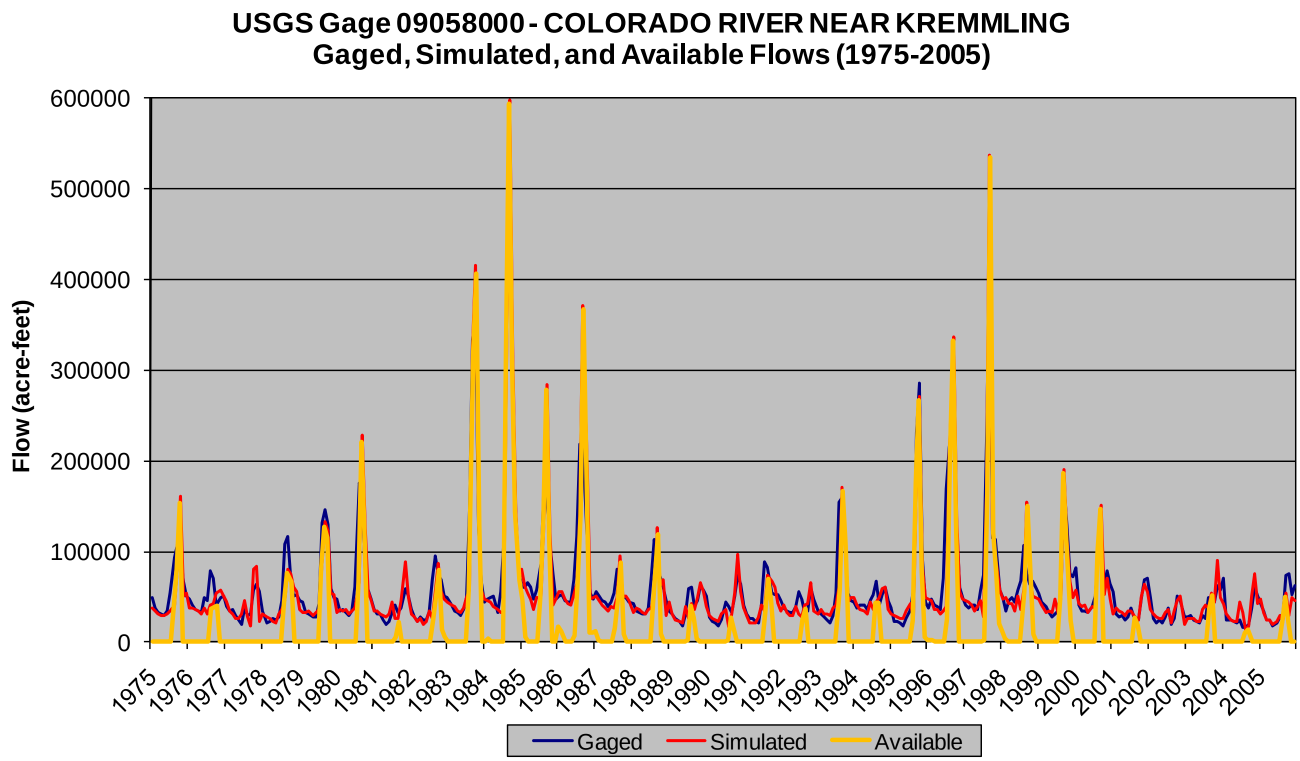


Figure 6.6 Baseline Results – Blue River below Green Mountain Reservoir



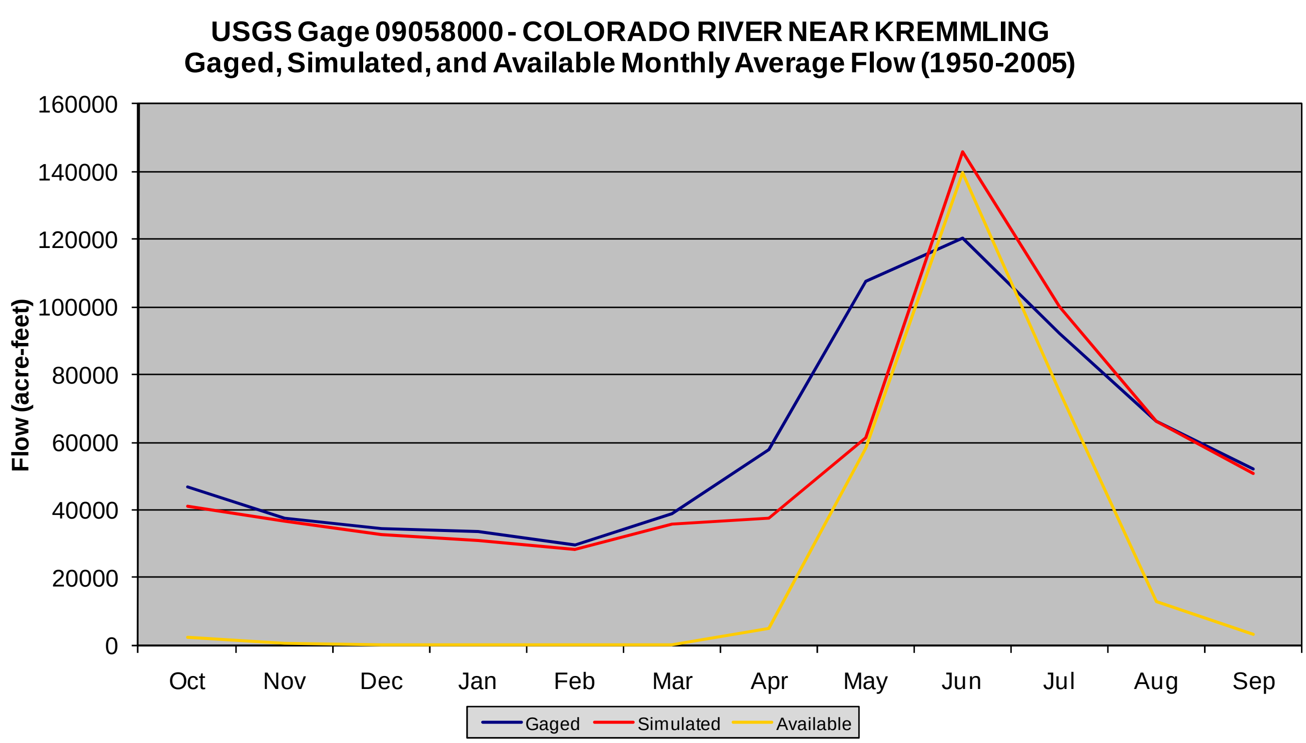
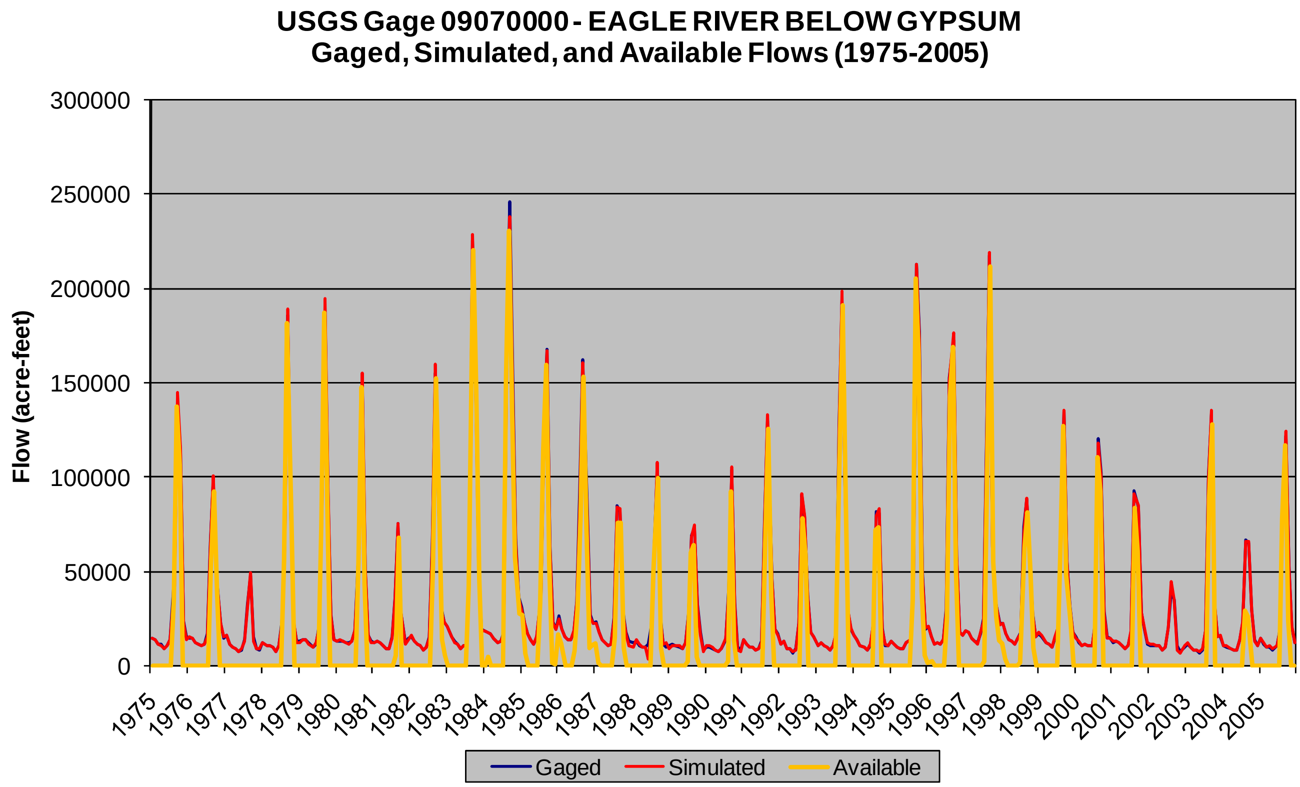


Figure 6.7 Baseline Results – Colorado River near Kremmling



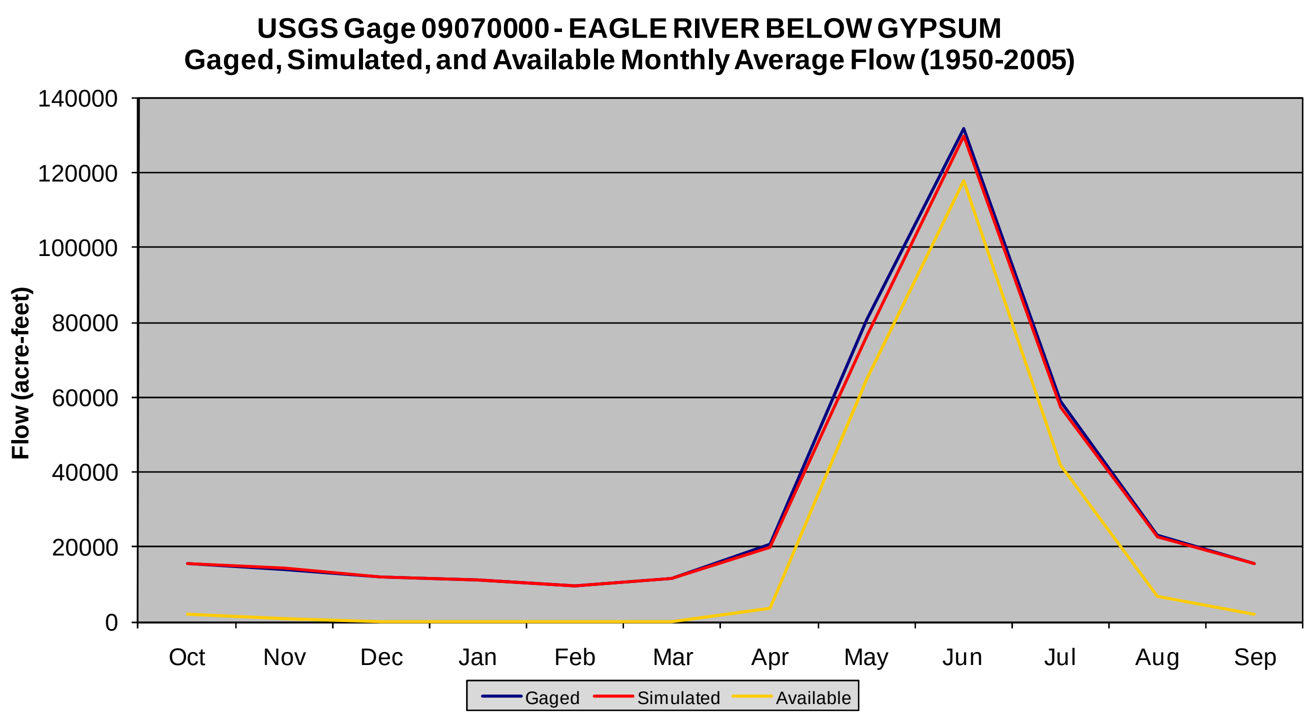
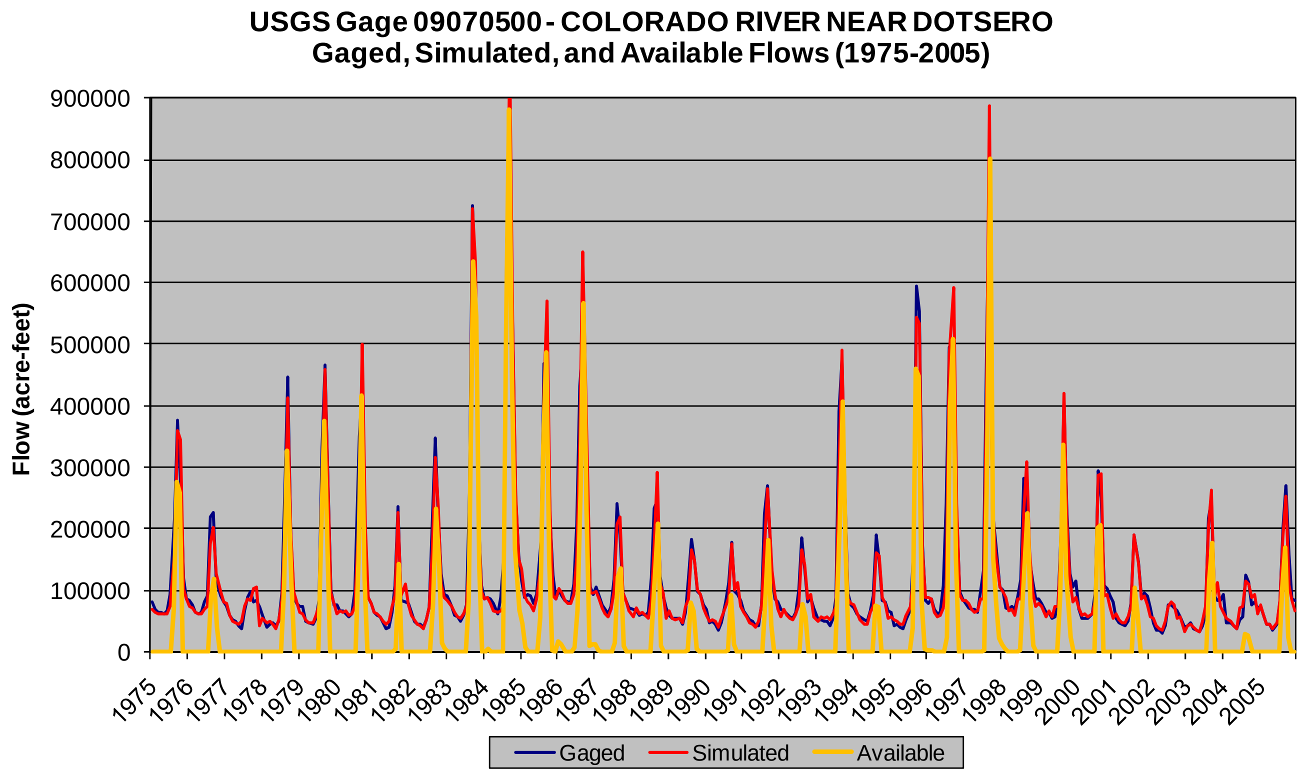


Figure 6.8 Baseline Results – Eagle River below Gypsum



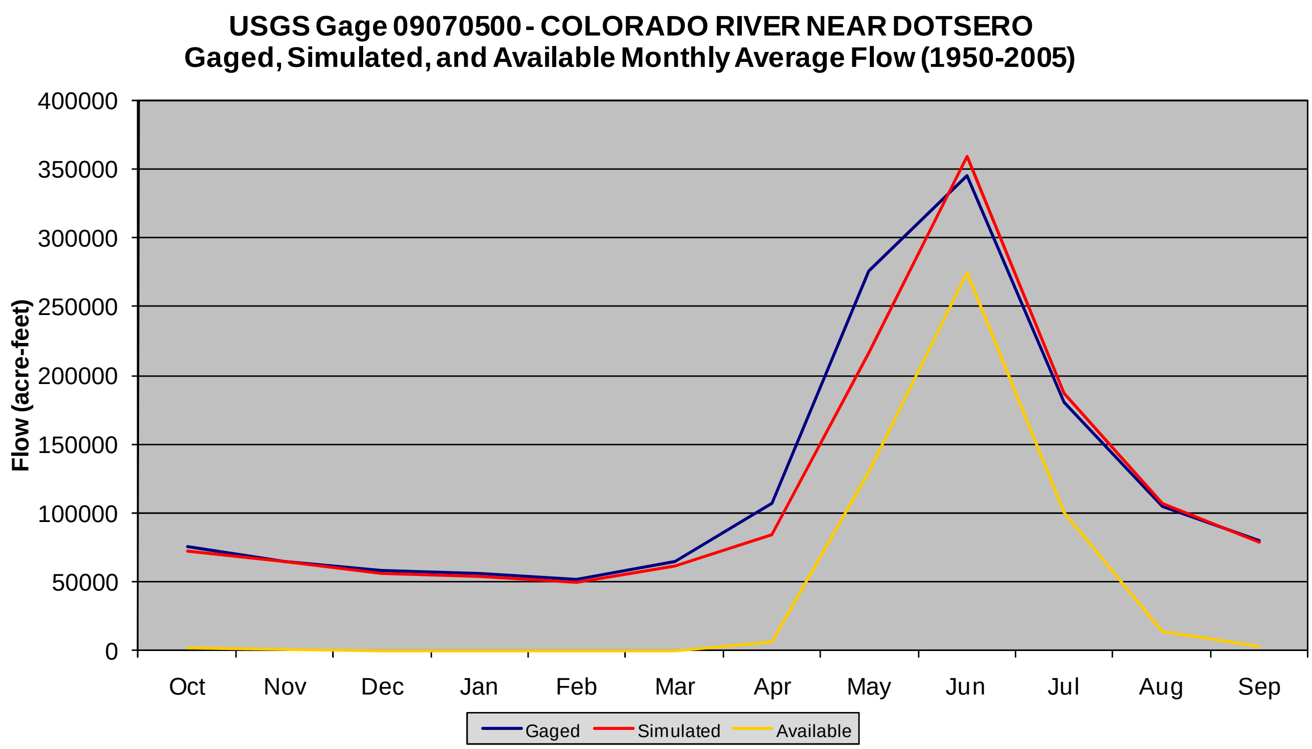
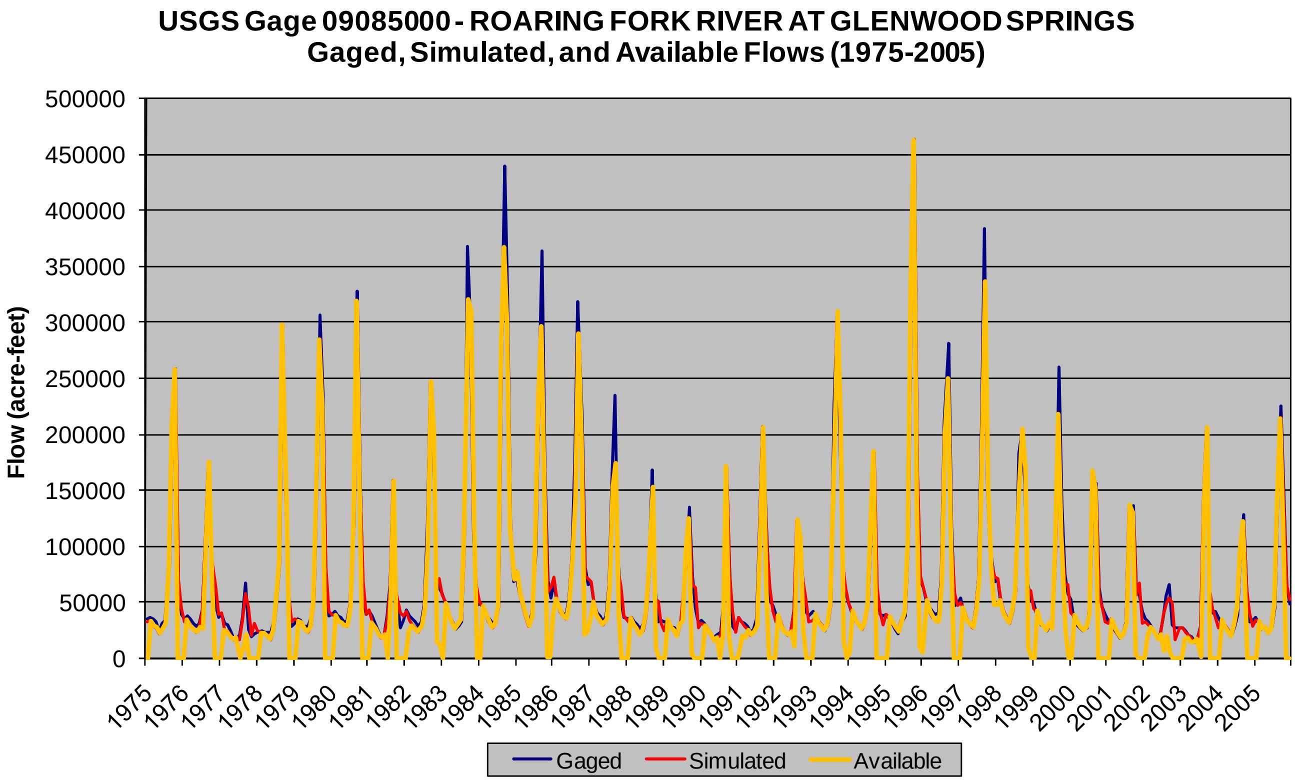


Figure 6.9 Baseline Results – Colorado River near Dotsero



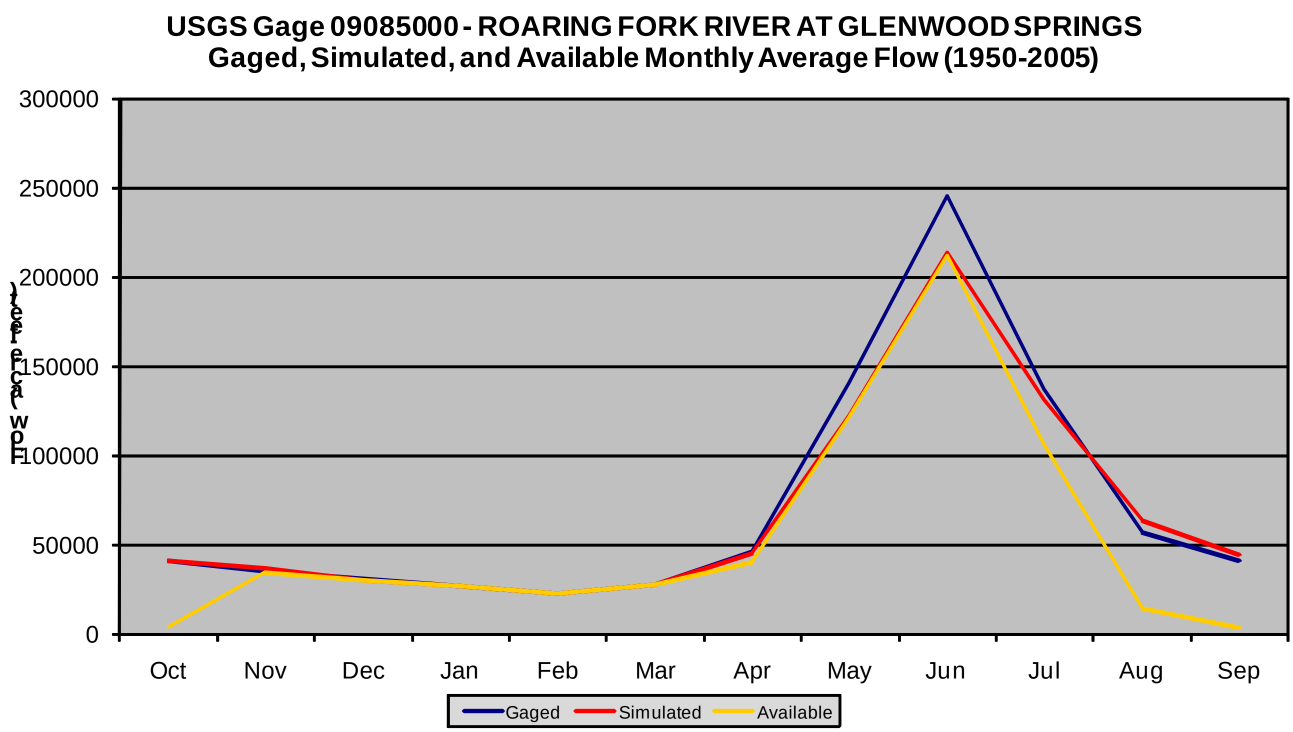
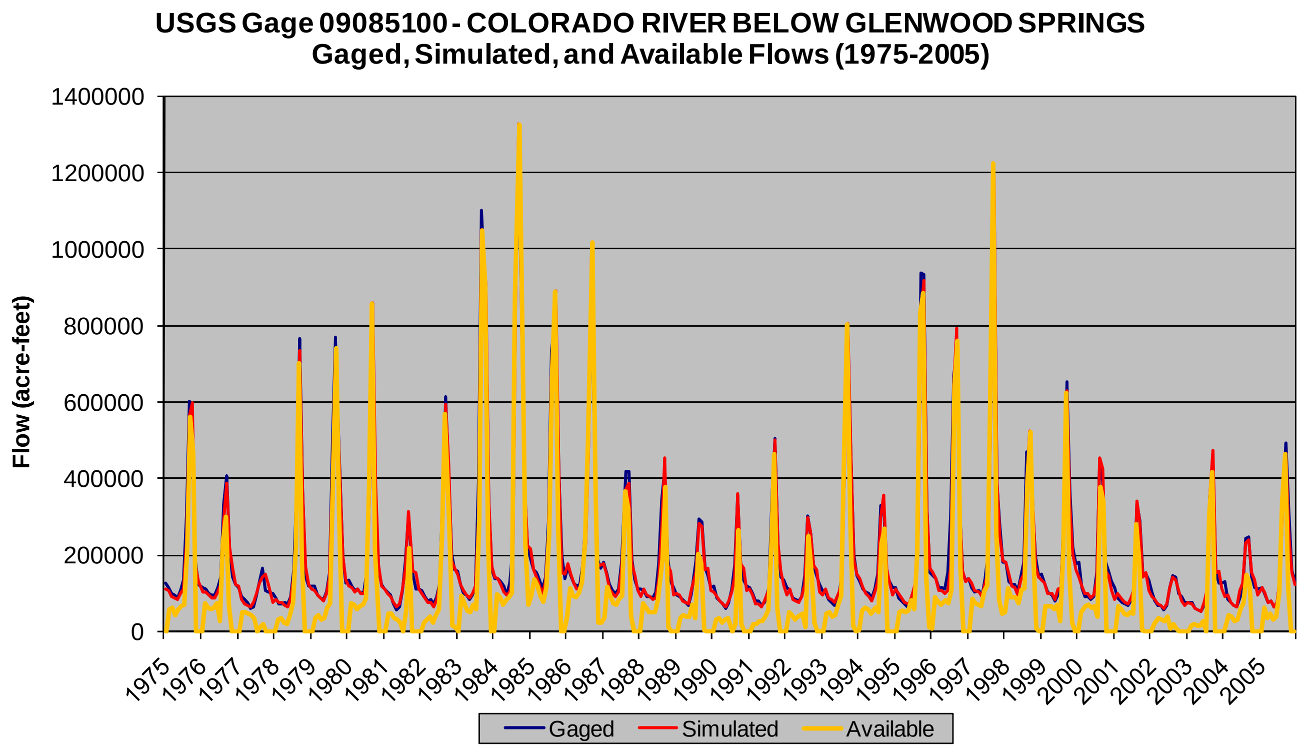


Figure 6.10 Baseline Results – Roaring Fork River at Glenwood Springs



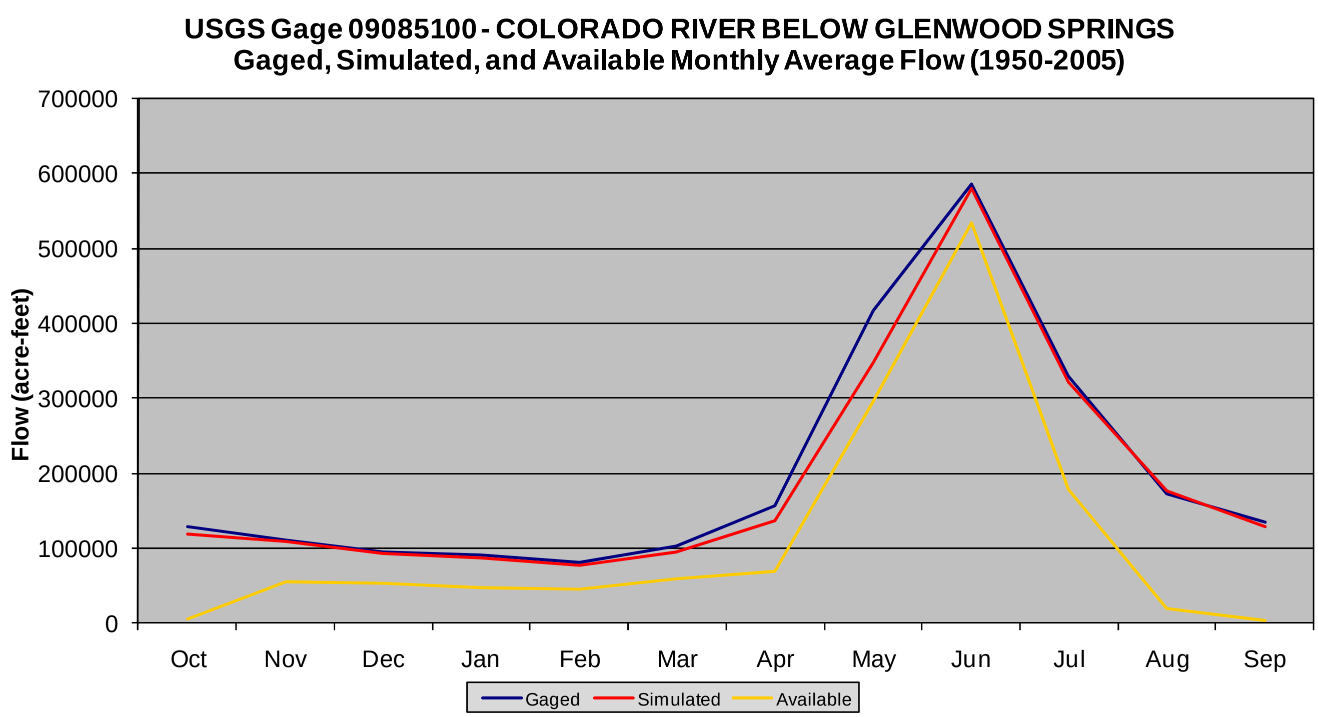
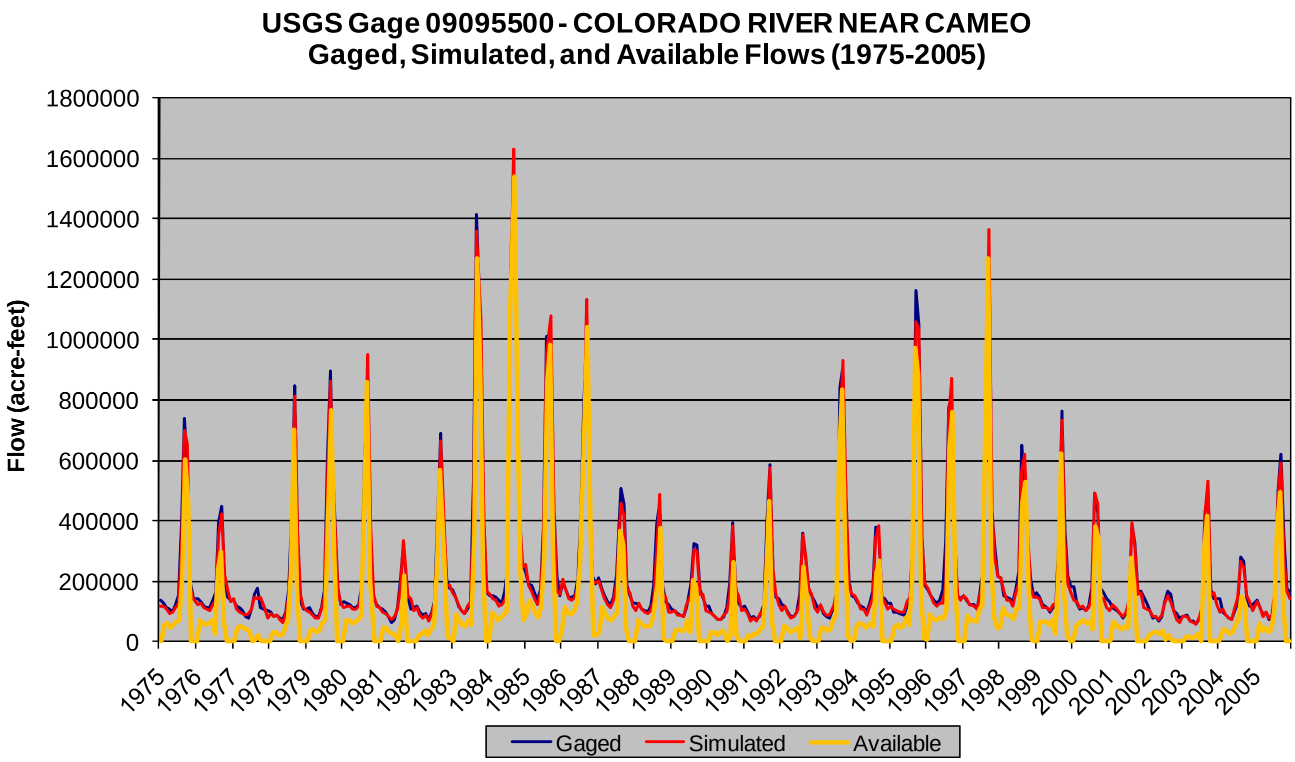


Figure 6.11 Baseline Results – Colorado River below Glenwood Springs



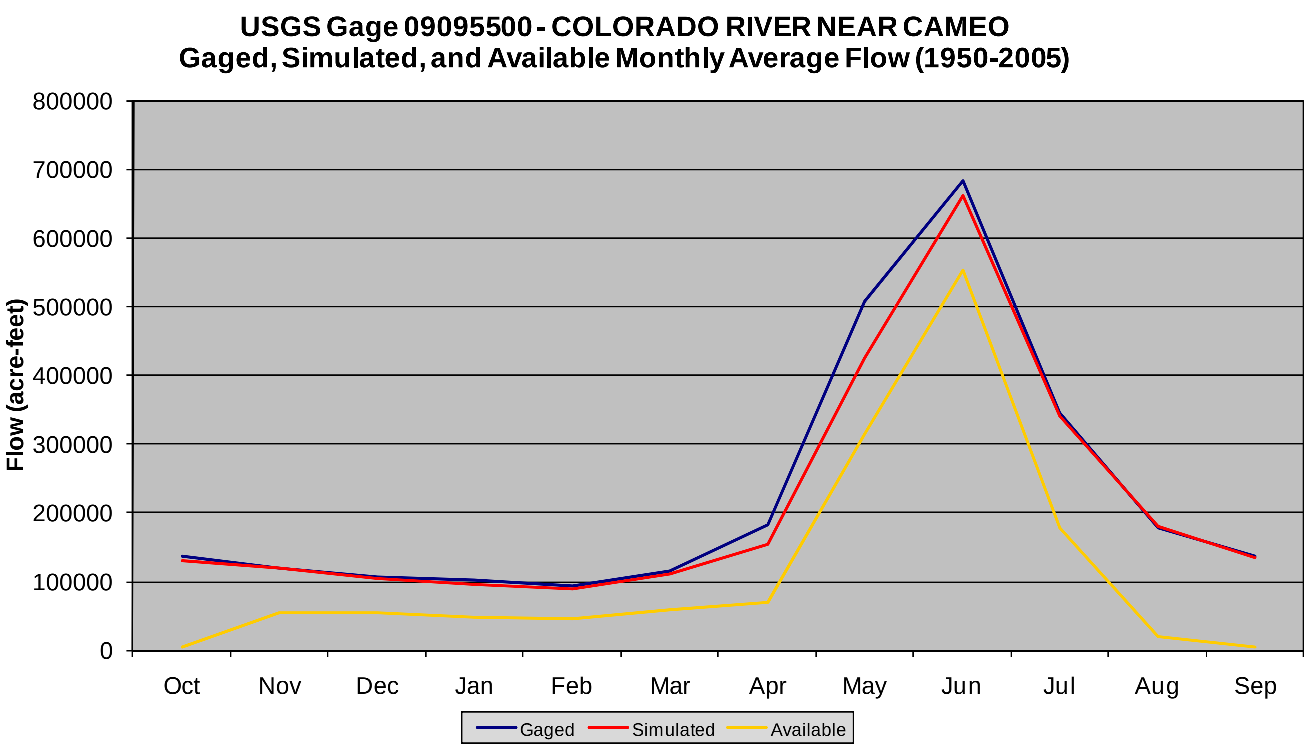
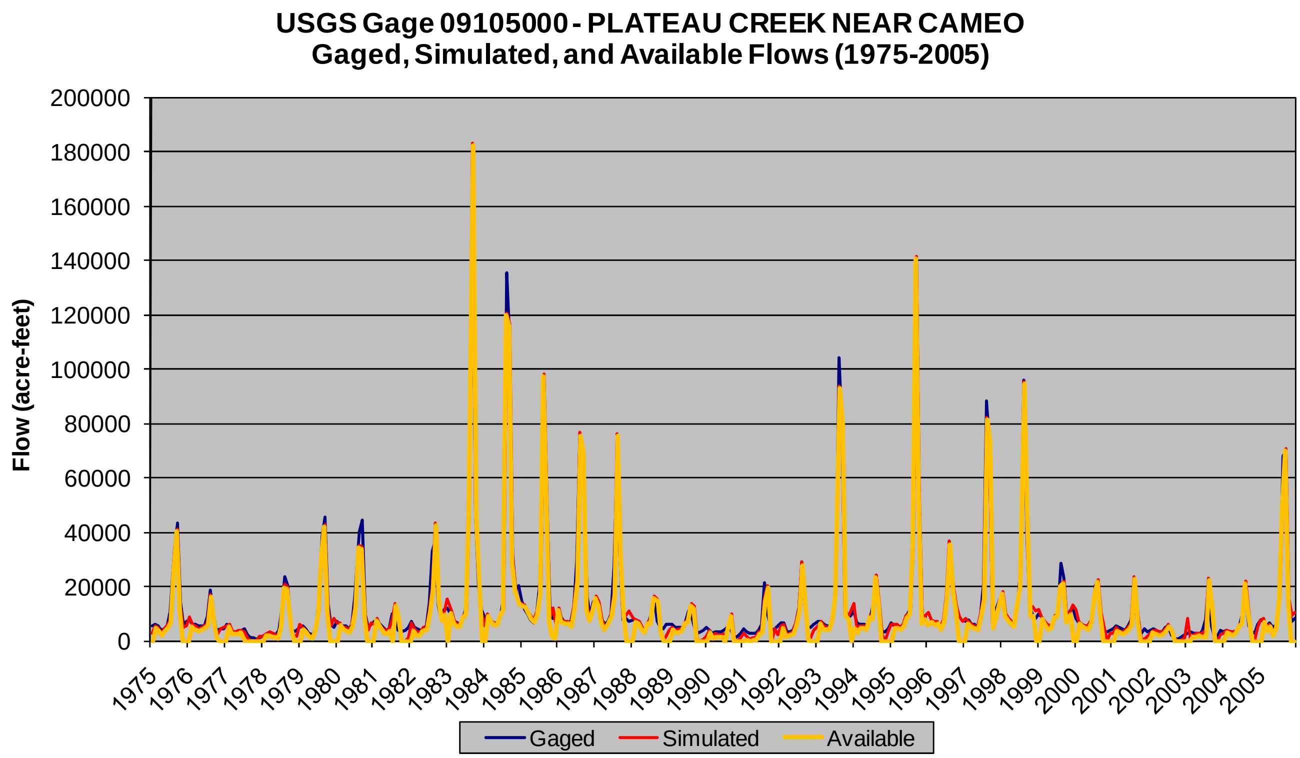


Figure 6.12 Baseline Results – Colorado River near Cameo



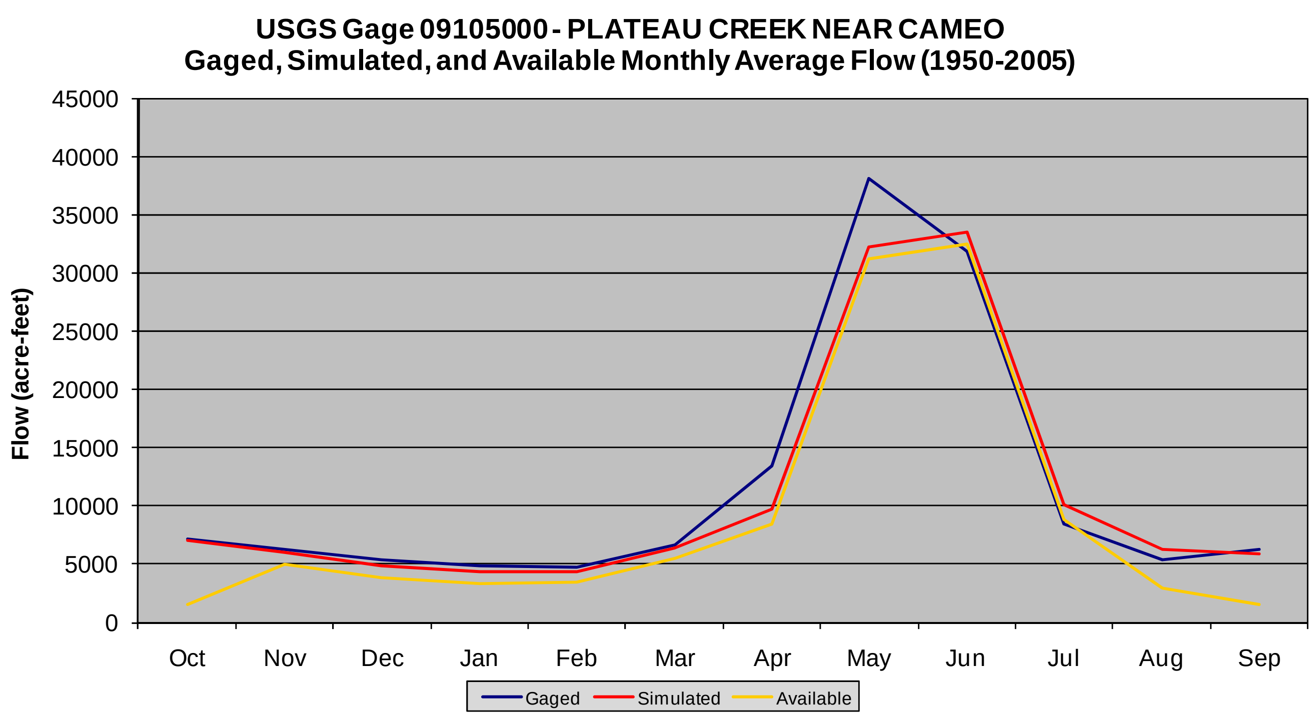
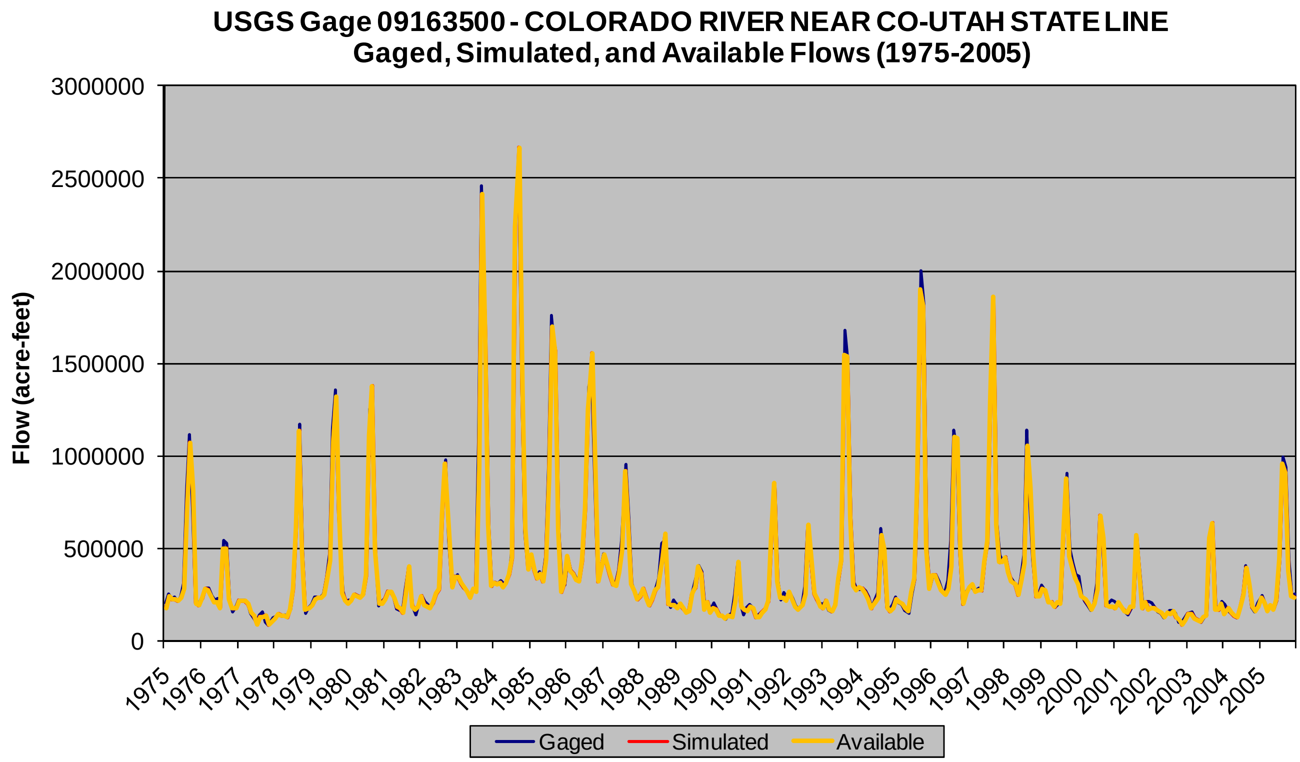


Figure 6.13 Baseline Results – Plateau Creek near Cameo



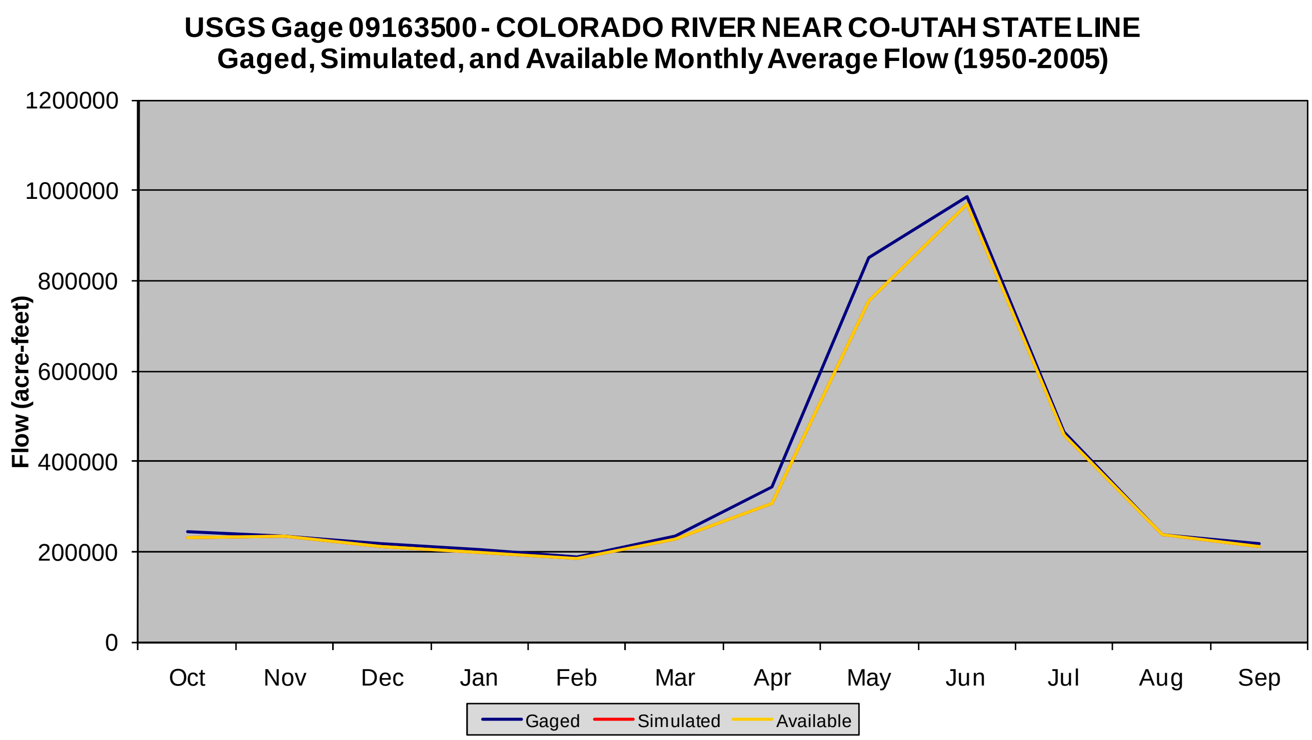


Figure 6.14 Baseline Results – Colorado River near Colorado-Utah State Line

7. Calibration

Calibration is the process of executing the model under historical conditions, and modifying estimated parameters to improve agreement between the model results and the historical record. This section describes the general approach taken in calibrating the Upper Colorado River Model. It describes specific areas of the basin that were revised during calibration, and it presents summaries comparing modeled results for 1975 through 2005 with historical values for the period.

7.1 Calibration Process

The Upper Colorado River Model was calibrated in a two-step process, based on the period 1975 through 2005. In the first step, demands were set to historical diversions, and reservoir levels were constrained to their historical levels. Reservoir storage was limited to the historical monthly content for each month. Reservoirs released water upon demand, but if the demand-driven operations left more water in a reservoir than it had historically, the model released enough water to the stream to achieve its historical end-of-month contents. In this step, the basic hydrology was assessed and baseflow distribution parameters and return flow characteristics were modified.

Reviewing the model run consisted of comparing simulated gage flows with historical flows, and determining where and why diversion shortages occurred. For example, a shortage might occur because a user's water right was limiting. But it might also occur because water is physically unavailable or the water right is called out. In this typical calibration problem, there may be too little baseflow in a tributary reach to support historical levels of diversion in the model. Gains may not be modeled as entering the system until the next downstream gage, bypassing the shorted structures. Because the historical diversion and consumption did not occur, the model then overestimates flow at the downstream gage. Baseflow distribution parameters can be adjusted such that more water entered the system within the tributary, and typically, incremental inflow below the tributary is then reduced. The first step of calibration might also expose errors such as incorrect placement of a gage, or incorrect treatment of imports.

In the second step, reservoirs responded to demands and were permitted to seek the level required to meet the demands. Model results were again reviewed, this time focusing on the operations. For example, operating criteria in the form of monthly targets might be added for reservoirs that operate for un-modeled reasons such as flood control, hydropower generation, or winter maintenance. As another example, where reservoir history revealed that annual administration was not strictly observed, the annual administration feature was removed.

The model at the conclusion of the second step is considered the calibrated model. Note that the model is calibrated on a basin-wide level, concentrating on gage and reservoir locations. When using this model for future analyses involving smaller areas of the basin, it is recommended that further stream flow evaluations be conducted. A refined calibration will improve results of local analyses.

7.2 Historical Data Set

Calibration is based on supplying input that represents historical conditions, so that resulting gage and diversion values can be compared with historical records. This data set is referred to as the "Historic data set", and it is helpful to understand how it differs from the Baseline data set described in Section 5.

7.2.1. Direct Flow Demand File

A primary difference in data sets is the representation of demands (*.ddm file). For calibration, both irrigation and non-irrigation demands were set to historical diversions; to the extent they were known. Gaps in the diversion records were filled using the automatic data filling algorithm described in Section 4.4.2. This demand reflects both limitations in the water supply and the vagaries of operations that cannot be predicted – headgate maintenance, dry-up periods, and so on.

Demands for irrigation multistructures and multiple node projects were placed at the point of diversion. Examples are the Fraser River Diversion Project (Moffat Tunnel) demands, Fryingpan-Arkansas Project, and Ute Water Conservancy District, where demands were placed on the individual tributary nodes and not at the summary node for the Historic data set. In the Baseline data set, the combined demands are placed at the summary node, and operating rules drive the diversions from the individual headgates.

7.2.2. Irrigation Water Requirement File

Irrigation water requirement file (*.iwr) for the Historic data set is based on historical irrigated acreage, whereas the Baseline irrigation water requirement is based on current irrigated acreage. Differences occur at structures that came on-line during the study period, or significantly increased or decreased acreage during the study period.

7.2.3. Instream Flow Monthly Demand File

Instream flow monthly demand file (*.ifm) for the Historic data set demands are limited to historical periods of operation, whereas Baseline demands are set for the entire study period. Another difference between the Historic and Baseline data sets is the representation of the releases from Green Mountain to the Shoshone power plant. In the Historic data set prior to 1985, releases from Green Mountain Reservoir where made to the Shoshone Minimum Flow node (950500) when there was insufficient flow in the river to meet Shoshone's senior right's historical demands. In the Baseline data set the Shoshone Minimum Flow demand was set to zero, and releases are made to individual HUP recipients. See Section 5.9.2 for more information.

7.2.4. Reservoir Station File, Reservoir Right File, and Reservoir Target File

In the Historic data set, reservoirs are inactive prior to commencement of their historical operations. Initial contents in the reservoir file (*.res) were set to their historical end-of-month content in September, 1908, and storage targets (*.tar file) were set to zero until the reservoir historically began to fill. Reservoir rights are on for the entire study period with the exception of Green Mountain's rights, which are on from 1943 forward. The date was based on the first year diversions to storage occurred at Green Mountain Reservoir. The date was required due to accounting of bypassed water against the first fill right, in accordance with the Interim Policy and the Blue River Decree.

In the first calibration step, maximum storage targets were set to historical end-of-month contents. In the second calibration step maximum reservoir storage targets were set to capacity for reservoirs that operated primarily for agricultural and municipal purposes. Maximum targets were set to operational targets according to rule curves provided by USBR for Green Mountain, Ruedi, and Willow Creek reservoirs; Denver provided a rule curve for Williams Fork reservoir; and a rule curve was developed for the Continental Hoosier Upper Blue Lakes reservoir based on historic operations. If capacity of a reservoir changed midway through the study period, the Historic model accounts for the enlargement (not applicable in the Upper Colorado River Model).

In the Baseline data set initial reservoir storage was set to average September end-of-month content, reservoir rights are on the entire study period, and maximum targets were set similar to the second calibration step for the entire study period.

7.2.5. Operational Rights File

The reservoir storage target file (*.tar) and the operating rules file (*.opr) work together to constrain reservoir operations in the first calibration step. The operational rights file includes rules to release water that remains in the reservoir above historical levels (specified in the target file) after demand-driven releases are made. In the second calibration step, release-to-target rules in the *.opr file remain on, but do not fire for most reservoirs, as targets were set to capacity. The exceptions are noted above in Section 7.2.3. In both calibration runs, when water is released to a downstream irrigation diversion, enough water is released to meet the diverter's historical diverted amount, regardless of the efficiency of that operation or whether crop irrigation water requirements are satisfied. Section 5.9 describes each operating rule used in the Baseline and Historic simulations.

Differences between the Baseline data set and the Historic data set are summarized in Table 7.1.

Table 7.1
Comparison of Baseline and Historical (Calibration) Files

Input File	Baseline Data Set	Historic data Set
Diversion demand (*.ddm)	▪ Irrigation structures – "Calculated" demand for full supply, based on crop requirements and historical efficiency ▪ Non-irrigation structures – estimated current demand ▪ Demands placed on primary structures of multistructure systems and demands placed at use location for carrier systems	▪ Historical diversions ▪ Historical diversions for multistructures, Fraser River Diversion Project structures, Fryingpan-Arkansas Project structures, and Ute Water Conservancy District structures were set at individual diversion headgates
Irrigation water requirement (*.iwr)	▪ Calculated using 2000 irrigated acreage	▪ Calculated using historic irrigated acreage
Instream flow monthly demand (*.ifm)	▪ Demands were set for the entire study period. Shoshone Minimum Flow demands were set to zero	▪ Demands were limited to historical operations, Shoshone Call Flows were set to Shoshone's senior right's historical operations prior to 1985
Reservoir station (*.res)	▪ Initial content = average September end-of-month content	▪ Initial content = September 1908 end-of-month content, 0 if prior to construction
Reservoir rights (*.rer)	▪ Green Mountain Reservoir's first fill right on for the entire study period	▪ Green Mountain Reservoir's first fill right on from 1943 forward due to accounting for bypassed water under the Interim Policy administration of the Blue River Decree
Reservoir target (*.tar)	▪ Current maximum capacity except reservoirs that release for flood control or hydropower generation	▪ First step – historical eom contents, 0 prior to construction ▪ Second step –historical maximum capacity except reservoirs that release for flood control or hydropower generation, 0 prior to construction
Operational right (*.opr)	▪ Operating rules drive diversions to demand destination through multi-structure and carrier structures ▪ Reservoir releases were made to irrigation structures to satisfy headgate demands only if crop irrigation water requirements were not met by other sources.	▪ Release-to-target operations allowed reservoirs to release to target contents ▪ Step 1 calibration, reservoir releases were made to irrigation structures to satisfy headgate demands regardless if crop irrigation water requirements were met.

7.3 Calibration Issues

This section describes areas of the model that were investigated in the various calibration efforts of the Upper Colorado River Model. Note that in general, simulating using the variable efficiency approach improved basin-wide calibration from previous efforts.

7.3.1. General Reservoir Enhancements

Reservoirs without refill rights were assigned a free river water right to store during high flow periods. Water stored during these periods still count towards the reservoirs' one-fill rules, if applicable. These free rights were assigned junior administration numbers of 99999.99999. Calibration was improved in wet years.

7.3.2. Aggregated Structures and Diversion Systems

Several revisions have taken place to aggregated structures throughout the modeling process, generally in attempt to reduce shortages. The 1993 Irrigated Acreage Coverage, used as the basis for the aggregation of smaller structures, was supplemented by a 2000 irrigated acreage assessment after the initial modeling efforts were completed. As a result of the second acreage snap-shot, some structures were removed as key and added to aggregates. Several aggregated structures were moved within the network to better represent physical acreage location in the basin. In addition, several structures were combined into diversion systems to represent lands served by more than one ditch on the same tributary.

Aggregated irrigation structures located above a USGS streamflow gage were allowed to benefit from the gain seen at the gage. To make this gain available, these aggregated irrigation structures were made baseflow nodes and assigned area and precipitation values that allowed the gain at the gage be realized at the aggregated irrigation structure. Allowing aggregated diversion structures to benefit from gains seen at downstream gages resulted in less shortage to those aggregate structures.

Several aggregated irrigation structures have demands greater than the combined water rights for the individual structures included in the aggregate structure. To allow them to divert in times of excess flows, they were assigned a free-water right. Assigning free river rights aggregated structures resulted in less shortage to those structures located on the mainstem Colorado and the larger tributaries.

7.3.3. Baseflows

Significant effort was taken to accurately calculate baseflows at streamflow gages and then distribute the baseflow gains to upstream locations. Negative baseflows were calculated when too much water was "removed" or not enough water was "added" to historical streamflow gages. In the historical calibration simulation, this resulted in areas where simulated gage flows were high because negative baseflows were set to zero. The total amount of water in the system was not conserved. In areas where negative baseflows were calculated during the period of available diversion records, the amount of return flows that accrued upstream of a gage were revised. Overall, the amount of negative baseflows was reduced by more than 50 percent in the recent model update.

Most baseflow gains realized at stream gages were distributed to ungaged locations using the "gain approach," where the gain between gages was distributed upstream based on an area/precipitation pro ration. This approach did not work well for ungaged tributaries that have relatively small flow compared to the downstream gaged data. The "neighboring gage" approach distributes a percentage of actual baseflow (not gain) from a gaged location to upstream ungaged tributaries. Thirty-two baseflow nodes were assigned the "neighboring gage" approach during the recent model update. Many of these baseflow locations were tributary to Plateau Creek and the Roaring Fork. This reduced negative baseflows and resulted in better calibration of simulated versus historical diversions on the smaller ungaged tributaries.

7.3.4. Upper Mainstem

While evaluating the Windy Gap Firming project, Boyle Engineering Corporation identified additional Granby Reservoir end-of-month data not used in previous modeling efforts. In addition, the USBR provided Willow Creek Reservoir operational data for the previously missing time period of 1983 through 2004. These additional data were included to estimate baseflows in the upper potion of the Colorado River basin. Overall calibration improved at Granby Reservoir, Willow Creek Reservoir, and downstream gages.

7.3.5. Blue River

Significant updates to StateMod were tested in the implementation of the Interim Policy of the Blue River Decree. Operations of the Interim Policy were updated based on meetings with Denver Water, USBR, and conversations with the Division Engineer. See Section 5.18 for details of the Blue River Decree, Interim Policy, and the associated operating rules.

Historic diversions at the Green Mountain Reservoir Hydropower Plant were included in the Historic simulation and improved the call regime on the Blue River. Specifically, the simulated end-of-month contents in Dillon Reservoir more closely matched historic contents.

The Hoagland Canal diverts water from Elliott Creek, Martin Creek, Deep Creek and several other tributaries to the Blue River. In Phase II, this canal was modeled as a multi-structure with the primary demand on Elliott Creek. Historical diversions at Hoagland Canal were assigned to carrier structures on Martin Creek (360946) and Deep Creek (361018) according to their water right. However, since several of the tributaries which contribute water to the canal were not modeled, the canal was shorted by a large amount in all simulations. Therefore, the canal "headgate" was moved onto the mainstem of the Blue River, below the location of all the contributing tributaries, and modeled as a single point of diversion. The historical records for the Hoagland Canal (360662) were not disaggregated, and the secondary structures' water rights were assigned to 360662.

Operating rules for Clinton Gulch Reservoir were added to the Upper Colorado River Model based on previous model documentation.

7.3.6. Silt Project

Silt Project operations were reviewed and updated. Demands for the two irrigation structures, Dry Elk Valley Irrigation (950010) and Farmers Irrigation Company (950011), were revised based on irrigated acreage assigned to each structure, diversions through Grass Valley Canal (390563), diversions through the Silt Pump Canal (390663), and estimated releases from Grass Valley Reservoir (393505). Irrigation demands were met at 950010 and 950011 and simulated diversions through carrier 390563 improved from previous modeling efforts.

The area for the baseflow node representing West Rifle Creek was found to account for West, East and Middle Rifle Creeks - the entire drainage area for Rifle Gap Reservoir. This area was changed to account for the entire drainage area of West and Middle Rifle Creeks, and the area of East Rifle Creek below USGS gage 09091500. In addition, the capacity of the Grass Valley Canal was corrected from 117 cfs to its actual physical capacity of 60 cfs.

7.3.7. Roaring Fork

Ruedi Reservoir was not operating correctly prior to calibration due to the account priority changes made during Task Order LR-2. This was corrected by giving all accounts equal priorities for storage.

Hunter Creek (381594) diversions were separated from the Boustead north and south collection system (384625) diversions for the Historical simulation. A Boustead Summary node (954699) was added above the Boustead north and south collection node to simulate the total Boustead Tunnel demand for the calculated and baseline scenarios. Operating rules were added to deliver water from the Hunter node and the Boustead north and south collection system node to the summary node. The Hunter Creek water right was corrected to account for the sum of decrees (310 cfs) for the multiple collection systems (No Name, Midway, and Hunter Creeks), and the Boustead Tunnel capacity was increased from 945 to 1,000 cfs to represent actual capacity.

7.3.8. Plateau Creek

The Phase II consumptive use analysis used a combination of climate data from the Grand Valley area (Grand Junction and Fruita) and the town of Collbran. The average annual rainfall for the two Grand Valley climate stations is approximately 9 inches; however the station in Collbran averages 13.7 inches. There is also a large difference in average temperature between the stations. Structures in the Plateau Creek Basin were re-assigned this County-HUC, which resulted in more representative crop irrigation requirements.

In Phase II, only about one-half of the structures were tied to Vega's Project account. Based on information from the area water commissioners, explicit and aggregate structures in the basin, with the exception of Bonham Branch (720542) and Cottonwood Branch (720583) pipelines, Ute Pipeline headgate No 2 (720920), and structures on Buzzard, Leon and Park Creeks, were given operating rules to receive water from Vega's Project account. These structures are served by Southside Canal, either by releases from the canal into the tributaries or, by exchange for structures above the canal.

Leon Creek Aggregated Reservoir was added at the headwaters of Leon Creek to represent supplemental water for Kiggins Salisbury Ditch (720730), Leon Ditch (720744), and Leon Tunnel Canal. This reservoir was assigned a storage right of 1.0000, area-capacity data equivalent to that used for the Bonham and Cottonwood Aggregated Reservoirs, and a capacity of 4,933 acre-feet, representing the combined storage of Colby Horse Reservoir, Hunter Reservoir, and the Monument Reservoirs. Operating rules with an administration number of 99999.99999 were added that allow structures 720730, 720744 and 720758 to receive water from this reservoir. This aggregated reservoir was made a baseflow node using the neighboring gage approach with gage 09100500 on Cottonwood Creek.

The USBR provided daily data for the Vega Reservoir feeders and for releases to the South Side Canal and Galbraith Ditch for the period 1974 through 2002. This data was used to supplement records available in HydroBase.

Numerous aggregated structures (72_ADC056, 72_ADC057, 72_ADC059, 72_ADC060, 72_ADC061, 72_ADC062, and 72_ADC063) were moved from Plateau Creek to their respective tributaries. This change increased the demand on the Collbran Project, specifically Vega Reservoir via South Side Canal operations, and more closely represented the historic project operations.

Gages 09101500 – Bull Creek at Upper Station and 09104000 – Coon Creek near Mesa were changed from gage nodes to other baseflow nodes. These gages had relatively short periods of record that preceded the calibration period. The filled stream flow data created calibration problems. The gage locations were left in the model as other nodes and are used as baseflow distribution locations.

Ute Water Conservancy District diversion data and operations were updated based on conversations with District personnel and the Water Commissioner.

7.3.9. 15-Mile Reach Endangered Fish Flows

Instream flow demands and reservoir operations were added and revised based on meetings with USFWS and USBR and from data supplied by CWCB. Previously, the fish demand nodes had been modeled as diversion structures. In this update the fish demand nodes were changed to instream flow nodes to utilize the natural flow in the river. See Section 5.19 for details of the reservoir releases to the 15-Mile Reach Endangered Fish Flow demands and the associated operating rules.

7.4 Calibration Results

Calibration of the Upper Colorado River Model is considered very good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. Over half the diversion structures' shortages are at or below 1 percent on an annual basis, and the basin wide shortage is around 1 percent per year, on average. Simulated reservoir contents are representative of historical values.

7.4.1. Water Balance

Table 7.2 summarizes the water balance for the Upper Colorado River Model, for the calibration period (1975-2005). The following are observations based on the summary table:

- Stream water inflow to the basin averages 5.69 million acre-feet per year, and stream water outflow averages 4.59 million acre-feet per year.
- Annual diversions amount to approximately 4.72 million acre-feet on average, indicating that there is extensive re-diversion of return flows in the basin.
- Approximately 1.05 million acre-feet per year are consumed.
- The column labeled "Inflow – Outflow" represents the net result of gain (inflow, return flows, and negative change in reservoir and soil moisture contents) less outflow terms (diversions, outflow, evaporation, and positive changes in storage), and indicates that the model correctly conserves mass.

Table 7.2
Average Annual Water Balance for Calibrated Upper Colorado River Model 1975-2005(af/yr)

Month	Stream Inflow	Return	From Soil Moisture	Total Inflow	Diversions	Resvr Evap	Stream Outflow	Resvr Change	To Soil Moisture	Soil Moisture Change	Total Outflow	Inflow - Outflow	CU
OCT	266,656	351,297	1,260	619,213	389,212	2,609	265,200	-39,067	2,617	-1,357	619,213	0	41,417
NOV	198,013	199,493	53	397,560	178,411	554	252,552	-34,010	998	-945	397,560	0	25,466
DEC	184,004	222,270	0	406,274	219,108	-969	229,434	-41,299	613	-613	406,274	0	31,412
JAN	177,736	206,632	0	384,367	213,109	-931	216,496	-44,307	498	-498	384,367	0	31,695
FEB	173,150	183,357	0	356,506	193,419	188	201,394	-38,495	424	-424	356,506	0	28,570
MAR	235,353	191,240	528	427,121	209,517	1,535	253,639	-38,098	592	-63	427,122	0	31,584
APR	406,843	247,352	2,808	657,003	308,275	3,357	336,315	6,269	2,930	-122	657,023	-20	43,552
MAY	1,189,469	365,074	5,088	1,559,631	560,911	7,456	835,040	151,136	11,735	-6,647	1,559,631	0	137,254
JUN	1,481,320	458,115	3,661	1,943,096	762,409	10,482	992,328	174,215	9,347	-5,687	1,943,094	2	241,628
JUL	752,038	448,562	9,082	1,209,682	675,300	9,936	510,752	4,611	1,223	7,859	1,209,681	1	215,425
AUG	350,567	405,250	7,347	763,165	542,745	7,151	254,132	-48,211	1,011	6,336	763,165	0	139,848
SEP	275,297	391,016	3,815	670,128	471,125	4,819	243,536	-53,167	1,754	2,062	670,128	0	83,210
TOT	5,690,446	3,669,658	33,642	9,393,746	4,723,541	46,187	4,590,818	-423	33,742	-99	9,393,764	-17	1,051,061

Note: Consumptive Use (CU) = Diversion (Divert) * Efficiency + Reservoir Evaporation (Evap)

7.4.2. Streamflow Calibration Results

Table 7.3 summarizes the annual average streamflow for water years 1975 through 2005, as estimated in the calibration run. It also shows average annual values of actual gage records for comparison. Both numbers are based only on years for which gage data are complete. Figures 7.1 through 7.14 (at the end of this section) graphically present monthly streamflow estimated by the model compared to historical observations at key streamflow gages, in both time-series format and as scatter graphs. When only one line appears on the time-series graph, it indicates that the simulated and historical results are the same at the scale presented. The “goodness of fit” is indicated by the R^2 value shown on each scatter graph.

Calibration based on streamflow simulation for gages is generally very good in terms of both annual volume and monthly pattern. Exceptions include gages below Granby, Green Mountain and Homestake reservoirs due to differences in current operations (as modeled) versus historical operations, hydropower operations, and other non-standard operations. Ranch Creek near Fraser has a large deviation in terms of percentage but was a minor concern based on small total flow volume. Plateau Creek near Collbran deviated from historical gage information possibly due to limited gage data and inadequate understanding of operations. These exceptions do not significantly affect mainstem or major tributary calibration.

Simulation of streamflow on the mainstem of the Colorado River below Granby Reservoir and Willow Creek below Willow Creek Reservoir accurately model annual volume, but the monthly patterns vary from gaged. Calibration has improved in the upper portion of the basin due to a better understanding of the interactions between Willow Creek Reservoir and Feeder Canal, Windy Gap, and Granby Reservoir. However, the lack of gage data on Willow Creek and missing winter gage data on the mainstem of the Colorado River just below Granby Reservoir create unintended affects on the system when simulating strictly based on operating criteria. Step 1 calibration results, when the reservoirs “release to target” of historical end-of-month contents, are also shown on Figures 7.1 and 7.2.

Simulation of streamflows on Williams Fork below Williams Fork Reservoir and Blue River below Green Mountain Reservoir accurately model annual volume, but the monthly patterns vary from gaged. Williams Fork and Green Mountain Reservoirs are modeled using forecasting curves provided by the Denver Water Board and USBR that are intended to mimic hydropower and other operations. It is clear that the rule curves are used only as guidelines and decisions based on other factors drive actual operations. Because of the large volume of water stored and released from these reservoirs, relatively small deviations from historic reservoir operations result in large deviations in downstream flow. Additionally, the Blue River Decree is being simulated under the current administration outlined in the Interim Policy, which differs from historical administration. Step 1 calibration results, when the reservoirs “release to target” of historical end-of-month contents, are also shown on Figures 7.5 and 7.6, further reinforcing the conclusion regarding streamflow gages below these reservoirs.

Table 7.3
Historical and Simulated Average Annual Streamflow Volumes (1975-2005)
Calibration Run (acre-feet/year)

Gage ID	Historical	Simulated	Historical -Simulated Volume	Historical -Simulated Percent	Gage Name
09010500	45,792	45,792	0	0%	Colorado R Below Baker Gulch, Nr Grand Lake, CO.
09011000	57,764	57,764	0	0%	Colorado River Near Grand Lake, CO.
09019500	39,532	38,856	676	2%	Colorado River Near Granby
09021000	31,132	31,407	-275	-1%	Willow Creek Below Willow Creek Reservoir
09024000	13,309	13,652	-344	-3%	Fraser River At Winter Park
09025000	10,289	10,401	-112	-1%	Vasquez Creek At Winter Park, CO.
09026500	15,221	15,228	-8	0%	St. Louis Creek Near Fraser, CO.
09032000	8,860	9,519	-658	-7%	Ranch Creek Near Fraser, CO.
09032499	8,064	8,064	0	0%	Meadow Creek Reservoir Inflow
09032500	Missing gage data during calibration period				Ranch Creek Near Tabernash, CO.
09033500	Missing gage data during calibration period				Strawberry Creek Near Granby, CO.
09034250	183,828	183,460	367	0%	Colorado River At Windy Gap, Near Granby, CO.
09034500	168,787	168,430	357	0%	Colorado River At Hot Sulphur Springs, CO.
09034800	Missing gage data during calibration period				Little Muddy Creek Near Parshall, CO.
09034900	7,564	7,564	0	0%	Bobtail Creek Near Jones Pass, CO.
09035500	14,124	14,167	-43	0%	Williams Fork Below Steelman Creek, CO.
09036000	72,517	72,561	-43	0%	Williams Fork River Near Leal, Co
09037500	79,248	78,908	340	0%	Williams Fork River Near Parshall, Co
09038500	92,719	92,396	323	0%	Williams Fork River Below Williams Fork Reservoir
09039000	22,365	22,600	-236	-1%	Troublesome Creek Near Pearmont, CO.
09040000	22,498	22,583	-85	0%	East Fork Troublesome C Near Troublesome, CO.
09041000	49,395	49,521	-126	0%	Muddy Creek Near Kremmling, CO.
09041200	Missing gage data during calibration period				Red Dirt Creek Near Kremmling, CO.
09041500	66,565	64,760	1,805	3%	Muddy Creek At Kremmling, CO.
09046600	69,345	69,274	72	0%	Blue River Near Dillon, CO.
09047500	45,449	45,454	-5	0%	Snake River Near Montezuma, CO.
09050100	75,063	75,197	-135	0%	Tenmile Creek Below North Tenmile Creek At Frisco
09050700	146,624	147,007	-383	0%	Blue River Below Dillon Reservoir
09052800	18,677	18,677	0	0%	Slate Creek At Upper Station, Near Dillon, CO.
09053500	312,567	323,090	-10,523	-3%	Blue River Above Green Mountain Reservoir, CO.
09054000	22,776	22,776	0	0%	Black Creek Below Black Lake, Near Dillon, CO.
09055300	14,558	14,558	0	0%	Cataract Creek Near Kremmling, CO.
09057500	301,300	299,310	1,991	1%	Blue River Below Green Mountain Reservoir
09058000	718,265	719,561	-1,296	0%	Colorado River Near Kremmling
09060500	24,031	24,031	0	0%	Rock Creek Near Toponas, CO.
09060700	Missing gage data during calibration period				Egeria Creek Near Toponas, CO.
09063000	28,262	28,286	-24	0%	Eagle River At Red Cliff, CO.
09064000	19,824	20,519	-694	-4%	Homestake Creek At Gold Park, CO.
09065100	37,802	37,802	0	0%	Cross Creek Near Minturn
09065500	22,232	22,232	0	0%	Gore Creek At Upper Station, Near Minturn, CO.
09067300	Missing gage data during calibration period				Alkali Creek Near Wolcott, CO.
09068000	Missing gage data during calibration period				Brush Creek Near Eagle, CO.
09069500	Missing gage data during calibration period				Gypsum Creek Near Gypsum, CO.

Gage ID	Historical	Simulated	Historical -Simulated Volume	Percent	Gage Name
09070000	407,419	407,691	-272	0%	Eagle River Below Gypsum
09070500	1,455,699	1,458,447	-2,748	0%	Colorado River Near Dotsero
09071300	9,755	9,755	0	0%	Grizzly Creek Near Glenwood Springs, CO.
09072500	Missing gage data during calibration period				Colorado River At Glenwood Springs, CO.
09073400	71,115	71,244	-128	0%	Roaring Fork River Near Aspen
09074000	30,203	30,237	-35	0%	Hunter Creek Near Aspen
09074800	31,675	31,675	0	0%	Castle Creek Above Aspen, CO.
09075700	50,076	50,076	0	0%	Maroon Creek Above Aspen, CO.
09078600	76,658	78,265	-1,606	-2%	Fryingpan River Near Thomasville
09080400	123,912	125,502	-1,590	-1%	Fryingpan River Near Ruedi
09080800	Missing gage data during calibration period				West Sopris Creek Near Basalt, CO.
09081600	215,575	215,575	0	0%	Crystal River Above Avalanche Creek Near Redstone
09082800	10,923	10,923	0	0%	North Thompson Creek Near Carbondale, CO.
09084000	Missing gage data during calibration period				Cattle Creek Near Carbondale, CO.
09084600	Missing gage data during calibration period				Fourmile Creek Near Glenwood Springs, CO.
09085000	860,602	862,895	-2,292	0%	Roaring Fork River At Glenwood Springs
09085100	2,370,982	2,376,022	-5,040	0%	Colorado River Below Glenwood Springs
09085200	40,635	40,649	-14	0%	Canyon Creek Above New Castle, CO.
09087500	Missing gage data during calibration period				Elk Creek At New Castle, CO.
09088000	Missing gage data during calibration period				Baldy Creek Near New Castle
09089500	30,280	30,280	0	0%	West Divide Creek Near Raven
09090700	Missing gage data during calibration period				East Divide Creek Near Silt, CO.
09091500	Missing gage data during calibration period				East Rifle Creek Near Rifle, CO.
09092500	3,591	3,591	0	0%	Beaver Creek Near Rifle
09092600	Missing gage data during calibration period				Battlement Creek Near Parachute
09093000	35,518	35,518	0	0%	Parachute Creek Near Parachute CO.
09093500	22,997	23,357	-360	-2%	Parachute Creek At Parachute, CO.
09093700	2,816,135	2,821,770	-5,634	0%	Colorado River Near De Beque
09095000	38,970	39,483	-513	-1%	Roan Creek Near De Beque, CO.
09095500	2,726,210	2,731,806	-5,596	0%	Colorado River Near Cameo
09096500	22,259	29,974	-7,715	-35%	Plateau Creek Near Collbran, CO.
09097500	30,447	31,248	-802	-3%	Buzzard Creek Near Collbran
09100500	Missing gage data during calibration period				Cottonwood Creek At Upper Sta, Near Molina, CO.
09104500	Missing gage data during calibration period				Mesa Creek Near Mesa, CO.
09105000	154,723	156,829	-2,106	-1%	Plateau Creek Near Cameo
09152500	1,841,072	1,841,070	2	0%	Gunnison River Near Grand Junction
09163500	4,585,370	4,590,818	-5,447	0%	Colorado River Near Colorado-Utah State Line

7.4.3. Diversion Calibration Results

Table 7.4 summarizes the average annual shortage for water years 1975 through 2005, by tributary or sub-basin in Colorado. Table 7.6 (at the end of this section) shows the average annual shortages for water years 1975 through 2005 by structure. On a basin-wide basis, average annual diversions differ from historical diversions by 1.8 percent in the calibration run. Note that total diversions shown in Table 7.4 and 7.6 are not the same as total diversions shown in Table 7.2. Diversions in Table 7.2 include diverted amounts both at carriers and their destination.

- Aggregate nodes may be shorted if the associated structures historically re-diverted other aggregated structures' return flows.
- Aggregate nodes with senior water rights could preempt junior water rights that they could not physically call out due to the placement of the aggregate nodes on mainstem tributaries (See Appendix A).
- Diversions on smaller tributaries without historical streamflow records are often shorted because of a lack of understanding of hydrology.

Table 7.4
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2005)
Calibration Run (acre-feet/year)

			Historical minus Simulated	
Water District - Sub-basin	**Historical**	**Simulated**	**Volume**	**Percent**
WD 51 – Upper Colorado/Fraser Rivers	442,851	441,043	1,808	0.4%
WD 50 – Muddy/Troublesome Creeks	85,870	83,630	2,240	2.6%
WD 36 – Blue River	162,082	158,748	3,334	2.1%
WD 52 & 53 – Piney/Cottonwood and Tribs North of the Colorado River	856,781	847,324	9,457	1.1%
WD 37 – Eagle River	126,504	125,353	1,151	0.9%
WD 38 – Roaring Fork River	491,240	481,907	9,333	1.9%
WD 39 – Rifle/Elk/Parachute Creeks	122,351	117,872	4,479	3.7%
WD 45 and 70 – Divide and Roan Creeks	174,348	168,676	5,672	3.3%
WD 72 – Lower Colorado River	1,705,009	1,693,611	11,398	0.7%
Basin Total	**4,167,036**	**4,118,164**	**48,872**	**1.8%**

7.4.4. Reservoir Calibration Results

Figures 7.15 through 7.29 (located at the end of this chapter) present reservoir EOM contents estimated by the model compared to historical observations at selected reservoirs. The following can be observed:

- Dillon Reservoir did not simulate historical EOM contents for the years 1983 through 1986. During this time, according to Denver Water, maintenance operations required a lower reservoir level. During that time flows that were in priority to store were bypassed.

- Grass Valley and Rifle Gap Reservoirs did not simulate as they did historically. Historical project demands are not available; therefore, much of the data used in the analysis is estimated.

- Simulated Vega Reservoir and the diversions associated with the Collbran Project are affected by the lack of stream flow data on Plateau Creek and its tributaries.

- Green Mountain, Ruedi, Williams Fork, and Willow Creek reservoirs operational targets appear to be general operating guidelines and do not explicitly mimic historic operations.

7.4.5. Consumptive Use Calibration Results

Crop consumptive use is estimated by StateMod and reported in the consumptive use summary file (*.xcu) for each diversion structure in the simulation. This file includes consumptive use for municipal and industrial diversions in addition to agricultural consumptive use. The crop consumptive use estimated by StateCU is reported in the water supply-limited summary file (*.wsl) for each agricultural diversion structure in the basin. Therefore, to provide a one-to-one comparison, only structures in the StateCU analysis are included in the comparison below.

Table 7.5 shows the comparison of StateCU estimated crop consumptive use compared to StateMod estimate of crop consumptive use for explicit structures, aggregate structures, and basin total. As shown, both explicit and aggregate structure consumptive use match StateCU results very well. Historical diversions are used by StateCU to estimate supply-limited (actual) consumptive use. The approximately 2 percent difference is consistent with the overall basin diversion shortages simulated by the model.

Table 7.5
Average Annual Crop Consumptive Use Comparison (1975-2004)

Comparison	StateCU Results (af/yr)	Calibration Run Results (af/yr)	% Difference
Explicit Structures	329,178	322,738	2.0%
Aggregate Structures	165,326	163,075	1.4%
Basin Total	494,504	485,813	1.8%

Table 7.6
Historical and Simulated Average Annual Diversions (1975-2005)
Calibration Run (acre-feet/year)

			Historical - Simulated		
WDID	**Historical**	**Simulated**	**Volume**	**Percent**	**Name**
360606	0	0	0	0%	ELLIOTT CREEK FEEDER [1]
360645	4,175	3,787	388	9%	GUTHRIE THOMAS DITCH
360649	6,174	5,714	461	7%	Hamilton Davidson Div Sy
360660	2,423	2,355	68	3%	HIGH MILLER DITCH
360662	7,895	7,776	120	2%	Hoagland Div Sys
360671	2,250	2,023	227	10%	INDEPENDENT BLUE DITCH
360687	1,339	1,270	69	5%	KIRKWOOD DITCH
360709	5,821	5,563	258	4%	LOBACK DITCH
360725	578	514	64	11%	MARY DITCH
360728	955	901	54	6%	MAT NO 1 DITCH
360729	1,063	1,013	50	5%	MAT NO 2 DITCH
360734	1,241	981	259	21%	MCKAY DITCH
360765	2,183	1,995	188	9%	PALMER-MCKINLEY DITCH
360780	1,168	1,043	125	11%	PLUNGER DITCH
360784	588	588	0	0%	RANKIN NO 1 DITCH
360796	1,501	1,446	54	4%	SAUMS DITCH
360800	1,678	1,671	7	0%	SLATE CREEK DITCH
360801	3,087	2,732	354	11%	SMITH DITCH
360829	474	473	1	0%	STRAIGHT CREEK DITCH
360841	1,907	2,062	-155	-8%	TENMILE DIVERSION NO 1
360868	2,151	2,063	88	4%	WESTLAKE DITCH
360881	0	0	0	12%	GREEN MTN HYDRO-ELECTRIC [4]
360908	355	284	71	20%	KEYSTONE SNOWLINE DITCH
360989	0	0	0	0%	MAGGIE POND (SNOWMAKING)
361008	1,222	884	338	28%	BRECKENRIDGE PIPELINE
361016	126	112	13	11%	COPPER MTN SNOWMAKING
364626	521	515	5	1%	VIDLER TUNNEL COLL SYS
364683	0	0	0	0%	CON-HOOSIER SYS BLUE R D [1]
364684	63,515	63,515	0	0%	BLUE RIVER DIVR PROJECT
364685	91	91	0	0%	BOREAS NO 2 DITCH
364699	0	0	0	0%	CON-HOOSIER TUNNEL [1]
36_ADC017	20,645	20,645	0	0%	Upper Blue River
36_ADC018	8,876	8,876	0	0%	Blue River abv Green Mou
36_ADC019	9,030	9,030	0	0%	Blue River bl Green Moun
370519	1,436	1,234	203	14%	BRAGG NO 1 DITCH
370539	3,936	3,936	0	0%	CHATFIELD BARTHOLOMEW D
370548	2,960	2,866	94	3%	C M STREMME GATES DITCH
370560	1,872	1,753	120	6%	CREAMERY DITCH
370561	3,111	3,111	0	0%	DAGGETT AND PARKER DITCH
370571	2,282	2,197	85	4%	J M DODD DITCH
370635	1,019	1,012	7	1%	HERNAGE DITCH
370642	4,403	4,344	60	1%	HOLLINGSWORTH DITCH
370655	1,710	1,710	0	0%	H O R DITCH
370658	2,249	2,151	97	4%	HOWARD DITCH
370686	1,843	1,843	0	0%	LOVE AND WHITE DITCH
370694	2,540	2,512	28	1%	MATHEWS DITCH
370708	2,138	2,133	5	0%	METCALF DITCH
370723	1,010	997	13	1%	NEILSON SOUTH DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
370743	2,841	2,691	150	5%	ONEILL AND HOLLAND DITCH
370823	6,593	6,549	45	1%	STRATTON AND CO DITCH
370830	1,860	1,809	51	3%	TERRELL AND FORD DITCH
370843	1,146	1,144	3	0%	UPPER FROST DITCH
370848	4,233	4,113	119	3%	WARREN DITCH
371091	1,031	1,017	14	1%	EWING PLACER DITCH
371146	0	0	0	0%	WOLCOTT PUMP PIPELINE
374614	24,580	24,580	0	0%	HOMESTAKE PROJ TUNNEL
374641	1,731	1,726	5	0%	COLUMBINE DITCH
374643	0	0	0	0%	HOMESTAKE PROJ CONDUIT [1]
374648	2,757	2,753	4	0%	WARREN E WURTS DITCH
37_ADC029	17,041	17,041	0	0%	Eagle River abv Brush Cr
37_ADC030	17,216	17,190	26	0%	Brush Creek
37_ADC031	10,193	10,193	0	0%	Eagle River bl Gypsum
380516	1,665	1,234	431	26%	ATKINSON DITCH
380517	2,241	2,238	3	0%	ATKINSON CANAL
380528	8,956	8,884	72	1%	BASIN DITCH
380545	1,641	1,570	70	4%	BORAM AND WHITE DITCH
380547	4,316	4,264	52	1%	BOWLES AND HOLLAND DITCH
380569	1,801	1,773	28	2%	C AND M DITCH
380572	2,543	2,337	205	8%	CAPITOL FALLS DITCH
380573	1,435	1,433	2	0%	CAPITOL PARK DITCH
380574	7,757	7,719	38	0%	CARBONDALE DITCH
380606	1,050	1,033	16	2%	COLLINS CREEK DITCH
380618	5,433	5,227	206	4%	CRANE AND PEEBLES DITCH
380639	1,452	1,322	130	9%	DESERT DITCH
380651	10,697	10,680	16	0%	EAST MESA DITCH
380659	2,389	2,347	42	2%	ELI CERISE DITCH
380663	5,752	5,619	133	2%	ELLA DITCH
380667	499	424	75	15%	EUREKA NO 1 DITCH
380688	809	809	0	0%	FOUR MILE DITCH
380712	14,108	13,707	401	3%	GLENWOOD DITCH
380715	6,587	6,495	92	1%	GRACE AND SHEHI DITCH
380720	3,448	3,391	58	2%	GREEN MEADOW DITCH
380740	5,119	5,096	23	0%	HARRIS & REED DITCH
380755	3,497	3,397	101	3%	HOLDEN DITCH
380757	18,299	18,127	171	1%	HOME SUPPLY DITCH
380800	4,214	4,155	59	1%	KESTER DITCH
380822	276	210	66	24%	LIGNITE DITCH
380838	1,626	1,609	17	1%	LOWER DITCH
380840	11,882	11,756	126	1%	LOWLINE DITCH
380854	3,068	3,065	2	0%	MAROON DITCH
380861	1,208	1,162	45	4%	MAURIN DITCH
380869	4,445	4,445	0	0%	MIDLAND FLUME DITCH
380879	854	848	5	1%	MONARCH DITCH
380880	3,654	3,105	548	15%	Mt. Sopris Div Sys
380881	6,554	4,998	1,556	24%	MOUNTAIN MEADOW DITCH
380890	1,289	1,237	52	4%	MCKENZIE WILDCAT DITCH
380893	1,700	1,438	262	15%	MCKOWN DITCH
380902	2,578	2,462	116	5%	NEEDHAM DITCH
380925	3,235	3,228	7	0%	PARK DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
380930	18,088	17,669	419	2%	PATERSON D JACOB EXT
380939	2,884	2,880	5	0%	PIONEER DITCH
380959	2,784	2,644	140	5%	RED ROCK BLUFF DITCH
380966	4,104	4,104	0	0%	ROBERTSON DITCH
380968	13,883	13,816	67	0%	ROBINSON DITCH
380970	8,214	8,133	81	1%	ROCKFORD DITCH
380981	7,378	7,356	23	0%	SALVATION DITCH
380989	916	849	67	7%	SHIPPEE DITCH
380994	929	806	124	13%	SLOSS DITCH
380996	7,581	7,557	24	0%	SLOUGH D AND BANNING LAT
381012	2,984	2,927	58	2%	SNOWMASS DIVIDE DITCH
381018	4,974	4,857	116	2%	SOUTHARD AND CAVANAUGH
381038	13,524	13,433	92	1%	SWEET JESSUP CANAL
381052	1,202	1,147	55	5%	CARBONDALE WTR SYS & PL
381062	3,535	3,498	37	1%	UNION DITCH
381066	357	357	0	0%	VAN CLEVE NO 1 DITCH
381073	5,039	5,005	34	1%	WACO DITCH
381078	5,845	5,279	565	10%	WALKER WONDER DITCH
381095	1,317	1,293	24	2%	WILLIAMS NO 1 D CAP CR
381101	2,386	2,347	39	2%	WILLOW CREEK DITCH
381104	856	856	0	0%	WILLOW AND OWL DITCH
381121	1,156	1,148	8	1%	ALEXIS ARBANEY DITCH
381132	1,628	1,628	0	0%	WALTHEN DITCH
381147	5,336	5,250	87	2%	KAISER AND SIEVERS DITCH
381441	1,230	1,230	0	0%	EAST SNOWMASS BRUSH C PL
381481	562	530	32	6%	VAN CLEVE-FISHER FDR D
381594	10,225	10,190	35	0%	FRY ARK PR HUNTER TUNNEL
381661	1,139	1,112	27	2%	SALVATION DITCH VAGN EXT
381790	3,958	3,836	122	3%	RED MOUNTAIN EXT DITCH
384613	5,338	5,336	2	0%	IVANHOE RESERVOIR TUNNEL
384617	38,188	38,059	128	0%	IND P TM DVR TUNNEL NO 1
384625	39,286	37,681	1,604	4%	FRY ARK PR BOUSTEAD TUNL
384717	268	219	49	18%	WEST THREE MILE DITCH [1]
38_ADC033	29,704	29,704	0	0%	Upper Roaring Fork
38_ADC034	17,402	17,402	0	0%	Snowmass Creek
38_ADC035	12,267	12,267	0	0%	Frying Pan River
38_ADC036	13,457	13,445	12	0%	West Sopris Creek
38_ADC037	20,967	20,967	0	0%	Roaring Fork abv Crystal
38_ADC038	13,722	13,696	26	0%	Crystal River
38_ADC039	6,030	6,030	0	0%	Cattle Creek
38_ADC040	2,520	2,520	0	0%	Lower Roaring Fork
390532	2,696	2,696	0	0%	CLOUGH NO 1 DITCH
390537	1,313	1,307	6	0%	CORNELL DITCH
390539	1,904	1,889	15	1%	CORYELL DITCH
390540	1,309	927	382	29%	CORYELL JOINT STOCK IRRI
390547	1,391	1,391	0	0%	DAVIE DITCH
390548	2,009	2,001	7	0%	DEWEESE DITCH
390562	1,923	1,181	742	39%	GRANLEE DITCH
390563	0	0	0	0%	GRASS VALLEY CANAL [1]
390574	6,003	6,003	0	0%	GRAND TUNNEL DITCH
390585	1,129	1,117	12	1%	HIBSCHLE BENBOW DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Historical - Simulated Percent	Name
390590	1,842	1,116	726	39%	JANGLE DITCH
390610	3,790	3,093	697	18%	LOW COST DITCH
390612	15,933	15,933	0	0%	LOWER CACTUS VALLEY D
390635	1,625	1,609	16	1%	PARACHUTE DITCH
390638	790	766	24	3%	PIERSON AND HARRIS DITCH
390645	9,310	9,180	130	1%	RIFLE CREEK CANON DITCH
390663	0	0	0	0%	SILT PUMP CANAL [1]
390672	5,789	5,078	711	12%	THOMPKINS DITCH
390687	11,783	11,632	151	1%	WARE AND HINDS DITCH
390701	1,174	1,115	60	5%	RED ROCK DITCH
390825	7,026	6,851	175	2%	WILLIAMS CANAL
390967	1,443	1,422	22	2%	RIFLE TOWN OF PUMP & PL
390990	1,434	1,434	0	0%	WEST LAT RIFLE CR CANON
394725	1,321	1,294	27	2%	Vulcan Ditch Div Sys
39_ADC041	16,723	16,385	338	2%	Elk Creek
39_ADC045	5,648	5,648	0	0%	Rifle Creek
420520	161	161	0	0%	GRAND JCT GUNNISON PL
420541	456,717	456,667	51	0%	REDLANDS POWER CANAL
450514	2,564	2,393	171	7%	BATTLEMENT DITCH
450576	9,010	8,629	381	4%	DIVIDE CREEK HIGHLINE D
450584	1,836	1,475	362	20%	EAST DIVIDE CREEK DITCH
450616	1,399	1,386	13	1%	H AND S DITCH
450632	1,068	1,041	27	3%	HOLMES DITCH
450635	618	594	24	4%	HUDSON & SULLIVAN DITCH
450638	1,252	1,116	136	11%	HUNTLEY DITCH
450668	9,842	9,842	0	0%	LAST CHANCE DITCH
450675	559	551	7	1%	LOUIS REYNOLDS DITCH
450685	851	800	50	6%	MAMM CREEK DITCH
450693	2,252	2,236	16	1%	MINEOTA DITCH
450704	4,321	4,005	316	7%	MULTA-TRINA DITCH
450705	857	792	65	8%	MURRAY AND YULE DITCH
450725	4,147	3,913	234	6%	PORTER DITCH
450743	5,906	5,906	0	0%	RISING SUN DITCH
450749	419	412	7	2%	RODERICK DITCH
450788	596	502	94	16%	SYKES AND ALVORD DITCH
450790	2,063	1,908	156	8%	TALLMADGE AND GIBSON D
450793	1,704	1,583	121	7%	TAUGHENBAUGH DITCH
450810	725	721	4	0%	WARD AND REYNOLDS DITCH
450818	1,608	1,545	63	4%	WEST DIVIDE CREEK DITCH
450861	8,378	8,378	0	0%	LARKIN DITCH
450969	29,177	29,144	32	0%	BLUESTONE VALLEY DITCH
45_ADC042	10,227	10,227	0	0%	Colorado River bl Garfie
45_ADC043	7,149	7,149	0	0%	Colorado River bl Divide
45_ADC044	4,823	4,823	0	0%	Colorado R bl Mamm Creek
45_ADC046	4,794	4,794	0	0%	Colorado River bl Beaver
45_ADC047	6,580	6,580	0	0%	Colorado River bl Cache
45_ADC048	12,878	12,878	0	0%	Colorado River nr De Beq
500526	1,321	1,321	0	0%	BLICKLEY DITCH
500539	1,009	1,009	0	0%	CLIFF DITCH
500574	2,633	2,602	31	1%	HARDSCRABBLE DITCH
500576	4,315	4,278	37	1%	HAYPARK CANAL HGT NO 1

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
500582	1,430	1,386	44	3%	HERDE DITCH
500585	872	872	0	0%	HOGBACK DITCH
500593	5,368	5,139	229	4%	KIRTZ DITCH NO 2
500598	803	760	44	5%	LANDSLIDE DITCH
500601	1,121	1,075	46	4%	MARTIN NO 1 DITCH
500606	4,131	3,985	146	4%	MISSOURI DITCH
500612	1,010	962	49	5%	MCELROY NO 1 DITCH
500613	742	713	29	4%	MCELROY NO 2 DITCH
500617	3,411	3,290	121	4%	MCMAHON DITCH
500627	972	972	0	0%	PASS CREEK DITCH
500628	1,123	929	194	17%	PICKERING DITCH
500632	747	747	0	0%	PLEASANT VIEW DITCH
500653	2,625	2,621	3	0%	TOM ENNIS DITCH
500654	2,968	2,953	15	0%	TROUBLESOME DITCH
500656	918	884	34	4%	TYLER DITCH
500731	838	827	11	1%	CLIFF DITCH HGT NO 2
500734	6,756	6,592	164	2%	Deberard Div Sys
50_ADC012	8,817	8,817	0	0%	Troublesome Creek
50_ADC013	6,120	5,455	665	11%	Upper Muddy Creek
50_ADC014	7,305	7,016	289	4%	Muddy Creek abv Tyler Di
50_ADC015	4,062	4,032	30	1%	Muddy Creek abv Red Dirt
50_ADC016	3,135	3,133	2	0%	Lower Muddy Creek
50_ADC020	9,837	9,837	0	0%	Colorado River bl Kremml
510529	25,800	25,800	0	0%	Big Lake Div Sys
510546	6,843	6,736	107	2%	BUNTE HIGHLINE DITCH
510585	3,502	3,412	90	3%	COFFEE MCQUEARY DITCH
510594	2,142	2,077	65	3%	CROOKED CREEK DITCH NO 1
510629	1,780	1,741	40	2%	FARRIS SOUTH SIDE DITCH
510639	12,089	12,079	10	0%	Jim_Creek
510660	553	548	5	1%	GASKILL DITCH
510699	2,463	2,457	6	0%	HAMMOND NO 1 DITCH
510700	790	790	0	0%	HAMMOND NO 2 DITCH
510728	4,214	4,119	95	2%	HAMILTON-CABIN CR DITCH
510763	7,736	7,592	144	2%	KINNEY BARRIGER DITCH
510788	1,981	1,981	0	0%	LYMAN DITCH
510810	2,741	2,607	134	5%	MUSGRAVE DITCH
510829	231	231	0	0%	PEAVEY NO 2 DITCH
510831	1,119	1,102	18	2%	PETERSON DITCH NO 1
510848	11,763	11,735	28	0%	REDTOP VALLEY DITCH
510858	285	245	40	14%	ROCK CREEK DITCH
510876	1,693	1,585	109	6%	SCYBERT DITCH
510880	1,674	1,659	14	1%	SELAK LARRABEE DITCH
510883	1,698	1,686	12	1%	SHERIFF DITCH (156)
510893	4,179	4,135	45	1%	SOPHRONIA DAY DITCH
510924	2,335	1,567	768	33%	SYLVAN DITCH
510934	1,083	1,071	12	1%	TRAIL CREEK DITCH
510939	1,736	1,689	47	3%	UTE BILL NO 2 DITCH
510941	3,473	3,677	-204	-6%	Vail Irr Div Sys
510948	1,507	1,495	12	1%	WALDON HOLLOW DITCH
510958	0	0	0	0%	CBT WILLOW CREEK FEEDER [1]
511070	2,249	2,235	14	1%	HENDERSON MINE WTR SYS

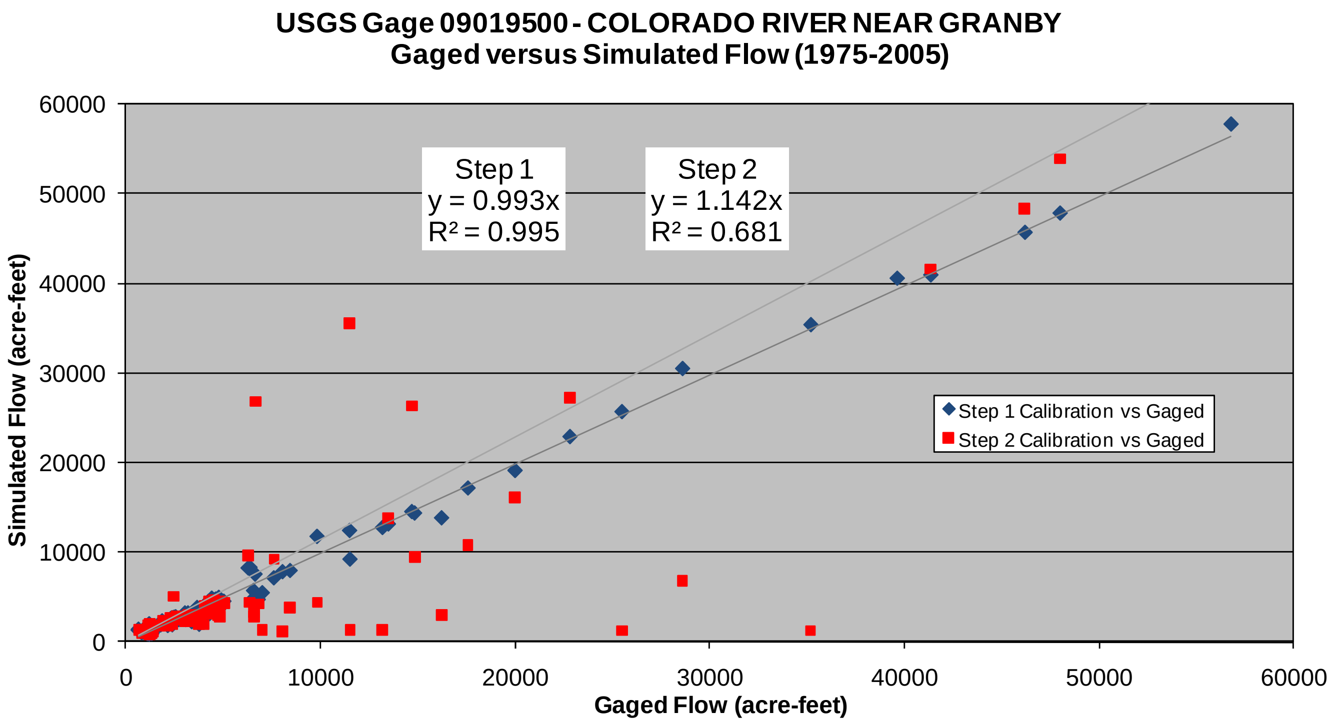
WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
511149	1,481	1,423	57	4%	THOMPSON PUMP NO 2
511237	0	0	0	0%	WILLIAMS FORK POWER COND
511269	7,943	7,937	6	0%	Ranch_Creek
511309	9,754	9,753	1	0%	St_Louis_Cr
511310	14,949	14,916	33	0%	Vasquez_Creek
514601	18,265	18,265	0	0%	GRAND RIVER DITCH
514603	4,088	4,044	43	1%	WILLIAMS FORK TUNNEL
514625	719	711	8	1%	BERTHOUD CANAL TUNNEL
514634	227,476	227,476	0	0%	CBT ALVA B ADAMS TUNNEL
514655	1,030	1,010	0	0%	MOFFAT WATER TUNNEL
514700	0	0	0	0%	WINDY GAP PUMP PL CANAL [1]
51_ADC001	3,205	3,193	12	0%	Colorado River nr Granby
51_ADC002	2,196	2,190	6	0%	Willow Creek
51_ADC003	3,704	3,634	70	2%	Ranch Creek
51_ADC004	5,523	5,523	0	0%	Fraser River bl Crooked
51_ADC005	4,542	4,542	0	0%	Tenmile Creek
51_ADC006	4,485	4,485	0	0%	Fraser River at Granby
51_ADC007	8,137	8,137	0	0%	Colorado River abv Hot S
51_ADC008	5,730	5,730	0	0%	Colorado River abv Willi
51_ADC009	3,886	3,886	0	0%	Upper Williams Fork
51_ADC010	3,758	3,758	0	0%	Lower Williams Fork
51_ADC011	5,802	5,802	0	0%	Colorado River abv Troub
520559	995	932	63	6%	GUTZLER DITCH
520572	677	636	41	6%	HOG EYE DITCH
520658	1,264	992	273	22%	WILMOT DITCH
52_ADC021	17,140	17,140	0	0%	Black Tail & Sheephorn C
52_ADC027	6,269	6,231	38	1%	Colorado River abv Derby
530555	8,703	8,525	178	2%	Derby Div Sys
530584	752,222	747,099	5,123	1%	SHOSHONE POWER PLANT
530585	4,434	4,434	0	0%	GLENWOOD L WATER CO SYS
530621	674	348	326	48%	HIGHWATER DITCH
530632	373	309	64	17%	HORSE MEADOWS DITCH
530657	3,419	3,318	101	3%	KAYSER DITCH
530678	2,302	2,285	17	1%	LION BASIN DITCH
530780	2,854	2,802	53	2%	ROGERS DITCH
530783	464	161	302	65%	ROYAL FLUSH DITCH
530800	4,585	4,584	1	0%	SOUTH DERBY DITCH
530883	2,539	2,229	310	12%	WILSON AND DOLL DITCH
531051	0	0	0	0%	GLENWOOD L WATER CO SYS [1]
531082	375	123	252	67%	MACFARLANE DITCH
53_ADC022	1,290	530	761	59%	Upper Egeria Creek
53_ADC023	2,966	1,970	995	34%	King Creek
53_ADC024	4,407	3,890	517	12%	Egeria Creek abv Toponas
53_ADC025	2,818	2,816	2	0%	Toponas Creek
53_ADC026	7,903	7,862	41	1%	Colorado River abv Alkal
53_ADC028	8,614	8,614	0	0%	Derby Creek
53_ADC032	19,494	19,494	0	0%	Colorado River abv Glenw
700521	3,568	3,212	355	10%	CLEAR CREEK DITCH
700530	3,347	3,154	193	6%	CREEK AND NEWMAN DITCH
700550	1,573	1,135	438	28%	H V C AND S DITCH
700571	465	348	117	25%	NEW HOBO DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
700580	5,697	5,393	303	5%	RESERVOIR DITCH
700583	2,445	2,387	57	2%	ROAN CREEK NO 2 DITCH
700584	1,742	1,728	14	1%	ROAN CREEK NO 3 DITCH
700596	1,136	1,064	73	6%	UPPER ROAN CREEK DITCH
70_ADC049	13,662	11,822	1,841	13%	Upper Roan Creek
70_ADC050	3,110	3,110	0	0%	Colorado River nr Cameo
720512	1,692	1,692	0	0%	Arbogast Pump Div Sys
720514	1,459	1,416	43	3%	ARKANSAS DITCH
720533	2,804	2,639	165	6%	BERTHOLF LANHAM UPDIKE D
720542	7,419	7,868	-448	-6%	BONHAM BRANCH PIPELINE [3]
720557	452	451	2	0%	BULL BASIN HIGHLINE D
720558	3,438	3,052	386	11%	BULL CREEK DITCH
720574	1,769	1,714	55	3%	COAKLEY KIGGINS DITCH
720580	1,273	1,090	183	14%	COOK DITCH
720583	5,709	3,154	2,555	45%	COTTONWOOD BRANCH PL [3]
720596	852	763	90	11%	DAVENPORT D (COTTNWD)
720607	718	714	4	1%	EAKIN-SMITH DITCH
720616	1,243	1,181	63	5%	NEW ERIE CANAL
720628	1,316	1,313	3	0%	GALBRAITH DITCH
720643	1,224	1,196	28	2%	GOLDEN AGE DITCH
720644	1,914	1,889	25	1%	GRAND JCT COLO R PL
720645	260,410	259,930	480	0%	GRAND VALLEY CANAL
720646	0	0	0	0%	GRAND VALLEY PROJECT [1]
720649	1,843	1,801	42	2%	GROVE CR DITCH CO NO 1 D
720703	4,586	4,493	93	2%	HOOSIER DITCH
720721	744	721	24	3%	JOHNSON AND STUART DITCH
720729	858	846	12	1%	KIGGINS GOYN DITCH
720730	1,573	1,568	5	0%	KIGGINS SALISBURY DITCH
720731	2,695	2,409	286	11%	KING DITCH
720744	381	381	0	0%	LEON DITCH
720746	0	0	0	0%	LEON PARK FEEDER CANAL [1]
720764	152	152	0	0%	MARTIN CRAWFORD DITCH
720766	1,236	1,016	220	18%	Ute WCD Carver Ranch
720784	5,543	5,473	70	1%	MESA CREEK DITCH
720799	5,238	5,176	62	1%	MORMON MESA DITCH
720807	0	0	0	0%	MOLINA POWER PLANT [3]
720813	63,739	63,739	0	0%	ORCHARD MESA IRR DIS SYS
720816	814	814	0	0%	PALISADE TOWN PL (RAPID)
720818	4,062	3,796	266	7%	PALMER DITCH
720820	0	0	0	0%	Park Creek DivSys [1]
720821	236	205	31	13%	PARKER DITCH
720823	952	778	174	18%	PARK VIEW DITCH
720831	1,922	1,831	91	5%	PIONEER OF PLATEAU DITCH
720852	667	660	7	1%	RMG Div Sys
720870	3,698	3,600	98	3%	SILVER GAUGE DITCH
720879	0	0	0	25%	SOUTHSIDE CANAL [1]
720911	1,192	787	405	34%	TEMS DITCH
720920	7,254	7,253	1	0%	UTE PIPELINE HGT NO 2
720933	2,732	2,694	38	1%	WEST SIDE DITCH
720938	4,497	4,335	162	4%	WILDCAT DITCH (BIG CR)
721233	1,585	1,510	75	5%	UPPER HIGHT DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
721329	598	561	37	6%	Rapid Creek PP DivSys
721330	0	0	0	0%	COLORADO R PUMPING PLANT
721339	541	231	310	57%	COON CREEK PIPELINE
721487	0	500	-500	0%	UTE PIPELINE HGT NO _DIV
724715	1,676	1,676	0	0%	LEON TUNNEL CANAL
724721	0	0	0	0%	OWENS CREEK DITCH [1]
72_ADC051	1,781	1,732	49	3%	Plateau Creek abv Vega R
72_ADC052	2,707	2,703	4	0%	Plateau Creek bl Vega Rs
72_ADC053	7,192	7,141	50	1%	Salt Creek
72_ADC054	4,095	3,924	170	4%	Upper Buzzard Creek
72_ADC055	3,621	3,621	0	0%	Plateau Creek bl Buzzard
72_ADC056	3,380	3,310	70	2%	Upper Grove Creek
72_ADC057	4,101	3,990	111	3%	Lower Grove Creek
72_ADC058	4,340	4,340	0	0%	Kimball Creek
72_ADC059	7,251	6,749	502	7%	Big Creek
72_ADC060	3,120	2,697	423	14%	Cottonwood Creek
72_ADC061	5,403	4,710	693	13%	Bull Creek
72_ADC062	4,014	3,902	112	3%	Coon Creek
72_ADC063	3,431	3,409	22	1%	Mesa Creek
72_ADC064	3,112	3,112	0	0%	Plateau Creek
72_ADC065	12,407	12,407	0	0%	Colorado River nr State
72_AMC001	0	0	0	0%	72_AMC001 Colorado River
950001	322,079	321,372	707	0%	Grand Valley Project
950002	215,646	214,283	1,363	1%	USA Power Plant
950003	0	0	0	0%	Orchard Mesa Check [4]
950004	100,767	100,766	0	0%	OMID Hydraulic Pump
950005	0	0	0	0%	OMID Pre-1985 Bypass [4]
950006	0	0	0	0%	OMID Post-1985 Bypass [4]
950007	44,956	44,180	775	2%	USA PP-Winter-OM Stip
950008	43,755	43,537	218	0%	USA PP-Summer-OM Stip
950010	4,231	4,185	46	1%	Dry Elk Valley Irr
950011	12,812	12,619	193	2%	Farmers Irrigation Comp
950020	0	0	0	0%	Ute Water Treatment
950030	889	884	5	1%	Mason Eddy-Ute
950050	27,147	27,030	117	0%	Redlands Power Canal Irr
950051	6,589	6,274	315	5%	Grand Junction Demands
950060	0	0	0	0%	Green_Mtn_Contract_Dem.
950061	0	0	0	0%	Green_Mtn_Annual_Rep_Est.
952001	1,642	1,642	0	0%	15-Mile Fish Requirement
953001	0	0	0	0%	Ruedi Rnd 1-Muni Demand
953002	0	0	0	0%	Ruedi Rnd 1-Ind Demand
953003	0	0	0	0%	Ruedi Rnd 2-Muni Demand
953004	0	0	0	0%	Ruedi Rnd 2-Ind Demand
953005	0	0	0	0%	Ruedi Addl Demand
953101	0	0	0	0%	Wolford Fraser Demand
953102	0	0	0	0%	Wolford MidPark Demand
953103	0	0	0	0%	Wolford Market Demand
953668D	0	0	0	0%	HUP Release Node
953709D	0	0	0	0%	HUP Release Node
954512D	0	0	0	0%	HUP Release Node
954516D	0	0	0	0%	HUP Release Node

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
954683	8,662	8,540	122	1%	Continental_Hoosier_Tunn
954699	0	0	0	0%	Boustead_Summary
955001	1,428	1,428	0	0%	Vail Valley Consolidated
955002	388	286	101	26%	Keystone Municipal
955003	1,345	1,320	25	2%	Vail Valley Consolidated
956001	0	0	0	0%	Future Depletion #1
956002	0	0	0	0%	Future Depletion #2
Basin Total	**4,167,036**	**4,118,164**	**48,872**	**1.8%**	

1) Carrier Structures – demand and use reported at user structure
2) Green Mountain Reservoir modeled operations are based on current operations and differ from historical operations
3) Molina Power Plant is operated with the demand at the power plant (720807) but historic diversions were recorded at the two carrier structures (720542 and 720583) therefore, historic diversions and simulated diversions are shown at the carrier structures
4) OMID Check and Bypass operations redivert USA Power Plant diversions, so are not reported again here



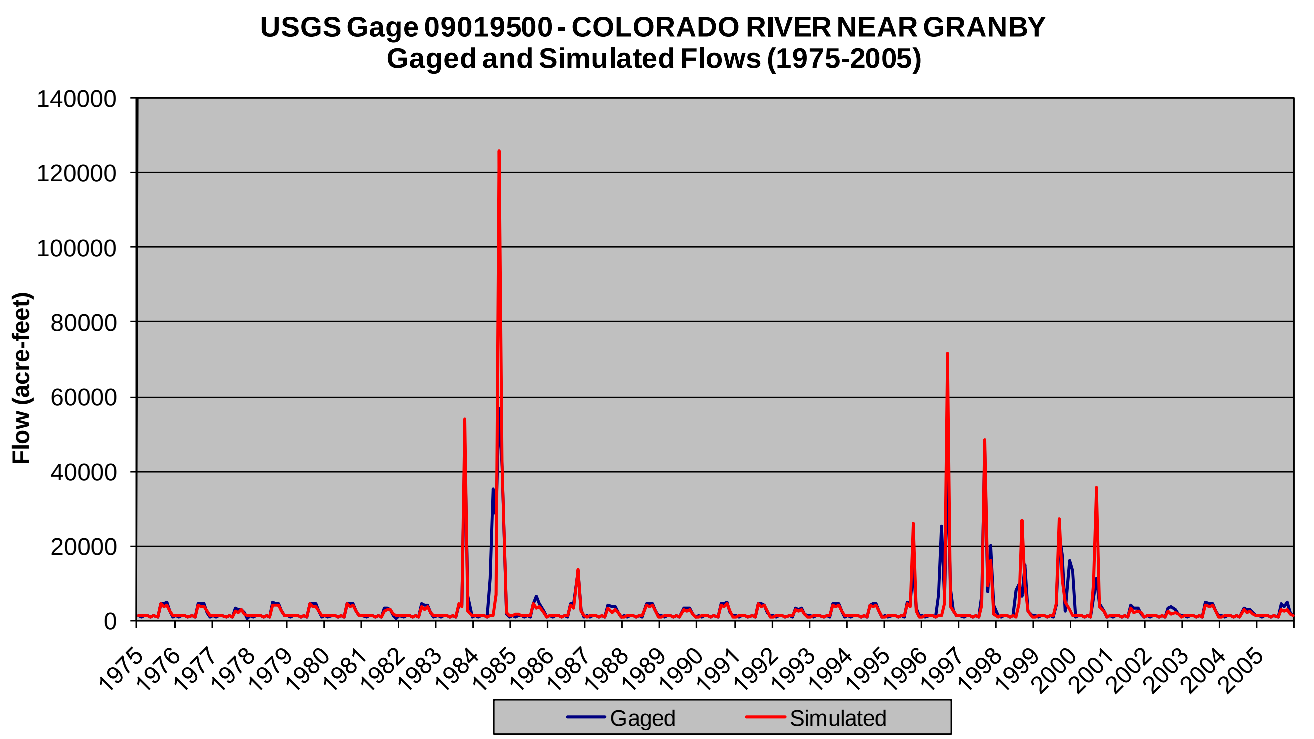
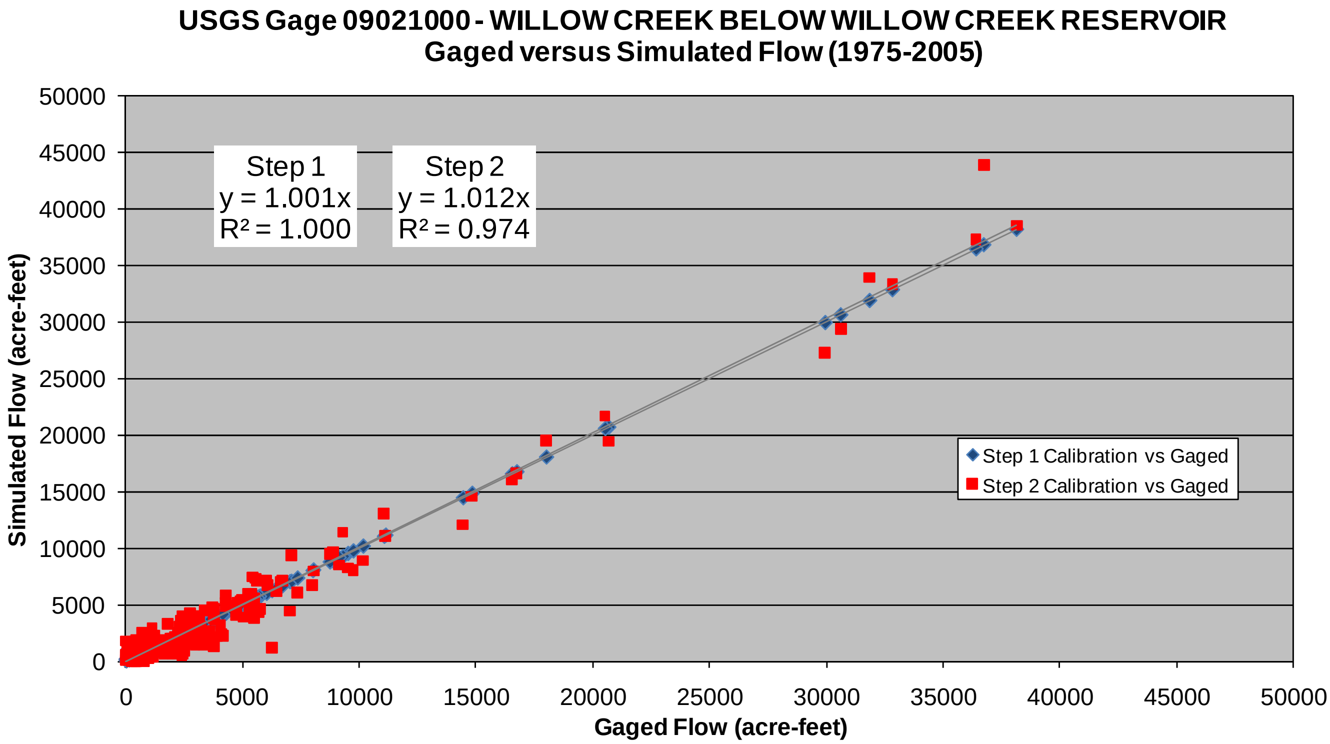


Figure 7.1 Streamflow Calibration – Colorado River near Granby



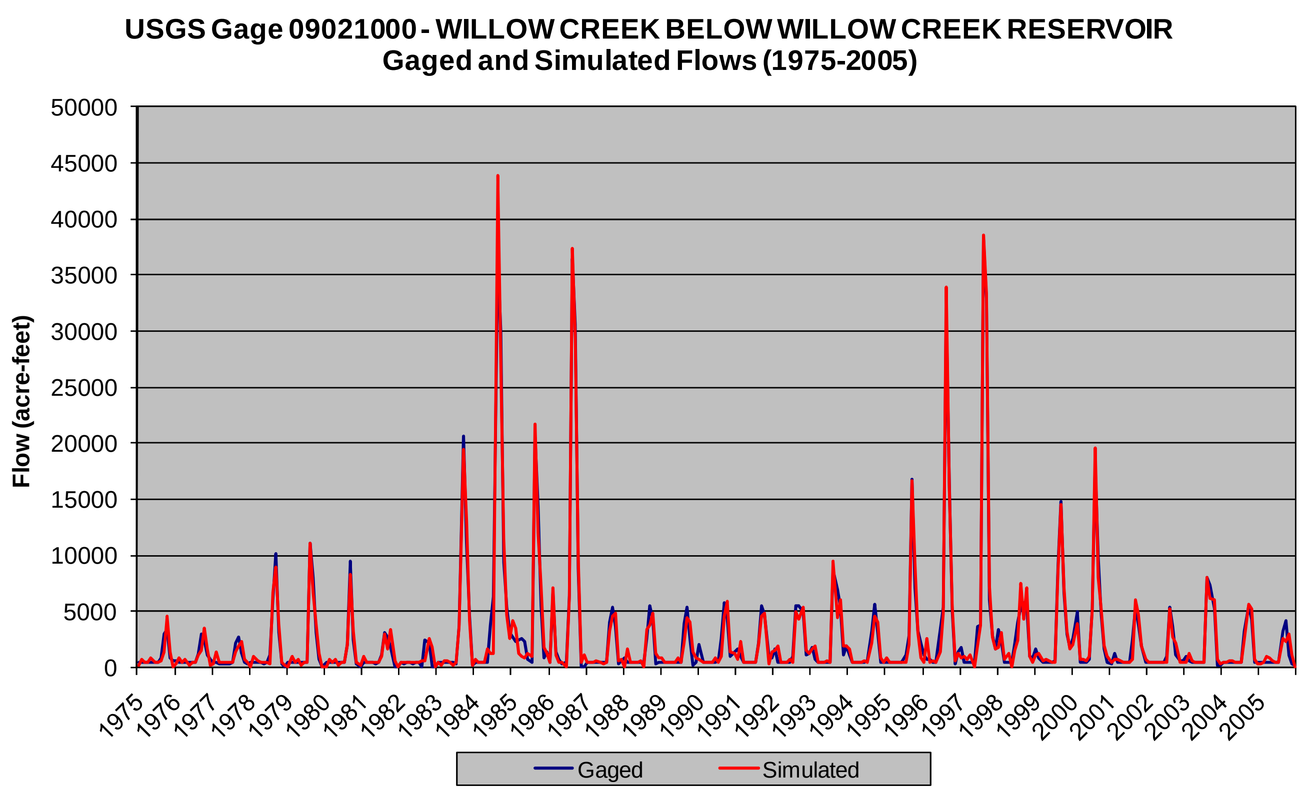
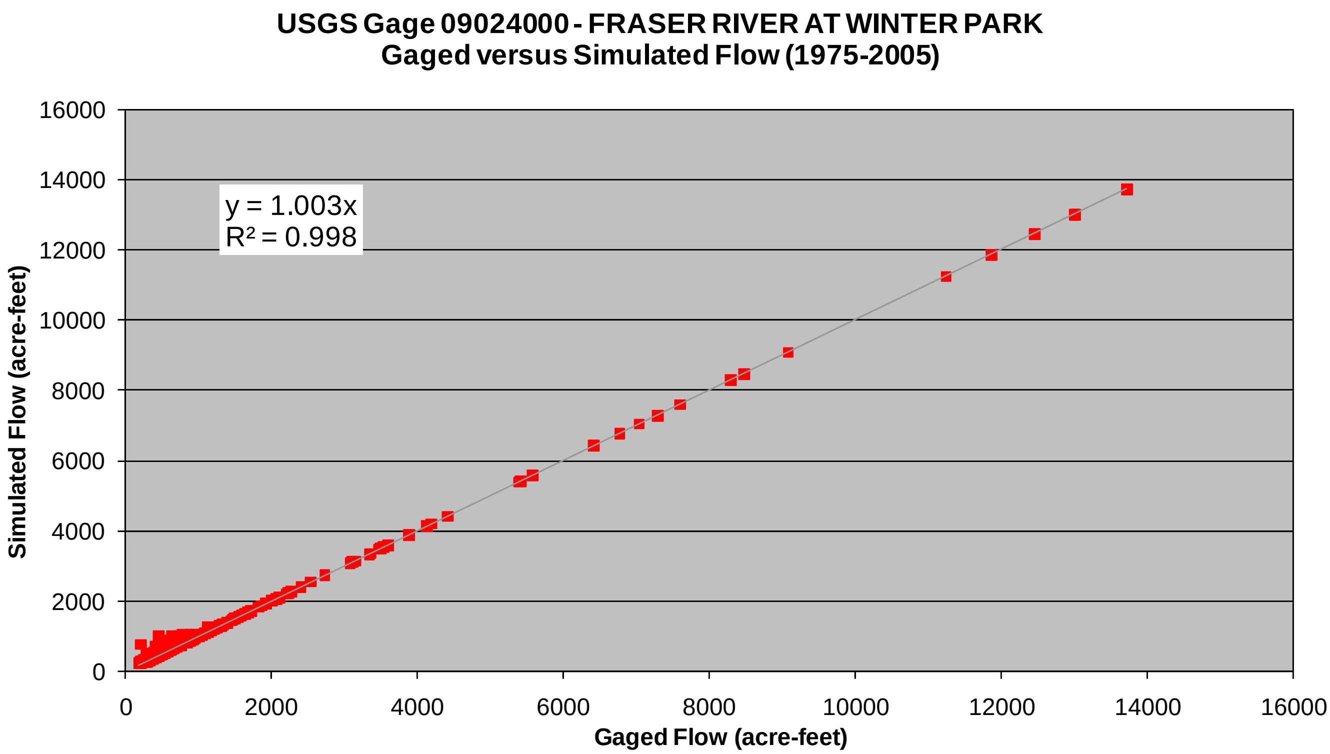


Figure 7.2 Streamflow Calibration – Willow Creek below Willow Creek Reservoir



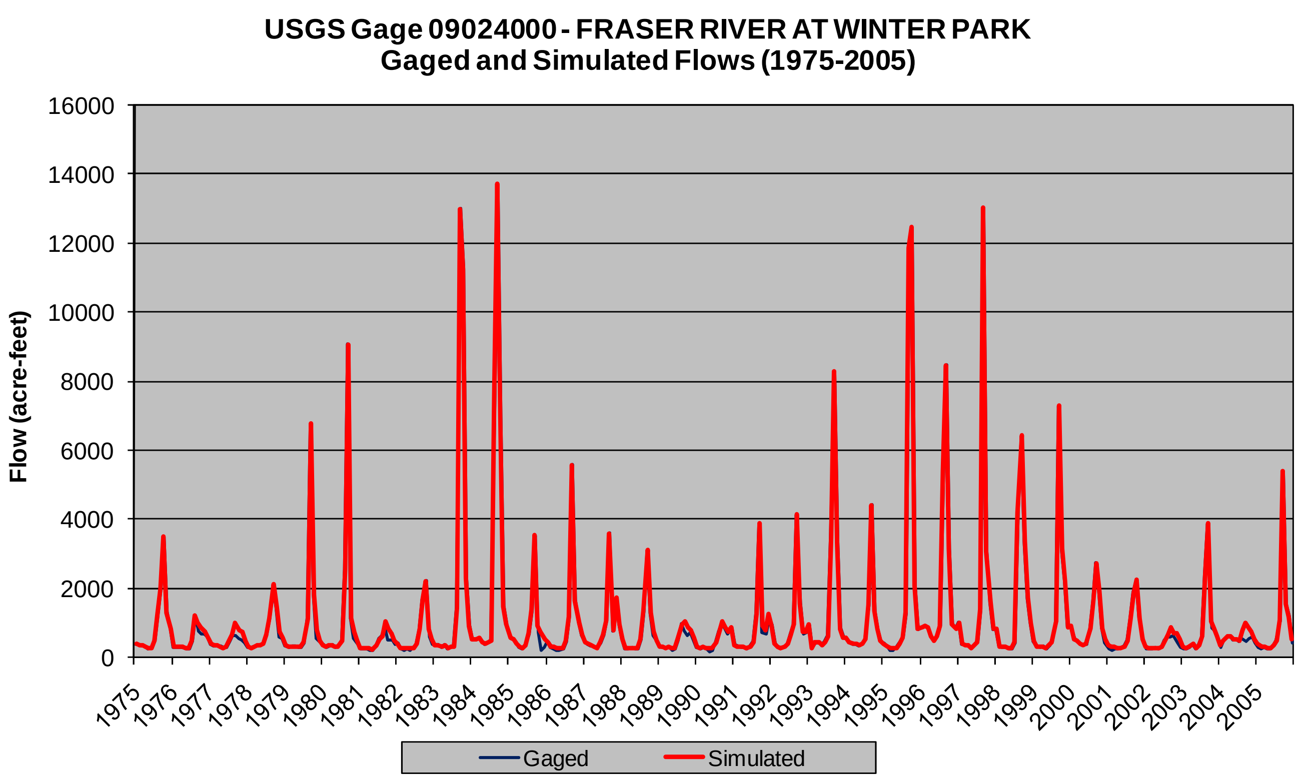
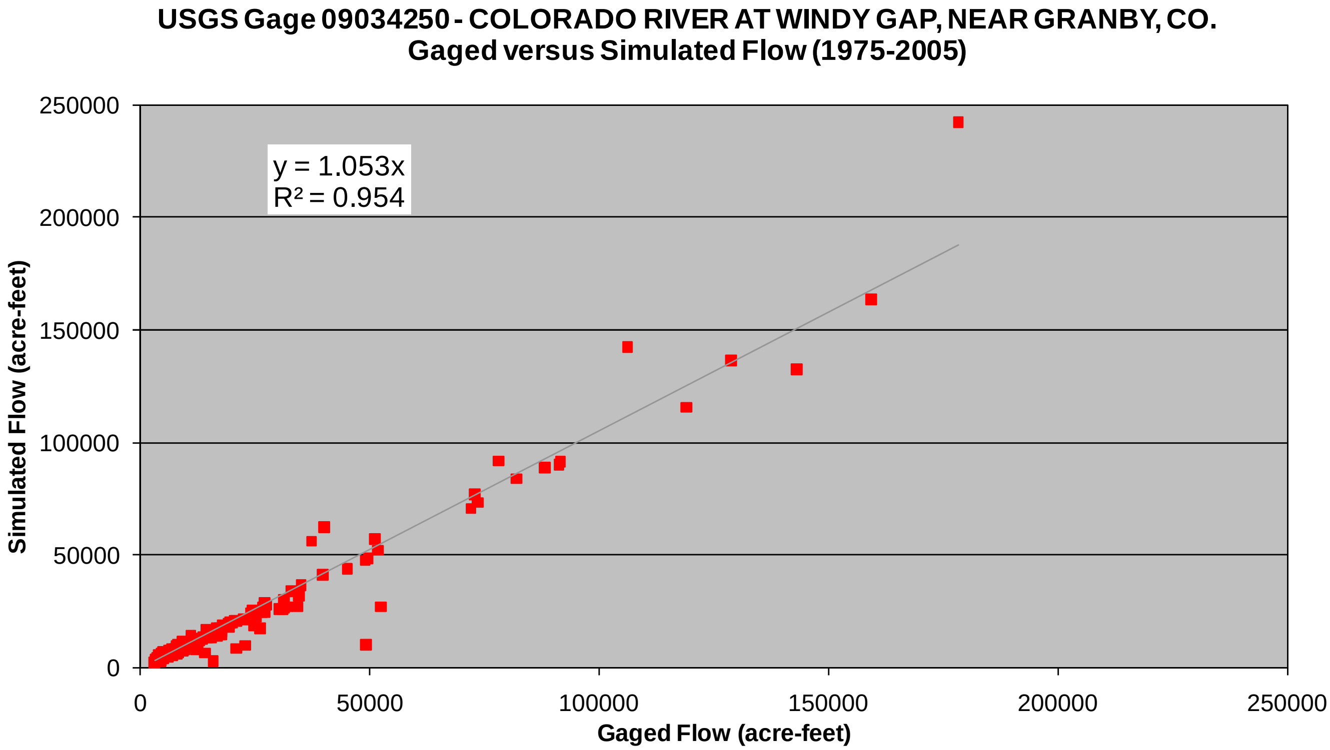


Figure 7.3 Streamflow Calibration – Fraser River at Winter Park



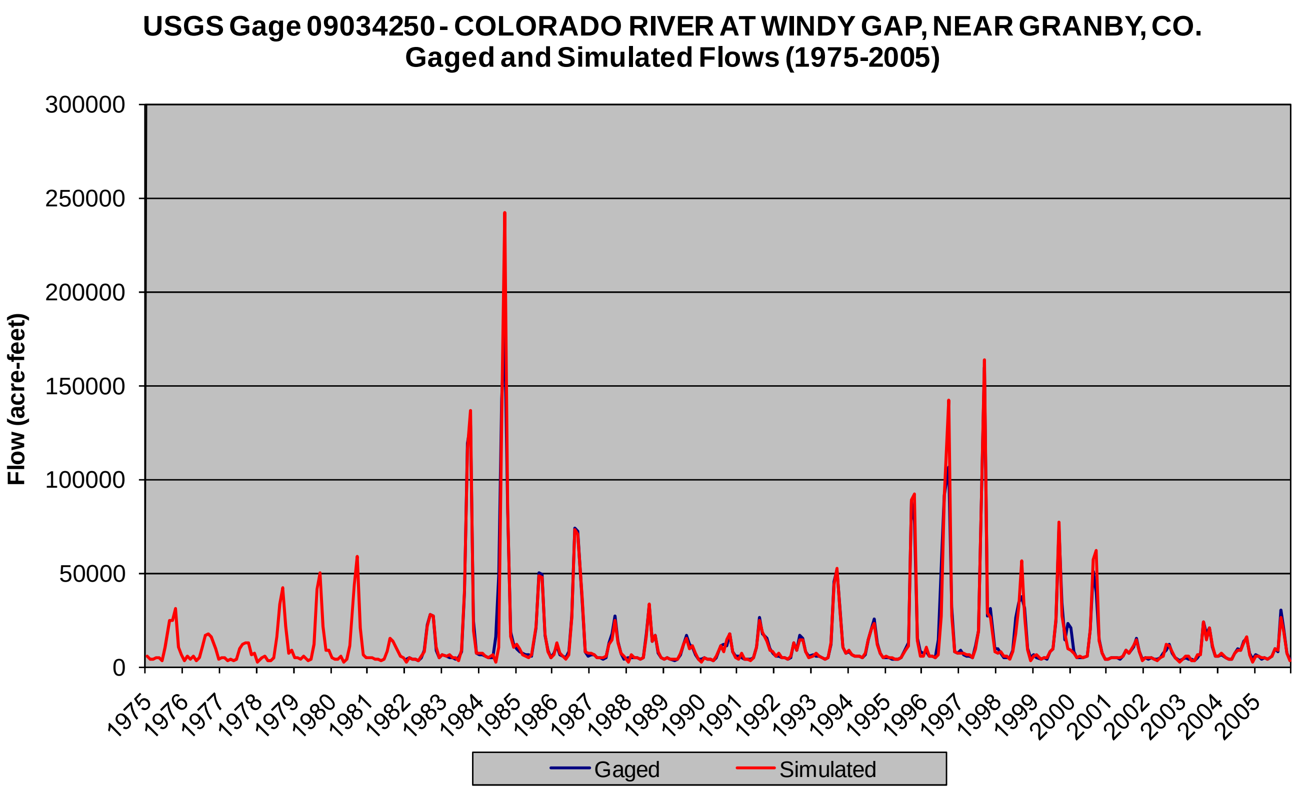
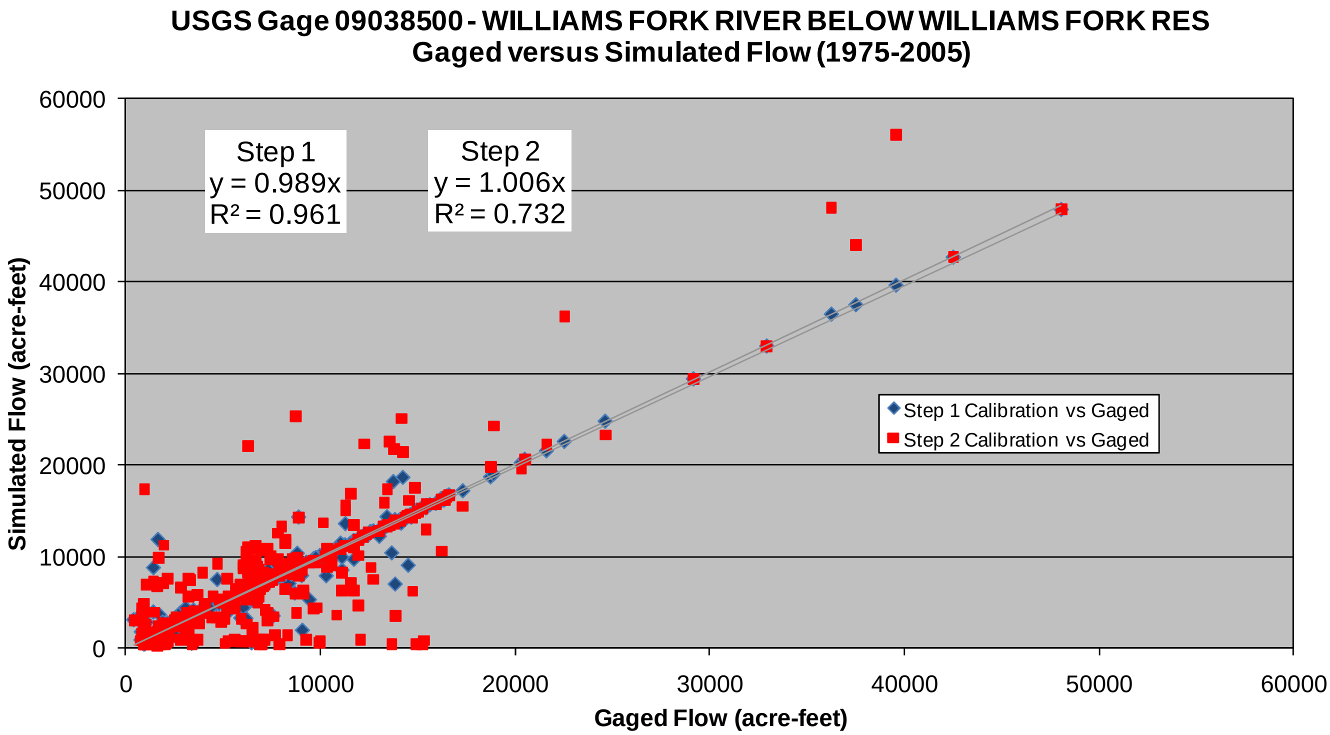


Figure 7.4 Streamflow Calibration – Colorado River at Windy Gap, near Granby, CO.



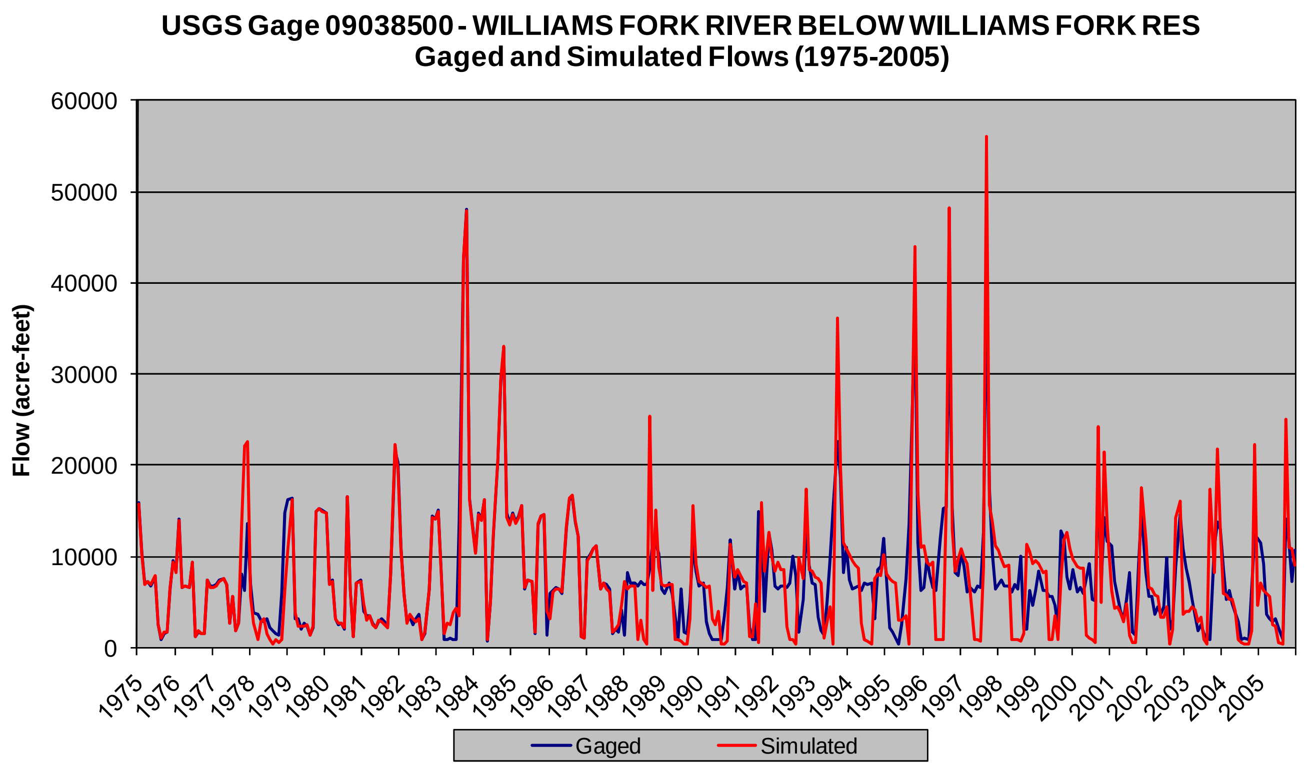
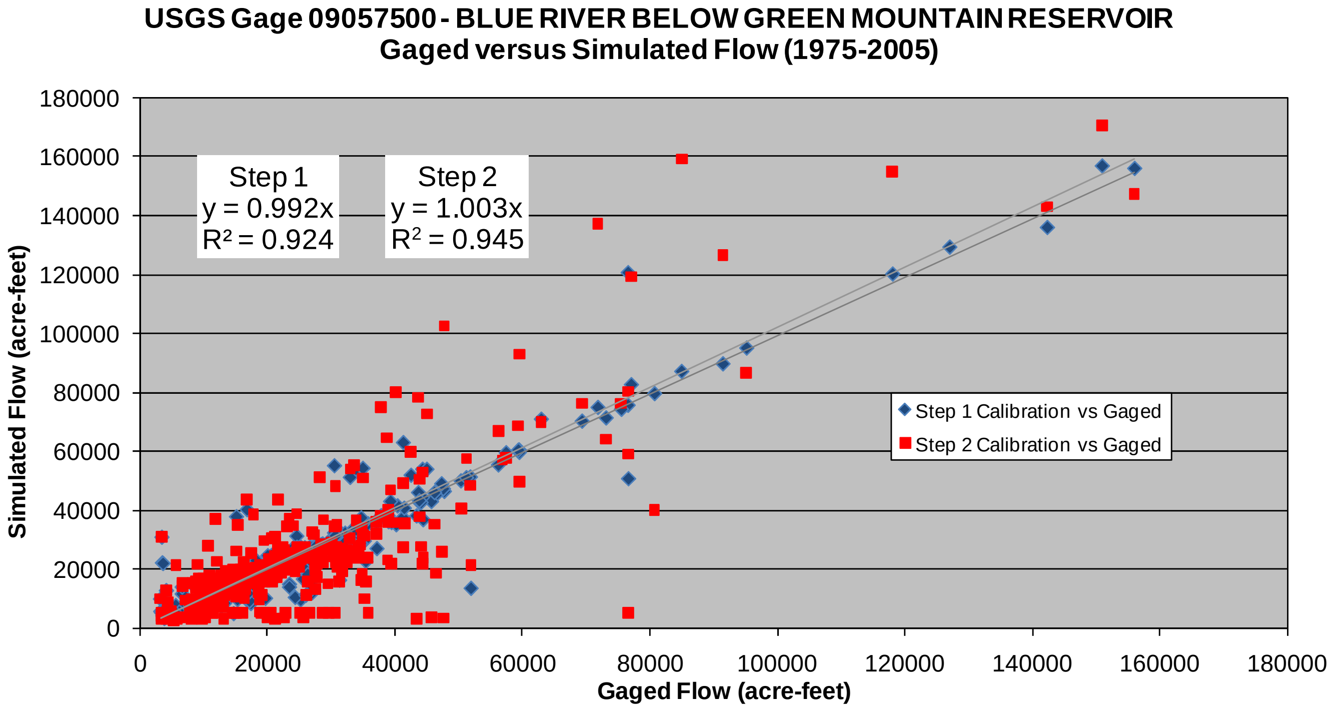


Figure 7.5 Streamflow Calibration – Williams Fork River below Williams Fork Res.



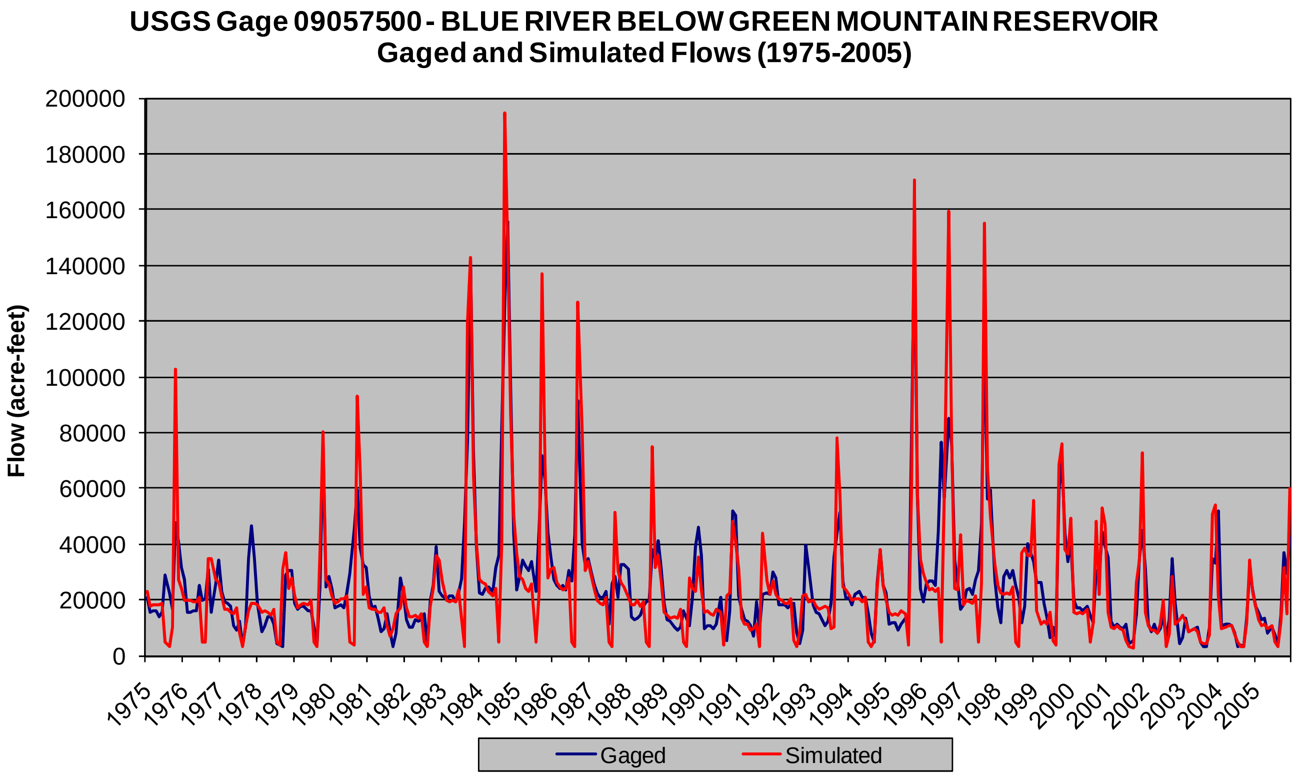
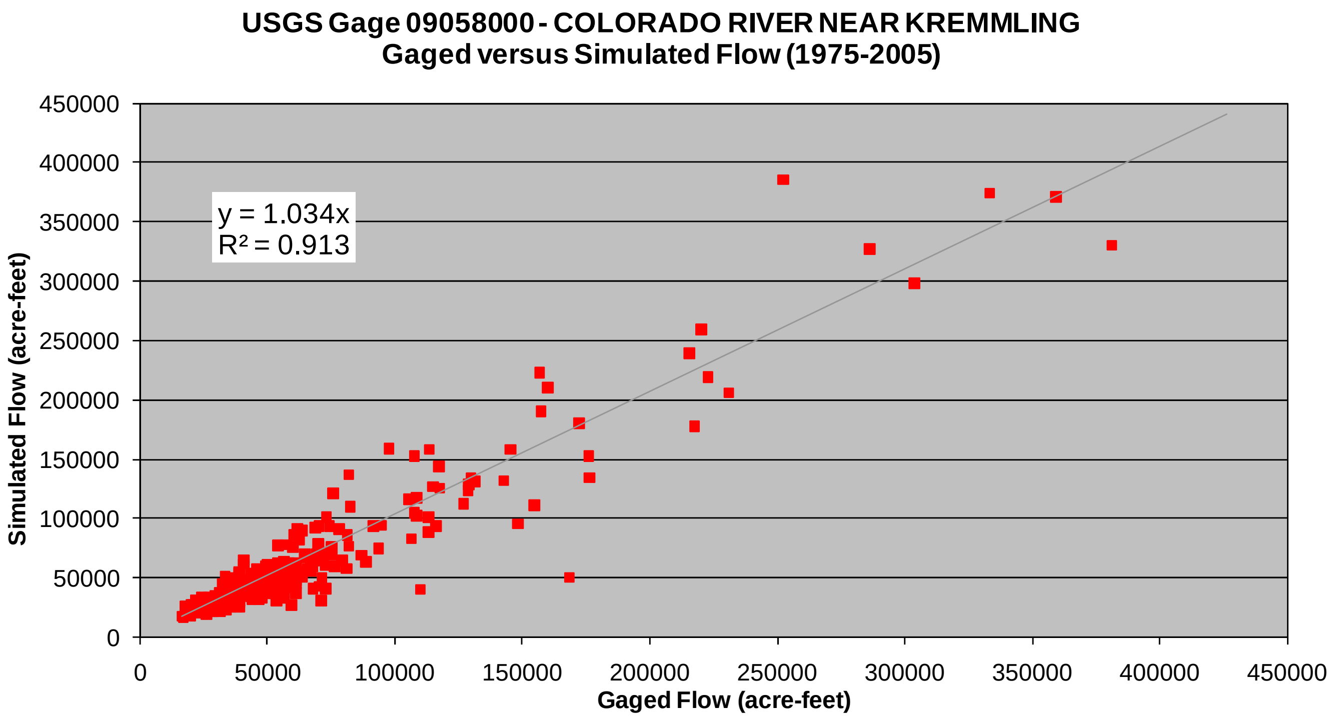


Figure 7.6 Streamflow Calibration – Blue River below Green Mountain Reservoir



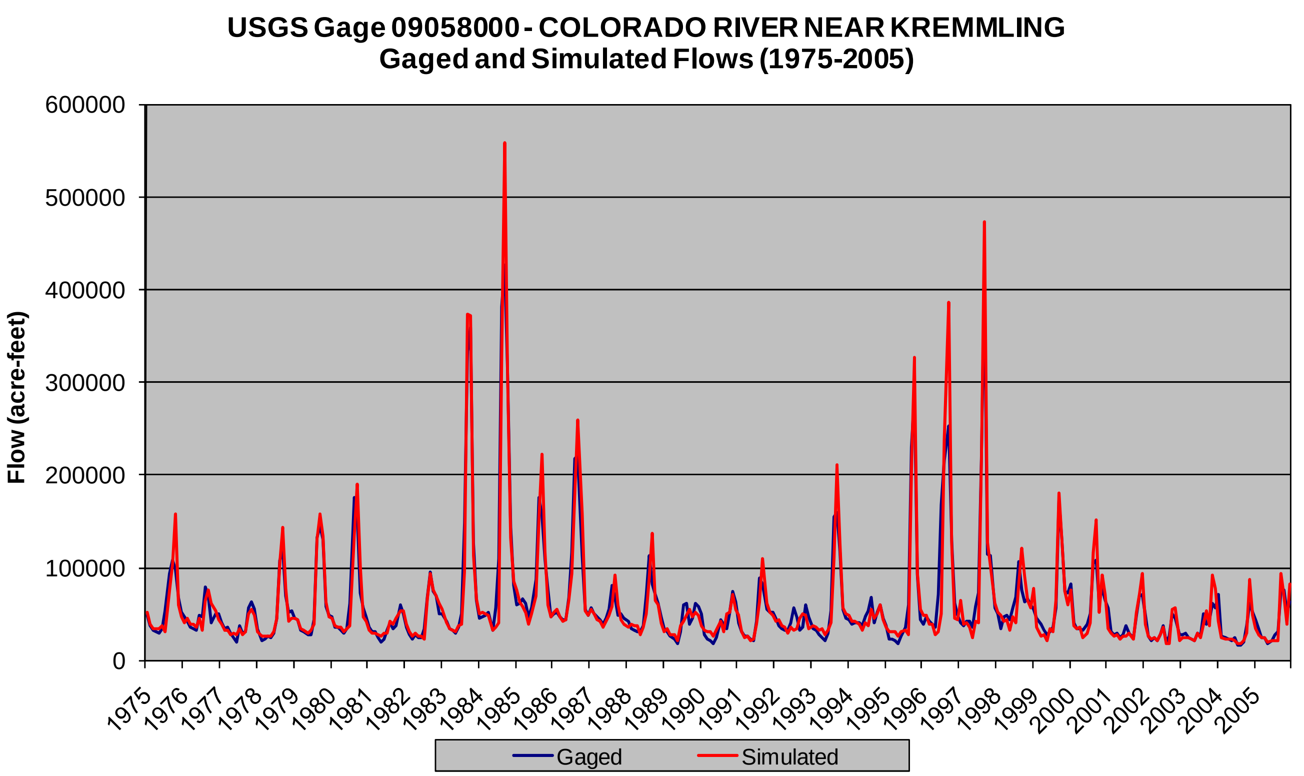
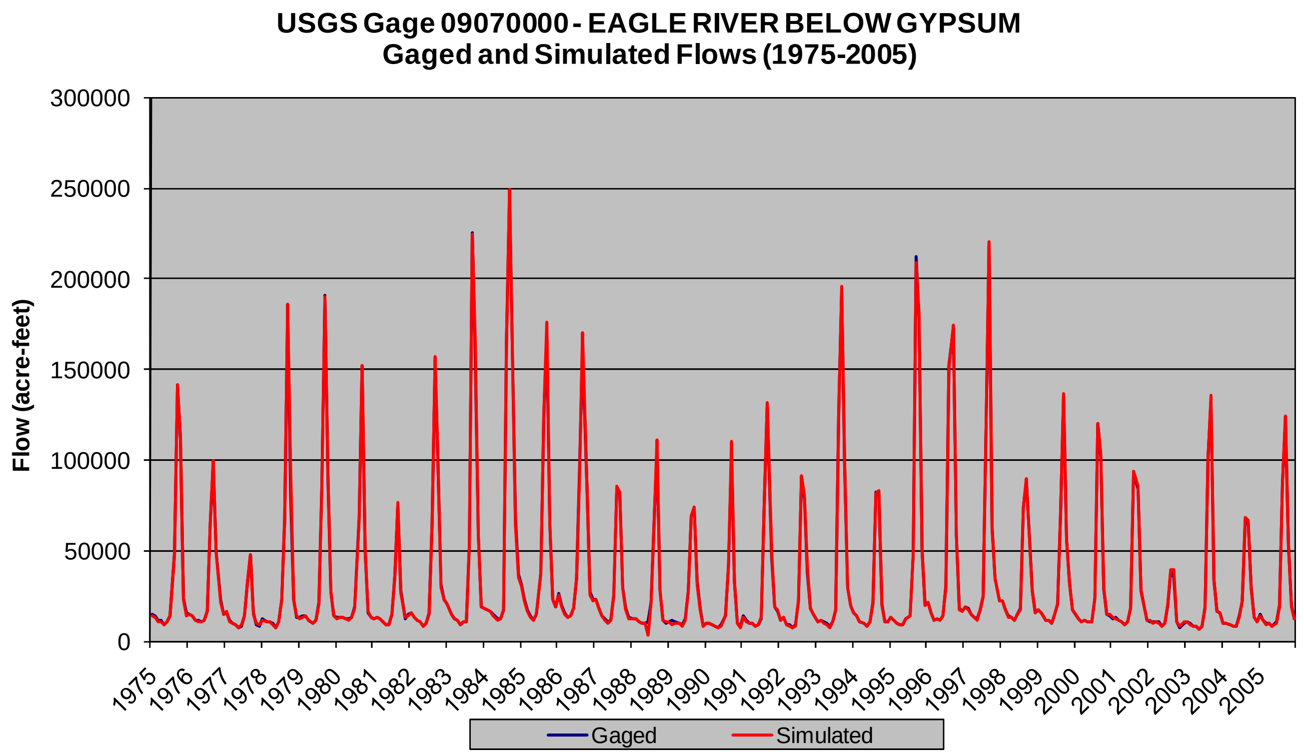


Figure 7.7 Streamflow Calibration – Colorado River near Kremmling



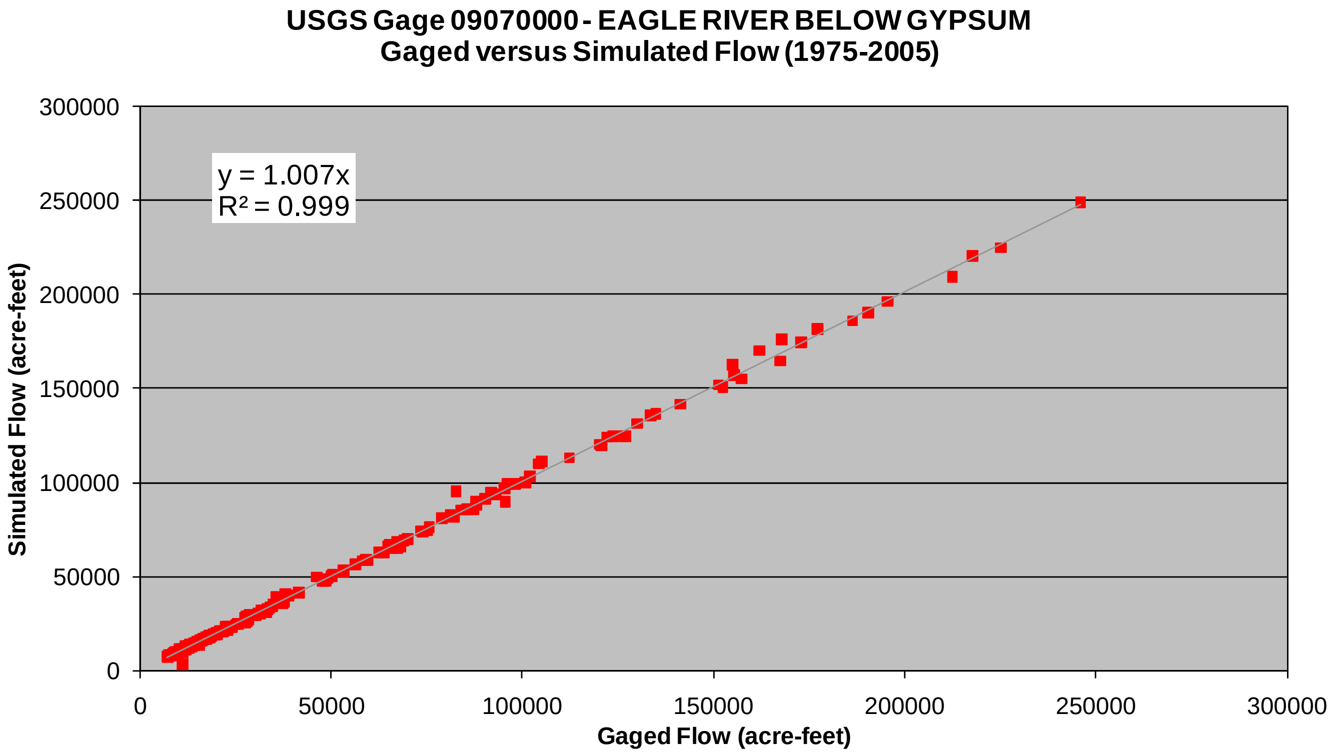
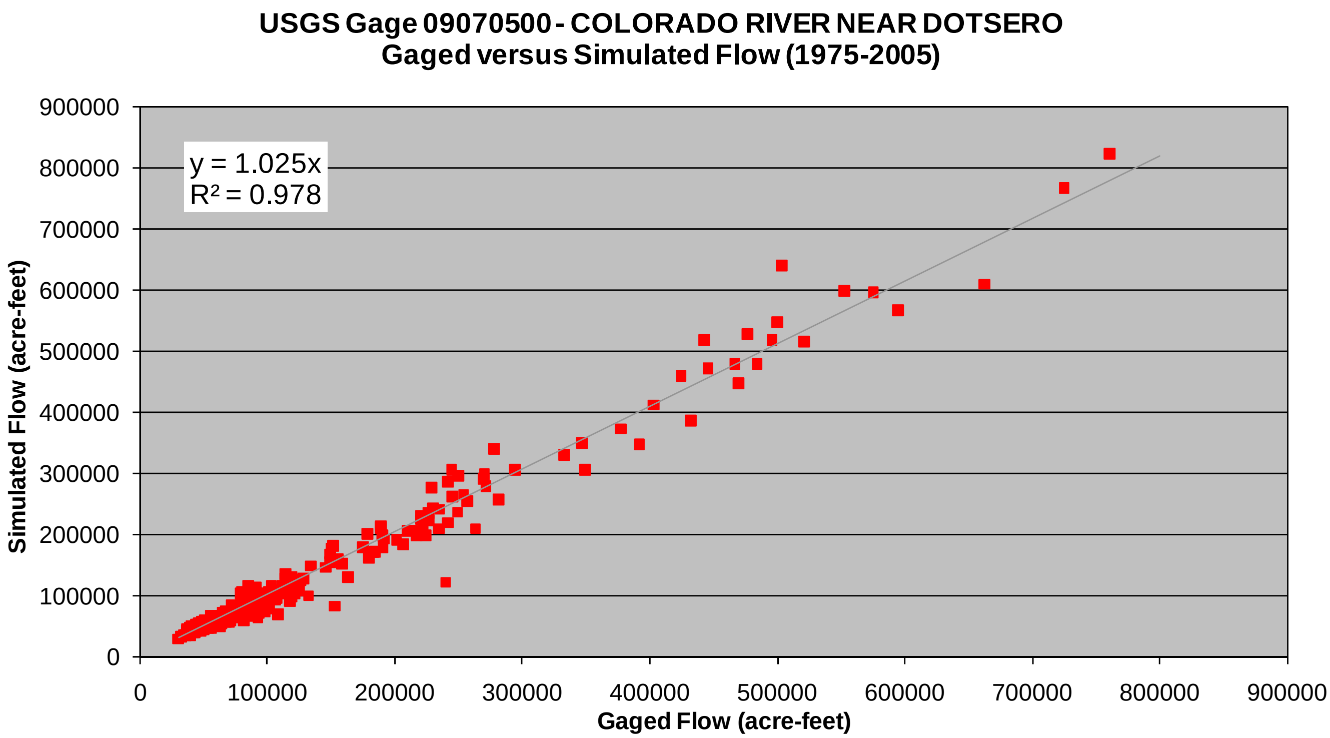


Figure 7.8 Streamflow Calibration – Eagle River below Gypsum



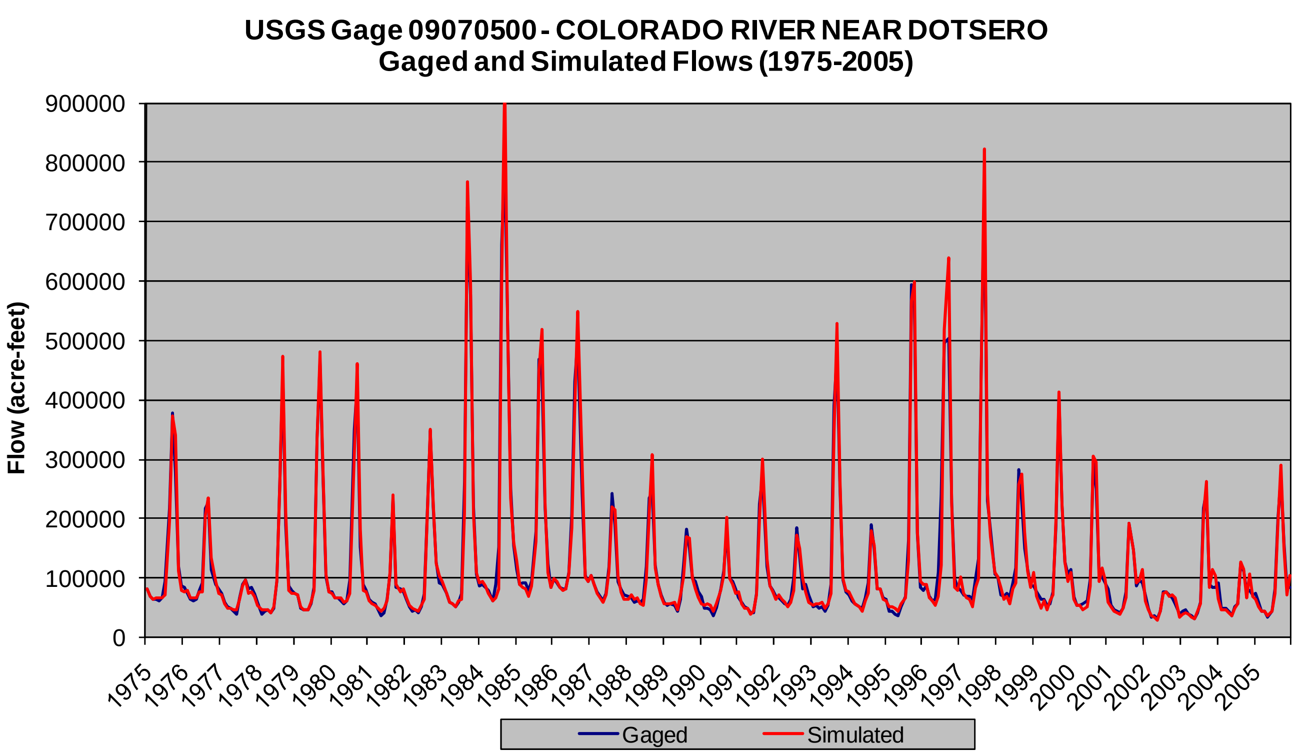
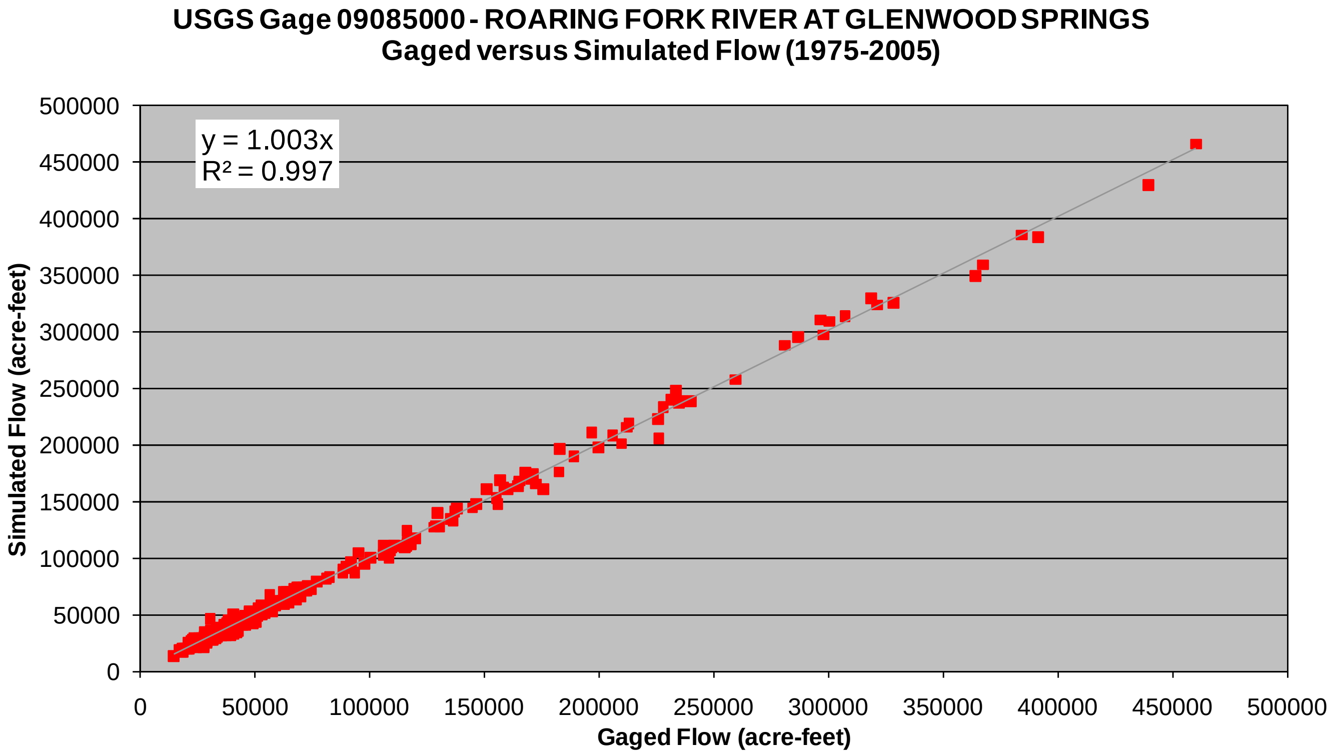


Figure 7.9 Streamflow Calibration – Colorado River near Dotsero



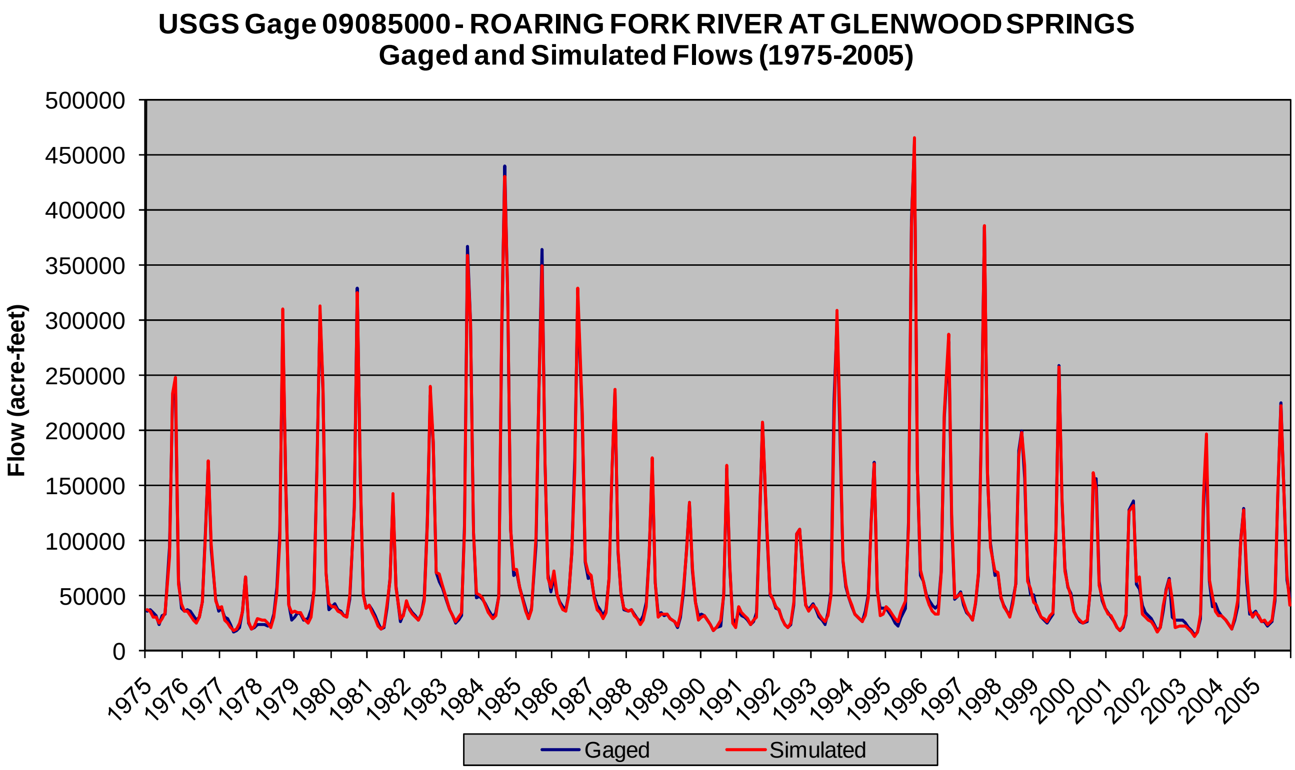
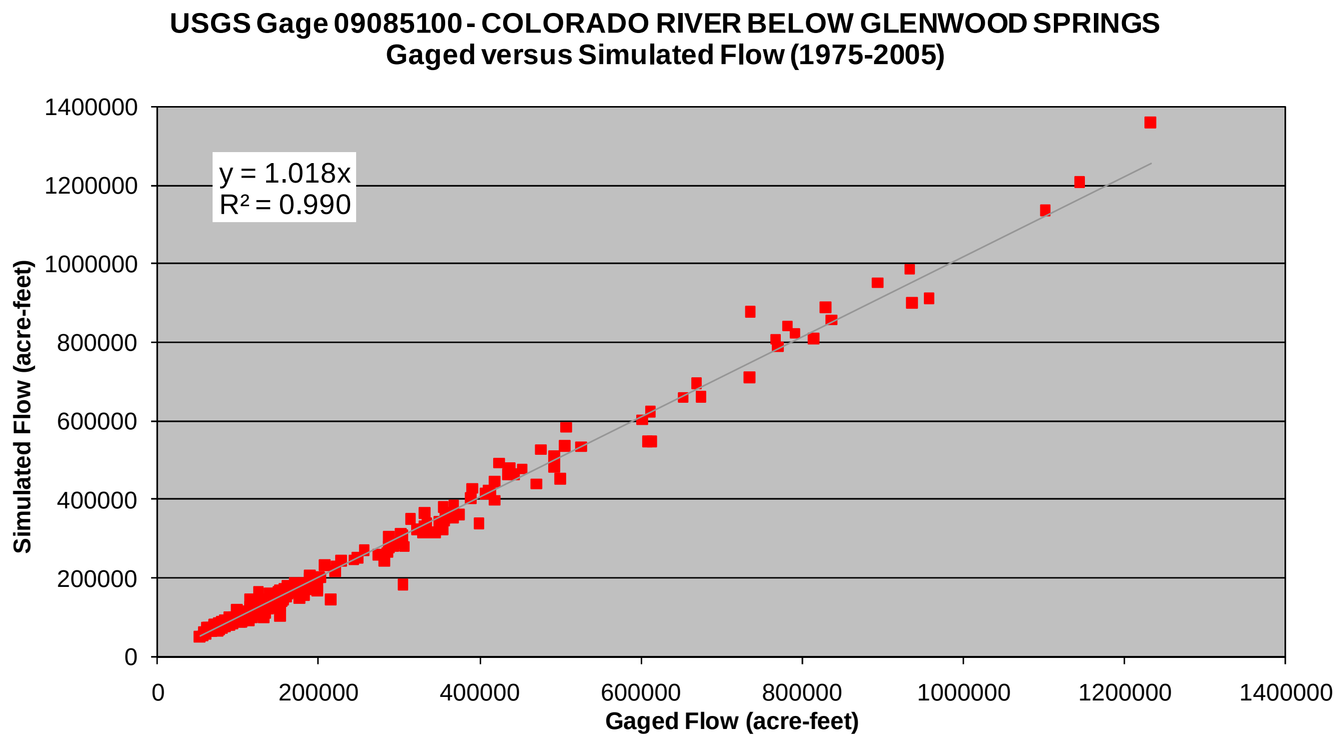


Figure 7.10 Streamflow Calibration – Roaring Fork River at Glenwood Springs



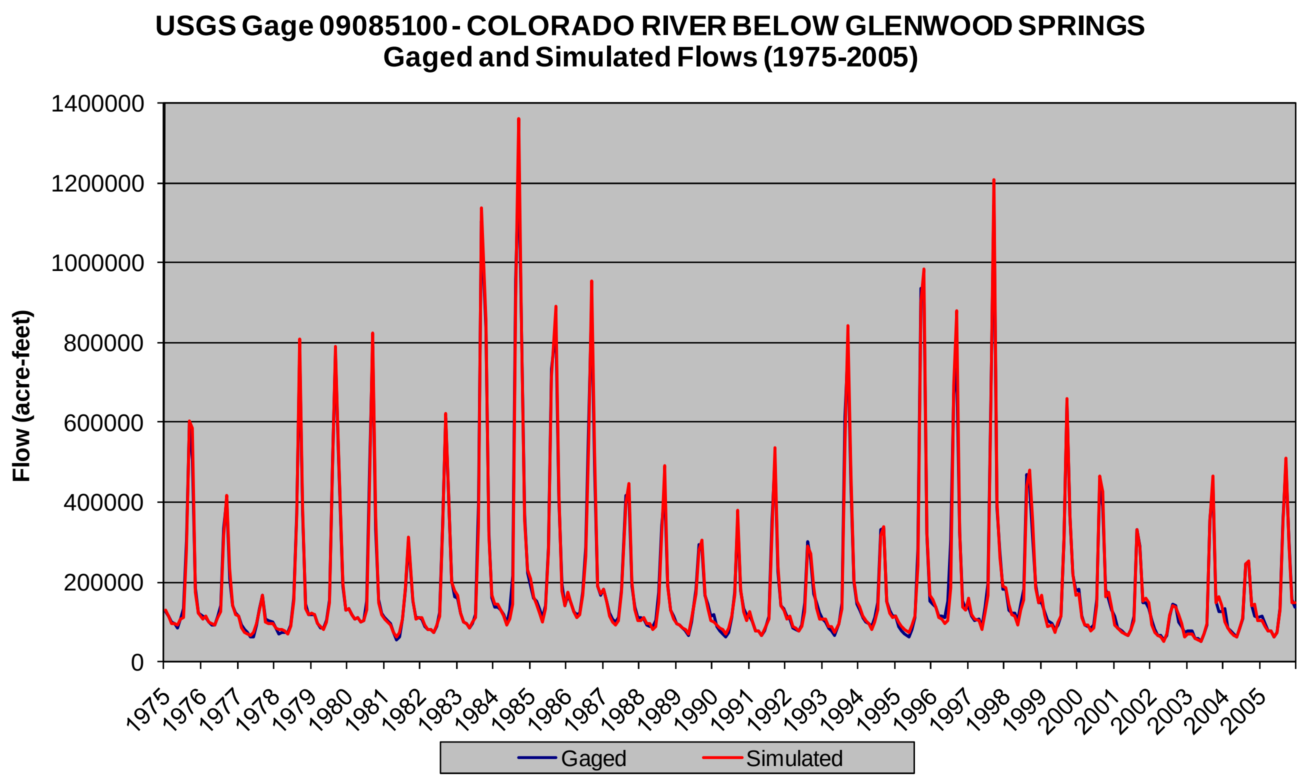
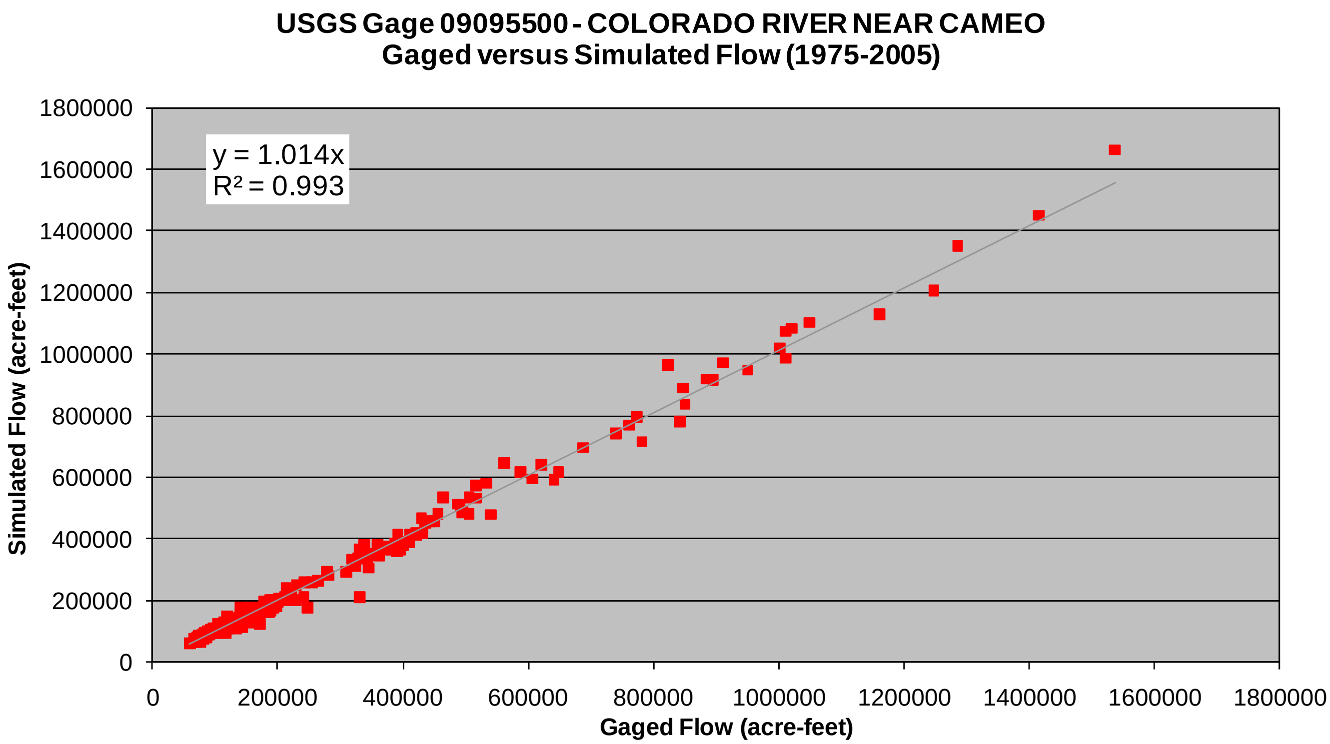


Figure 7.11 Streamflow Calibration – Colorado River below Glenwood Springs



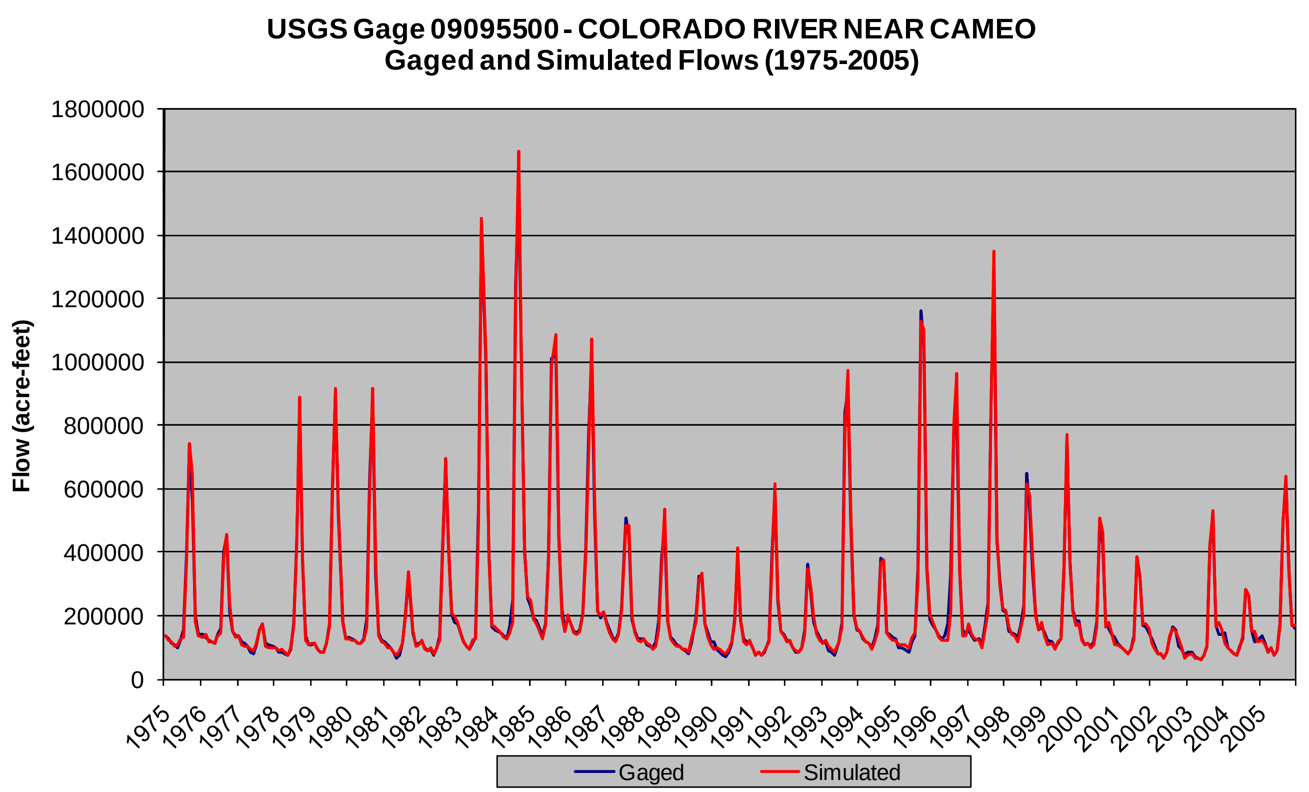
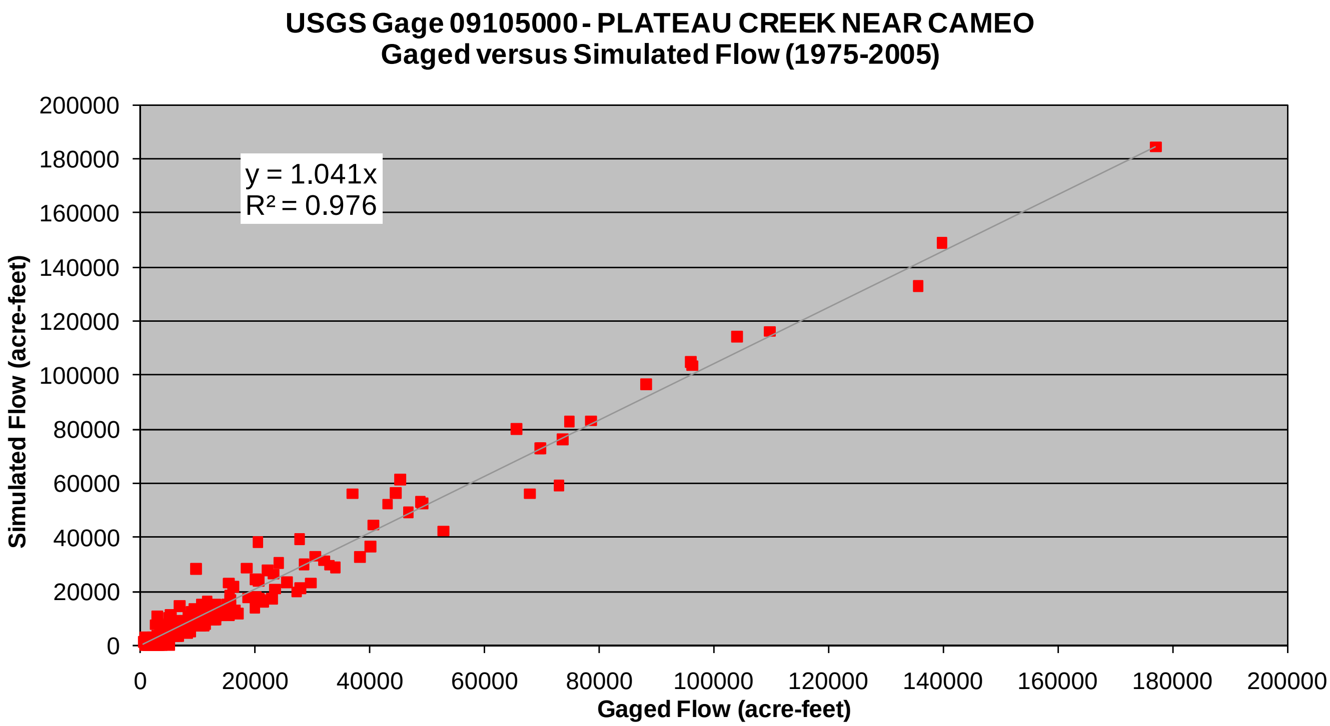


Figure 7.12 Streamflow Calibration – Colorado River near Cameo



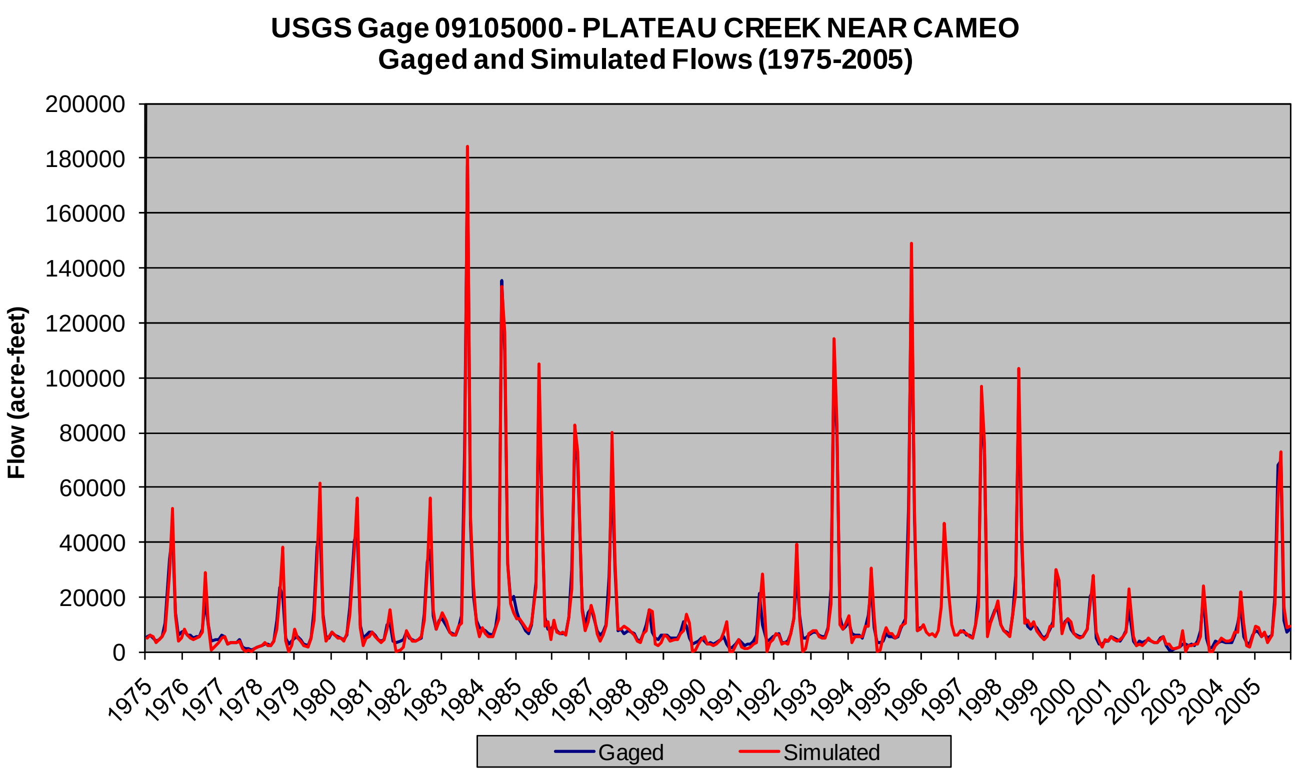
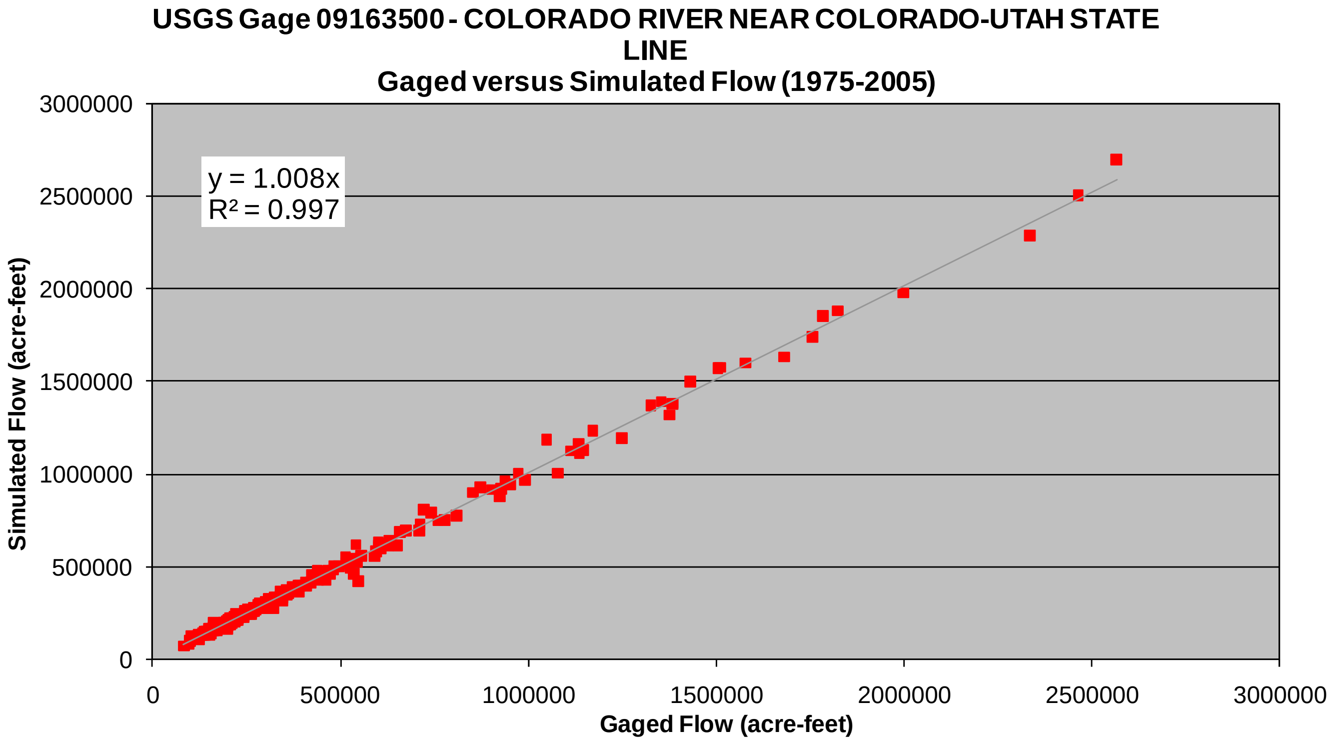


Figure 7.13 Streamflow Calibration – Plateau Creek near Cameo



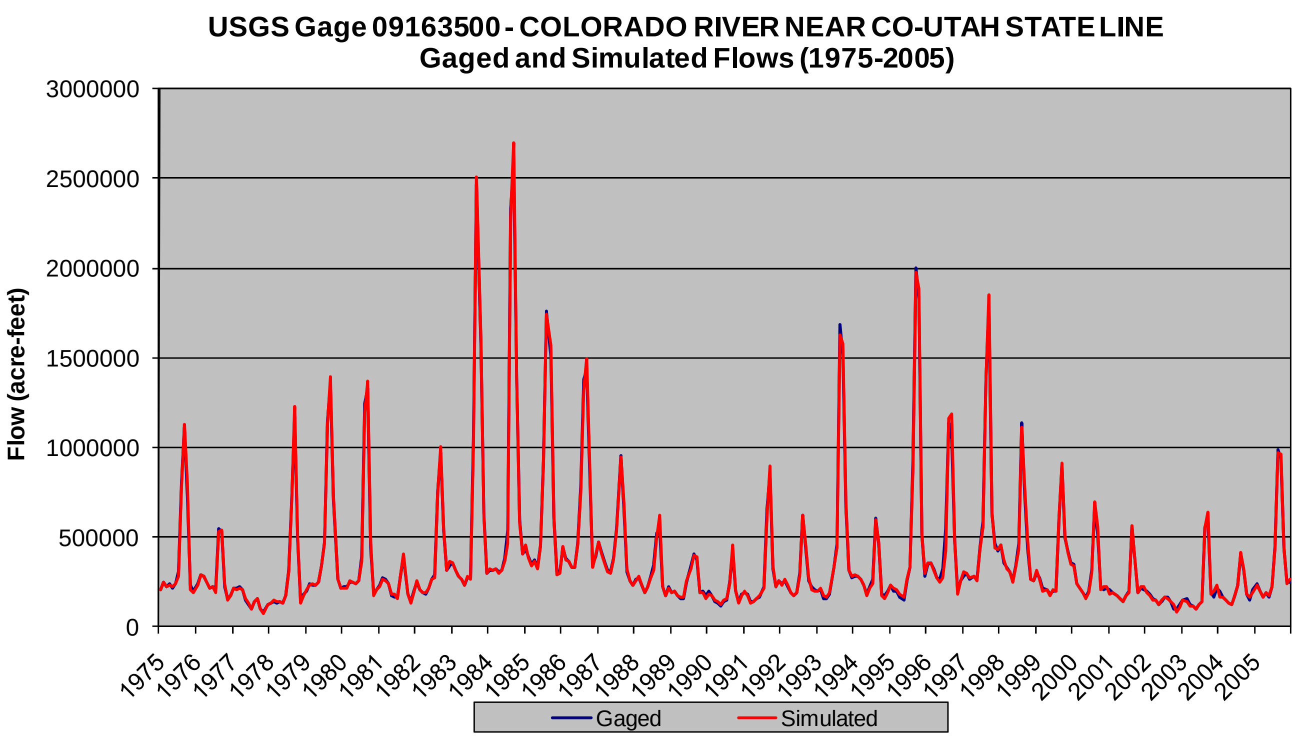


Figure 7.14 Streamflow Calibration – Colorado River near Colorado-Utah State Line

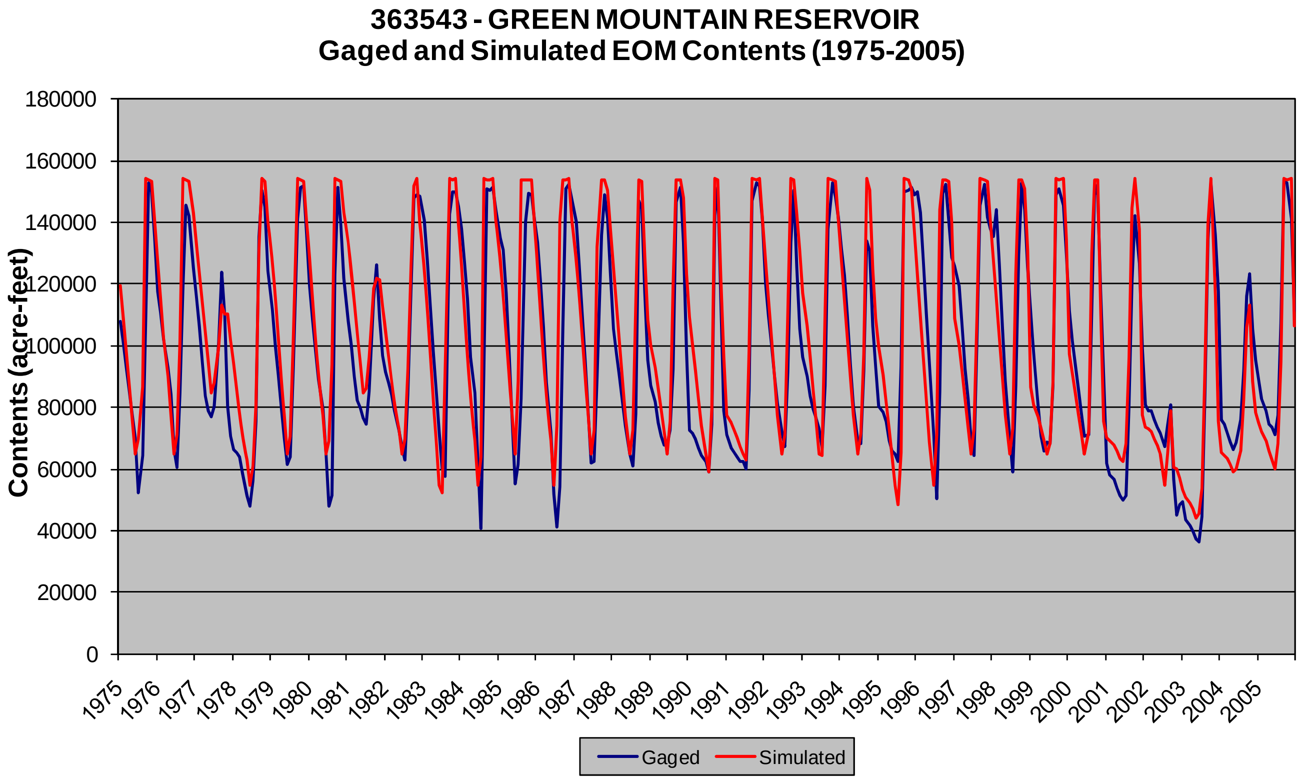


Figure 7.15 Reservoir Calibration – Green Mountain Reservoir

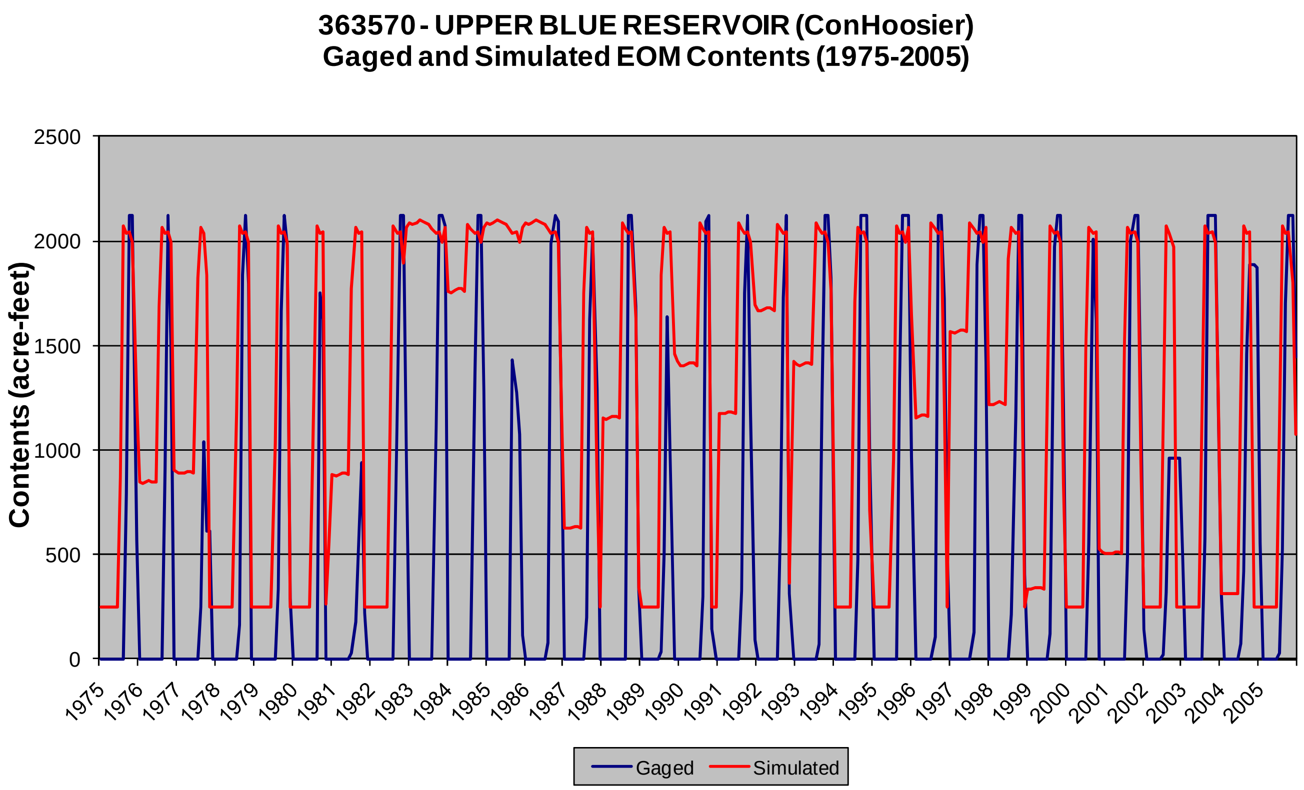


Figure 7.16 Reservoir Calibration – Upper Blue Reservoir (ConHoosier)

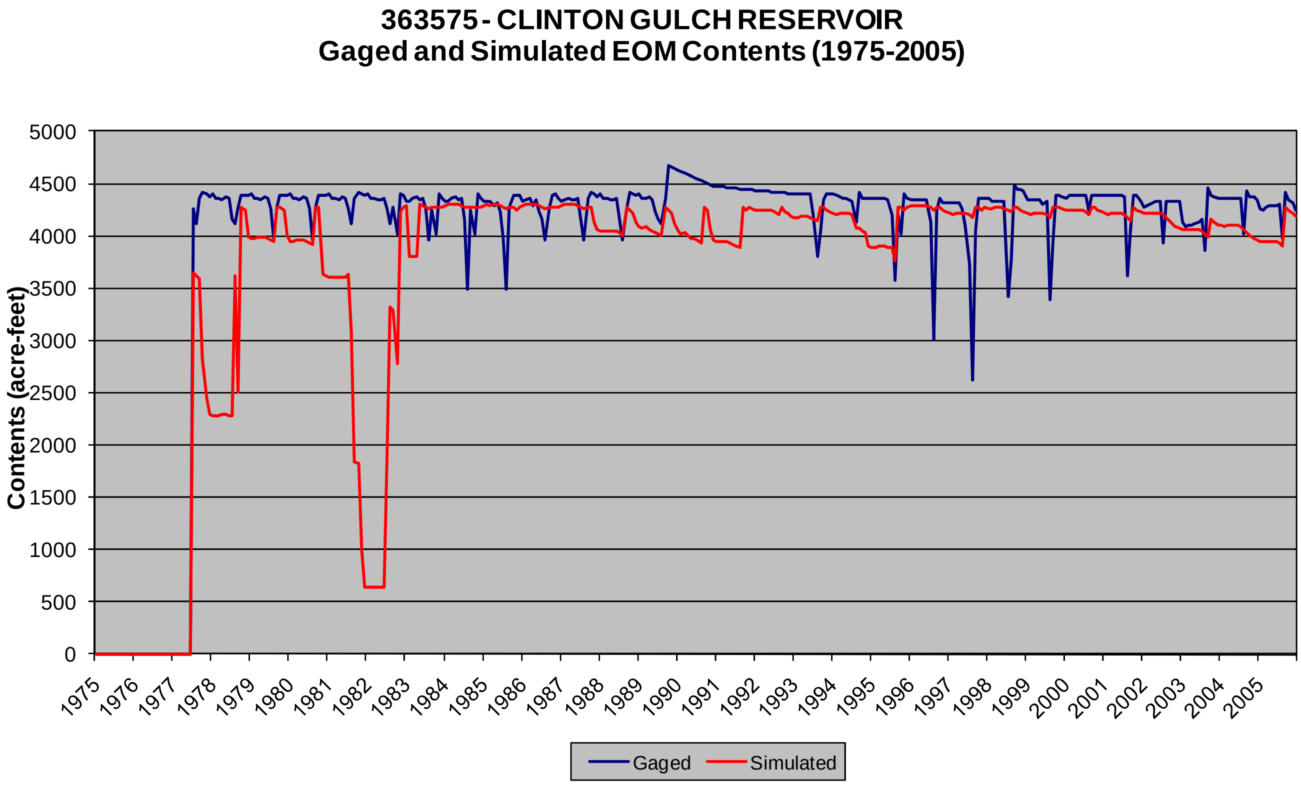


Figure 7.17 Reservoir Calibration – Clinton Gulch Reservoir

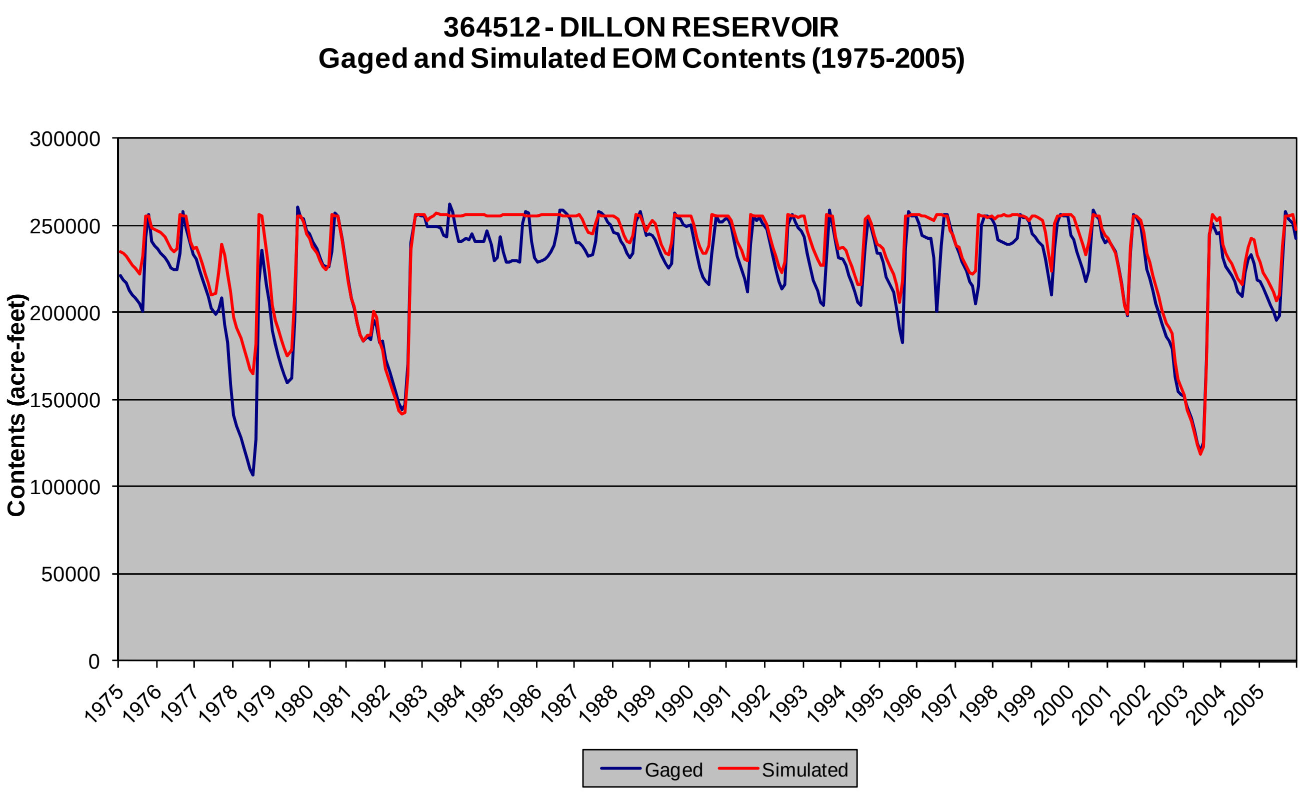


Figure 7.18 Reservoir Calibration – Dillon Reservoir

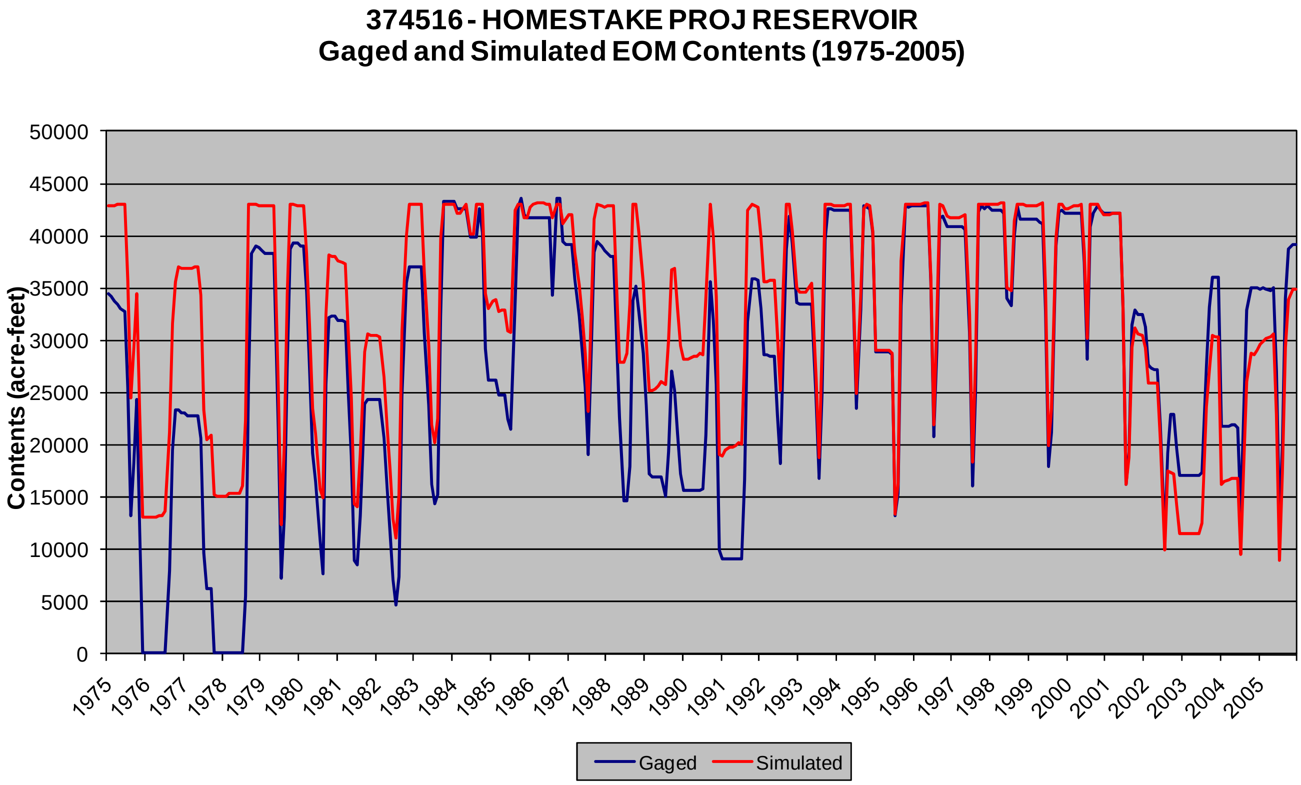


Figure 7.19 Reservoir Calibration – Homestake Proj Reservoir

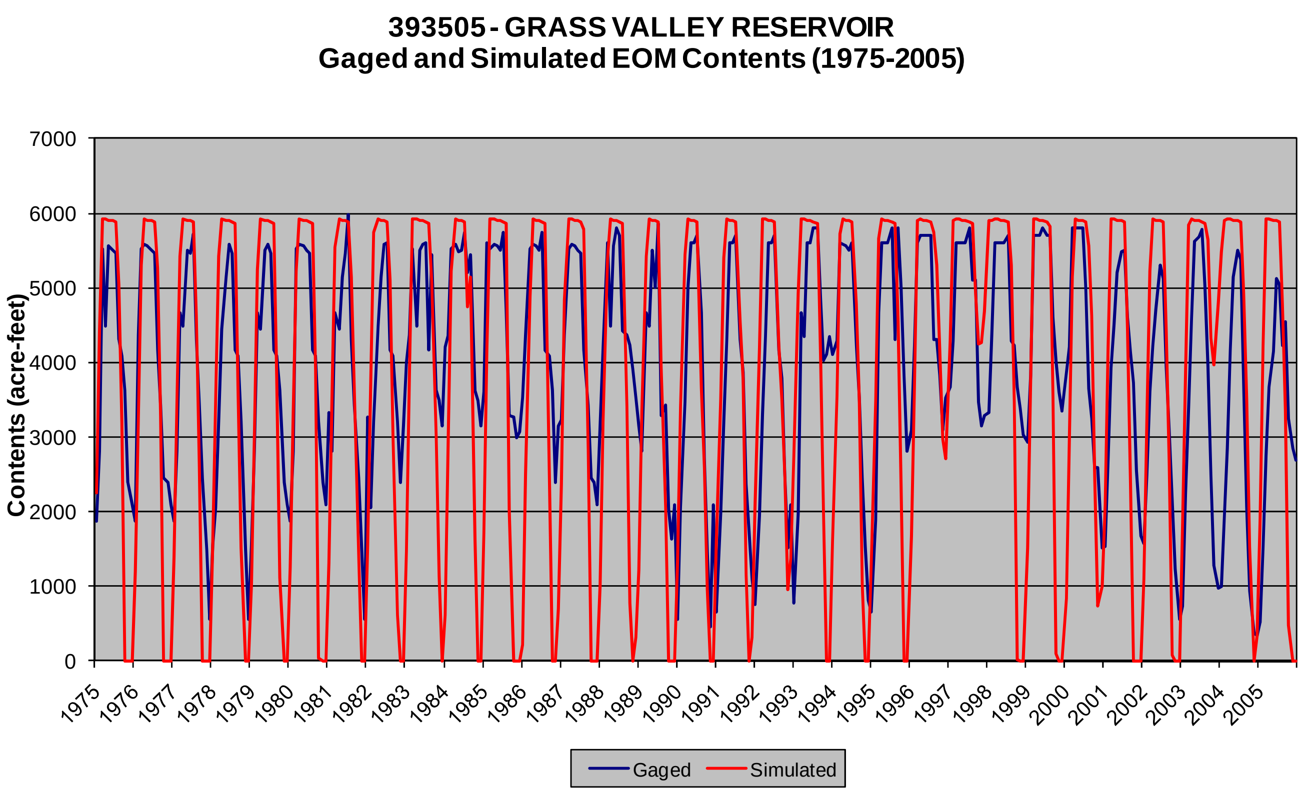


Figure 7.20 Reservoir Calibration – Grass Valley Reservoir

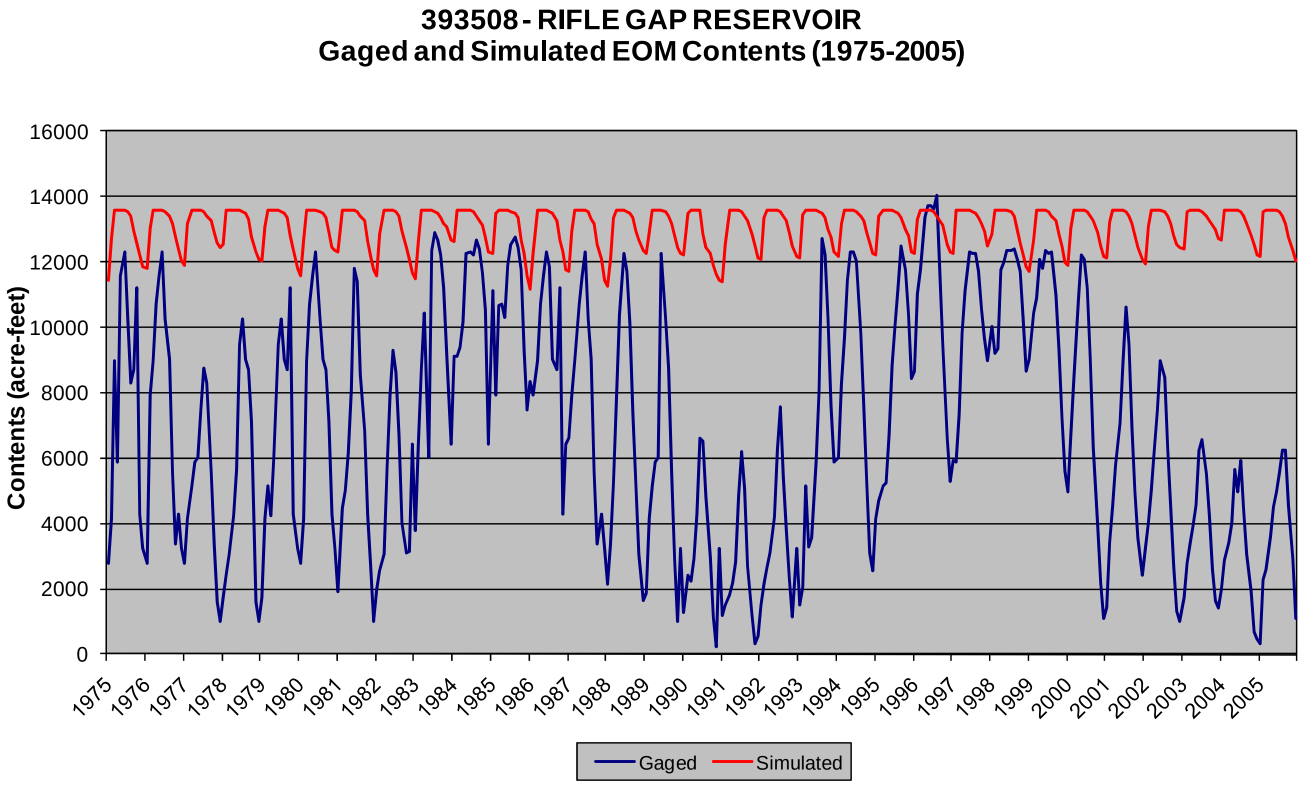


Figure 7.21 Reservoir Calibration – Rifle Gap Reservoir

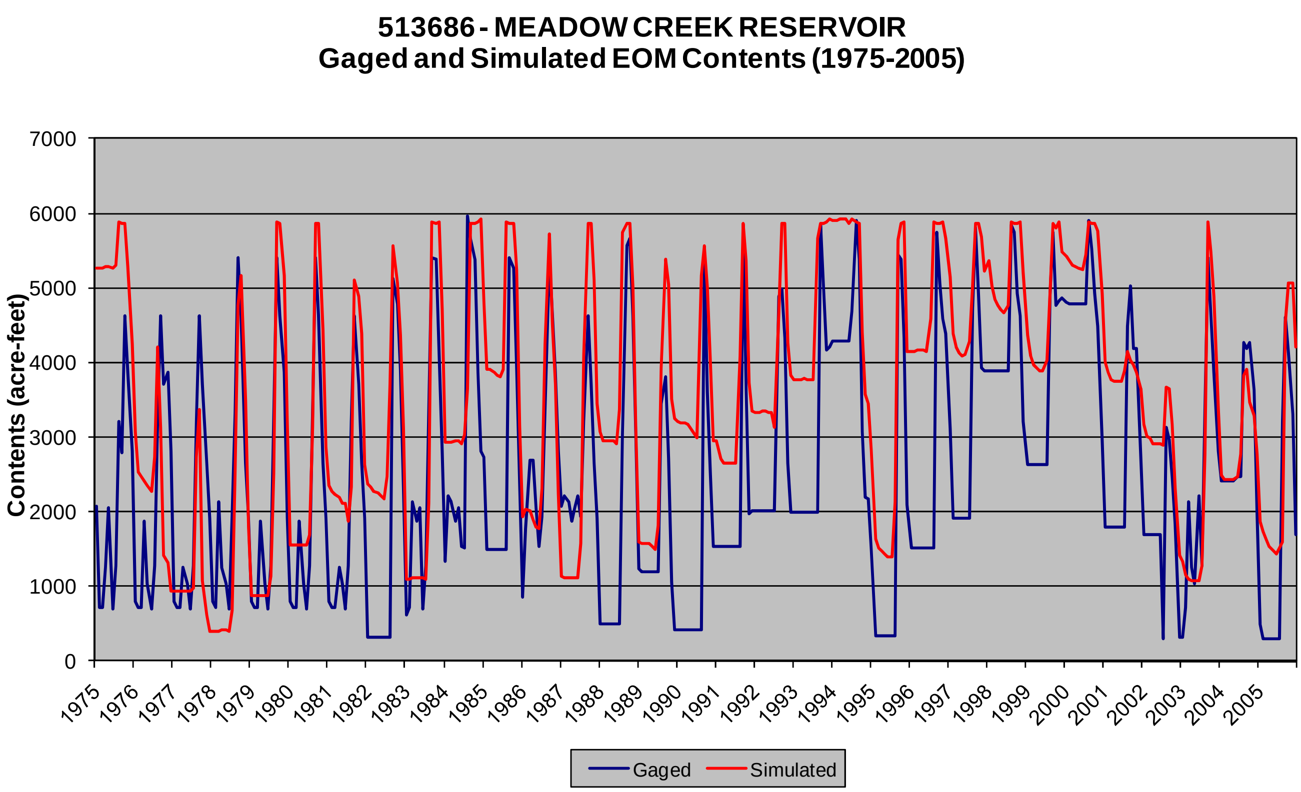


Figure 7.22 Reservoir Calibration – Meadow Creek Reservoir

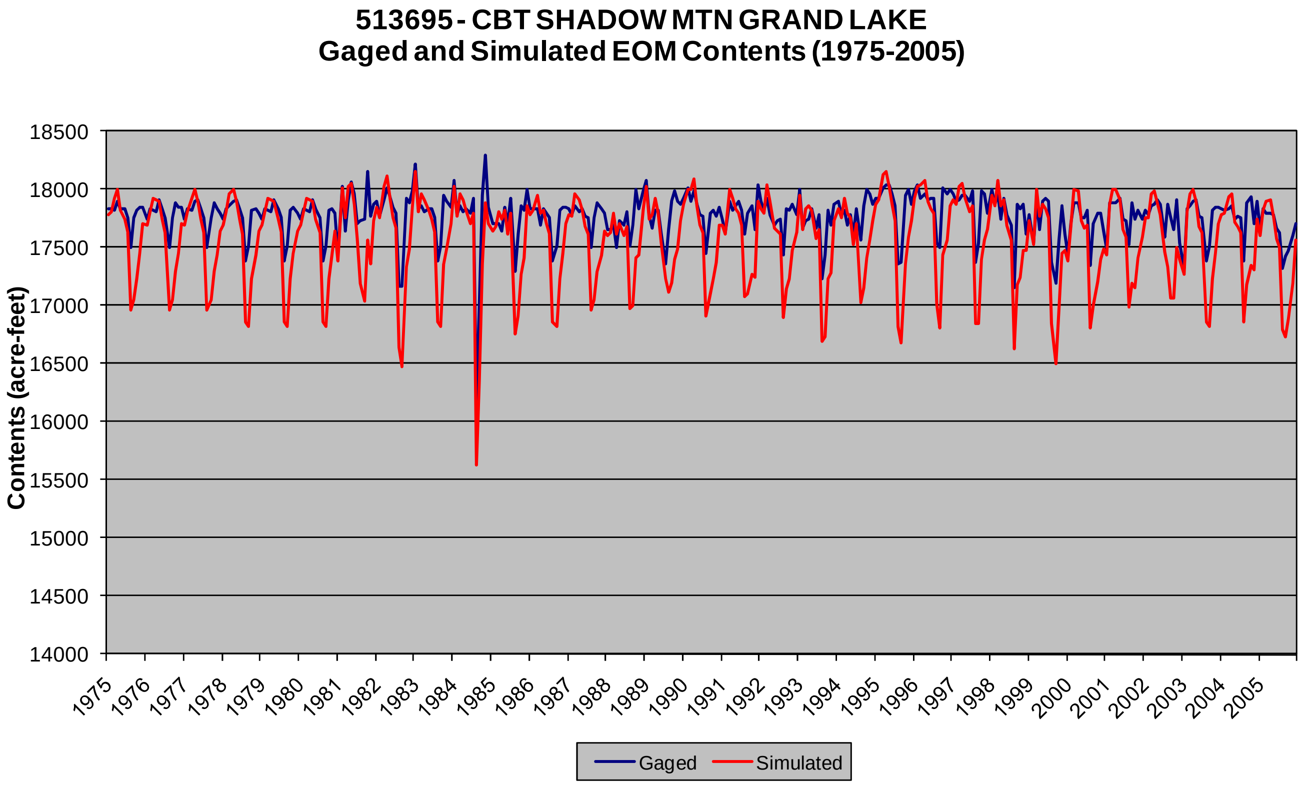


Figure 7.23 Reservoir Calibration – CBT Shadow Mtn Grand Lake

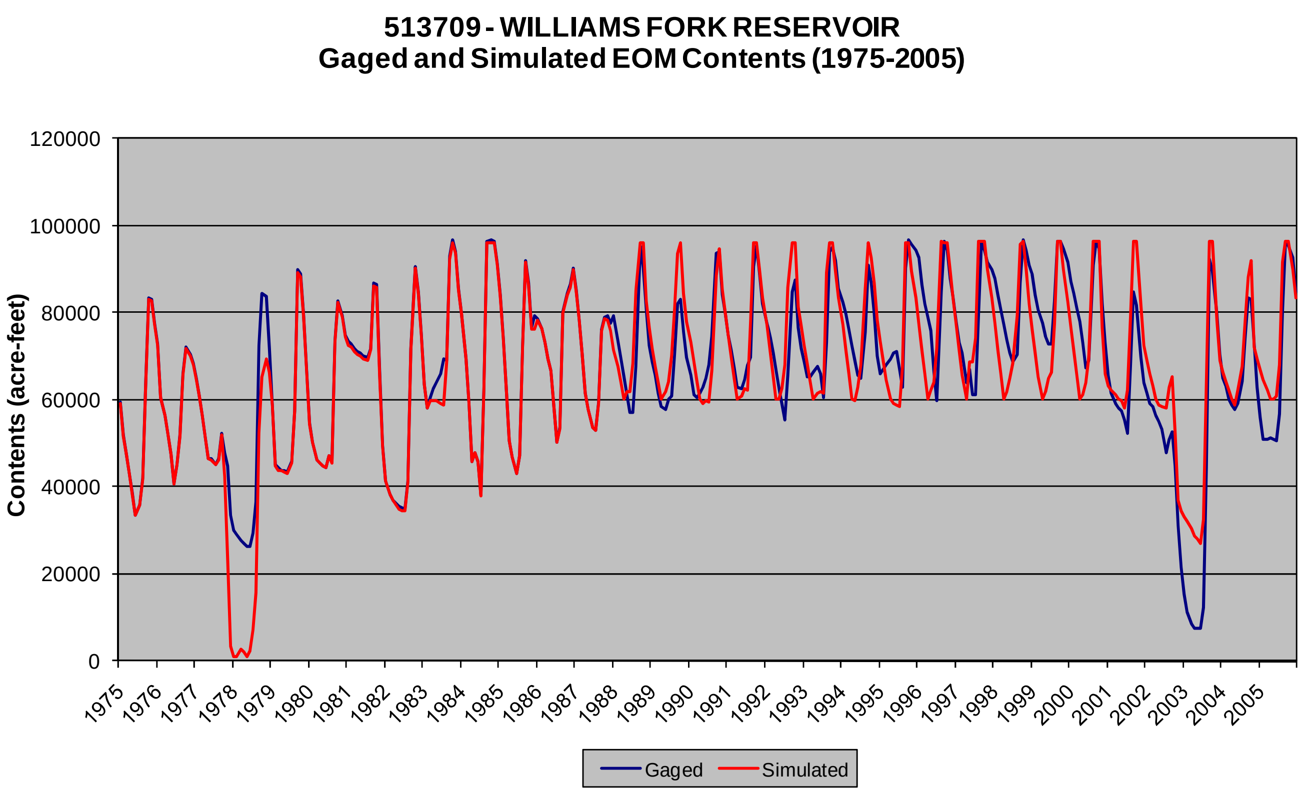


Figure 7.24 Reservoir Calibration – Williams Fork Reservoir

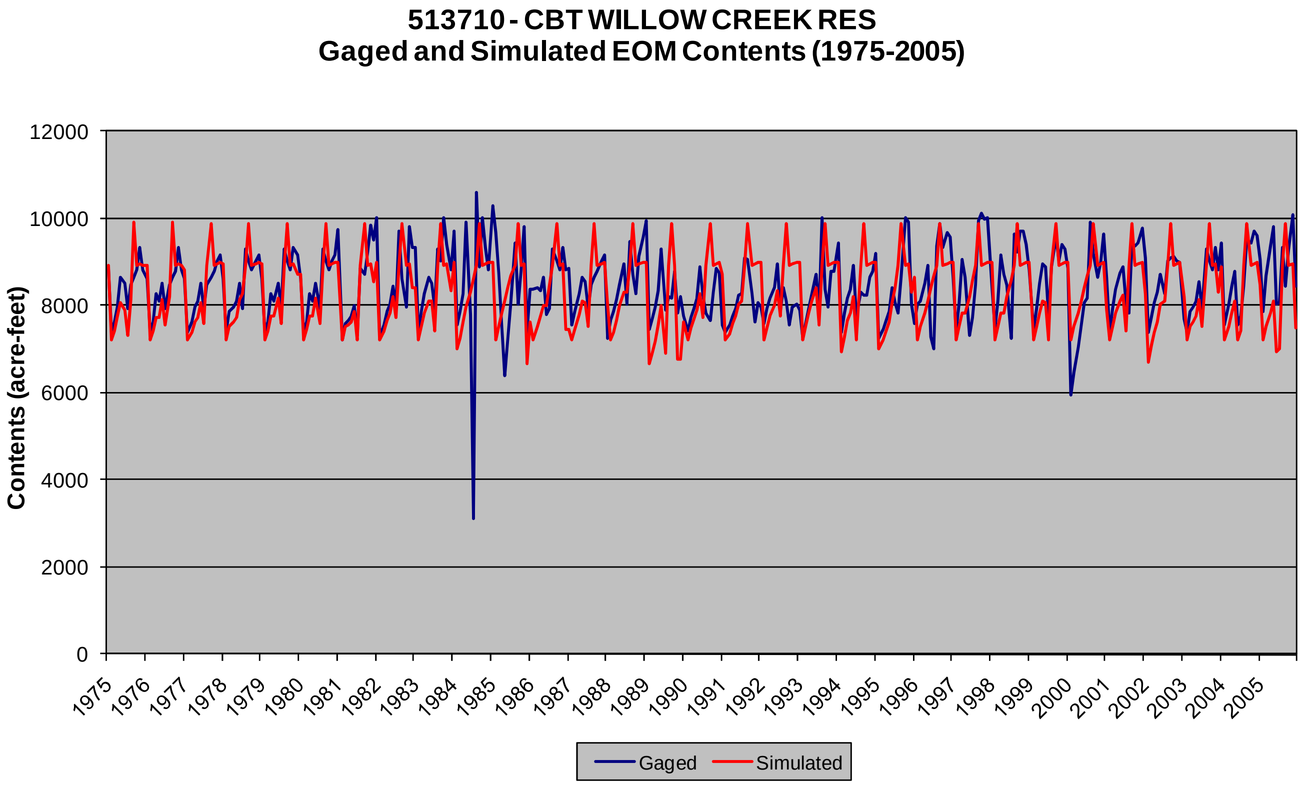


Figure 7.25 Reservoir Calibration – CBT Willow Creek Res

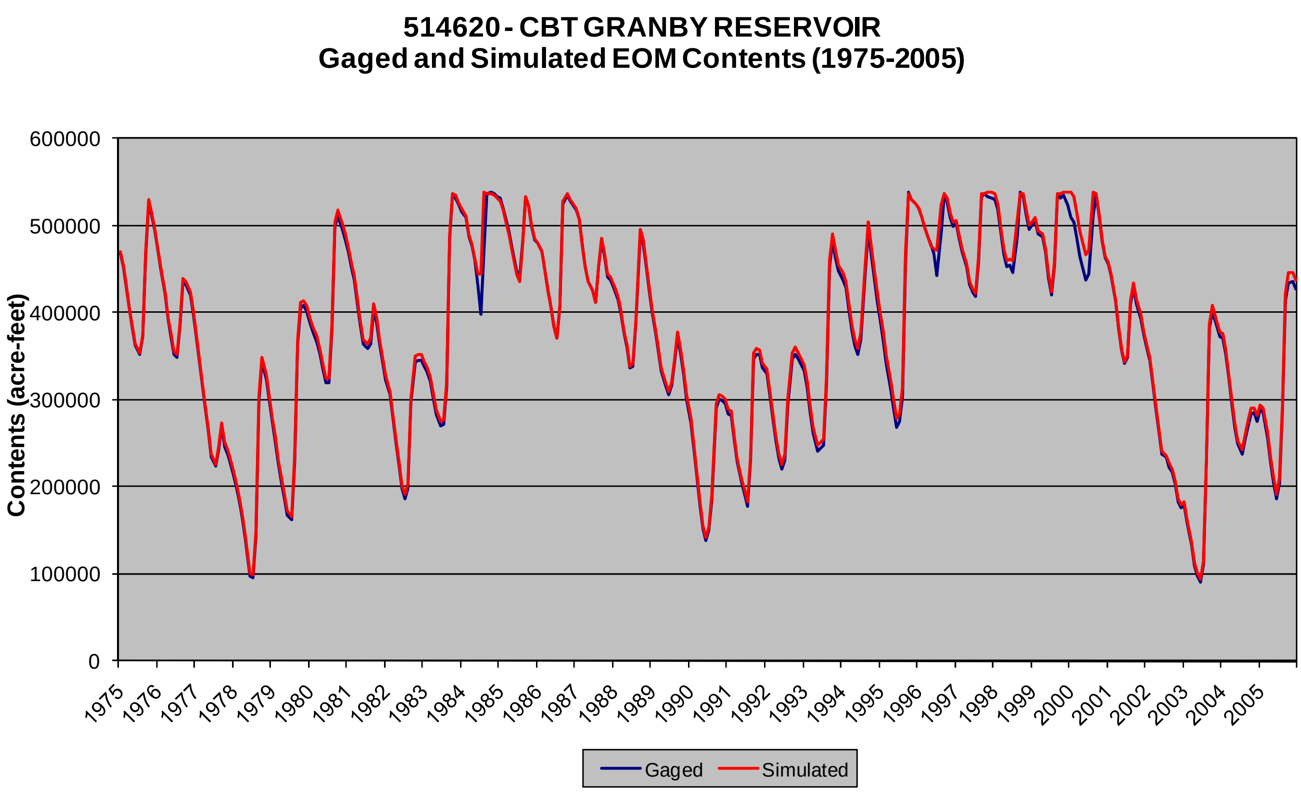


Figure 7.26 Reservoir Calibration – CBT Granby Reservoir

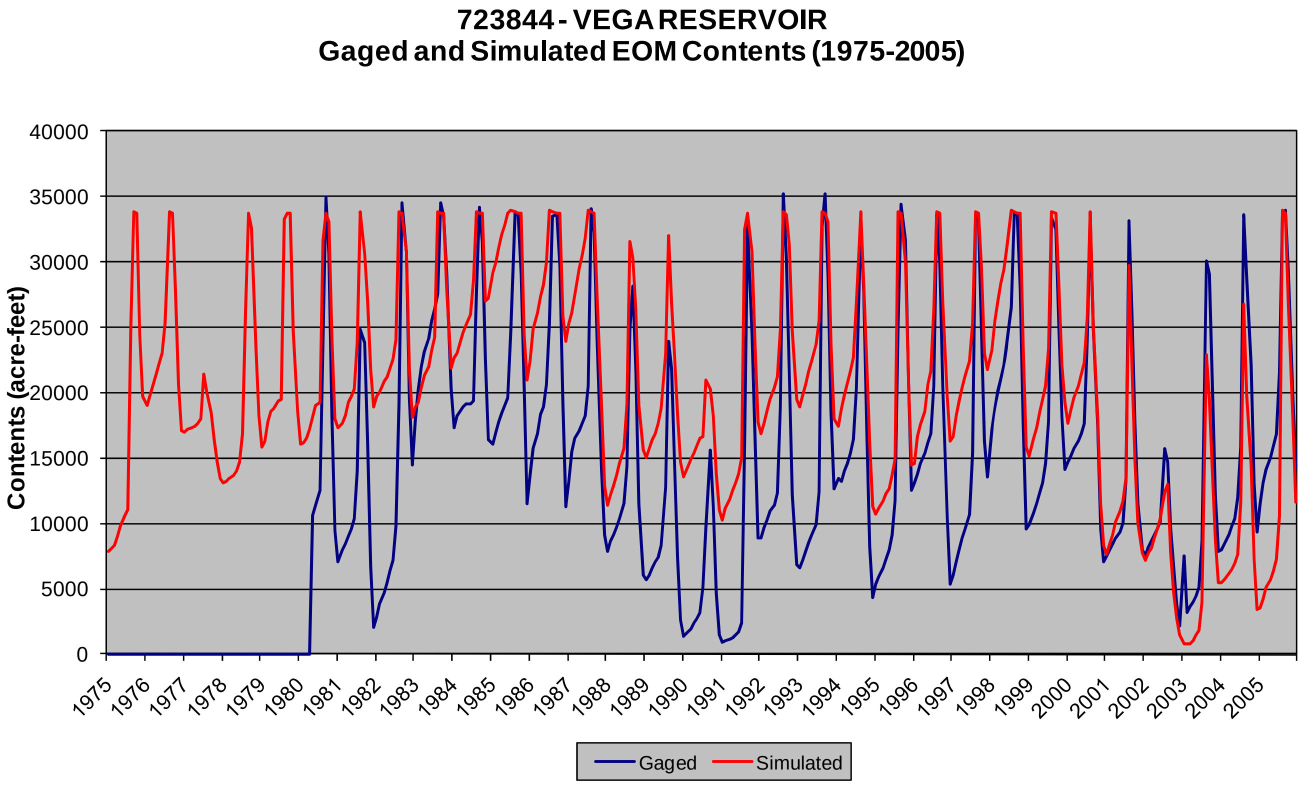


Figure 7.27 Reservoir Calibration – Vega Reservoir

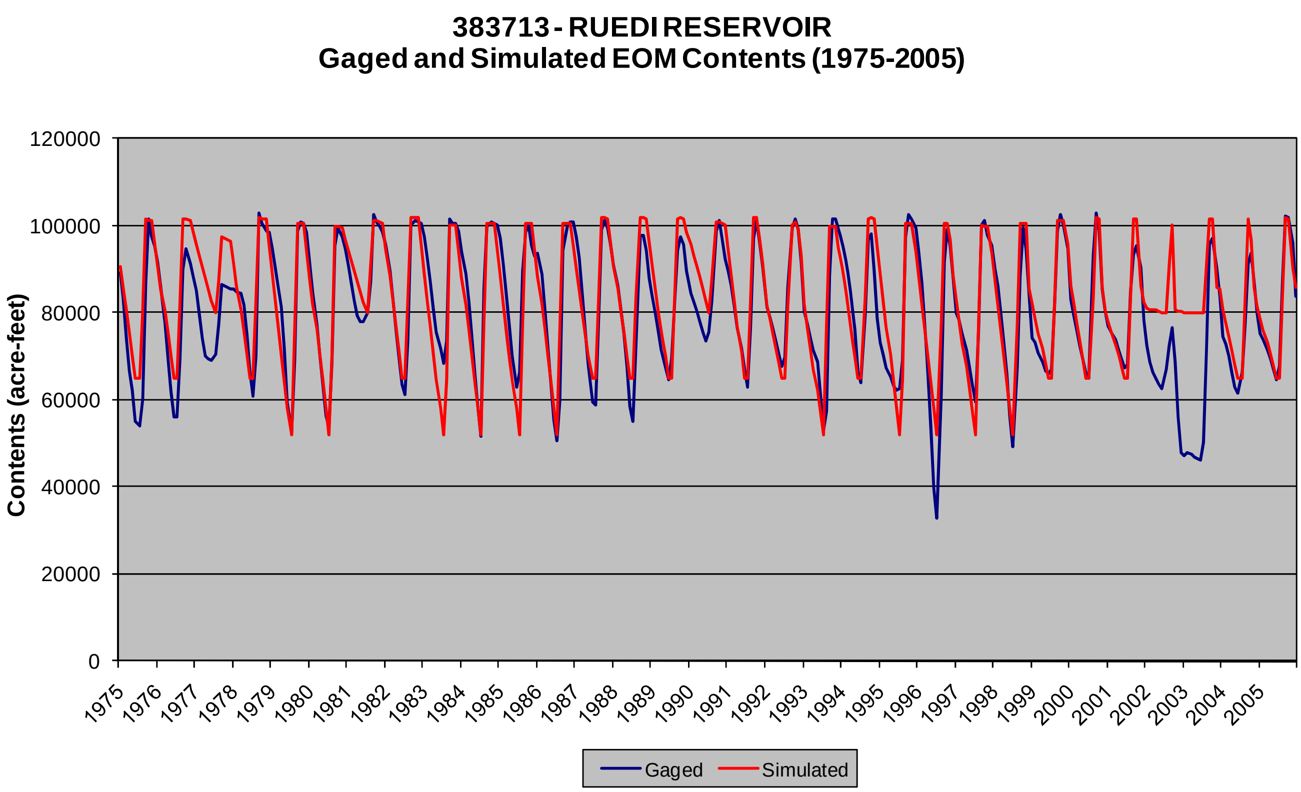


Figure 7.28 Reservoir Calibration – Ruedi Reservoir

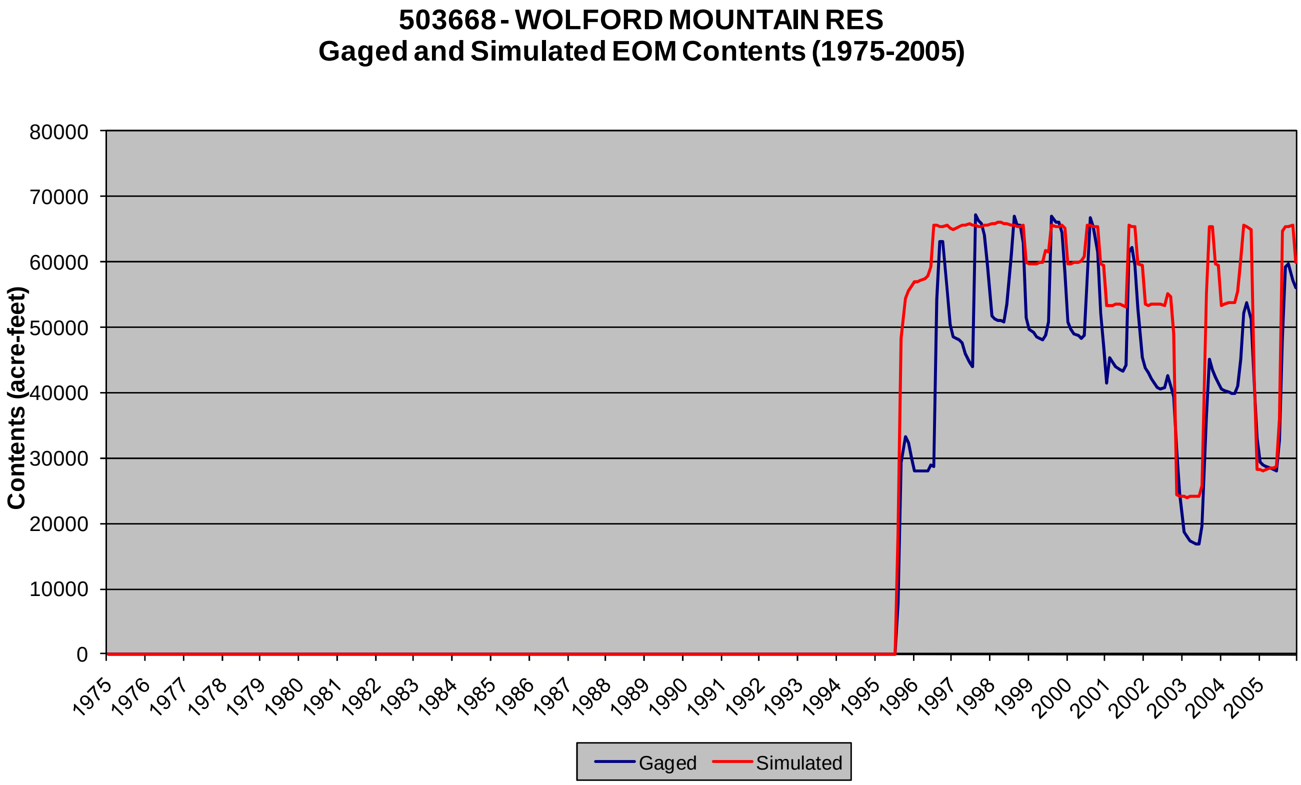


Figure 7.29 Reservoir Calibration – Wolford Mountain Res

8. Daily Baseline Results

Note: This section describes a Daily Baseline Data Set that was completed in January 2007. The monthly Upper Colorado Model Historical (calibration), Calculated and Baseline data files were updated in October 2009, and the 2009 calibration and Baseline data sets are described in this user manual. Inconsistencies between the 2008 and 2009 Daily Baseline Data Set are minor, and include:

1) maximum irrigation efficiency set to 0.60 in 2008, and set to 0.54 in 2009
2) differences in IWR for fields below 6,500 ft in elevation, because an elevation adjustment was applied to crop coefficients in the Blaney-Criddle analysis in the 2009 model
3) updated baseline demands for several transbasin diversions, including Roberts Tunnel, Adams Tunnel, and Con-Hoosier Tunnel, and
4) revision to the representation of the Ute Water Conservancy District system.

The approach described for the Daily Baseline Data Set is accurate, except for the items listed above. Table values in this appendix are expected to be similar to, but not exactly, what would be produced with an updated Daily Baseline Data

The “Daily Baseline” data set simulates current demands, current infrastructure and projects, and the current administrative environment, as though they had been in place throughout the modeled period on a daily time-step. The purpose of the Daily model data set is to capture daily variations in streamflow and call regime. The simulation period for the Daily model is 1975 through 2005. This is the period for which diversion data, and associated irrigation efficiencies, are most complete.

The most difficult part of developing a basin model is understanding the system. By first developing a monthly model, the system operation was investigated without the volume of information ultimately required for a daily model. The Daily model was developed to be able to simulate large and small flow events that occur within a monthly time step. Therefore, although daily baseflows are used, other terms required for daily analysis, such as diversion demands and reservoir targets, are developed using a simplified approach.

Daily baseflows are estimated using StateMod’s Daily Pattern approach. StateMod calculates each day’s baseflow by disaggregating monthly baseflows using the daily pattern of flow at selected historical gages. These “pattern gages” are representative of baseflows in sub-basins throughout the Colorado River basin.

Monthly Baseline demands were disaggregated to daily demands by connecting the midpoints of the monthly demand data. Reservoir targets were disaggregated by connecting the end points of monthly target data. Instream flow demands were disaggregated by setting them to the average daily value. Daily return flow delay patterns were used. The operating rights file is the same file used in the monthly Baseline simulation.

8.1 Daily Baseline Data Set

This section describes unique StateMod input files in the Daily Baseline Data Set. The data set is expected to be a starting point for users who want to apply the Upper Colorado River Model to a particular management issue on a daily basis. As with the monthly Baseline Data set, the investigator may want to understand how the river regime would change under a new use or different operations. The change needs to be quantified relative to how the river would look today absent the new use or different operation, which may be quite different from the historical record. The Daily Baseline data set provides a basis against which to compare future scenarios. Users may opt to modify the Daily Baseline data set for their own interpretation of current or near-future conditions.

The daily Baseline data set, and corresponding daily results, does not include any consideration for Colorado River Compact obligations, nor are conditional water rights represented in the daily Baseline data set. Variations of the daily Baseline data set could include conditional rights within the Colorado River basin, and would likely result in less available flow than presented here.

The following detailed, file-by-file description is intended to provide enough detail that this can be done with confidence. Only files that are different from the Baseline Data Set are described here. Other Baseline Data Set files are described in Section 5.

This section is divided into the following subsections:

- Section 8.1.1 describes the response file, which simply lists names of the rest of the data files. The section tells briefly what is contained in each of the named files, and whether they are different in the Daily Baseline data set.
- Section 8.1.2 describes the control file, which sets the execution parameter for the daily simulation.
- Section 8.1.3 describes the two streamflow files that define the disaggregation of monthly baseflow files.
- Section 8.1.4 includes files that define the methodology for disaggregating monthly demands and reservoir targets for the daily simulation.
- Section 8.1.5 describes the daily return flow delay pattern file.

Where to find more information

- The CDSS Technical memorandum “CDSS Daily Yampa Model – Task 2 Pilot Study” described the investigation into StateMod’s daily modeling approaches and the recommended approach for subsequent daily modeling of CDSS basins.
- For generic information on every daily input file listed below, see the StateMod documentation. It describes how input parameters are used, as well as format of the files.
- The input files used in both the Baseline data set and the Daily Baseline data set are described in detail in Section 5 – Baseline Data Set.

8.1.1. Response File (*.rsp)

The response file (cmdlyB.rsp) contains the names of all other data files required to run the model. New file names have been used for the files that are used only in daily modeling. The file is changed by hand-editing. Many files are used in both the monthly Baseline and Daily Baseline simulations and the applicable sections are referenced.

File Name	Description	Reference
cm2005.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 8.1.2
cm2005.rin	River Network file – lists every model node and specifies connectivity of network	Section 5.3.1
cm2005.ris	River Station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 5.3.2 & Section 8.1.3
cm2005.rib	Baseflow Parameter file – gives coefficients and related gage IDs for each baseflow node, with which StateMod computes baseflow gain at the node	Section 5.3.3
cm2005.rih	Historical Streamflow file – Monthly time series of streamflows at modeled gages	Section 5.3.4
cm2005x.xbm	Baseflow Data file – time series of undepleted flows at nodes listed in cm2005.ris	Section 5.3.5
cm2005.dds	Direct Diversion Station file – contains parameters for each diversion structure in the model, such as diversion capacity, return flow characteristics, and irrigated acreage served	Section 5.4.1 & Section 8.1.4
cm2005.dly	Delay Table – contains several return flow patterns that express how much of the return flow accruing from diversions in one month reach the stream in each of the subsequent months, until the return is extinguished	Section 5.4.2
cm2005.ddh	Historical Diversions – Monthly time series of historical diversions	Section 5.4.3
cm2005B.ddm	Monthly Demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
cm2005.ddr	Direct Diversion Rights file – lists water rights for direct diversion	Section 5.4.5
cm2005.str	StateCU Structure file – soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
cm2005.ipy	CU Irrigation Parameter Yearly file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
cm2005B.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3

File Name	Description	Reference
cm2005B.res	Reservoir Station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1
cm2005.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
cm2005.eom	Reservoir End-of-Month contents file – Monthly time series of historical reservoir contents	Section 5.6.3
cm2005B.tar	Reservoir Target file – monthly time series of maximum and minimum targets for each reservoir. A reservoir may not store above its maximum target, and may not release below the minimum target	Section 5.6.4
cm2005B.rer	Reservoir Rights file – lists storage rights for reservoirs	Section 5.6.5
cm2005.ifs	Instream Flow Station file – lists instream flow reaches	Section 5.7.1
cm2005.ifa cm2005B.ifm	Instream Flow Demand file – gives the decreed monthly instream flow rates	Section 5.7.2
cm2005.ifr	Instream Flow Right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches	Section 5.7.3
cm2005.pln	Plan Data file – contains parameters for each plan structure	Section 5.8
cm2005B.opr	Operational Rights file – specifies many different kinds of operations that were more complex than a direct diversion or an on-stream storage right. Operational rights could specify, for example, a reservoir release for delivery to a downstream diversion point, a reservoir release to allow diversion by exchange at a point which was not downstream, or a direct diversion to fill a reservoir via a feeder	Section 5.9
cm2005.out	Output Control File	N/A
cm2005.rbd	Daily Historic Baseflow file – Daily time series of baseflows at selected modeled gages	Section 8.1.3
cm2005.rid	Daily Historic Streamflow file – Daily time series of streamflows at selected modeled gages	Section 8.1.3
cm2005.dld	Delay Table – contains several return flow patterns that express how much of the return flow accruing from diversions in one day reach the stream in each of the subsequent days, until the return is extinguished	Section 8.1.5

8.1.2. Control File

The control file, which is created and maintained by editing manually, contains information that controls the model simulation. Changes made to the monthly Baseline control file are as follows:

1. The starting year of simulation was set to 1975,
2. The *ichk* variable was set to “8” to indicate the simulation should print detailed daily baseflow data to the log file,
3. The *iday* variable was set to “1” to indicate the simulation should be performed using a daily time-step.

8.1.3. River System Files

The daily pattern approach can be described as distributing monthly baseflows to daily baseflows based on the daily distribution of selected historical gages, or pattern gages. StateMod disaggregates the monthly baseflows by multiplying the daily historical gage flow QD_{gage} by the factor QM_{bf}/QM_{gage}, where QM_{bf} is the monthly baseflow and QM_{gage} is the monthly historical gage flow.

Two files work in conjunction to define the daily baseflows used in the Daily Baseline simulation; the river station file (cm2005.ris) and the daily baseflow file (cm2005.rbd). The river station file assigns each baseflow node to a representative historical streamflow gage with daily flow records in the daily baseflow file. Representative streamflow gages were identified based on the following criteria:

- Completeness of Daily Records. The streamflow gages within the Upper Colorado River Model were reviewed for completeness of daily records over the 1975 through 2005 study period. Note that although the recommended daily modeling period for the CRDSS basins is 1975 through 2005, many streamflow gages in the Colorado River basin have continuous records extending from the early 1900s.
- Basin and Baseflow Representation. Representative pattern gages were then selected based on the location and minimal upstream effects. Ideally, pattern gages should closely represent baseflows – they should have minimal influence from upstream diversions or storage. In the Colorado River basin this generally means they are relatively upstream on the tributaries.
- Historic Flow and Baseflow Comparison. Average historical monthly flows were compared to the average baseflows calculated using StateMod to quantify the upstream effects and verify the gage selections.

Table 8.1 shows the historical gages selected for use as pattern gages, and their period of record. The daily historic baseflow file (*.rbd) contains daily baseflows created by removing upstream influences from historic daily streamflow gage data extracted from HydroBase. Baseflow nodes in each sub-basin or drainage were assigned to the pattern gages in the river station file (*.ris) as shown. Figure 8.1 displays the assignments of pattern gages.

Table 8.1
Daily Pattern Gages Used for Upper Colorado River Model Sub-basins

Recommended Pattern Gage	Gage Period of Record	Basin Subdivision Assignment
09010500 - Colorado River below Baker Gulch, near Grand Lake, CO	1953 - 2005	Upper Colorado, Willow Creek, Corral Creek, and Troublesome Creek (Districts 51 and part of 50) and the Main Stem of the Colorado from the headwaters to the Dotsero Gage
09036000 - Williams Fork River near Leal, CO	1933 - 2005	Williams Fork River (Part of District 51)
09047500 - Snake River near Montezuma, CO	1942 - 1946 1951 - 2005	Blue River (District 36)
09063000 - Eagle River at Red Cliff, CO	1910 - 1925 1944 - 2005	Eagle River (Districts 37 and 52) and the Main Stem of the Colorado from the Dotsero Gage to the end of the model
09081600 - Crystal River above Avalanche Creek near Redstone	1955 - 2005	Roaring Fork (District 38)
09089500 - West Divide Creek near Raven	1955 - 2005	Divide Creek, Plateau Creek, Muddy Creek, and North Side Tributaries (Districts 39, 45, 50 (part), 53, 70, and 72)
09152500 – Gunnison River near Grand Junction	1896 - 1899 1901 - 1907 1916 - 2005	Gunnison River (District 42)

It was necessary to remove upstream influences from the gages historical record so they closely represent baseflows. This was automated using TSTool, as described in Appendix C. In addition a daily historic streamflow file (*.rid) was created to use in model comparisons. Pattern gages and other gages representing locations of interest are included.

Where to find more information

- Documentation for StateDMI describes the assignments of pattern gages to baseflow nodes.
- The StateMod documentation describes the procedure used to disaggregate monthly baseflows to daily baseflows.
- Appendix C includes a memorandum describing the task in which pattern gages were selected for the daily Colorado River modeling efforts.

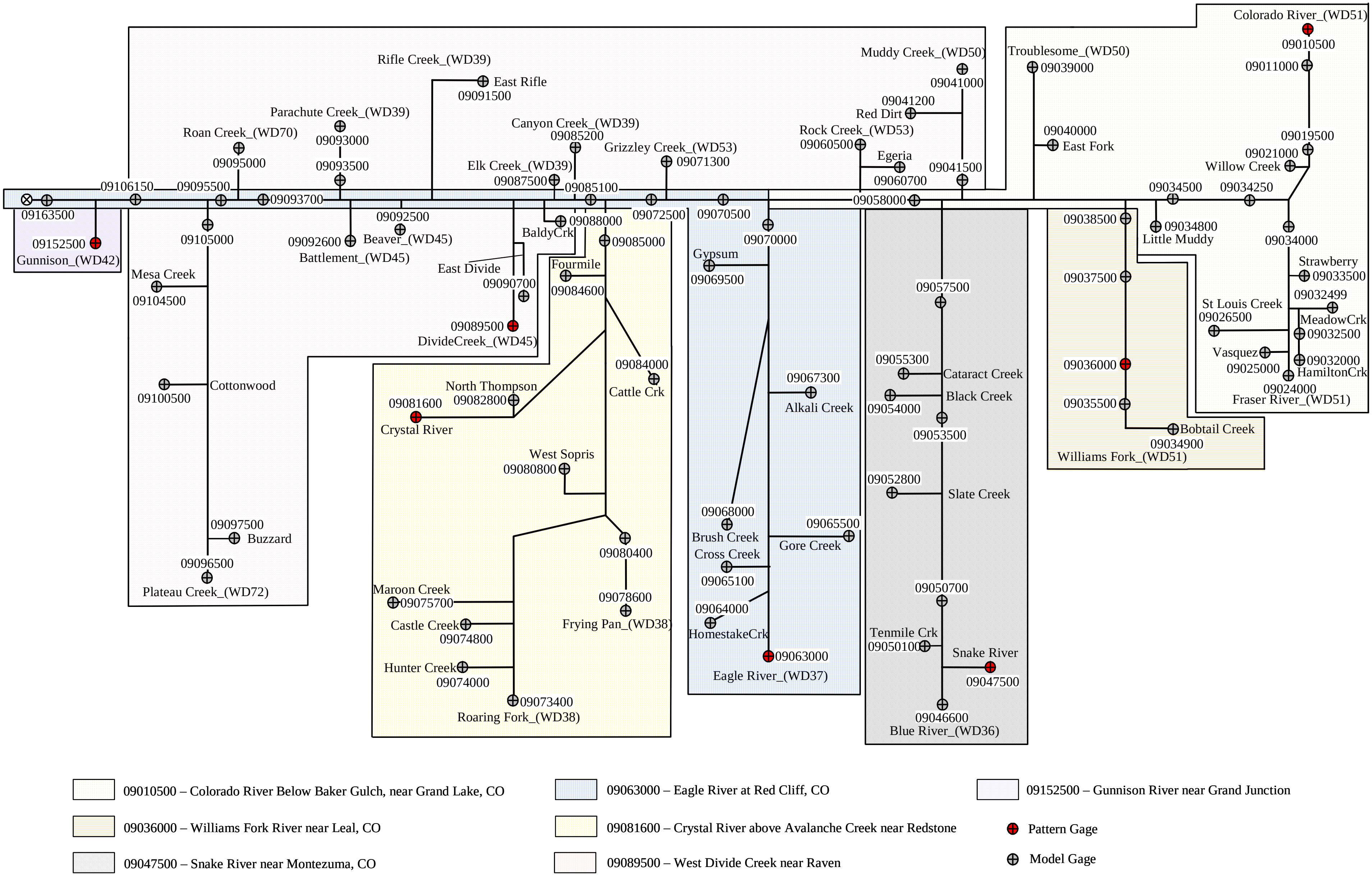


Figure 8.1 – Recommended Application of Daily Pattern Gages

8.1.4. Daily Demands and Reservoir Targets

The daily flag variable (*cdividy*) was set equal to “4” for all diversion stations in the direct diversion station file (cm2005.dds). This flag instructs StateMod, while in daily simulation mode, to disaggregate the monthly diversion demands found in the diversion demand file (cm2005B.ddm) by connecting the midpoints of the monthly data.

The daily flag variable (*cresidy*) was set equal to “5” for all reservoirs in the Baseline reservoir station file (cm2005B.res). This flag instructs StateMod, while in daily simulation mode, to develop daily targets by linearly “connecting” monthly reservoir targets found in the reservoir target file (cm2005B.tar).

The daily flag variable (*cifrdy*) was set equal to “0” for all instream flow nodes in the instream flow station file (cm2005.ifs). This flag instructs StateMod, while in daily simulation mode, to disaggregate the monthly instream flow demand found in the monthly annual instream flow file (cm2005.ifa) and the monthly instream flow file (cm2005B.ifm) to daily values by setting them to the average daily value.

Note that the variables described in this section are set when developing the monthly Baseline data set, but are only used by StateMod when the daily option is selected in the control file.

8.1.5. Daily Return Flow Delay Patterns File

The cm2005.dld file, which is hand-built with a text editor, describes the estimated re-entry of return flows into the river system on a daily basis. They are the daily equivalent of the monthly return flow patterns used in the Baseline simulation.

Where to find more information

- CDSS Memorandum “Colorado River Basin Representative Irrigation Return Flow Patterns”, Leonard Rice Engineers, January, 2005.

8.2 Daily Baseline Streamflows

Table 8.2 shows, for each gage, the average annual available flow from the Daily Baseline simulation compared to the average annual available flow from the Monthly Baseline simulation, based on the same simulation period (1975 through 2005). Available flow at a point is water that is not needed to satisfy instream flows or downstream diversion demand; it represents the water that could be diverted by a new water right. Daily simulation better represents large flow events that occur within a monthly time step. In general, available flow is greater for the daily simulation than the monthly simulation. Junior diverting structures can take advantage of these flows even if they are out-of-priority for much of the month.

Temporal variability of the Daily Baseline and Monthly Baseline simulated flows are illustrated in Figures 8.2 through 8.46 for three selected years for each of the daily pattern gages and for eight additional downstream gages: Colorado River near Granby, Fraser River at Winter Park, Williams Fork River below Williams Fork Reservoir, Blue River below Green Mountain Reservoir, Eagle River below Gypsum, Roaring Fork River at Glenwood Springs, Plateau Creek near Cameo, and Colorado River near Colorado-Utah State Line. The selected years represent wet (1984), average (2000) and dry (1977) years in the Colorado River basin. The historical gaged streamflow is also shown on these graphs. As shown, daily simulated streamflow represents the daily large and small flow events that occur within a monthly time step.

On average, Baseline demands are greater than historical demands; representing current levels of municipal and industrial use and full crop irrigation requirements. During the representative wet year, annual basin-wide Baseline demands are about 25 percent higher than historic demands. Simulated flows at the pattern gages, which are not affected by storage, are similar to gaged flows. However, simulated flows at gages below Granby, Williams Fork, and Green Mountain Reservoirs vary significantly from historical gaged flows throughout the year.

During the representative dry year, annual basin-wide Baseline demands are about 42 percent higher than historic demands. Simulated flows at gages below RIPRAP participating reservoirs are generally higher than historic flows, representing current release operations.

Table 8.2
Baseline Average Annual Flows for Upper Colorado River Model Gages (1975-2005)
Daily Simulation Compared to Monthly Simulation

Gage ID	Gage Name	Daily Simulated Available Flow (af)	Monthly Simulated Available Flow (af)	Difference Daily less Monthly (af)	% Difference
09010500	Colorado R Below Baker Gulch, Nr Grand Lake, CO.	1,671	466	1,205	72%
09011000	Colorado River Near Grand Lake, CO.	2,029	529	1,500	74%
09019500	Colorado River Near Granby	18,335	11,073	7,262	40%
09021000	Willow Creek Below Willow Creek Reservoir	24,599	21,598	3,001	12%
09024000	Fraser River At Winter Park	11,813	11,181	632	5%
09025000	Vasquez Creek At Winter Park, CO.	11,274	12,038	-764	-7%
09026500	St. Louis Creek Near Fraser, CO.	1,955	2,197	-243	-12%
09032000	Ranch Creek Near Fraser, CO.	8,203	8,100	103	1%
09032499	Meadow Creek Reservoir Inflow	2,293	3,124	-831	-36%
09032500	Ranch Creek Near Tabernash, CO.	23,086	19,634	3,452	15%
09033500	Strawberry Creek Near Granby, CO.	3,620	2,639	981	27%
09034250	Colorado River At Windy Gap, Near Granby, CO.	79,167	73,748	5,419	7%
09034500	Colorado River At Hot Sulphur Springs, CO.	90,133	83,894	6,239	7%
09034800	Little Muddy Creek Near Parshall, CO.	954	818	136	14%
09034900	Bobtail Creek Near Jones Pass, CO.	2,217	2,600	-383	-17%
09035500	Williams Fork Below Steelman Creek, CO.	3,173	4,885	-1,712	-54%
09036000	Williams Fork River Near Leal, Co	10,061	16,563	-6,502	-65%
09037500	Williams Fork River Near Parshall, Co	11,129	17,385	-6,257	-56%
09038500	Williams Fork River Below Williams Fork Reservoir	42,569	33,689	8,880	21%
09039000	Troublesome Creek Near Pearmont, CO.	6,046	4,909	1,137	19%
09040000	East Fork Troublesome C Near Troublesome, CO.	16,969	15,398	1,571	9%
09041000	Muddy Creek Near Kremmling, CO.	25,884	22,208	3,676	14%
09041200	Red Dirt Creek Near Kremmling, CO.	5,119	3,956	1,163	23%
09041500	Muddy Creek At Kremmling, CO.	45,633	41,804	3,829	8%
09046600	Blue River Near Dillon, CO.	16,828	20,246	-3,418	-20%
09047500	Snake River Near Montezuma, CO.	13,620	16,894	-3,274	-24%
09050100	Tenmile Creek Below North Tenmile Creek At Frisco	21,390	27,076	-5,686	-27%
09050700	Blue River Below Dillon Reservoir	39,940	49,876	-9,936	-25%
09052800	Slate Creek At Upper Station, Near Dillon, CO.	10,827	7,004	3,823	35%
09053500	Blue River Above Green Mountain Reservoir, CO.	67,745	71,584	-3,839	-6%

Gage ID	Gage Name	Daily Simulated Available Flow (af)	Monthly Simulated Available Flow (af)	Difference Daily less Monthly (af)	% Difference
09054000	Black Creek Below Black Lake, Near Dillon, CO.	14,312	9,349	4,963	35%
09055300	Cataract Creek Near Kremmling, CO.	6,826	4,769	2,057	30%
09057500	Blue River Below Green Mountain Reservoir	102,992	86,835	16,157	16%
09058000	Colorado River Near Kremmling	317,222	304,146	13,076	4%
09060500	Rock Creek Near Toponas, CO.	17,065	16,688	377	2%
09060700	Egeria Creek Near Toponas, CO.	2,091	1,749	342	16%
09063000	Eagle River At Red Cliff, CO.	21,313	22,742	-1,429	-7%
09064000	Homestake Creek At Gold Park, CO.	8,390	6,179	2,211	26%
09065100	Cross Creek Near Minturn	34,152	31,592	2,560	7%
09065500	Gore Creek At Upper Station, Near Minturn, CO.	19,097	17,730	1,367	7%
09067300	Alkali Creek Near Wolcott, CO.	1,487	1,557	-70	-5%
09068000	Brush Creek Near Eagle, CO.	18,347	17,579	768	4%
09069500	Gypsum Creek Near Gypsum, CO.	9,270	8,869	401	4%
09070000	Eagle River Below Gypsum	265,849	255,287	10,562	4%
09070500	Colorado River Near Dotsero	559,967	552,670	7,297	1%
09071300	Grizzly Creek Near Glenwood Springs, CO.	8,821	8,923	-102	-1%
09072500	Colorado River At Glenwood Springs, CO.	1,133,754	1,127,413	6,341	1%
09073400	Roaring Fork River Near Aspen	33,837	29,088	4,749	14%
09074000	Hunter Creek Near Aspen	20,315	20,178	137	1%
09074800	Castle Creek Above Aspen, CO.	22,134	20,045	2,089	9%
09075700	Maroon Creek Above Aspen, CO.	35,616	31,577	4,039	11%
09078600	Fryingpan River Near Thomasville	20,030	15,680	4,350	22%
09080400	Fryingpan River Near Ruedi	58,515	40,550	17,965	31%
09080800	West Sopris Creek Near Basalt, CO.	3,185	1,864	1,321	41%
09081600	Crystal River Above Avalanche Creek Near Redstone	143,443	143,174	269	0%
09082800	North Thompson Creek Near Carbondale, CO.	12,779	14,444	-1,665	-13%
09084000	Cattle Creek Near Carbondale, CO.	1,074	806	268	25%
09084600	Fourmile Creek Near Glenwood Springs, CO.	4,812	4,735	77	2%
09085000	Roaring Fork River At Glenwood Springs	702,743	685,370	17,373	2%
09085100	Colorado River Below Glenwood Springs	1,441,857	1,406,004	35,853	2%
09085200	Canyon Creek Above New Castle, CO.	29,884	31,974	-2,090	-7%
09087500	Elk Creek At New Castle, CO.	58,346	60,648	-2,302	-4%

Gage ID	Gage Name	Daily Simulated Available Flow (af)	Monthly Simulated Available Flow (af)	Difference Daily less Monthly (af)	% Difference
09088000	Baldy Creek Near New Castle	3,159	3,086	73	2%
09089500	West Divide Creek Near Raven	12,223	11,593	630	5%
09090700	East Divide Creek Near Silt, CO.	7,409	7,292	117	2%
09091500	East Rifle Creek Near Rifle, CO.	5,227	4,937	290	6%
09092500	Beaver Creek Near Rifle	1,280	973	307	24%
09092600	Battlement Creek Near Parachute	2,130	2,099	31	1%
09093000	Parachute Creek Near Parachute CO.	16,170	11,540	4,630	29%
09093500	Parachute Creek At Parachute, CO.	24,471	20,022	4,449	18%
09093700	Colorado River Near De Beque	1,502,036	1,464,179	37,857	3%
09095000	Roan Creek Near De Beque, CO.	24,465	17,595	6,870	28%
09095500	Colorado River Near Cameo	1,502,036	1,484,624	17,412	1%
09096500	Plateau Creek Near Collbran, CO.	22,990	21,496	1,494	6%
09097500	Buzzard Creek Near Collbran	36,679	33,893	2,786	8%
09100500	Cottonwood Creek At Upper Sta, Near Molina, CO.	622	91	531	85%
09104500	Mesa Creek Near Mesa, CO.	1,321	233	1,088	82%
09105000	Plateau Creek Near Cameo	127,744	117,576	10,168	8%
09152500	Gunnison River Near Grand Junction	1,323,460	1,370,974	-47,514	-4%
09163500	Colorado River Near Colorado-Utah State Line	4,481,495	4,307,843	173,652	4%

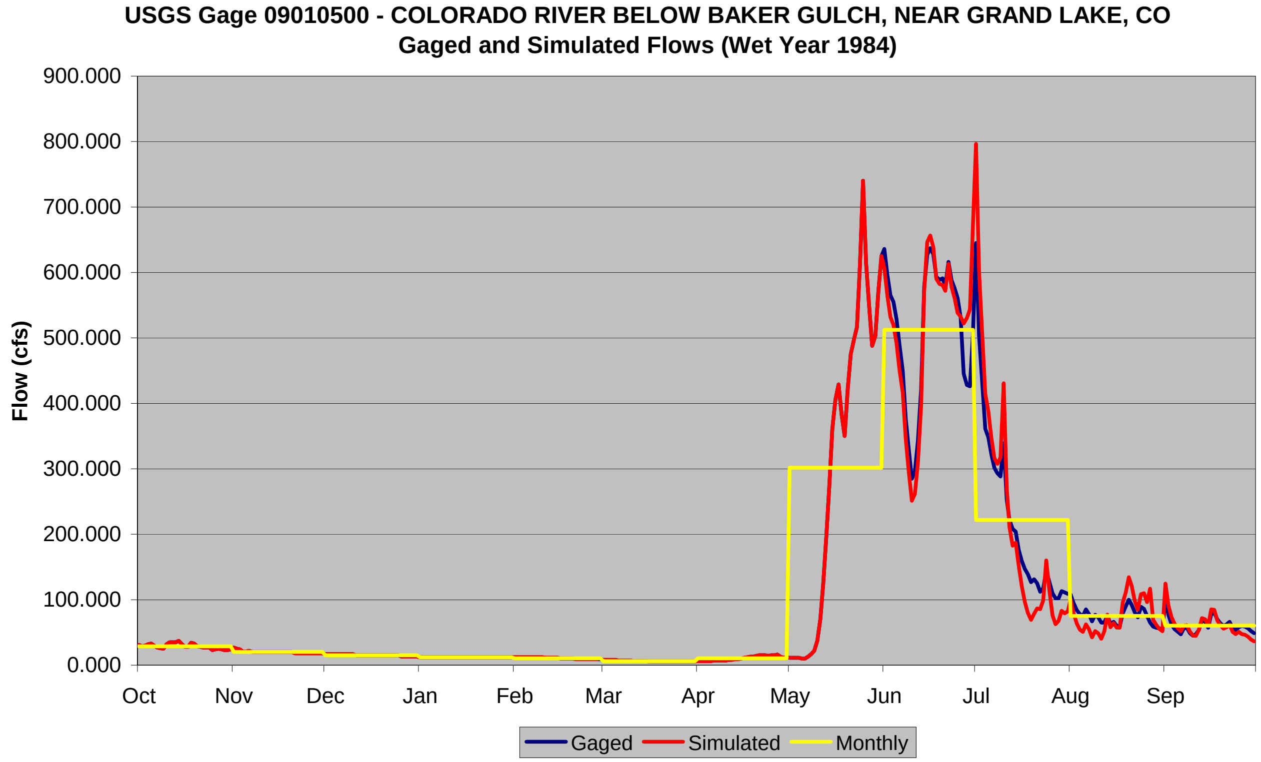


Figure 8.2 Daily Baseline Comparison, Wet Year – Colorado River below Baker Gulch, near Grand Lake, CO

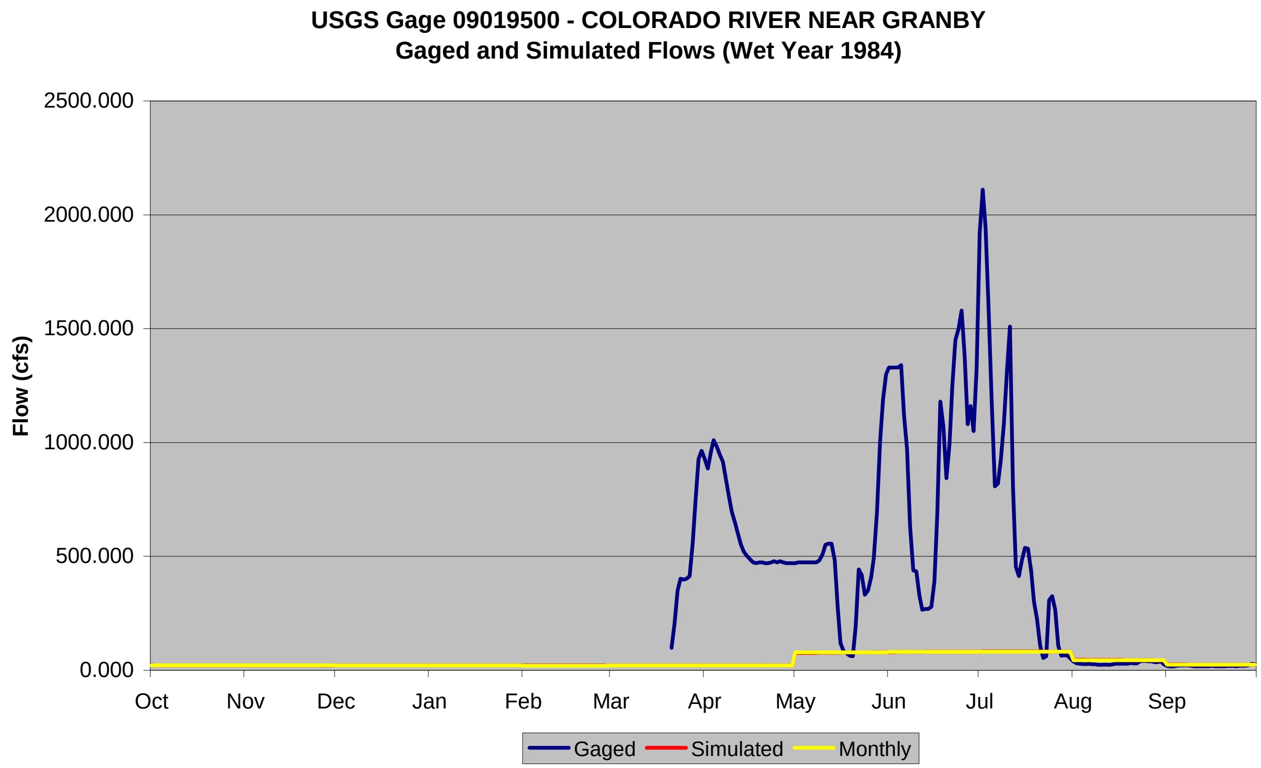


Figure 8.3 Daily Baseline Comparison, Wet Year – Colorado River near Granby

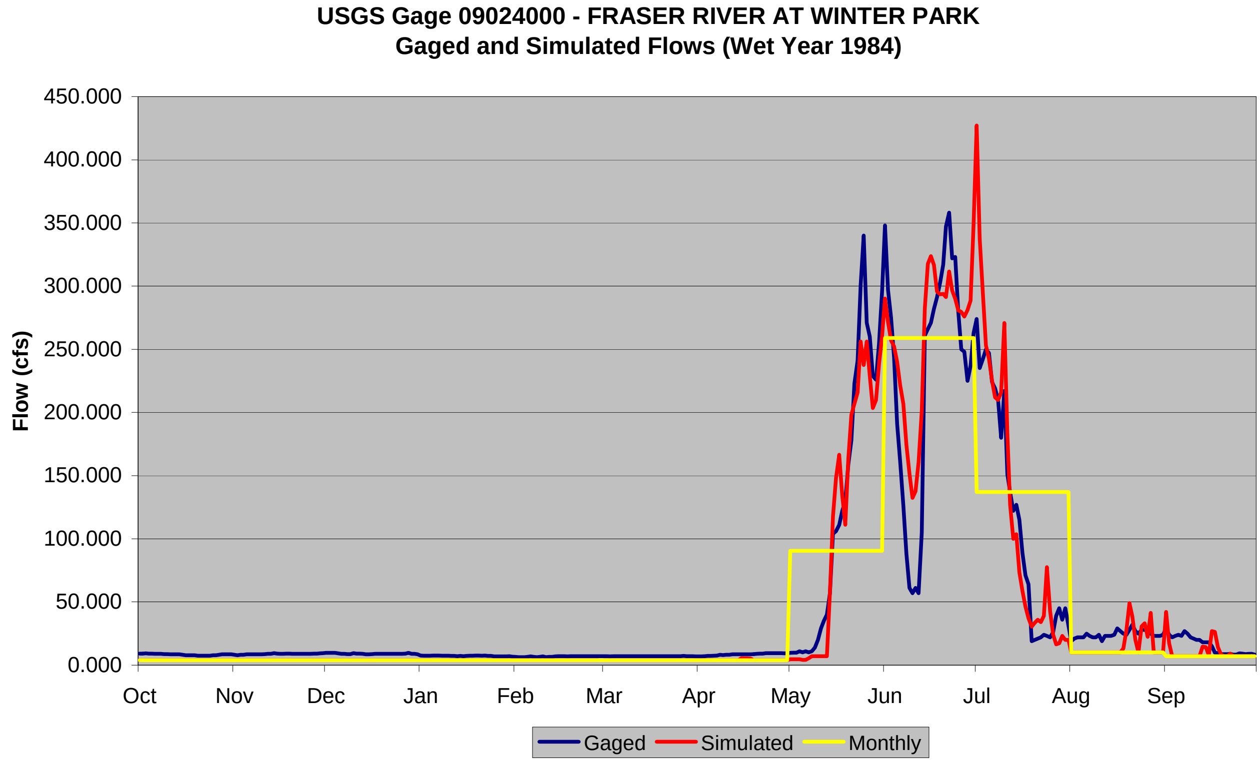


Figure 8.4 Daily Baseline Comparison, Wet Year – Fraser River at Winter Park

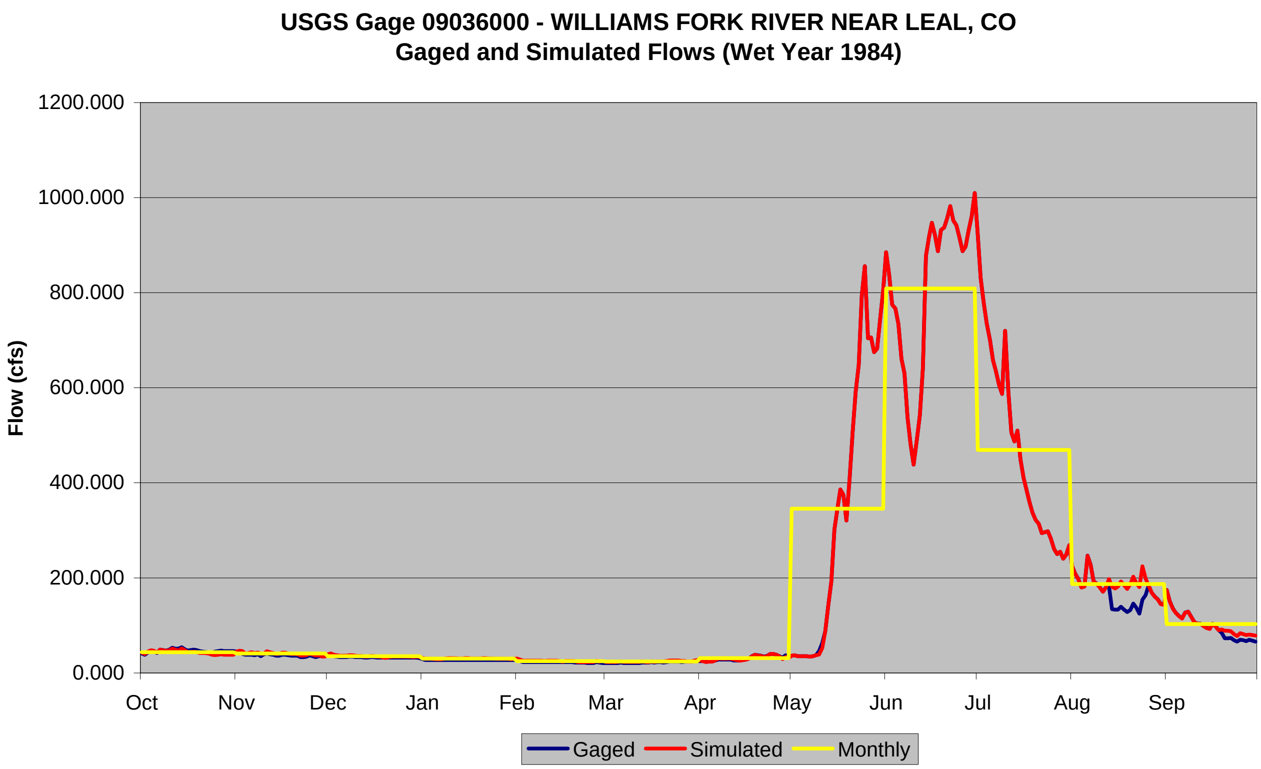


Figure 8.5 Daily Baseline Comparison, Wet Year – Williams Fork River near Leal, CO

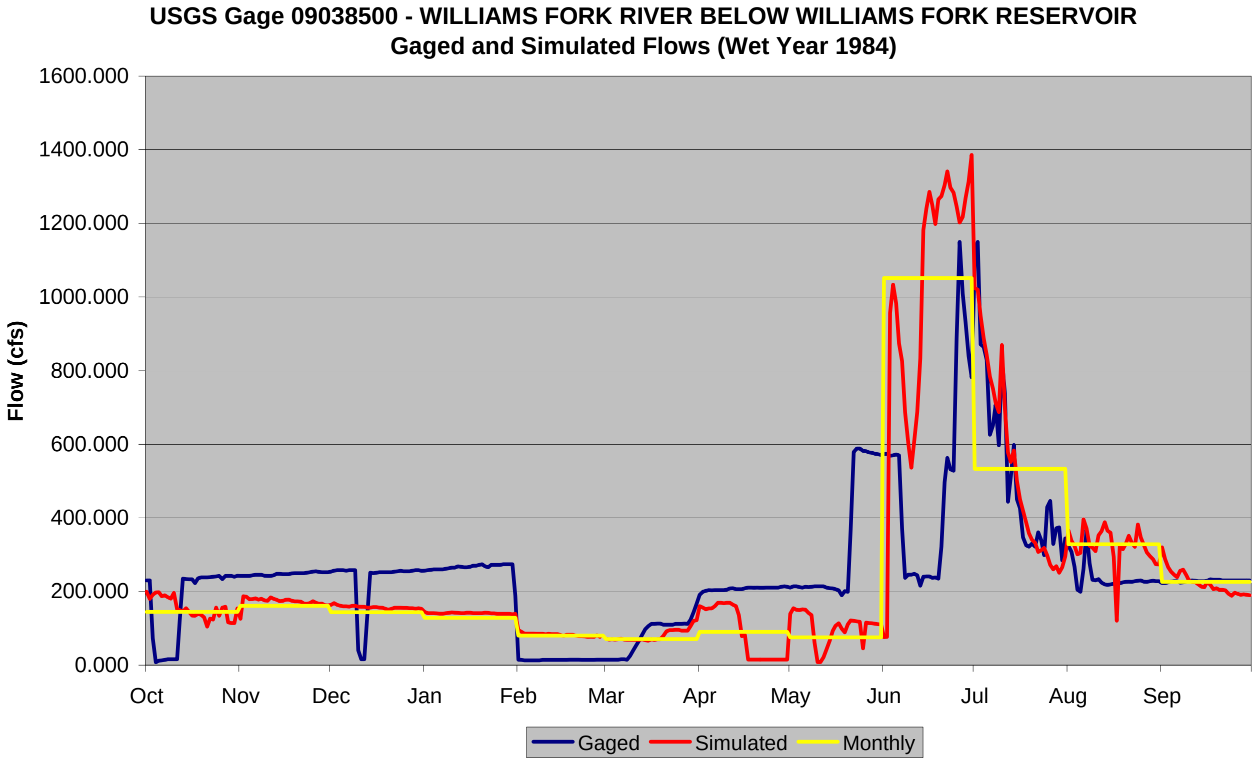


Figure 8.6 Daily Baseline Comparison, Wet Year – Williams Fork River below Williams Fork Reservoir

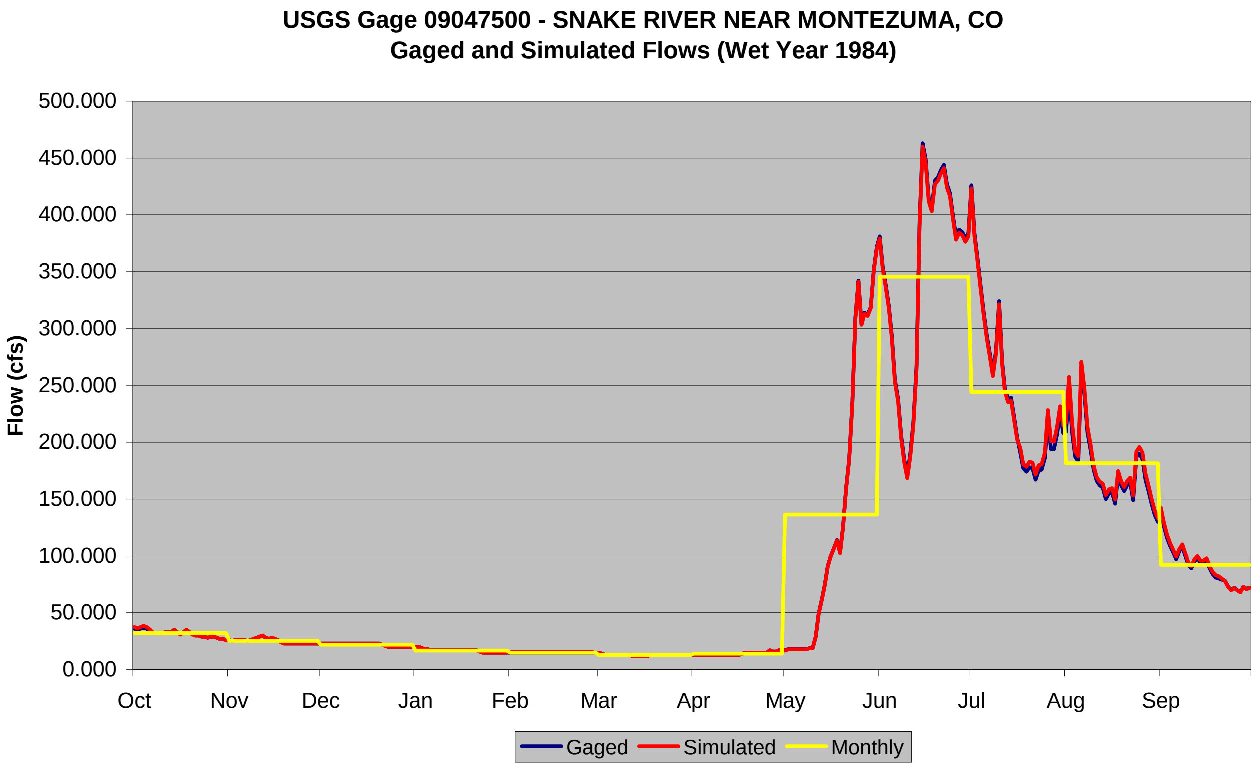


Figure 8.7 Daily Baseline Comparison, Wet Year – Snake River near Montezuma, CO

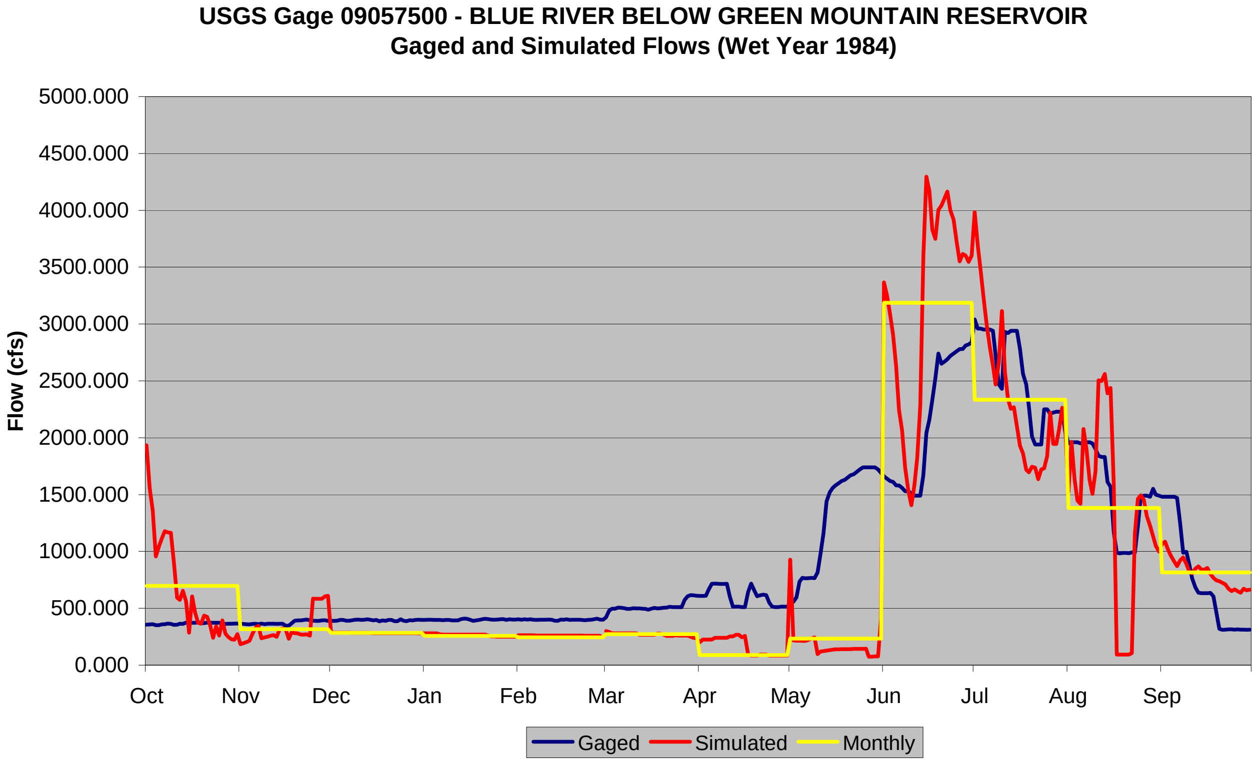


Figure 8.8 Daily Baseline Comparison, Wet Year – Blue River below Green Mountain Reservoir

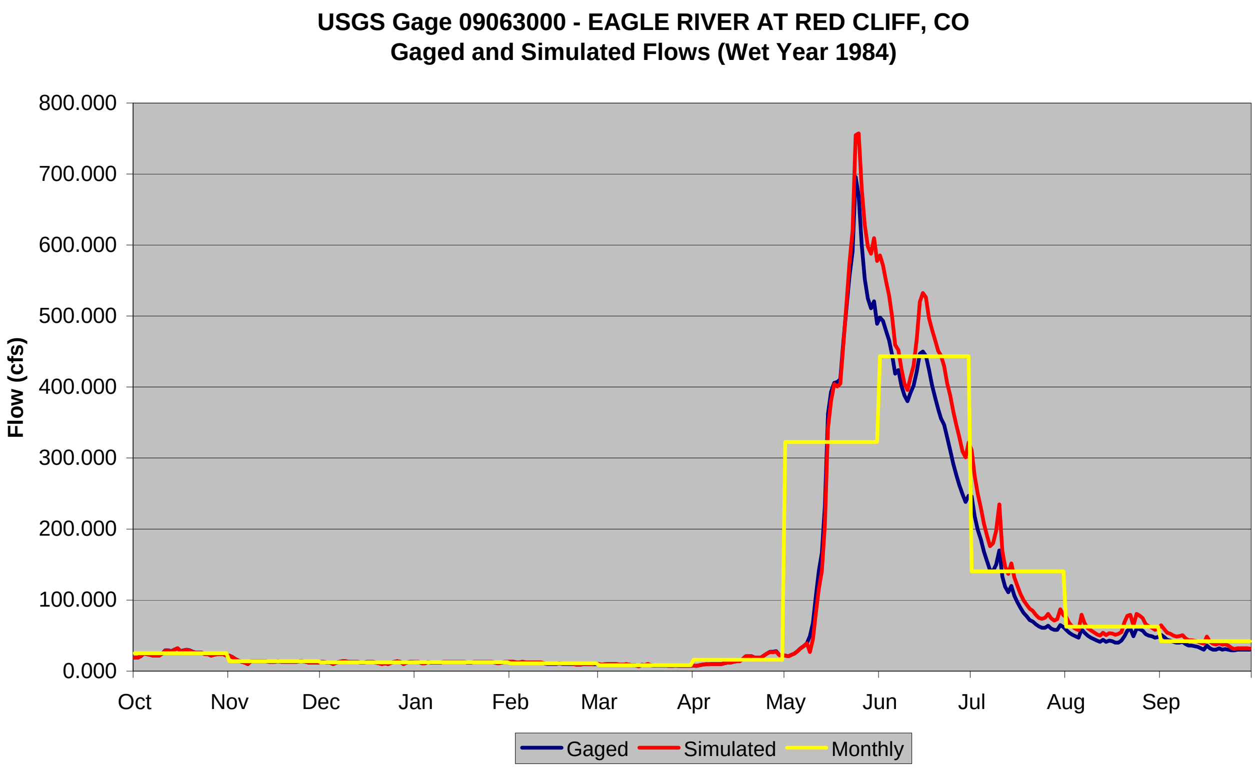


Figure 8.9 Daily Baseline Comparison, Wet Year – Eagle River at Red Cliff, CO

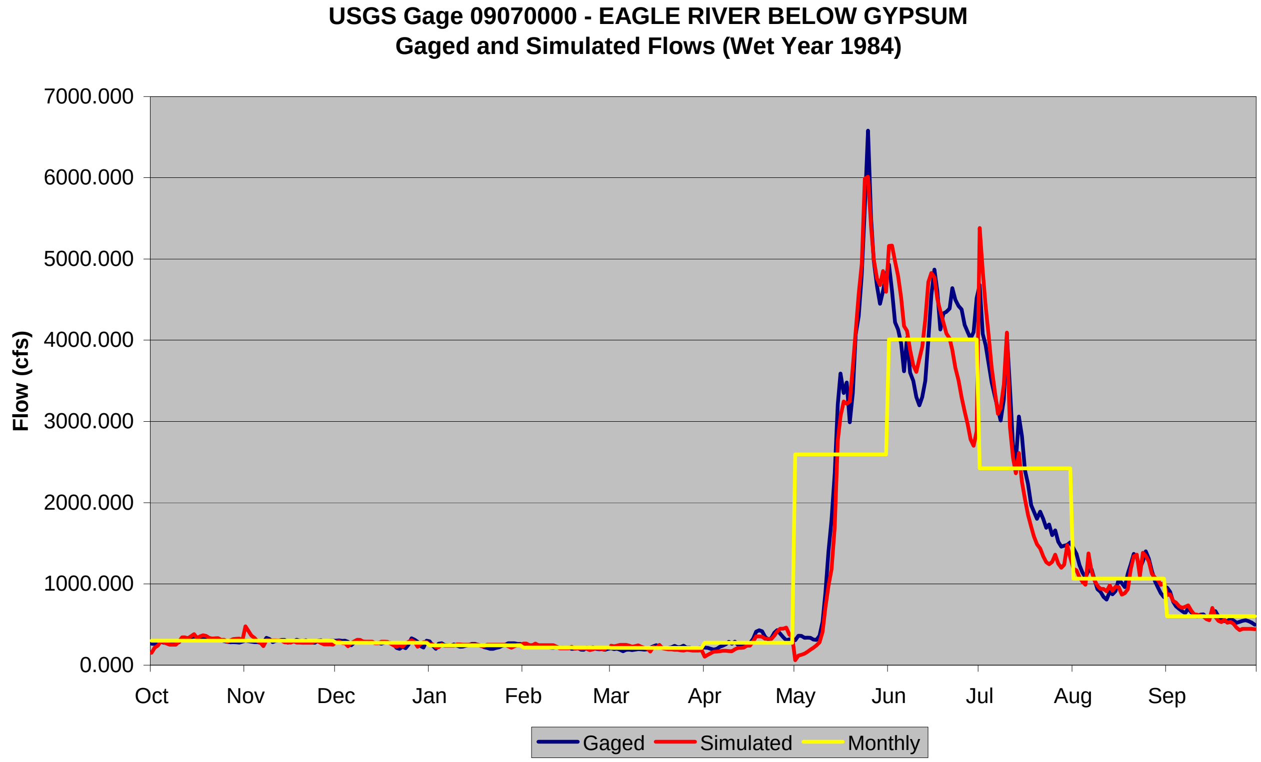


Figure 8.10 Daily Baseline Comparison, Wet Year – Eagle River below Gypsum

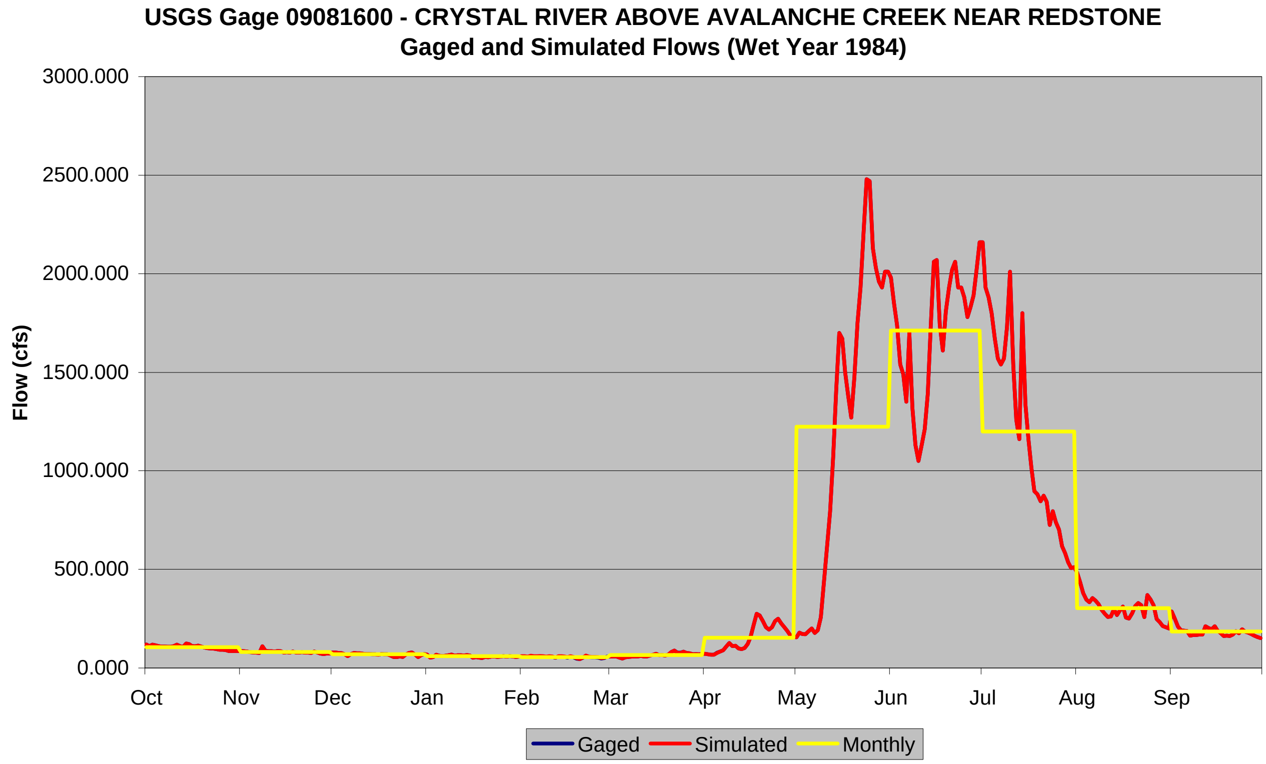


Figure 8.11 Daily Baseline Comparison, Wet Year – Crystal River above Avalanche Creek near Redstone

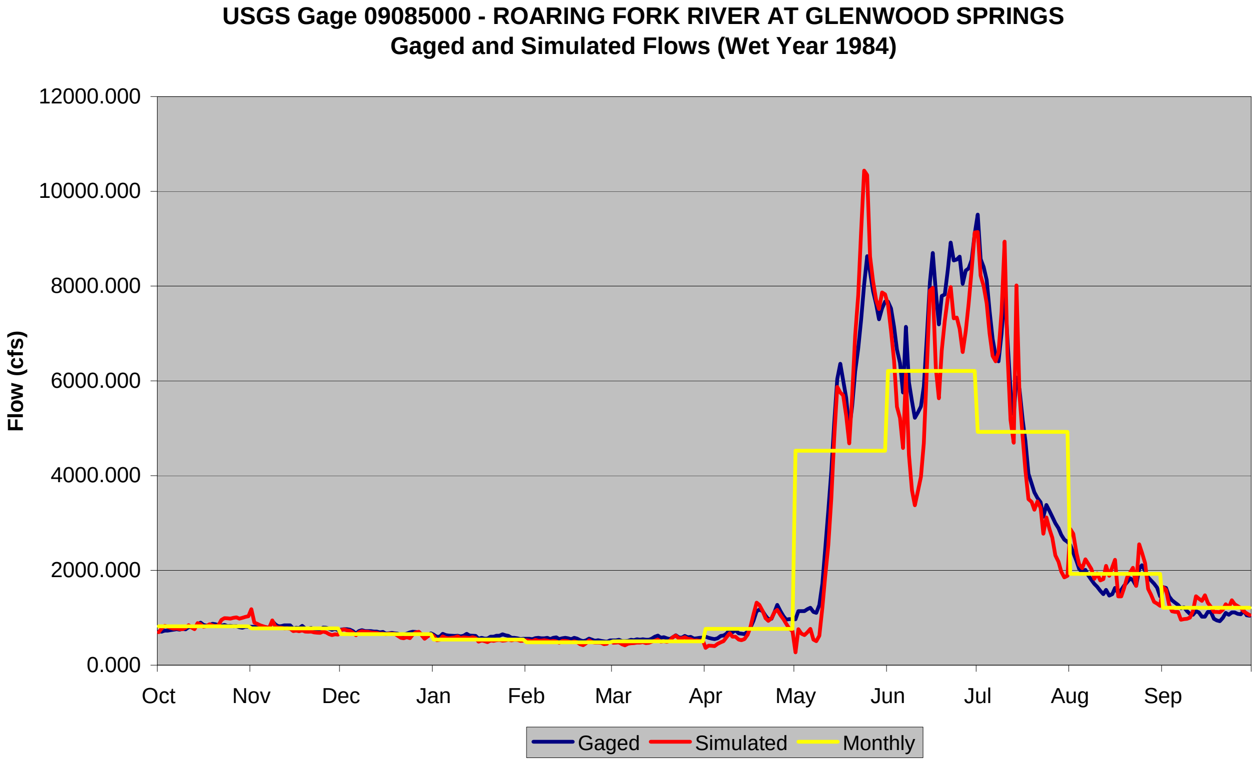


Figure 8.12 Daily Baseline Comparison, Wet Year – Roaring Fork River at Glenwood Springs

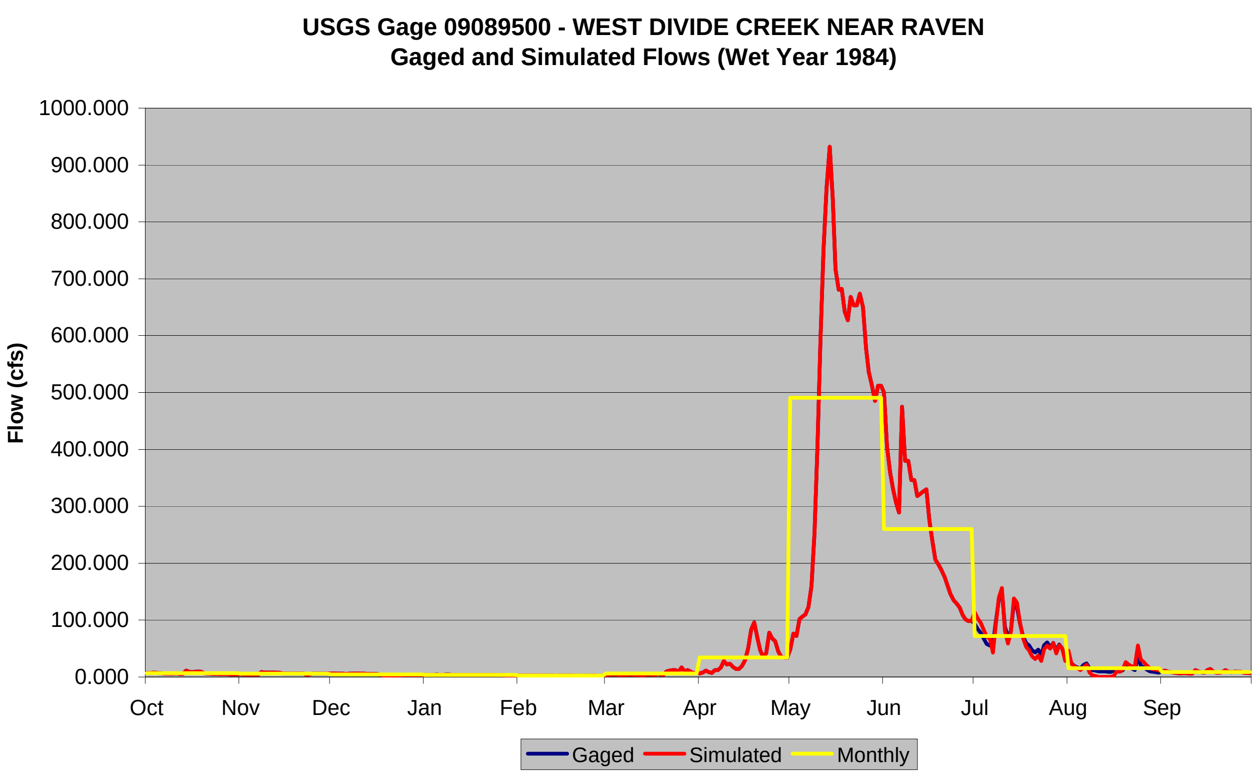


Figure 8.13 Daily Baseline Comparison, Wet Year – West Divide Creek near Raven

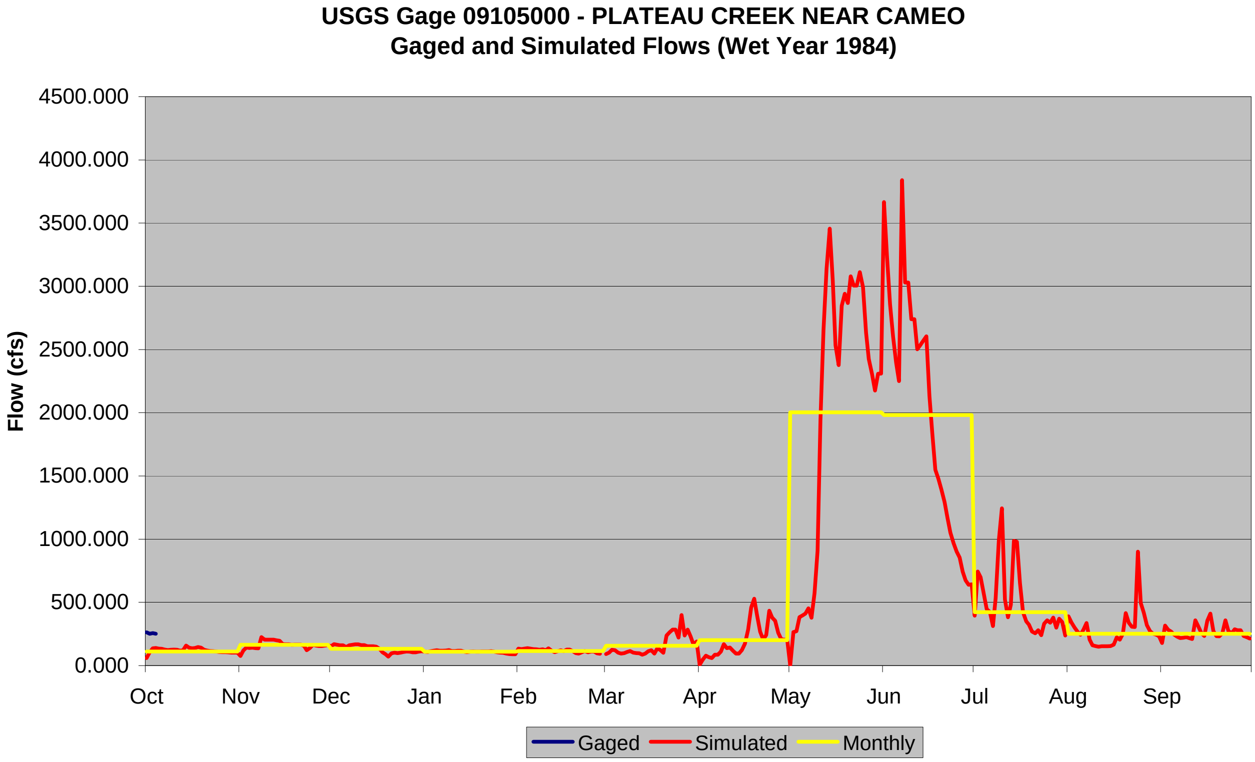


Figure 8.14 Daily Baseline Comparison, Wet Year – Plateau Creek near Cameo

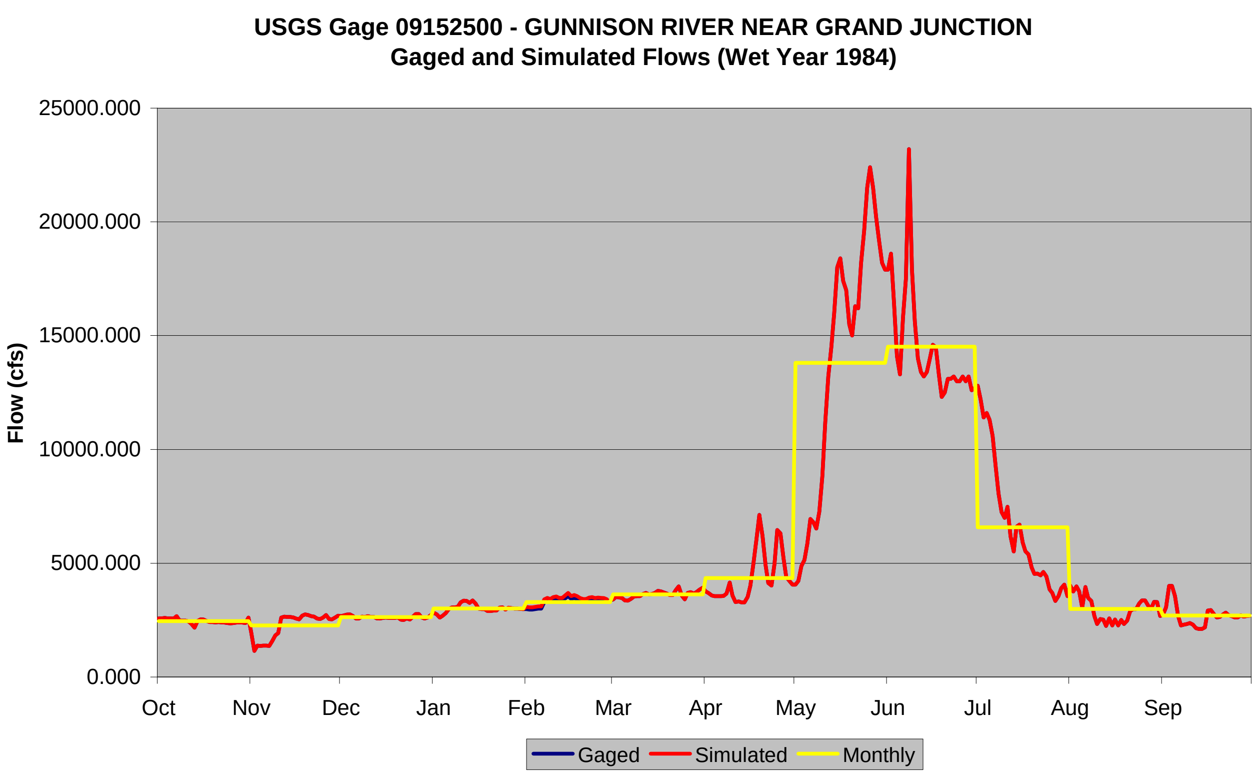


Figure 8.15 Daily Baseline Comparison, Wet Year – Gunnison River near Grand Junction

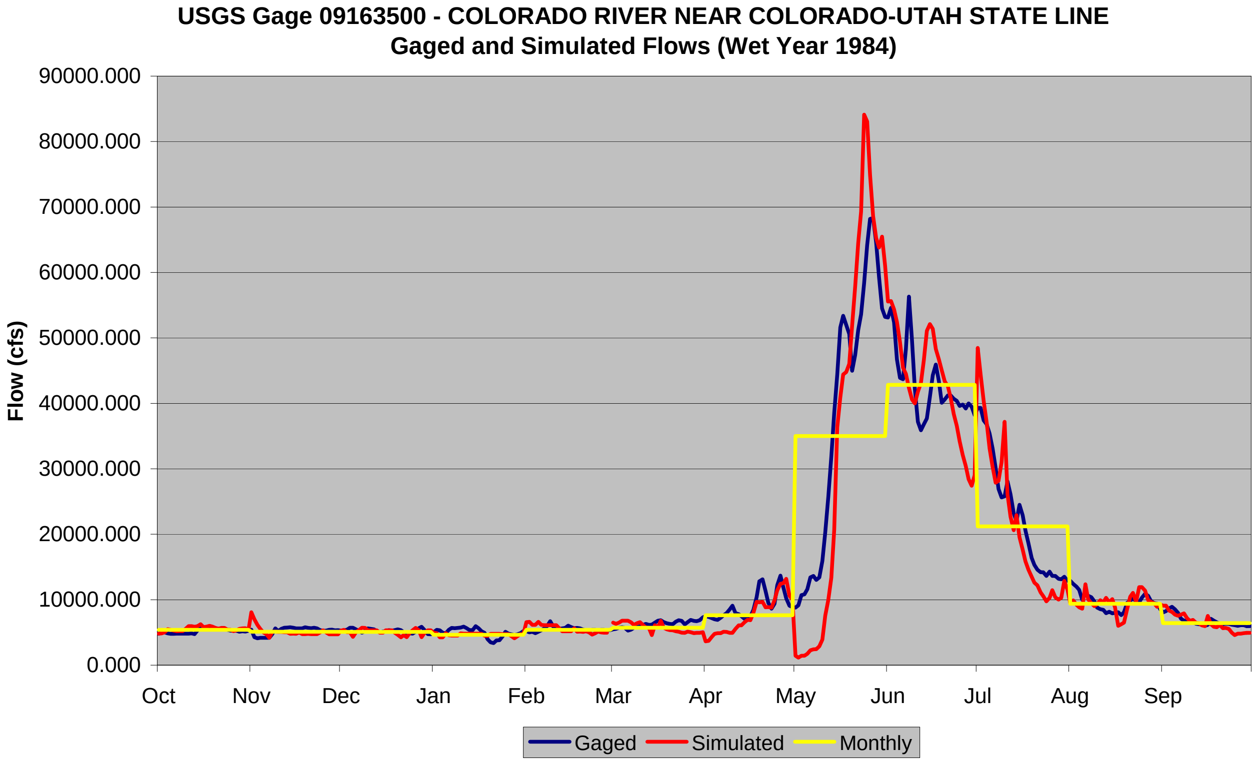


Figure 8.16 Daily Baseline Comparison, Wet Year – Colorado River near Colorado-Utah State Line

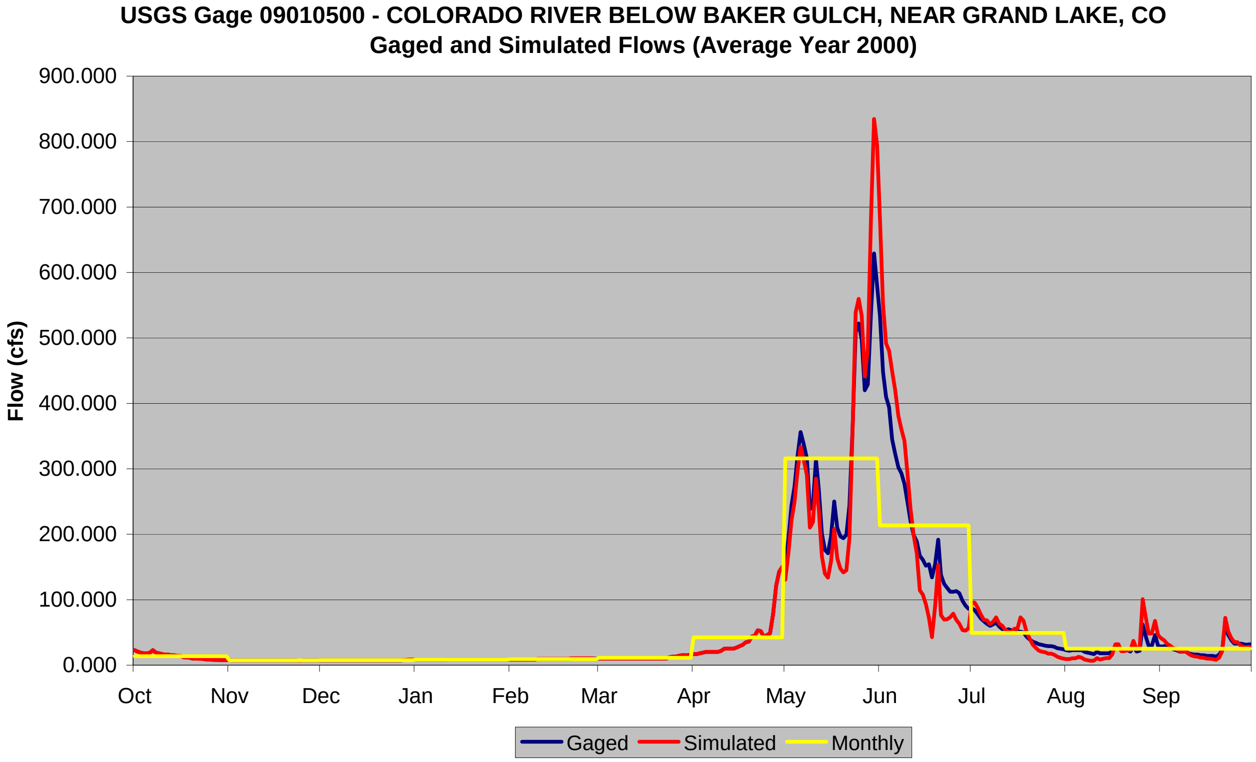


Figure 8.17 Daily Baseline Comparison, Average Year – Colorado River below Baker Gulch, near Grand Lake, CO

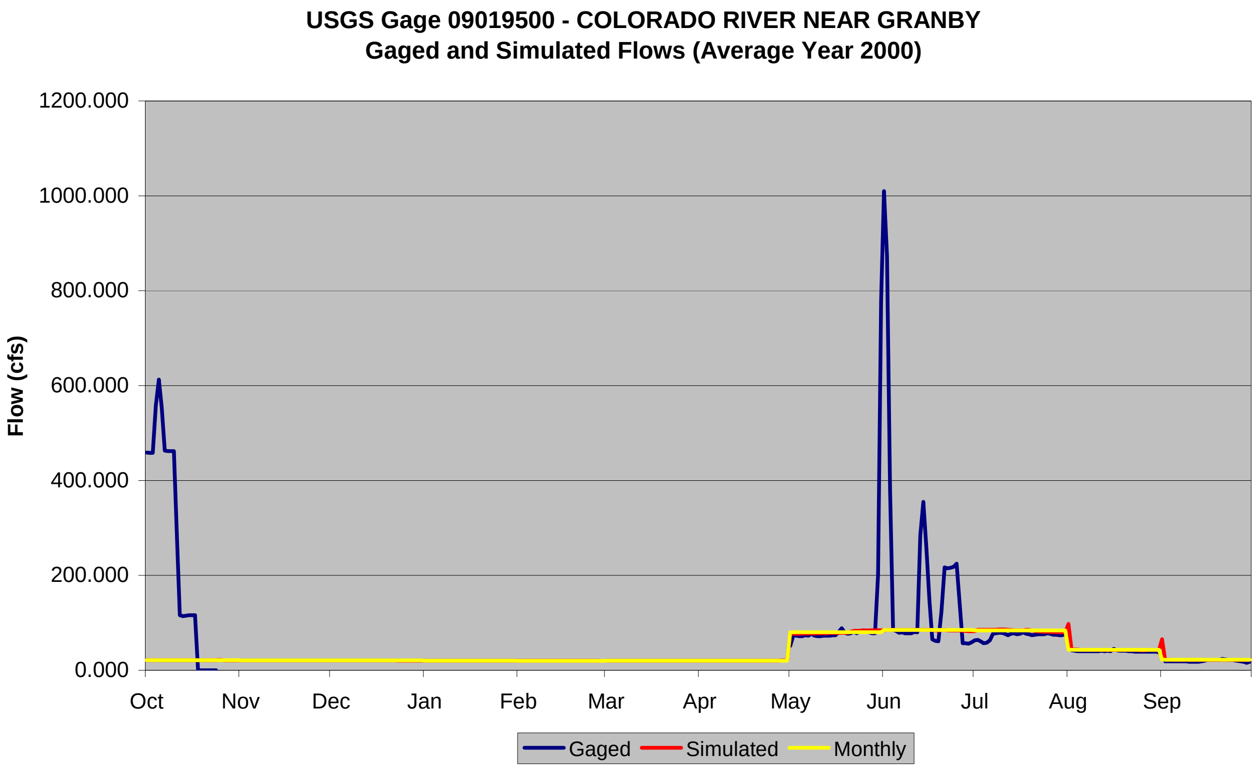


Figure 8.18 Daily Baseline Comparison, Average Year – Colorado River near Granby

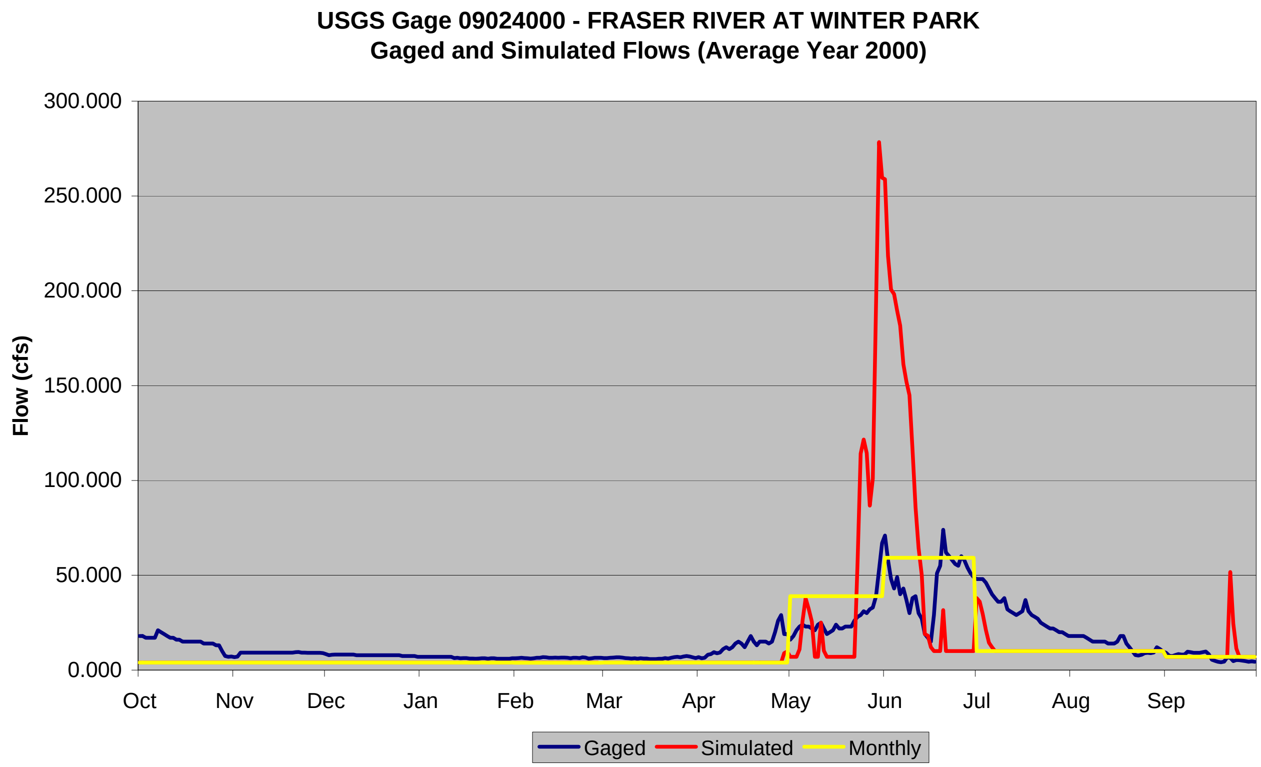


Figure 8.19 Daily Baseline Comparison, Average Year – Fraser River at Winter Park

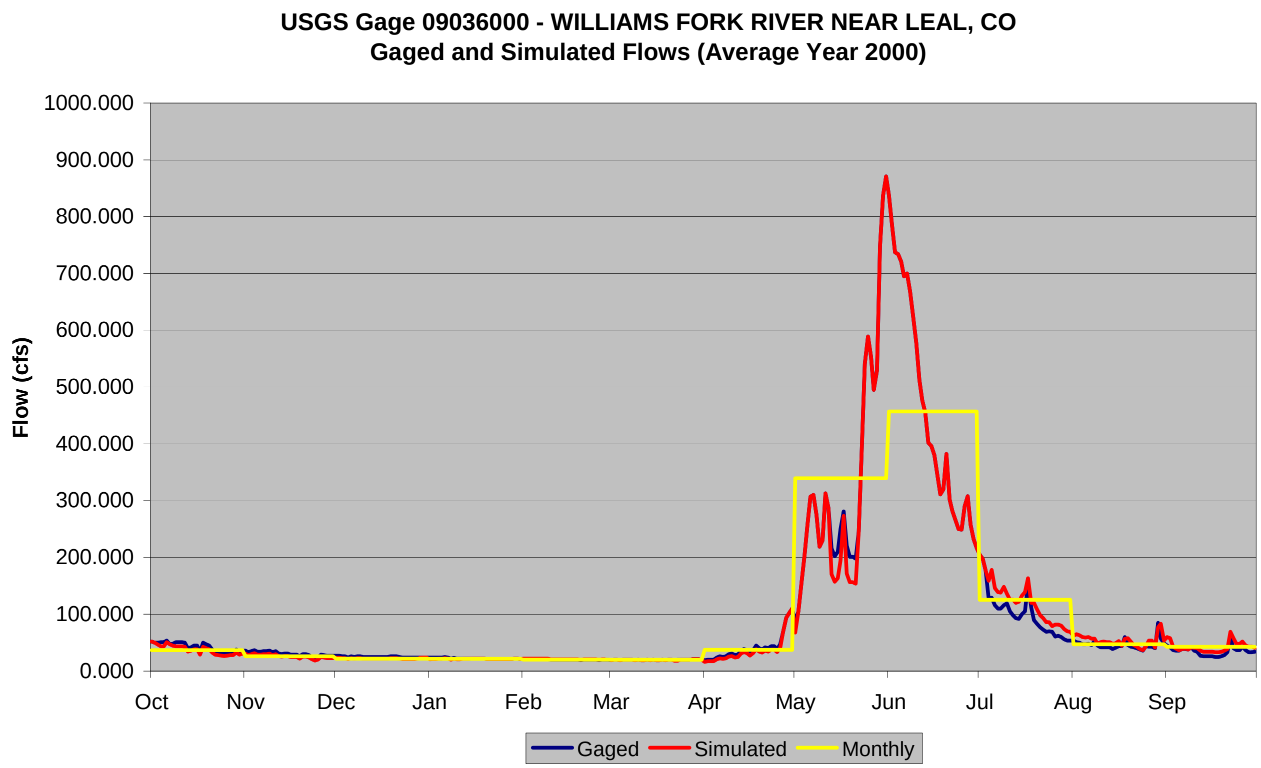


Figure 8.20 Daily Baseline Comparison, Average Year – Williams Fork River near Leal, CO

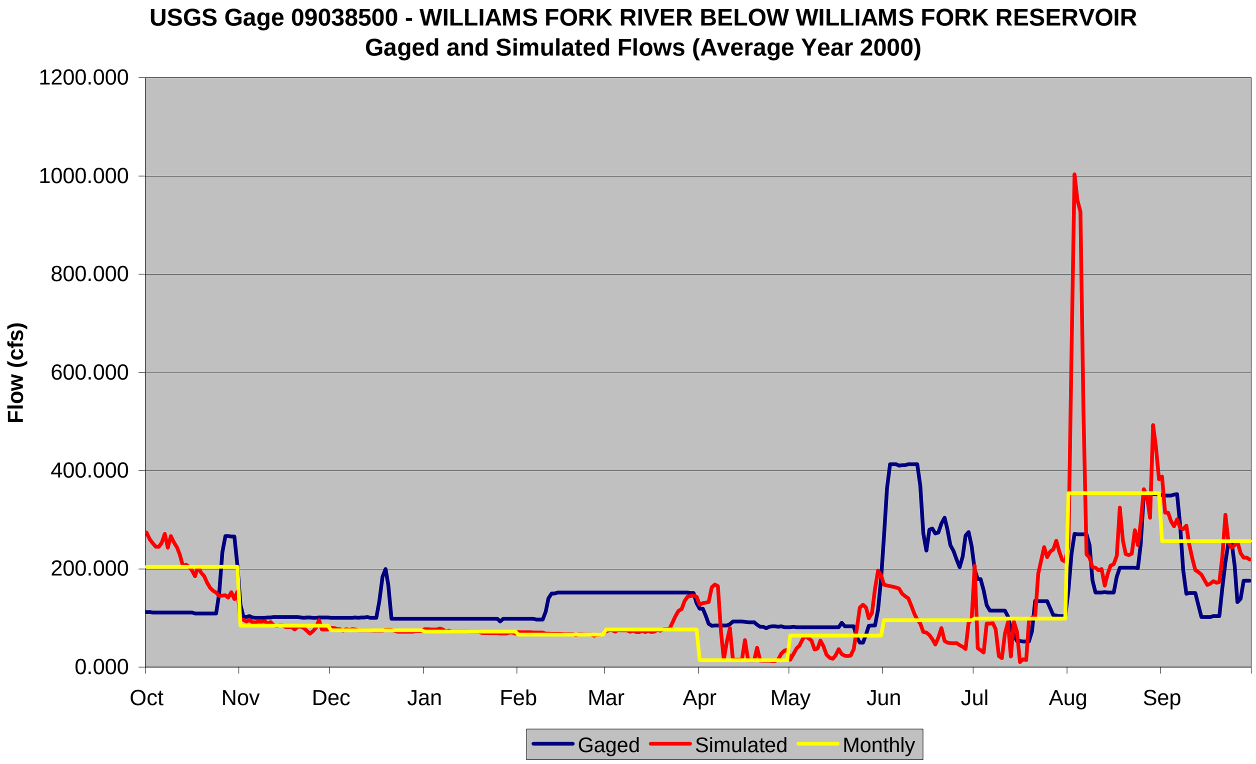


Figure 8.21 Daily Baseline Comparison, Average Year – Williams Fork River below Williams Fork Reservoir

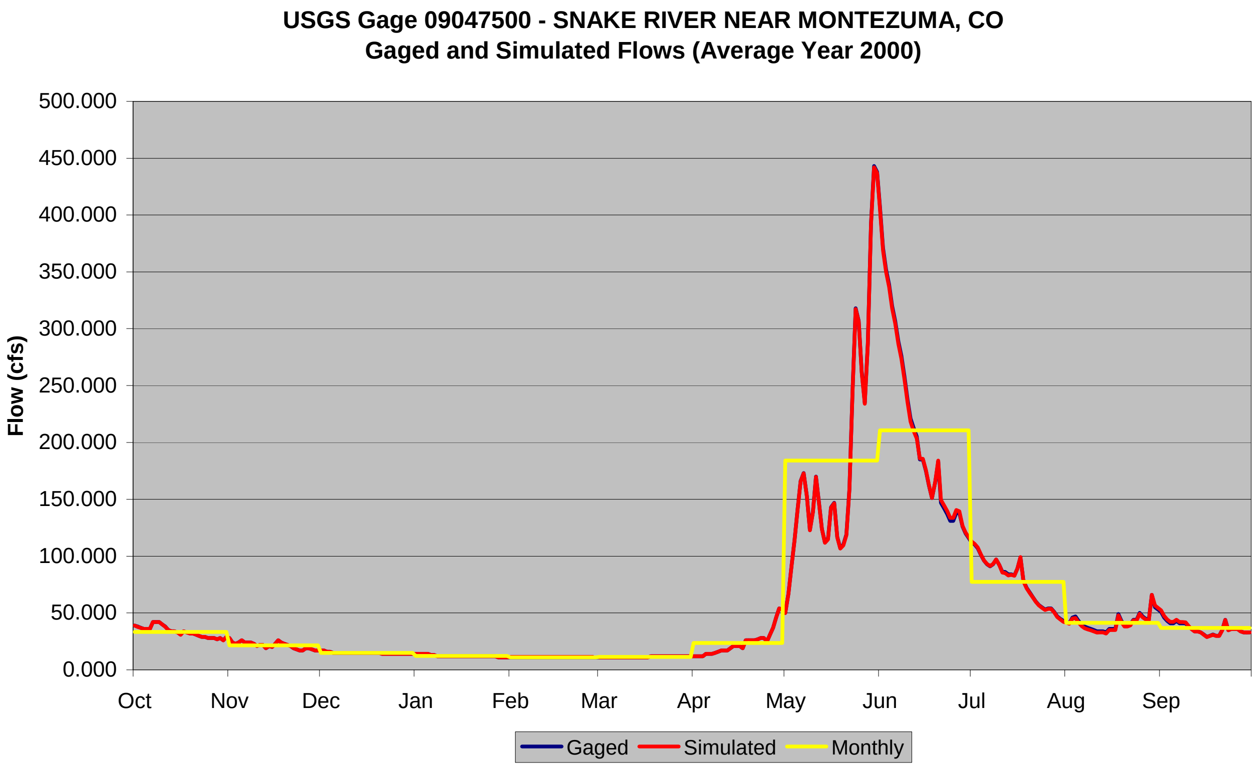


Figure 8.22 Daily Baseline Comparison, Average Year – Snake River near Montezuma, CO

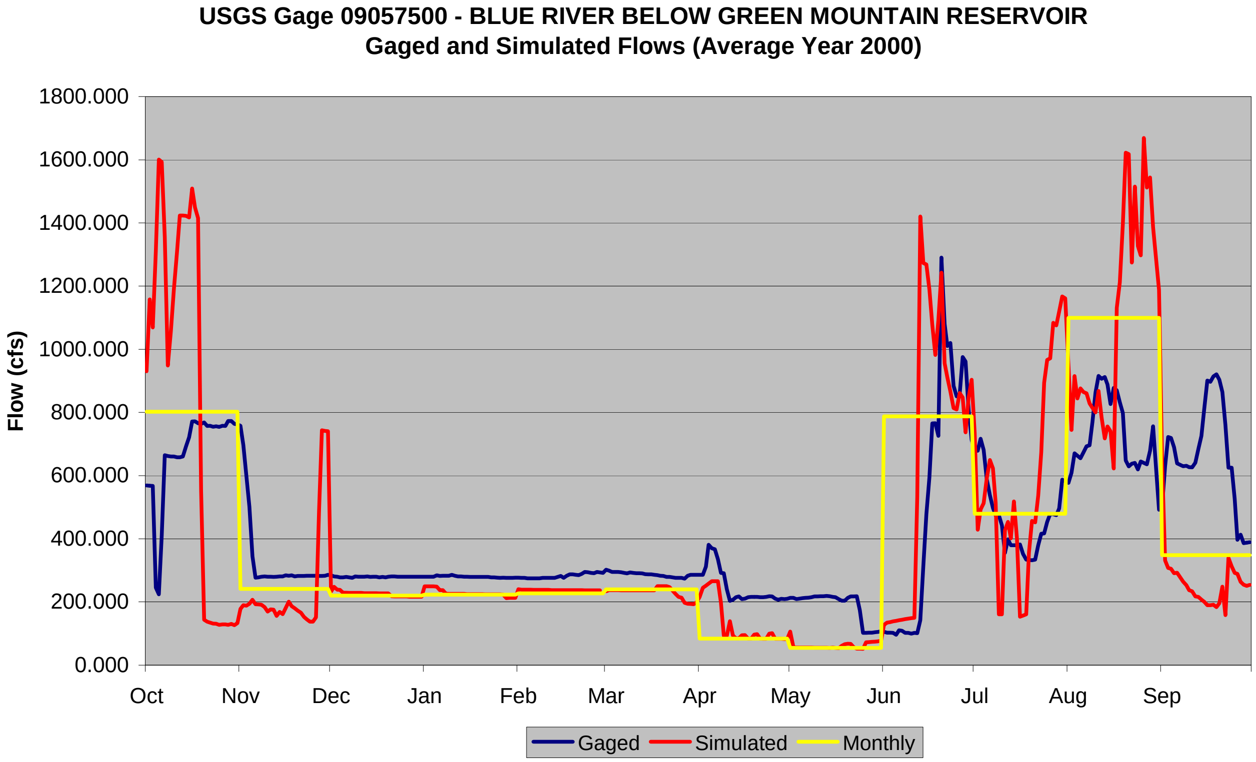


Figure 8.23 Daily Baseline Comparison, Average Year – Blue River below Green Mountain Reservoir

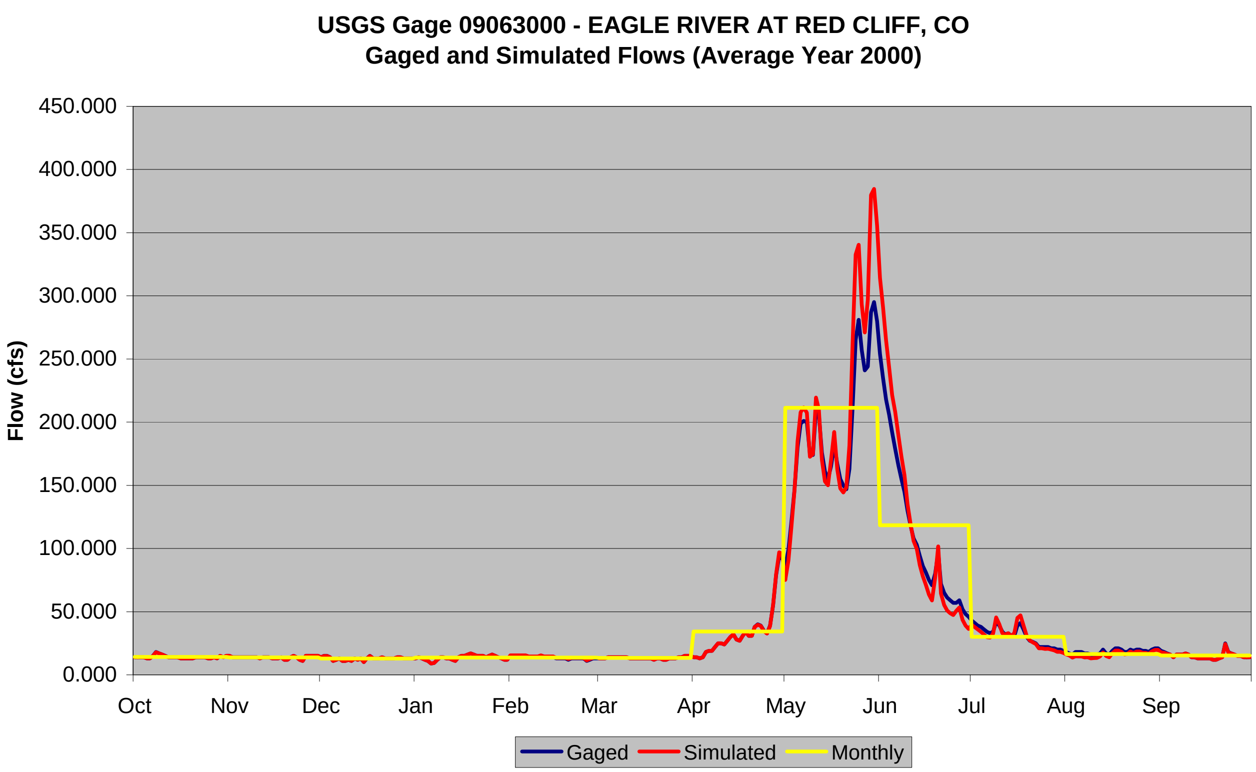


Figure 8.24 Daily Baseline Comparison, Average Year – Eagle River at Red Cliff, CO

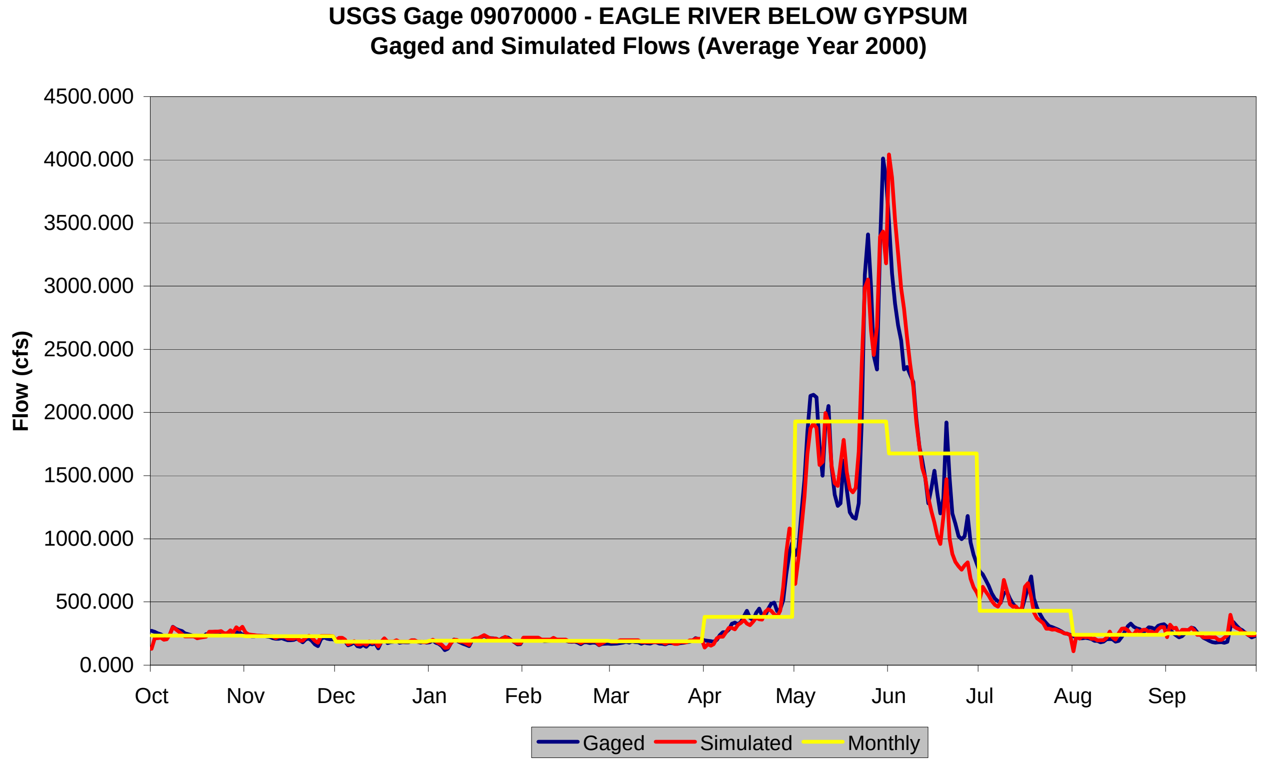


Figure 8.25 Daily Baseline Comparison, Average Year – Eagle River below Gypsum

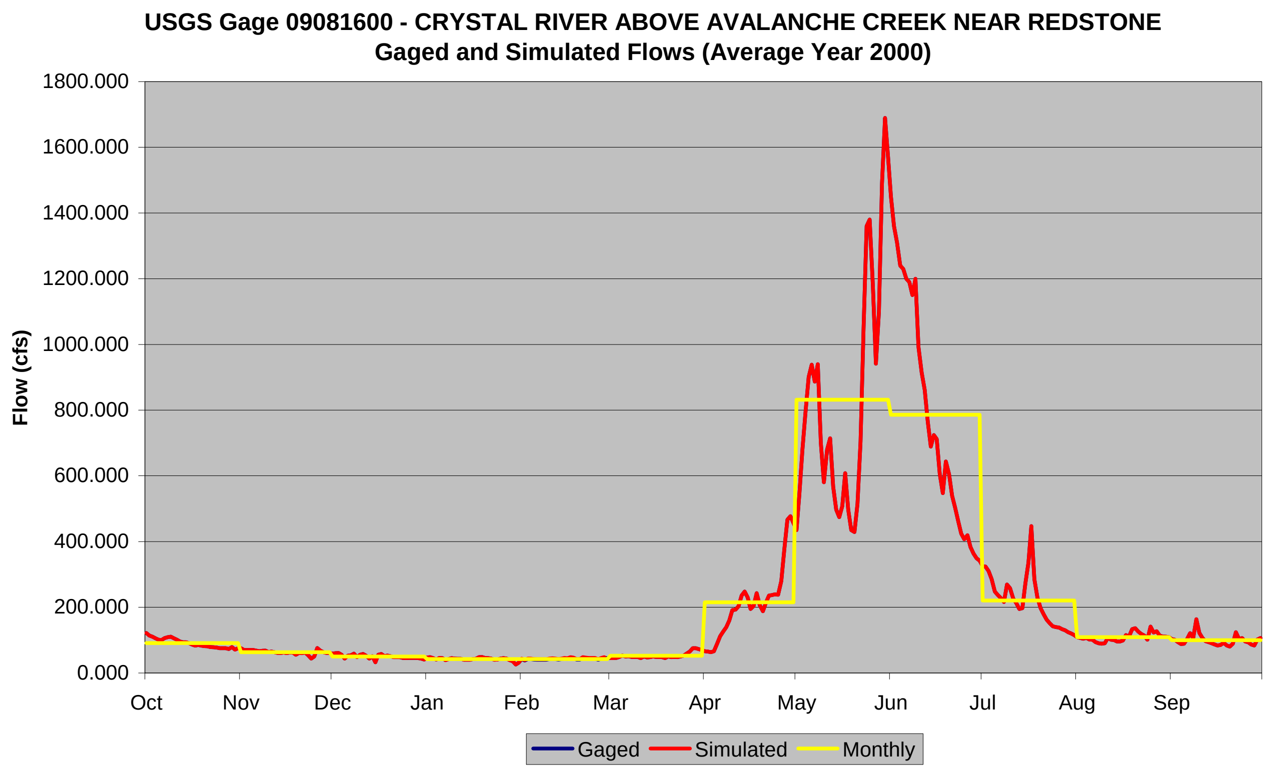


Figure 8.26 Daily Baseline Comparison, Average Year – Crystal River above Avalanche Creek near Redstone

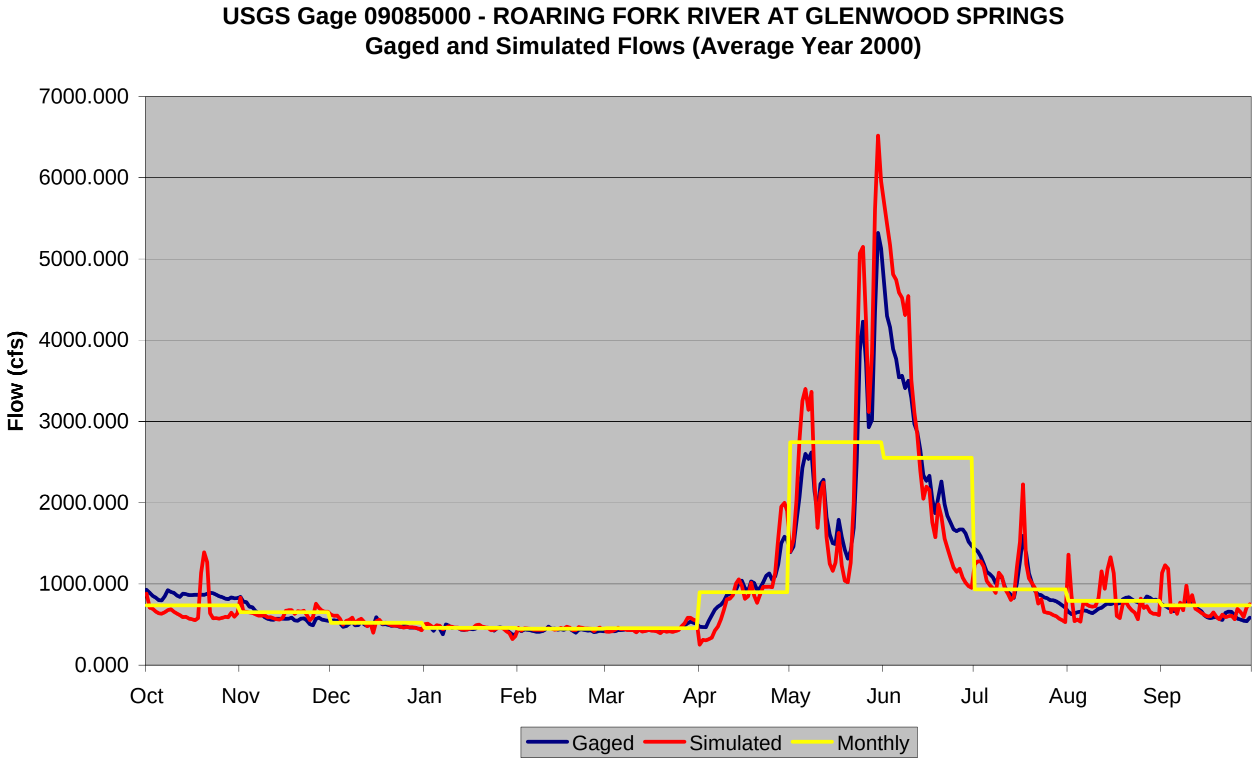


Figure 8.27 Daily Baseline Comparison, Average Year – Roaring Fork River at Glenwood Springs

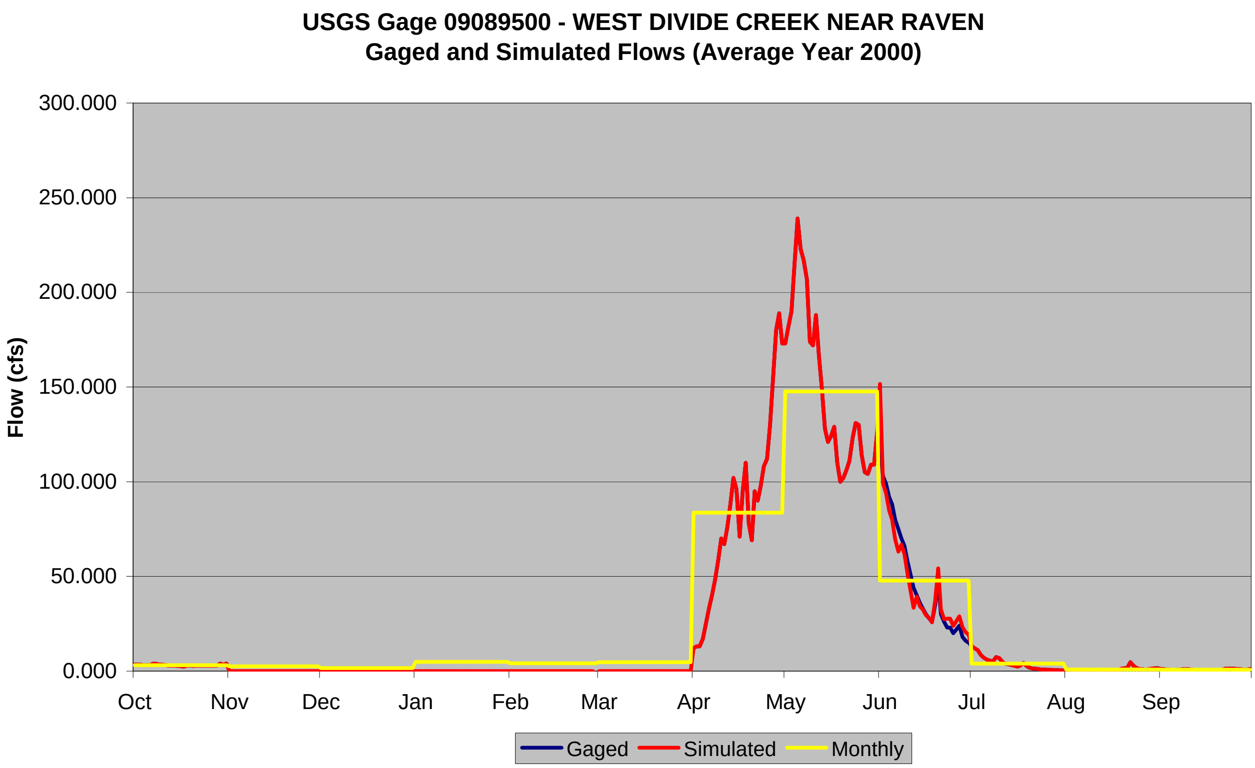


Figure 8.28 Daily Baseline Comparison, Average Year – West Divide Creek near Raven

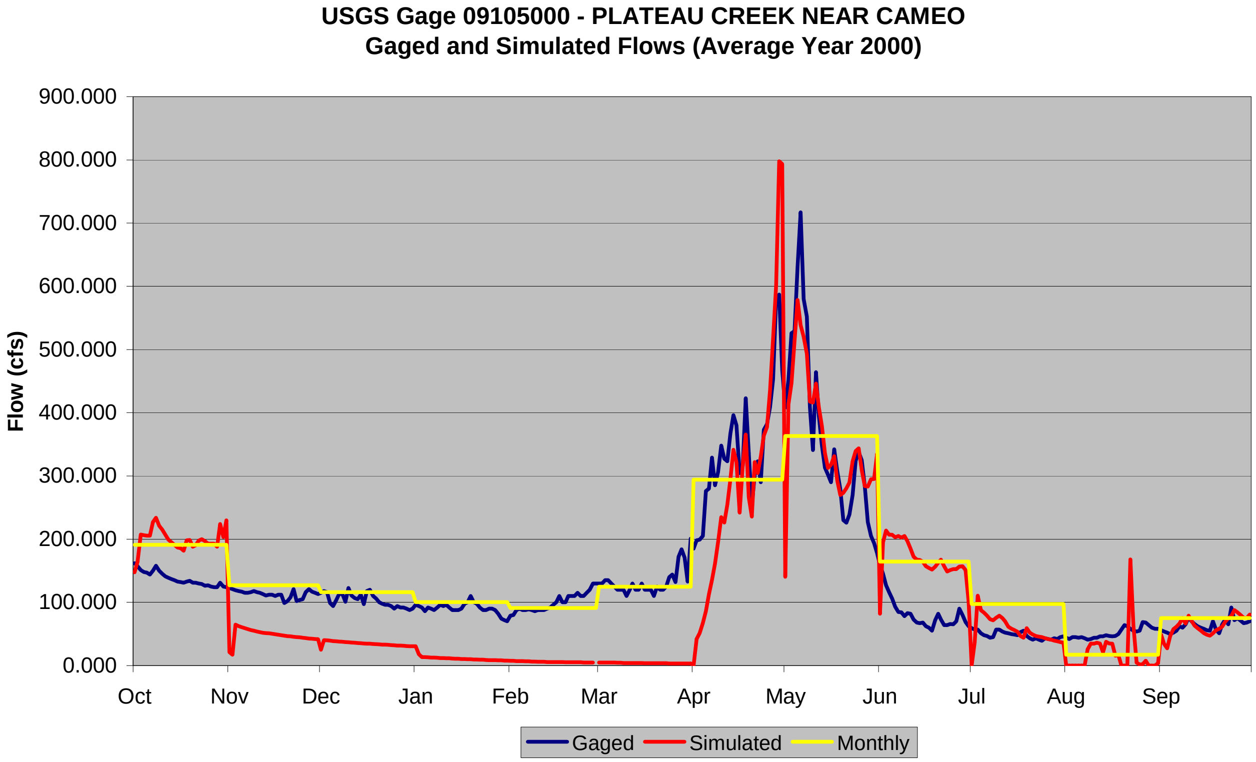


Figure 8.29 Daily Baseline Comparison, Average Year – Plateau Creek near Cameo

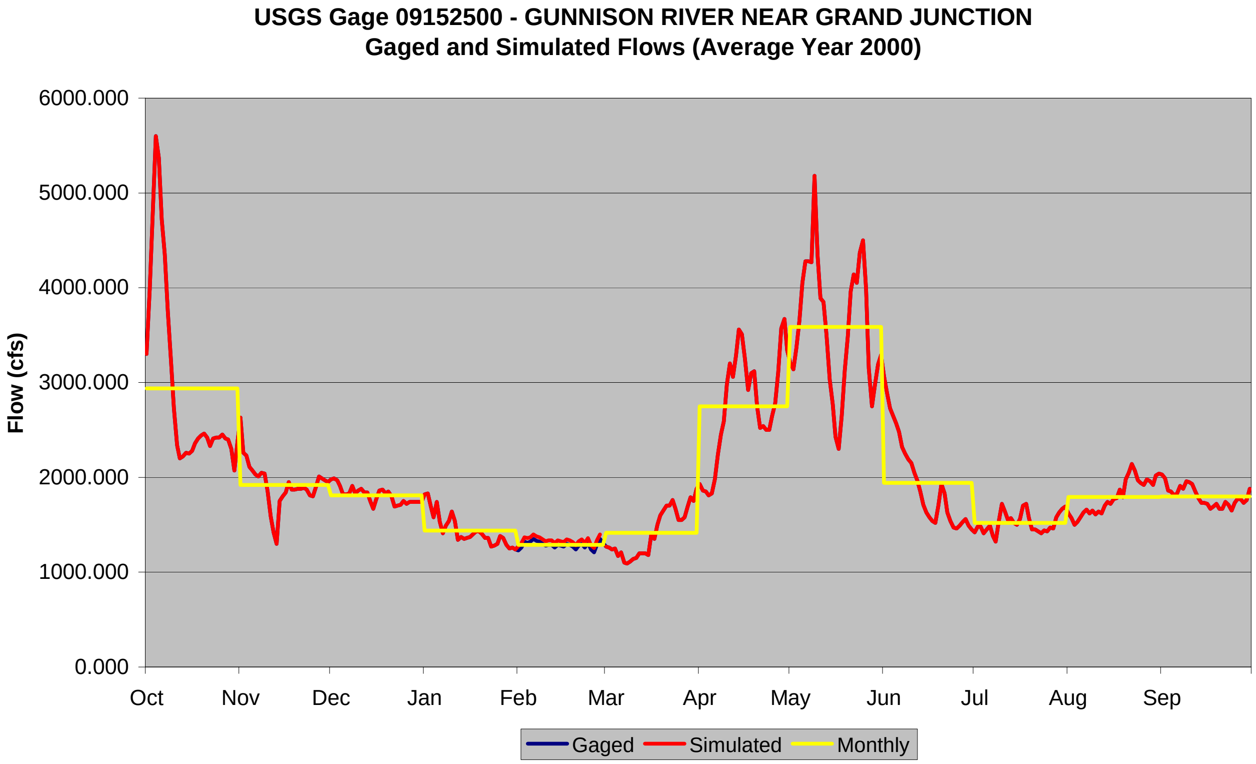


Figure 8.30 Daily Baseline Comparison, Average Year – Gunnison River near Grand Junction

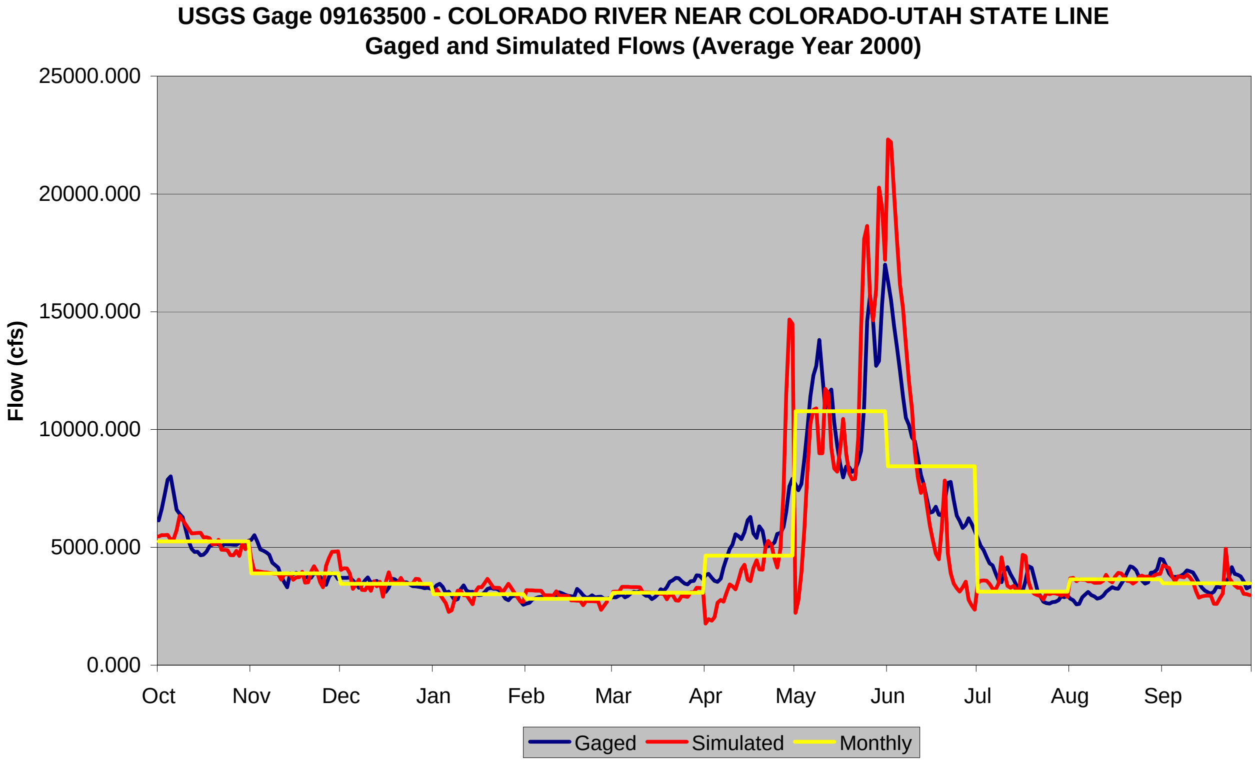


Figure 8.31 Daily Baseline Comparison, Average Year – Colorado River near Colorado-Utah State Line

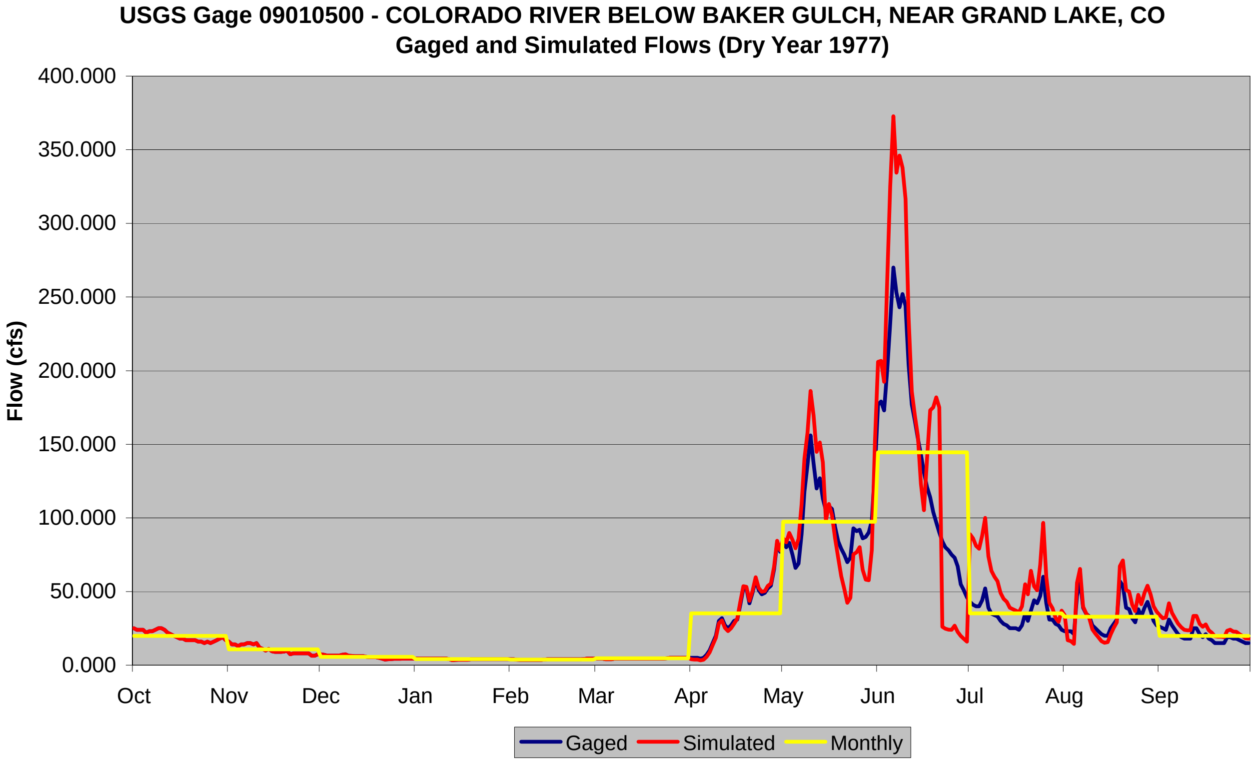


Figure 8.32 Daily Baseline Comparison, Dry Year – Colorado River below Baker Gulch, near Grand Lake, CO

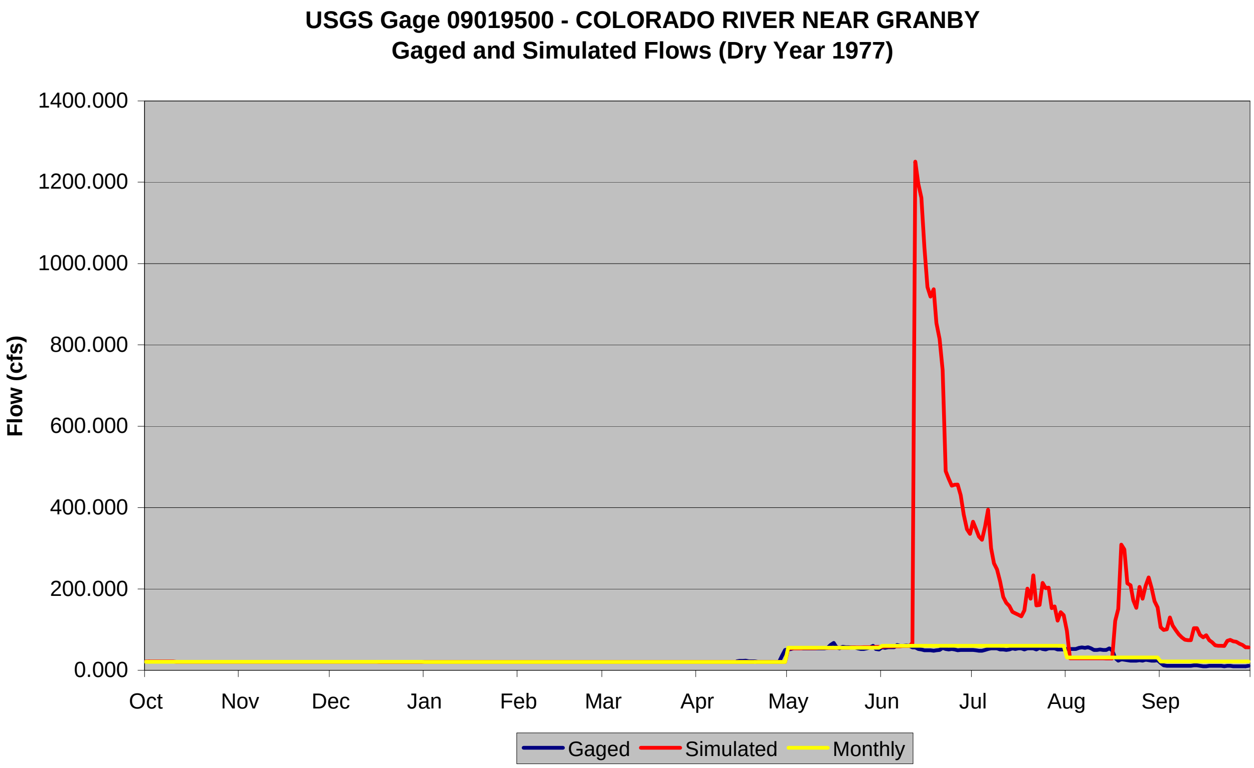


Figure 8.33 Daily Baseline Comparison, Dry Year – Colorado River near Granby

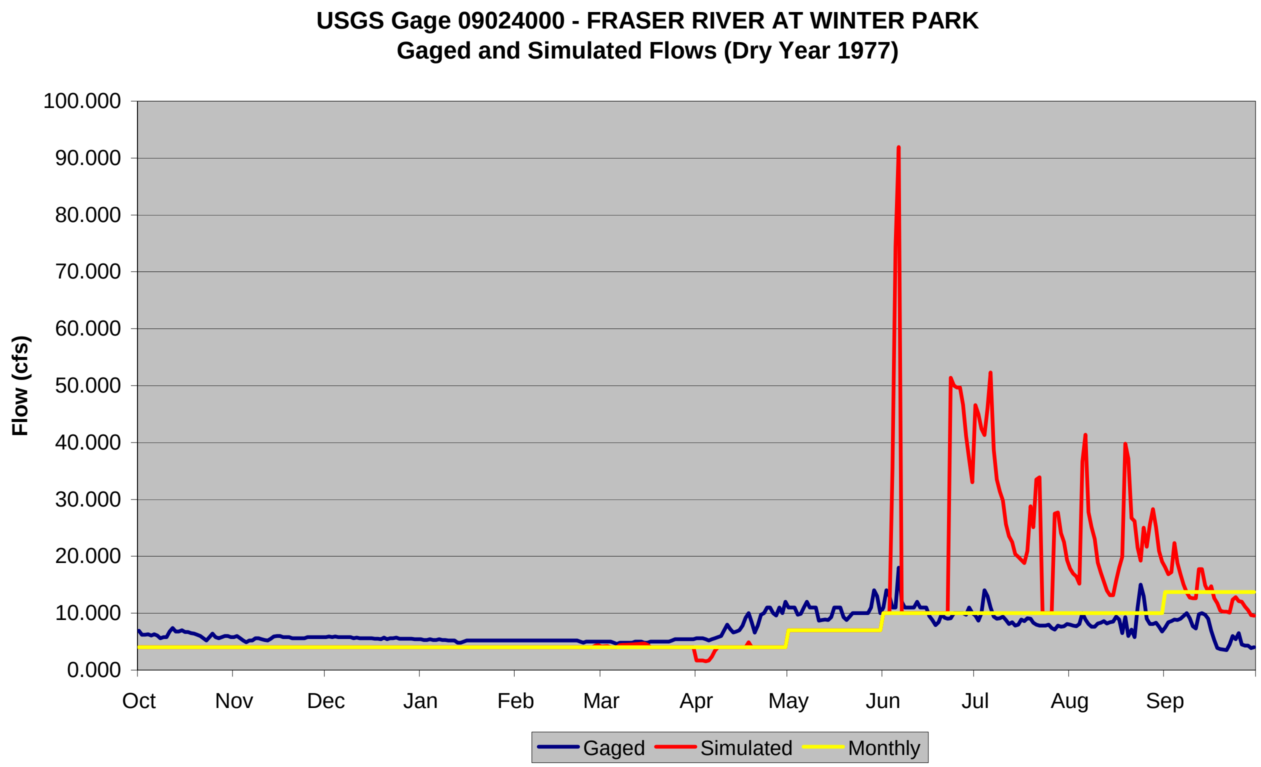


Figure 8.34 Daily Baseline Comparison, Dry Year – Fraser River at Winter Park

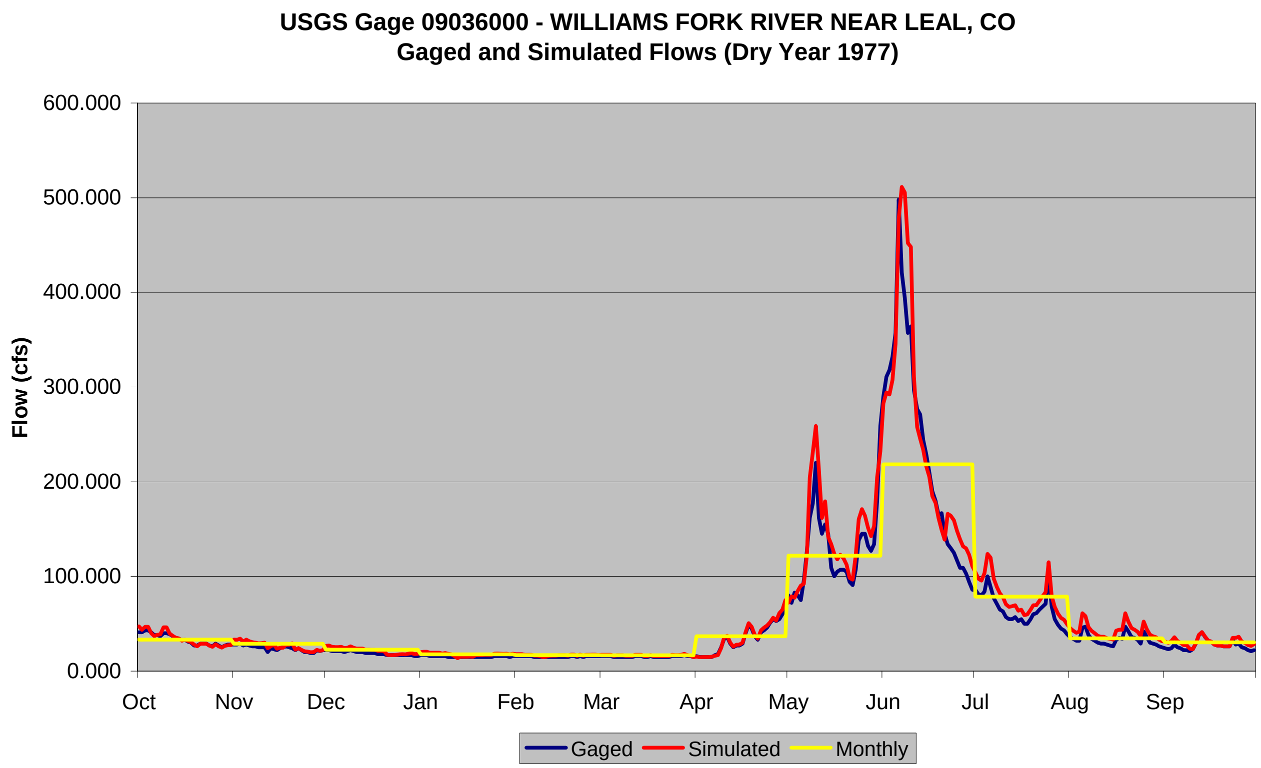


Figure 8.35 Daily Baseline Comparison, Dry Year – Williams Fork River near Leal, CO

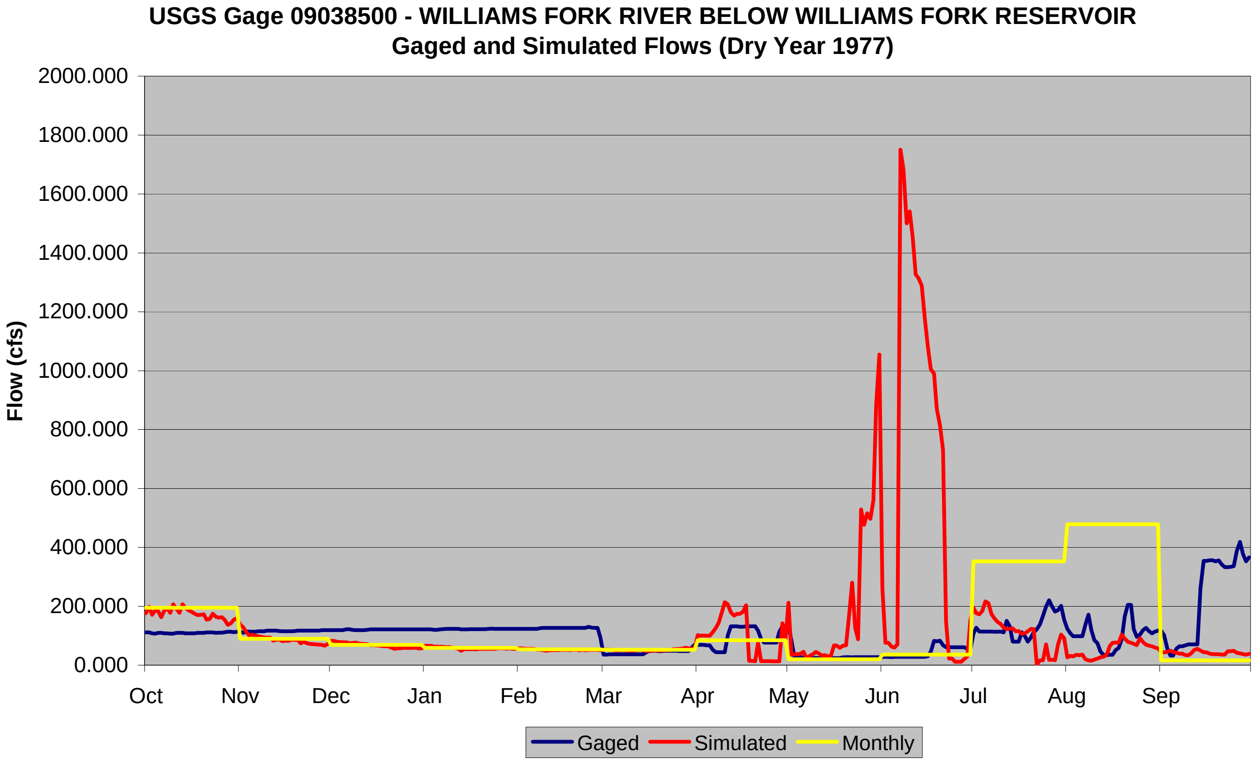


Figure 8.36 Daily Baseline Comparison, Dry Year – Williams Fork River below Williams Fork Reservoir

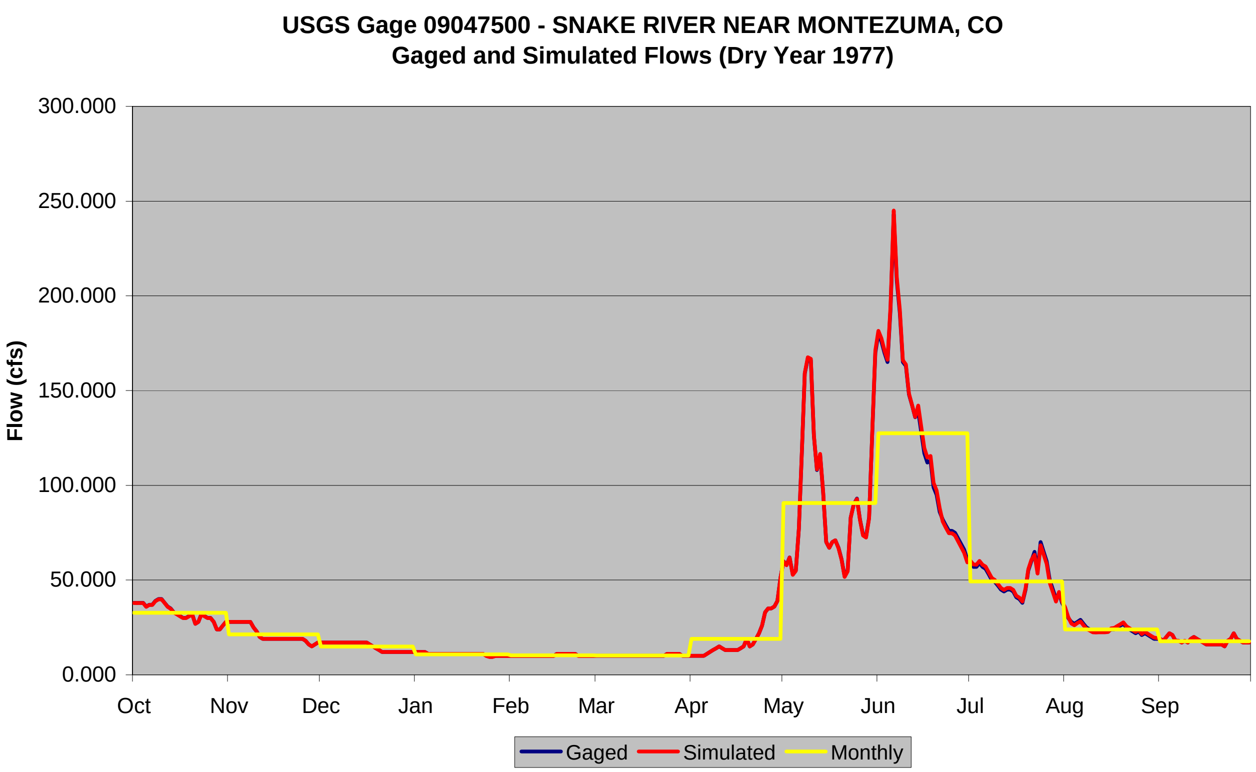


Figure 8.37 Daily Baseline Comparison, Dry Year – Snake River near Montezuma, CO

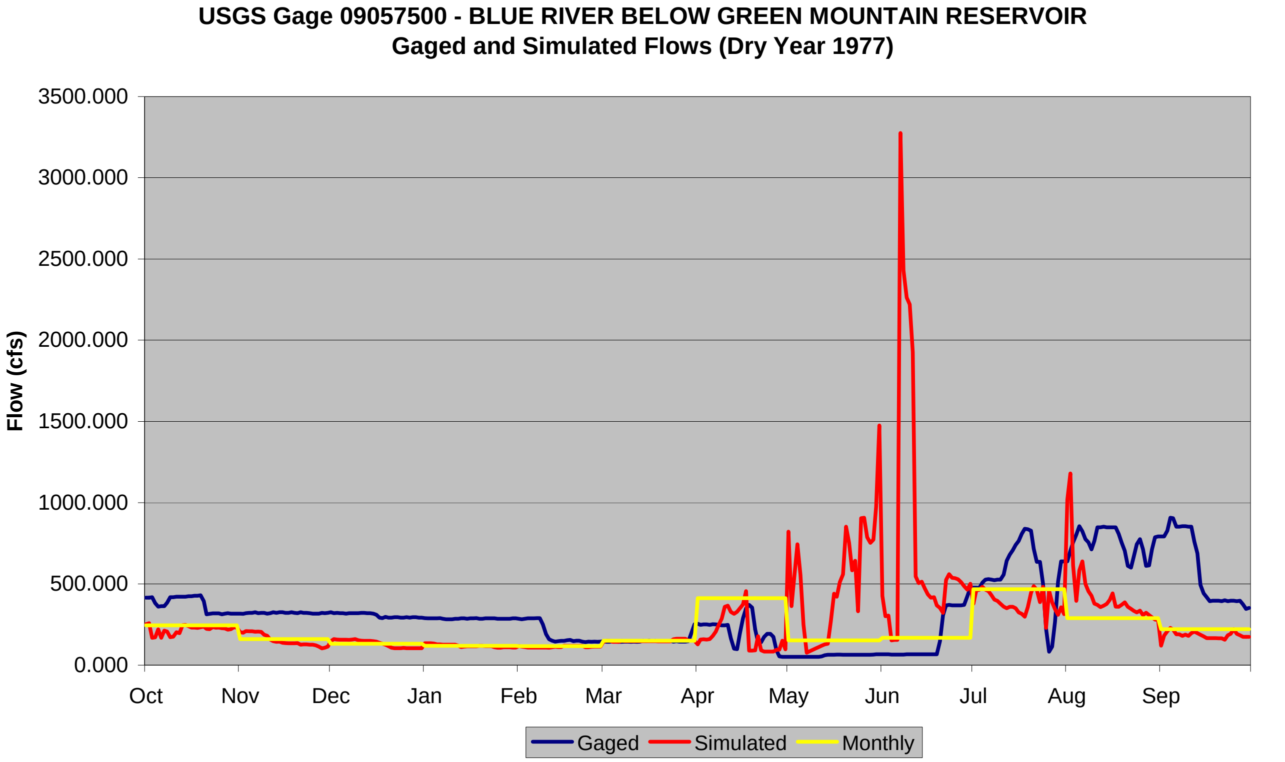


Figure 8.38 Daily Baseline Comparison, Dry Year – Blue River below Green Mountain Reservoir

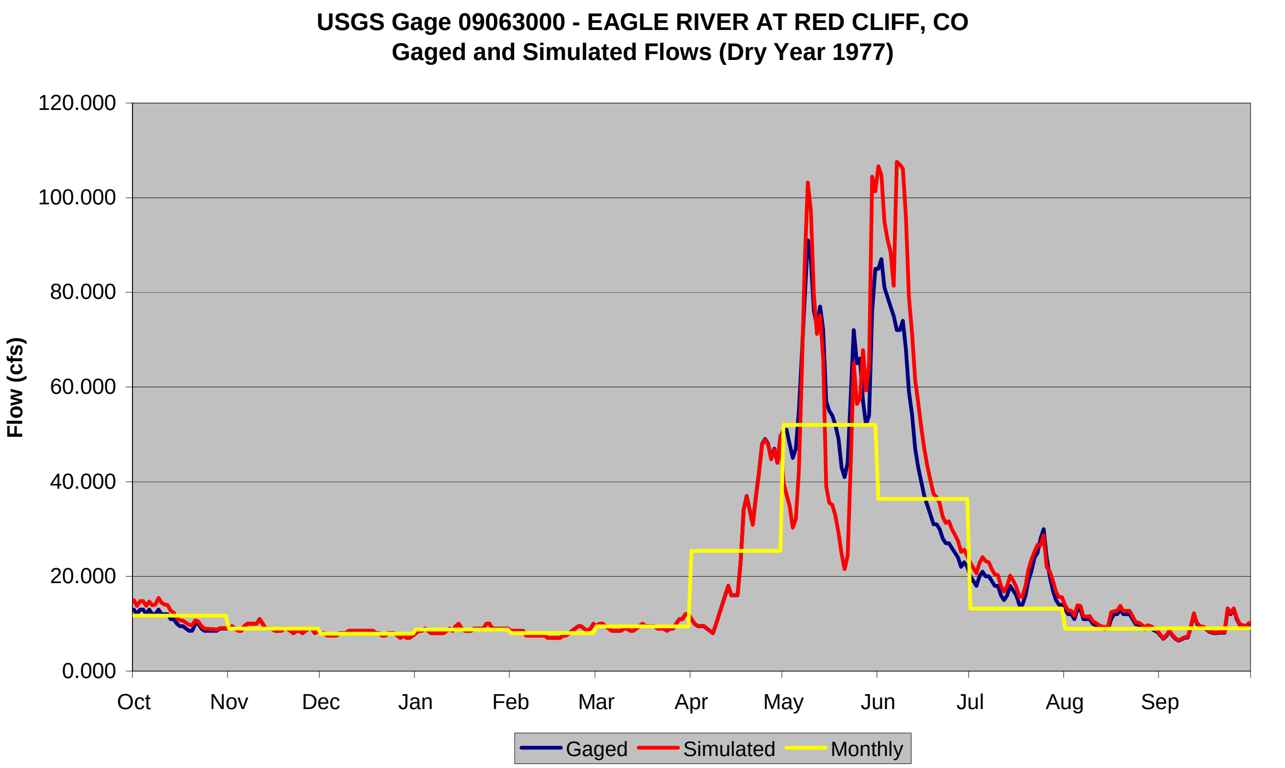


Figure 8.39 Daily Baseline Comparison, Dry Year – Eagle River at Red Cliff, CO

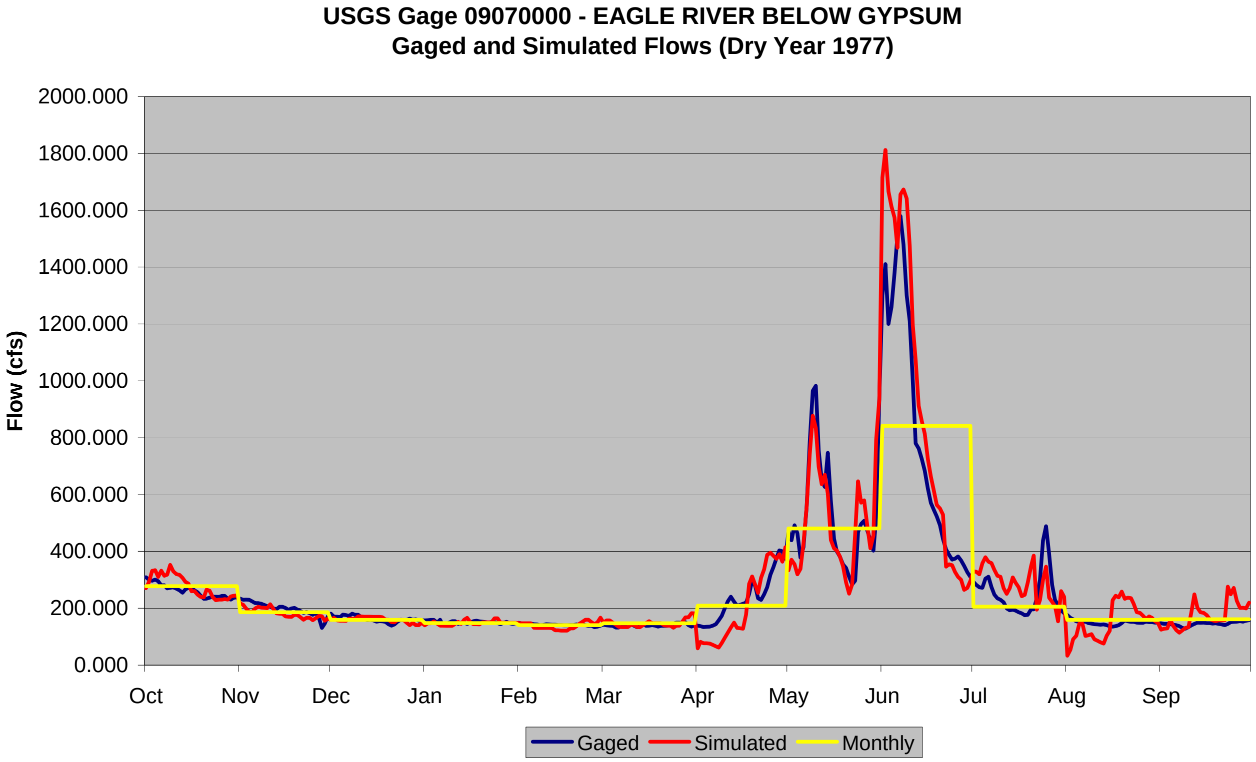


Figure 8.40 Daily Baseline Comparison, Dry Year – Eagle River below Gypsum

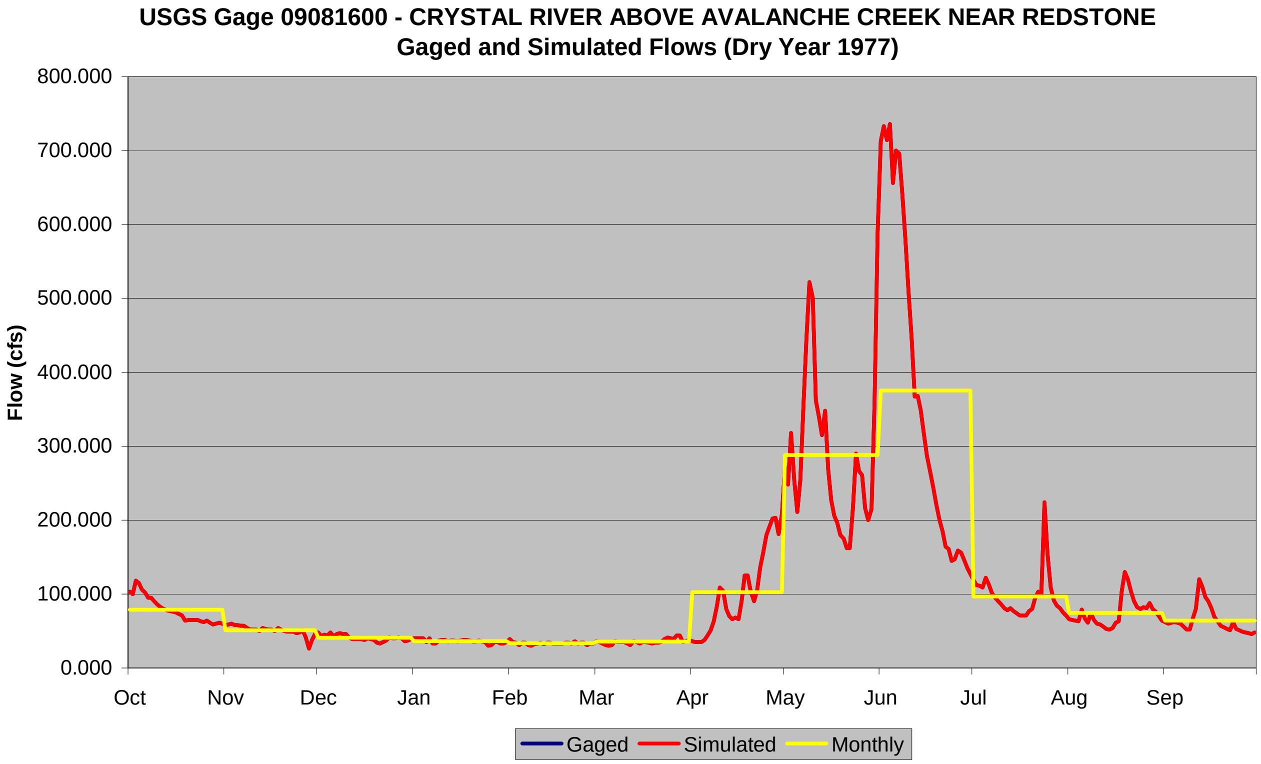


Figure 8.41 Daily Baseline Comparison, Dry Year – Crystal River above Avalanche Creek near Redstone

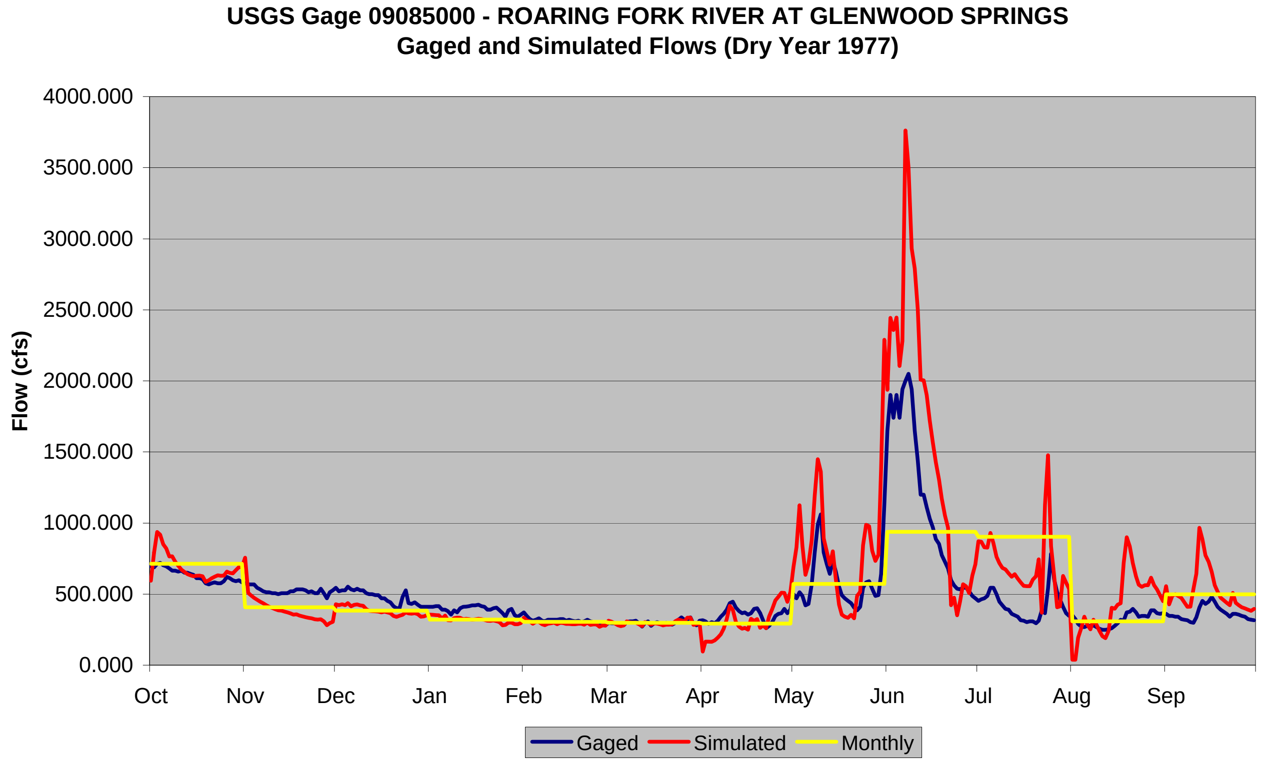


Figure 8.42 Daily Baseline Comparison, Dry Year – Roaring Fork River at Glenwood Springs

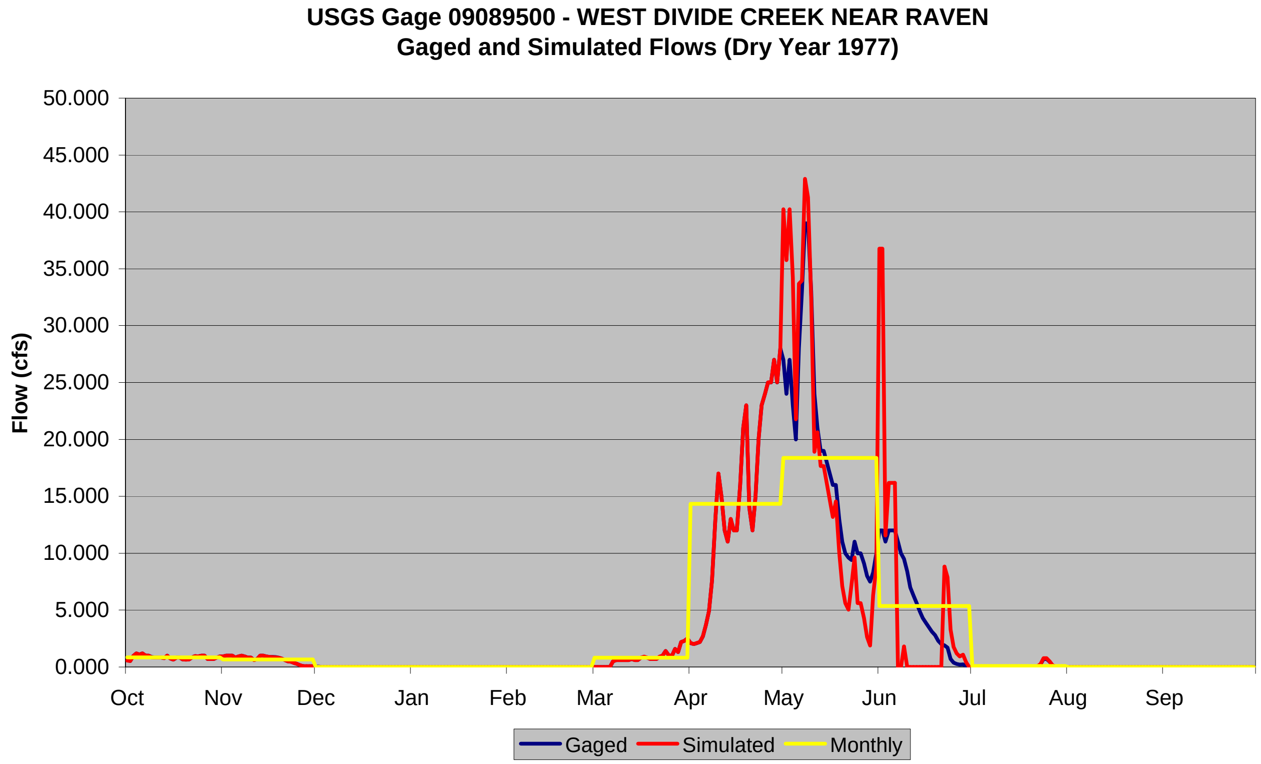


Figure 8.43 Daily Baseline Comparison, Dry Year – West Divide Creek near Raven

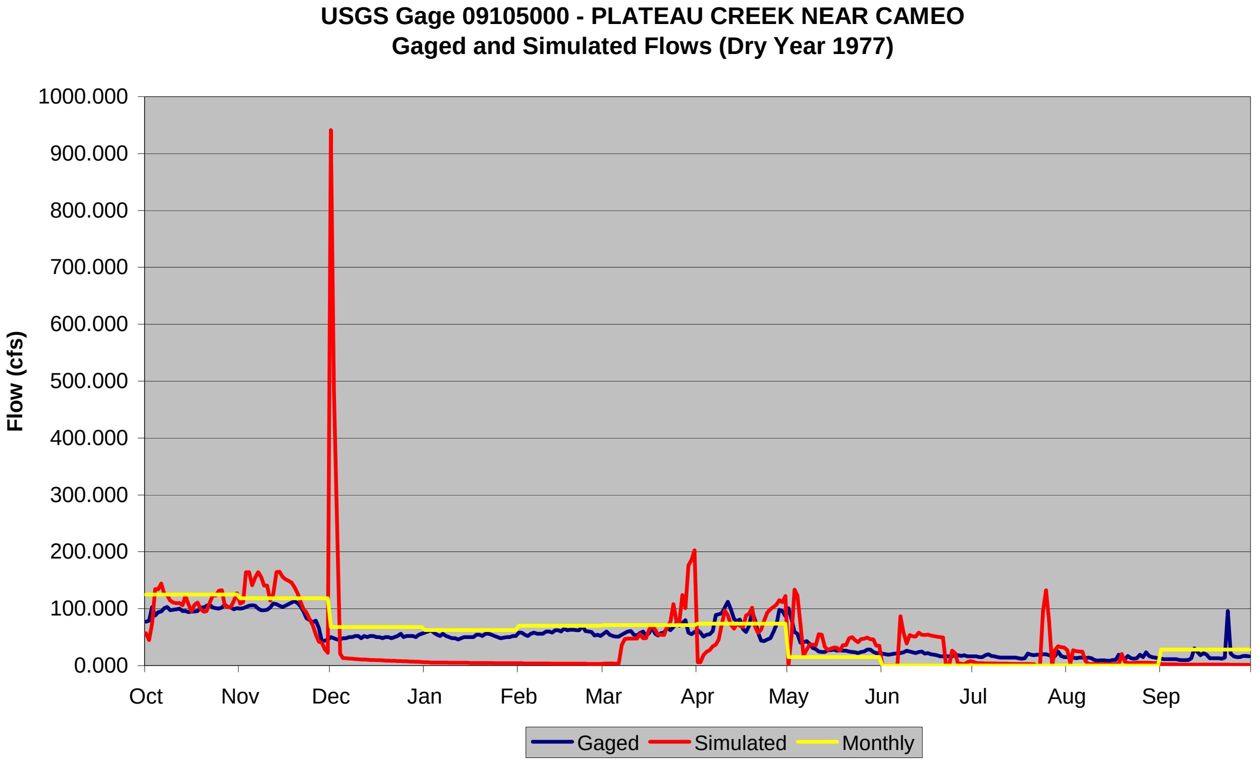


Figure 8.44 Daily Baseline Comparison, Dry Year – Plateau Creek near Cameo

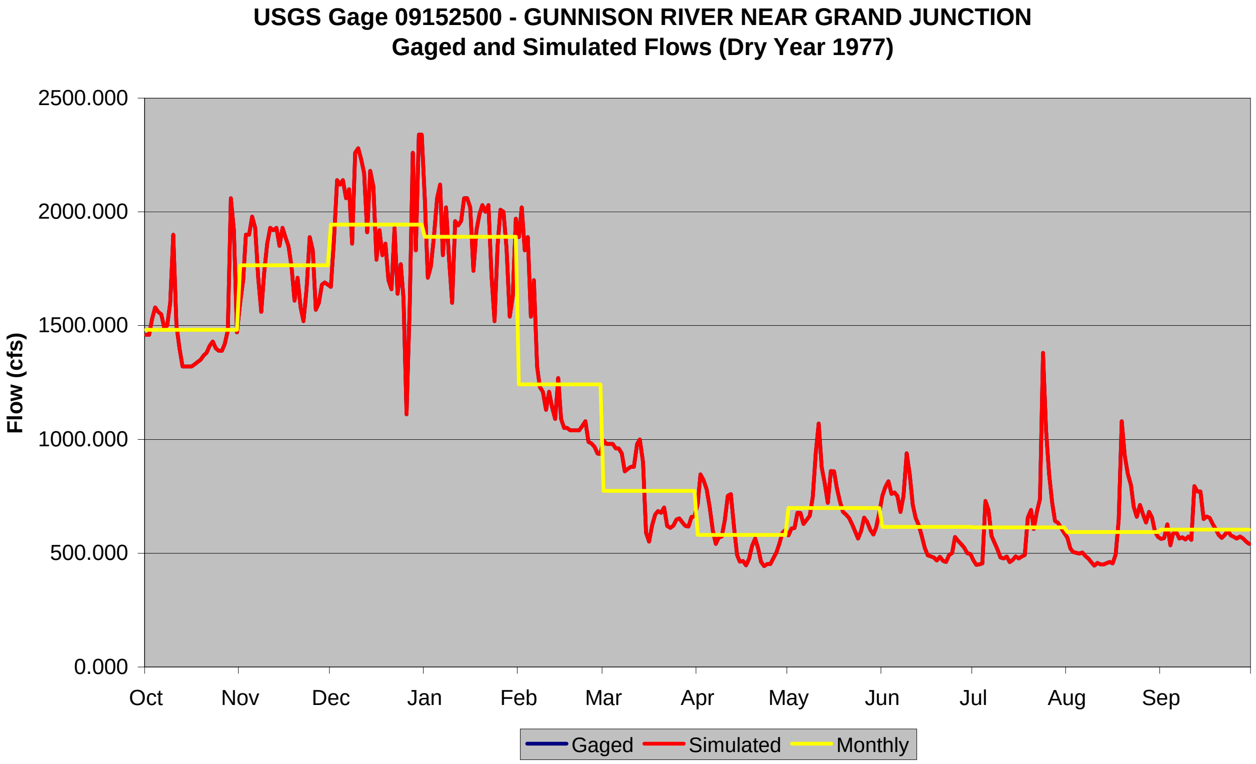


Figure 8.45 Daily Baseline Comparison, Dry Year – Gunnison River near Grand Junction

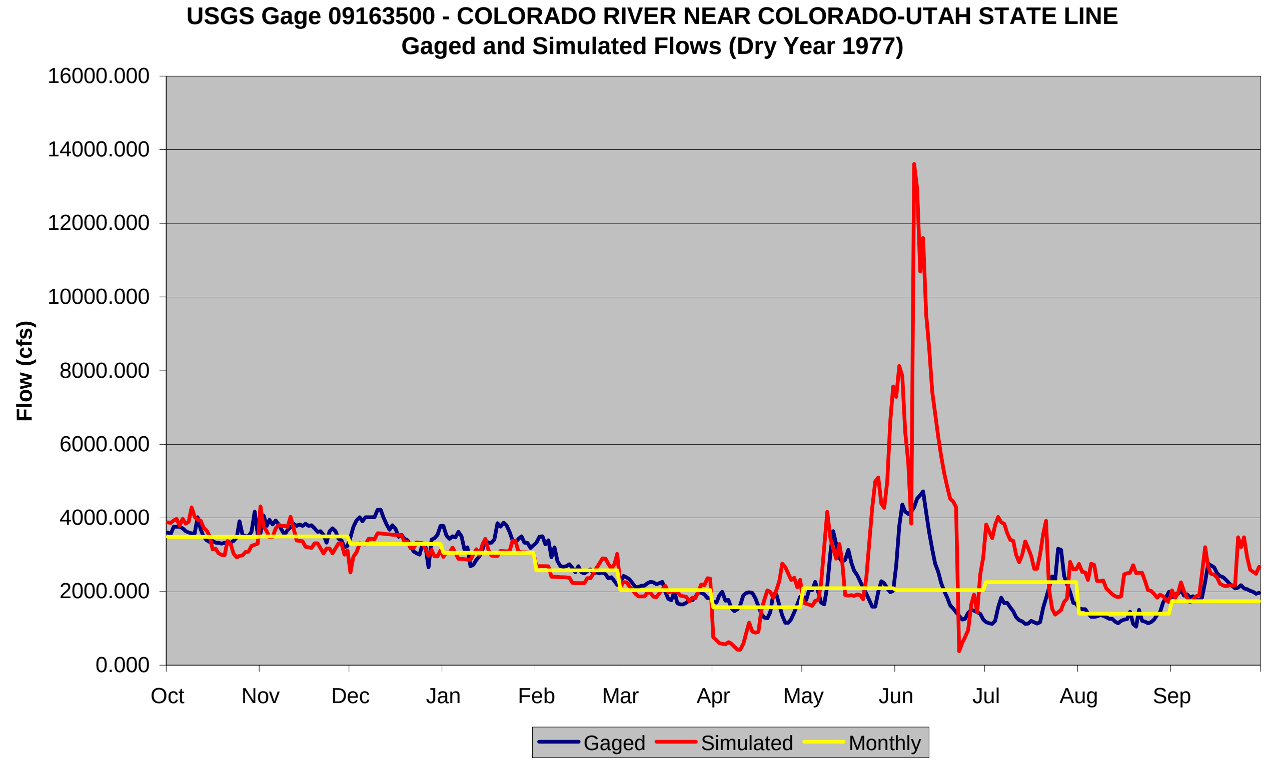


Figure 8.46 Daily Baseline Comparison, Dry Year – Colorado River near Colorado-Utah State Line

Appendix A

Aggregation of Irrigation Diversion Structures

1. Colorado River Aggregated Irrigation Structures
2. Define Water Right Classes (Section D.3 from Previous Documentation)

CDSS Memorandum
Final - Revised

To: Ray Alvarado

From: LRE, Erin Wilson, Jennifer Ashworth, and James Heath

Subject: **Colorado River Aggregated Irrigation Structures StateCU and Water Budget Maintenance - Task 10**

Date: July 27, 2006

Introduction

The original CRDSS StateMod and StateCU modeling efforts were based on the 1993 irrigated acreage coverage developed during initial CRDSS efforts. An irrigated acreage assessment representing year 2000 was recently performed for the CRDSS (western slope) basins. In each of the four Water Divisions (4, 5, 6, and 7), a portion of the 2000 acreage was tied to structures that did not have identified acreage in the 1993 coverage, therefore are not currently represented in the CRDSS models. In addition, structures that were identified as “Key” during the initial CRDSS efforts, in part based on irrigated acreage from the 1993 assessment, were no longer shown as irrigated in 2000. As part of this task, key and aggregate structure lists for the western slope basins were revised to include 100 percent of the irrigated acreage based on both the 1993 and 2000 assessment.

As part of the re-aggregation task, discrepancies in both the 1993 and 2000 irrigated acreages were identified. These discrepancies included:

- 1993 irrigated parcels were not assigned to a water source (structure),
- 1993 and 2000 parcels irrigating the same lands were assigned to different water sources,
- Structures identified as “Key” during efforts based on the 1993 coverage were not shown as irrigated in 2000, and
- Structure identifiers were incorrectly assigned to water districts where the acreage is located, instead of where the headgate is located. For example, acreage located in water district 40 was assigned by the water commissioner to structure 519. In the 2000 irrigated acreage coverage, the full WDID was entered as 4000519. However, the headgate for this structure is located in water district 41, and the correct WDID is 4100519.

Identified discrepancies were highlighted, and maps were sent to the Division Engineers for review. Both the 1993 and 2000 irrigated acreage coverages in each Water Division were revised based on the Division Engineers’ comments prior to revising the key and aggregated structures.

Approach

The following approach was followed to update the designation of key and aggregated irrigated structures in the Colorado basin.

1. Move Key structures to aggregations for future model updated based on comments received from the Division Engineer. In general, Key structures were removed if the Division Engineer indicated that they no longer irrigated lands in 2000 or where incorrectly assigned to irrigated lands in 1993.

2. Aggregate remaining irrigation structures identified in either the 1993 or 2000 irrigated acreage coverages based on the aggregate spatial boundaries defined during the previous Colorado modeling effort, as described in memorandum "Subtask 5.03 - Colorado River Basin Aggregated Irrigation Structures."

Results

Table 1 indicates the number of structures in the updated aggregation and provides a comparison of the aggregated acreage from the previous modeling effort to the acreage assigned to the aggregation based on the 1993 Updated GIS coverage and the 2000 GIS coverage.

Table 1
Updated Aggregation Summary

Aggregation ID	Aggregation Name	# of Structures	Previous Acres	1993 Acres	2000 Acres
51_ADC001	Colorado River nr Granby	11	547	547	550
51_ADC002	Willow Creek	7	501	501	785
51_ADC003	Ranch Creek	7	861	861	849
51_ADC004	Fraser River bl Crooked Creek	25	1,071	1,170	512
51_ADC005	Tenmile Creek	19	1,862	1,862	1,662
51_ADC006	Fraser River at Granby	9	840	840	626
51_ADC007	Colorado River abv Hot Sulphur Springs	24	1,283	1,372	667
51_ADC008	Colorado River abv Williams Fork	23	1,180	1,285	875
51_ADC009	Upper Williams Fork	14	881	881	897
51_ADC010	Lower Williams Fork	37	1,124	1,075	1,171
51_ADC011	Colorado River abv Troublesome Creek	17	753	852	716
50_ADC012	Troublesome Creek	28	1,238	1,238	1,794
50_ADC013	Upper Muddy Creek	19	1,691	1,713	1,987
50_ADC014	Muddy Creek abv Tyler Ditch	24	1,480	1,544	1,417
50_ADC015	Muddy Creek abv Red Dirt Creek	13	1,430	1,350	1,431
50_ADC016	Lower Muddy Creek	20	947	1,471	931
36_ADC017	Upper Blue River	53	2,086	1,896	821
36_ADC018	Blue River abv Green Mountain Rsvr	18	442	632	610

36_ADC019	Blue River bl Green Mountain Rsvr	28	1,572	1,554	2,082
50_ADC020	Colorado River bl Kremmling	20	1,699	1,471	1,643
52_ADC021	Black Tail & Sheephorn Creeks	71	2,734	2,734	1,902
53_ADC022	Upper Egeria Creek	7	964	394	308
53_ADC023	King Creek	11	809	809	1,377
53_ADC024	Egeria Creek abv Toponas Creek	9	745	2,450	1,262
53_ADC025	Toponas Creek	14	984	930	822
53_ADC026	Colorado River abv Alkali Canyon	38	947	932	958
52_ADC027	Colorado River abv Derby Creek	19	1,093	1,072	970
53_ADC028	Derby Creek	15	1,346	1,330	1,518
37_ADC029	Eagle River abv Brush Creek	43	2,000	2,851	1,220
37_ADC030	Brush Creek	32	1,607	2,605	599
37_ADC031	Eagle River bl Gypsum	33	1,451	1,583	971
53_ADC032	Colorado River abv Glenwood Springs	64	1,641	1,632	1,868
38_ADC033	Upper Roaring Fork	61	2,297	2,621	704
38_ADC034	Snowmass Creek	34	2,260	2,472	1,545
38_ADC035	Frying Pan River	27	753	751	358
38_ADC036	West Sopris Creek	22	1,229	1,195	600
38_ADC037	Roaring Fork abv Crystal River	29	2,160	2,156	1,156
38_ADC038	Crystal River	37	1,476	1,601	1,021
38_ADC039	Cattle Creek	24	1,506	1,502	1,025
38_ADC040	Lower Roaring Fork	16	1,184	1,318	1,107
39_ADC041	Elk Creek	39	1,516	1,516	1,432
45_ADC042	Colorado River bl Garfield Creek	54	1,360	1,728	1,406
45_ADC043	Colorado River bl Divide Creek	46	1,702	1,933	2,266
45_ADC044	Colorado R bl Mamm Creek	28	2,167	3,464	2,176
39_ADC045	Rifle Creek	30	1,531	1,541	1,324
45_ADC046	Colorado River bl Beaver Creek	27	1,452	1,120	1,172
45_ADC047	Colorado River bl Cache Creek	29	1,443	1,420	1,610
45_ADC048	Colorado River nr De Beque	46	2,076	2,182	2,795
70_ADC049	Upper Roan Creek	44	1,881	1,811	1,725
70_ADC050	Colorado River nr Cameo	22	1,645	1,313	1,063
72_ADC051	Plateau Creek abv Vega Rsvr	9	578	1,008	466
72_ADC052	Plateau Creek bl Vega Rsvr	7	755	894	774
72_ADC053	Salt Creek	22	1,531	1,641	1,120
72_ADC054	Upper Buzzard Creek	24	2,095	2,065	1,200
72_ADC055	Plateau Creek bl Buzzard Creek	16	1,030	1,011	928

72_ADC056	Upper Grove Creek	14	881	1,226	872
72_ADC057	Lower Grove Creek	13	1,250	1,213	881
72_ADC058	Kimball Creek	11	837	722	524
72_ADC059	Big Creek	26	1,094	710	970
72_ADC060	Cottonwood Creek	6	631	631	816
72_ADC061	Bull Creek	12	751	751	612
72_ADC062	Coon Creek	23	1,845	1,615	806
72_ADC063	Mesa Creek	20	1,198	1,405	1,650
72_ADC064	Plateau Creek	25	846	794	254
72_ADC065	Colorado River nr State Line	54	2,139	1,809	2,050
Total		**1,669**	**86,908**	**92,576**	**74,209**

Eighteen structures identified as Key in the previous CRDSS efforts are now included in aggregated structures as follows:

- 3700545 – C K P Ditch. This structure had no acreage assigned in 2000 – the only remaining use is on a golf course which was not included in the GIS assessment.
- 3700583 – Eagle Town of Grav Sys. This structure had no acreage assigned in 2000 – it has been transferred for use within the Town of Eagle.
- 3700683 – Leonard Horn Ditch No 1. This structure had no acreage assigned in the 2000 coverage and no recorded diversions in 2000. It began diverting again in 2003.
- 3700820 – Squire & Hammond Ditch. This structure had no acreage assigned in the 2000 coverage. Diversion records end in 1999.
- 3700841 – Ulin and Co. Ditch. This structure had no acreage assigned in the 2000 coverage and no recorded diversions in 2000. It began diverting again in 2003.
- 3700856 – White Ditch. This structure is no longer being used for irrigation. It is being used by the Town of Eagle.
- 3700857 – Wilkinson Ditch. This structure had no acreage assigned in the 2000 coverage and no recorded diversions in 2000. It began diverting again in 2003.
- 3800749 – Herrick Ditch. This structure had no acreage assigned in the 2000 coverage. Diversions and acreage were recorded under another ditch.
- 3800853 – Marolt Ditch. This structure is no longer being used for irrigation. It is being used by the City of Aspen.
- 3800924 – Paradise Ditch. This structure had no acreage assigned in the 2000 coverage. Diversion records end in 1999.
- 3801026 – Stapleton Brothers Ditch. This structure had no longer irrigates. It now provides water to Buttermilk for snow making.
- 3801028 – Stein Arlian Marolt Ditch. This structure is no longer being used for irrigation.
- 4500519 – Beaver Cr Grass Mesa Ditch. This structure is an alternate point for structure 4500644. Neither structure had irrigated acreage assigned in the 2000 coverage.
- 5100910 – St. Louis Ditch. This structure is no longer being used for irrigation. It is now owned by Denver.
- 5100530 – Big Six Ditch. This ditch is no longer irrigating and is now part of the Moffat System.

- 5100913 – St. Louis No 2 Ditch. This ditch is no longer irrigating and is now part of the Moffat System.
- 5000572 – George Jones Ditch. This ditch has been unusable since 1993.
- 5304715 – Stillwater Ditch. This ditch carrier transbasin water from Division 6. Water is used in aggregate structures 5300648, 5300533, and 5300887.

Table 2 indicates the structures in the updated diversion systems.

Table 2
Updated Diversion System Summary

Diversion System ID	Diversion System Name	WDID
3600649	Hamilton Davidson Div Sys	3600649
		3600541
3600662	Hoagland Div Sys	3600662
		3600946
		3601018
		3601047
		3601020
		3601019
		3600945
		3601048
		3601049
3800880	Mt. Sopris Div Sys	3800880
		3801633
3904725	Vulcan Ditch Div Sys	3904725
		3900685
5000734	Deberard Div Sys	5000734
		5000548
5100529	Big Lake Div Sys	5100529
		5100584
5100941	Vail Irr Div Sys	5100941
		5101231
5101309	Fraser River Div. Proj. - St. Louis Cr	5101309
		5100593
5300555	Derby Div Sys	5300555
		5300519
		5300521
7200512	Arbogast Pump Div Sys	7201072

		7200512
7200852	RMG Div Sys	7200852
		7200555
9500050	Redlands Power Canal Irr	7204713
7200766	Ute WCD Carver Ranch	7200766
		7201334
7201329	Rapid Creek PP DivSys	7201329
		7201235
7200820	Park Creek DivSys	7200820
		7200819

Five structures previously modeled as key should be modeled as “diversion system” according to water commissioner comments. These structures, and there associated system structures, include:

- 3600541 – Brush Creek Ditch. This structure serves the same lands as the Hamilton Davidson Ditch (3600649). It should be modeled as a diversion system with the Hamilton Ditch as the primary structure.
- 5100593 – Crooked Creek Supply Ditch. This ditch is now a supply to the Fraser River Diversion Project (Moffat Tunnel). It should be modeled as a diversion system with the St. Louis Creek Diversion as the primary structure.
- 5101231 – Vail Irrigation System Headgate No. 1. This structure serves the same lands as the Vail Irrigation System Headgate No. 2. This ditch was added to the Vail Irr Div Sys diversion system (5100941).
- 7200766 – Mason Eddy Ditch. This structure serves the same irrigated lands and municipal demands as the Carver Ranch Pipeline (7201334). These ditches were added to the Ute WCD Carver Ranch diversion system (7200766).
- 7200820 – Park Creek Ditch (Vega). This structure has diversion records recorded in two locations in HydroBase and therefore was combined with Park Creek Ditch (Park) (7200819). These ditches were added to the Park Creek DivSys diversion system (7200820).

One structure not previously modeled as key should be added to the model and be modeled as a “diversion system” according to water commissioner and user comments. This structure and associated system structures include:

- 7201329 – Rapid Creek Pumping Plant. This structure serves the same municipal demands as the Ute Pumping Station (7201235). These pump locations were added to the Rapid Creek PP DivSys diversion system (7201329).

Figure 1 shows the spatial boundaries of each aggregation. **Exhibit A**, attached, lists the diversion structures represented in each aggregate.

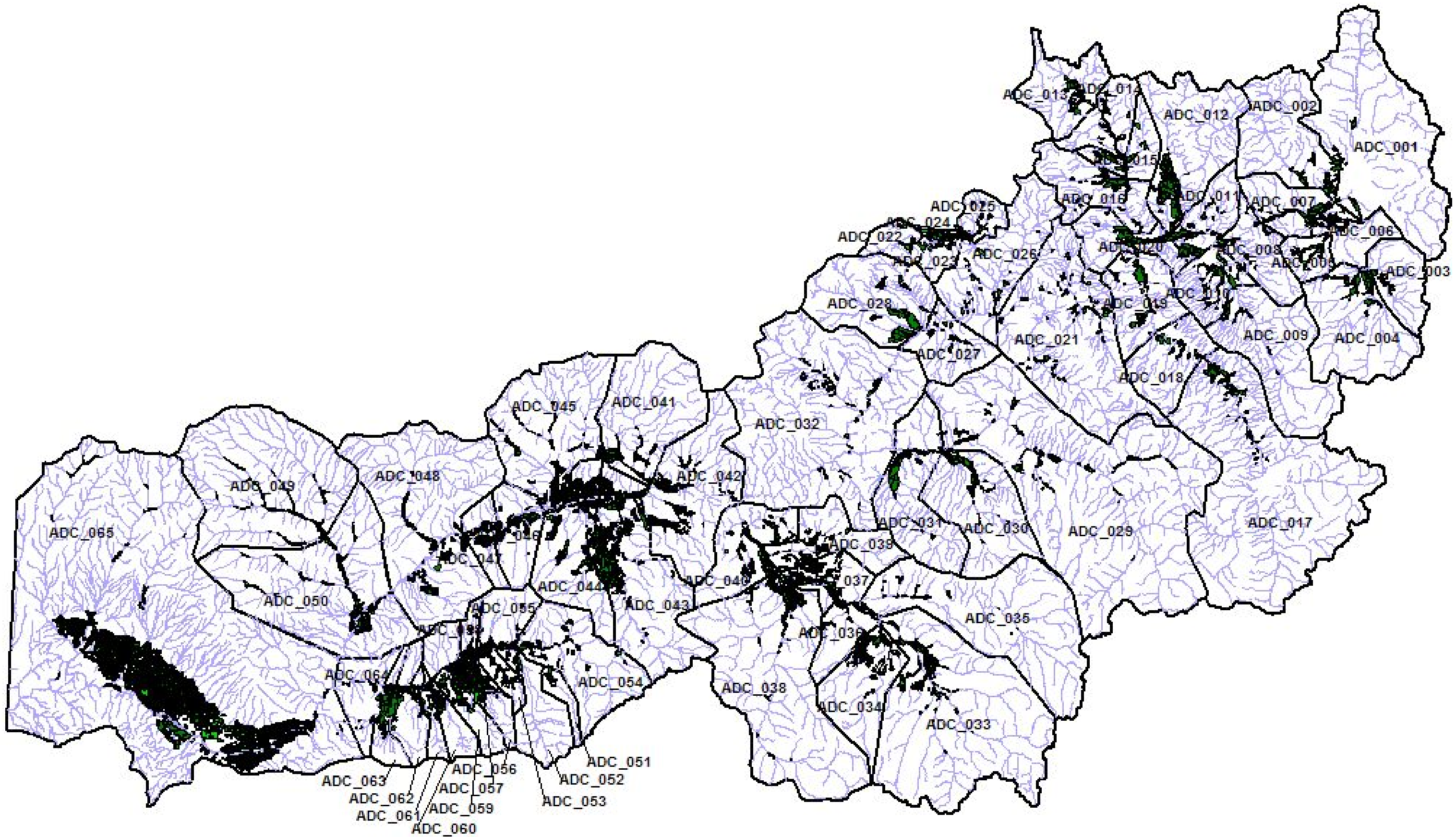


Figure 1 – Aggregate Structure Boundaries

Comments and Concerns

Table 3 shows the estimated total irrigated acreage associated with key and aggregated structures, by water district, for the original 1993 coverage, the updated 1993 coverage, and the 2000 coverage. The irrigated acreage decreased by about 12 percent between the updated 1993 coverage and the 2000 coverage.

Table 3
Colorado River Basin Acreage

Water District	Original 1993 Acreage	Updated 1993 Acreage	2000 Acreage
36	8,583	8,569	7,643
37	10,747	11,781	7,313
38	33,650	33,587	22,122
39	15,407	16,890	16,271
45	29,911	30,370	32,063
50	19,240	19,142	17,564
51	24,515	25,358	22,380
52	4,192	4,171	3,062
53	13,732	13,591	13,875
70	6,485	6,250	6,311
72	100,230	101,175	89,141
Total	266,692	270,884	237,745

It was observed in the 2000 irrigated acreage coverage that two structures were assigned acreage incorrectly. The Park Creek diversions that feed Vega Reservoir WDIDs 7200819 and 7200820 were assigned to parcel numbers 4922 and 5305 with areas of 3.80 and 6.00 acres, respectively. These two structures should not have associated acreage as they are carrier structures. The 1993 irrigated acreage was reviewed and structure information was retrieved for the acreage in question.

For aggregate 72_ADC055 acreage has been added to the 2000 coverage value for WDID 7200811 in the amount of 3.80 acres that was associated incorrectly to WDID 7200819.

For aggregate 72_ADC054 acreage has been added to the 2000 coverage value for WDID 7200652 in the amount of 6.00 acres that was associated incorrectly to WDID 7200820.

Additional acreage added to the above two aggregated structures in both StateCU and StateMod analyses by setting the total acreage for the structures with the setDiversionStation( ) command.

Recommendations

We recommend that consultants or State personnel performing future irrigated acreage updates understand the modeling concept of Key versus Aggregated/System structures. During updates, each Key structure should either be assigned to irrigated acreage, or an adequate explanation provided.

EXHIBIT A

Diversion Structures in Aggregates

Aggregation ID	Aggregation Name	WDID	1993 Acres	2000 Acres
51_ADC001	Colorado River nr Granby	5100580	71.40	50.80
		5100663	14.70	39.60
		5100703	228.20	253.10
		5100704	11.60	0.00
		5100707	84.60	17.80
		5100833	25.00	7.10
		5100841	81.90	85.10
		5100974	14.20	4.90
		5101032	0.00	54.60
		5101033	0.00	21.80
		5101048	15.80	15.60
51_ADC002	Willow Creek	5100742	79.50	148.00
		5100818	15.20	16.00
		5100819	109.80	52.00
		5100847	30.30	69.00
		5100920	34.30	0.00
		5100930	145.90	115.80
		5100962	85.70	384.60
51_ADC003	Ranch Creek	5100513	89.10	62.80
		5100568	119.10	188.90
		5100606	165.40	132.40
		5100681	61.00	36.10
		5100708	26.70	71.00
		5100727	286.20	288.50
		5100767	113.40	69.60
51_ADC004	Fraser River bl Crooked Creek	5100504	68.60	76.10
		5100530	31.20	0.00
		5100582	74.60	89.00
		5100592	124.30	0.00
		5100610	42.90	0.00
		5100635	11.60	11.60
		5100661	144.10	0.00
		5100662	0.00	9.10
		5100701	1.70	16.70
		5100752	65.70	0.00
		5100755	48.90	0.00
		5100758	16.80	0.00
		5100827	19.80	0.00
		5100828	7.30	0.00
		5100836	57.20	33.60
		5100881	22.60	0.00
		5100888	146.90	111.30
		5100894	17.30	0.00
		5100899	39.30	55.20

		5100900	12.80	10.50
		5100910	37.20	0.00
		5100913	31.00	0.00
		5100936	145.70	99.10
		5100989	1.70	0.00
		5100991	1.20	0.00
51_ADC005	Tenmile Creek	5100554	116.40	0.00
		5100556	0.00	14.10
		5100558	48.10	137.00
		5100560	0.00	9.80
		5100561	58.40	50.40
		5100579	180.90	210.70
		5100586	135.40	147.10
		5100616	36.80	64.10
		5100634	15.10	0.00
		5100653	394.60	244.00
		5100693	119.70	88.10
		5100696	59.60	70.70
		5100697	228.10	96.60
		5100779	65.20	89.70
		5100815	215.70	223.40
		5100820	39.90	128.30
		5100864	79.70	0.00
		5100865	68.50	0.00
		5100953	0.00	87.50
51_ADC006	Fraser River at Granby	5100601	24.80	6.90
		5100602	153.20	127.40
		5100665	0.00	69.90
		5100677	0.00	66.40
		5100735	377.00	137.20
		5100826	0.00	81.50
		5100918	43.50	25.60
		5100923	241.60	75.60
		5101294	0.00	35.20
51_ADC007	Colorado River abv Hot Sulphur	5100510	25.80	36.90
		5100596	323.70	0.00
		5100603	51.60	25.50
		5100671	74.10	0.00
		5100686	63.50	102.70
		5100691	0.00	6.30
		5100717	2.50	0.00
		5100718	64.10	31.50
		5100726	43.80	0.00
		5100764	84.10	0.00
		5100765	3.20	16.50
		5100787	26.50	0.00
		5100791	0.00	26.40
		5100792	9.60	0.00
		5100817	118.50	81.80

		5100853	330.10	104.70
		5100889	0.00	13.00
		5100906	63.00	81.40
		5100950	0.00	15.10
		5100963	0.00	36.90
		5100986	17.40	14.10
		5101076	0.00	54.40
		5101329	27.00	20.00
		5104039	43.90	0.00
51_ADC008	Colorado River abv Williams	5100508	0.00	33.30
		5100563	67.90	77.00
		5100564	10.80	0.00
		5100565	0.00	5.80
		5100566	33.60	39.70
		5100599	91.80	55.70
		5100608	104.40	108.60
		5100746	46.30	0.00
		5100747	56.50	57.30
		5100783	43.80	25.40
		5100795	307.70	26.00
		5100803	18.60	0.00
		5100805	42.70	0.00
		5100845	44.40	28.40
		5100846	32.00	64.00
		5100856	143.10	90.40
		5100890	95.30	102.20
		5100903	47.10	30.80
		5100938	43.50	21.60
		5100954	0.00	57.30
		5100966	31.50	38.00
		5100967	11.60	13.50
		5101068	12.00	0.00
51_ADC009	Upper Williams Fork	5100514	38.60	40.30
		5100516	97.90	13.50
		5100552	33.30	75.40
		5100624	82.30	117.90
		5100667	33.90	39.70
		5100689	44.30	32.30
		5100740	16.90	30.70
		5100741	0.00	94.60
		5100760	115.60	101.80
		5100786	151.20	62.20
		5100823	47.60	45.40
		5100875	60.90	81.10
		5100895	16.50	0.00
		5100955	141.60	162.00
51_ADC010	Lower Williams Fork	5100518	47.50	297.30
		5100525	28.90	41.00
		5100526	44.70	0.00

		5100539	9.30	4.60
		5100540	56.50	0.00
		5100542	6.80	0.00
		5100543	11.30	0.00
		5100545	47.90	32.90
		5100587	60.30	51.50
		5100588	87.00	44.30
		5100600	41.50	60.00
		5100614	0.00	19.30
		5100737	20.70	22.60
		5100769	19.90	23.80
		5100770	20.40	57.00
		5100771	34.90	19.50
		5100772	0.00	18.20
		5100773	14.60	0.00
		5100784	11.40	31.80
		5100812	33.90	0.00
		5100814	19.80	0.00
		5100824	25.80	29.40
		5100825	32.10	24.10
		5100860	87.60	126.50
		5100861	0.00	54.90
		5100866	58.50	31.70
		5100884	43.40	34.20
		5100885	12.00	29.00
		5100886	24.80	0.00
		5100901	8.30	0.00
		5100929	0.00	8.30
		5100937	112.30	26.20
		5100972	23.70	42.80
		5100973	11.20	0.00
		5101006	11.20	0.00
		5103679	7.10	0.00
		5103697	0.00	39.70
51_ADC011	Colorado River abv Troublesome Crk	5100503	70.50	45.90
		5100628	43.30	37.80
		5100668	70.90	25.30
		5100687	24.70	0.00
		5100715	62.70	73.60
		5100716	156.80	188.80
		5100798	5.30	0.00
		5100850	92.80	73.00
		5100851	25.90	18.20
		5100869	0.00	11.80
		5100871	0.00	29.70
		5100872	82.30	110.00
		5100919	38.50	0.00
		5100949	0.00	21.00
		5100951	42.60	27.40

		5100956	36.60	34.80
		5101198	99.00	19.00
50_ADC012	Troublesome Creek	5000515	72.90	49.30
		5000516	214.40	234.70
		5000517	0.00	131.60
		5000518	18.90	14.80
		5000519	36.70	39.30
		5000523	16.70	8.40
		5000530	26.80	0.00
		5000533	4.10	2.80
		5000534	25.90	34.60
		5000535	30.30	0.00
		5000565	48.00	41.90
		5000594	31.30	29.90
		5000604	75.70	39.90
		5000609	61.90	56.80
		5000625	23.50	17.40
		5000639	1.70	5.80
		5000644	40.90	47.90
		5000645	118.10	182.90
		5000649	38.70	37.50
		5000650	62.60	59.20
		5000661	101.70	0.00
		5000662	20.70	0.00
		5000666	11.20	0.00
		5000667	128.60	165.00
		5000732	0.00	316.20
		5000733	0.00	75.00
		5000742	18.20	203.10
		5000773	8.70	0.00
50_ADC013	Upper Muddy Creek	5000501	272.40	243.70
		5000502	27.70	0.00
		5000503	202.60	291.70
		5000504	66.70	71.30
		5000505	13.40	0.00
		5000506	126.60	121.80
		5000544	65.20	147.30
		5000545	125.90	87.20
		5000550	125.20	44.90
		5000600	11.90	0.00
		5000603	161.20	0.00
		5000615	221.20	171.20
		5000624	171.20	135.40
		5000674	13.50	9.50
		5000681	16.90	7.60
		5000683	22.60	46.30
		5000687	53.50	34.70
		5000688	15.50	49.20
		5000744	0.00	524.70

50_ADC014	Muddy Creek abv Tyler Ditch	5000500	51.80	81.60
		5000511	86.00	64.80
		5000513	51.80	15.30
		5000514	19.30	23.40
		5000531	78.60	87.70
		5000563	38.20	29.00
		5000564	35.40	23.80
		5000577	116.60	102.20
		5000580	80.30	81.10
		5000581	22.20	29.70
		5000583	80.10	34.00
		5000584	171.80	248.60
		5000599	119.20	64.80
		5000610	35.20	50.90
		5000611	21.00	0.00
		5000620	248.90	135.20
		5000638	182.80	143.70
		5000652	26.40	63.20
		5000658	30.10	27.30
		5000659	44.10	38.30
		5000665	4.20	0.00
		5000682	0.00	18.30
		5000711	0.00	22.40
		5000774	0.00	31.20
50_ADC015	Muddy Creek abv Red Dirt	5000509	37.10	197.50
		5000510	101.30	47.40
		5000521	159.50	0.00
		5000552	118.00	121.90
		5000562	19.40	0.00
		5000579	303.40	0.00
		5000631	112.50	460.10
		5000678	38.40	30.60
		5000679	30.80	62.60
		5000708	0.00	8.60
		5000720	293.80	302.90
		5000760	91.50	32.30
		5000770	44.40	167.10
50_ADC016	Lower Muddy Creek	5000507	96.90	96.90
		5000512	76.10	60.70
		5000536	43.10	0.00
		5000537	21.20	56.60
		5000540	19.10	24.60
		5000542	31.00	23.00
		5000572	394.70	0.00
		5000573	3.60	0.00
		5000575	27.80	36.10
		5000586	21.50	59.10
		5000589	192.90	214.20
		5000623	13.00	16.00

		5000629	8.30	6.60
		5000630	41.70	25.20
		5000634	39.30	0.00
		5000636	40.20	0.00
		5000641	94.50	185.90
		5000647	156.90	126.20
		5003618	20.60	0.00
		5300755	128.40	0.00
36_ADC017	Upper Blue River	3600507	24.90	56.30
		3600521	22.30	0.00
		3600540	46.60	0.00
		3600542	49.40	0.00
		3600569	73.50	74.90
		3600581	5.10	0.00
		3600582	8.90	0.00
		3600585	7.30	0.00
		3600591	10.40	0.00
		3600603	46.30	37.00
		3600611	33.60	0.00
		3600613	6.00	0.00
		3600617	29.70	20.90
		3600631	38.20	0.00
		3600637	7.50	0.00
		3600640	30.40	6.30
		3600642	150.20	116.70
		3600654	0.00	36.90
		3600658	65.90	0.00
		3600678	11.30	0.00
		3600681	16.00	0.00
		3600705	333.90	0.00
		3600713	3.50	0.00
		3600717	77.30	27.30
		3600720	26.80	0.00
		3600721	43.30	242.40
		3600723	5.70	0.00
		3600726	58.50	35.40
		3600727	43.10	7.90
		3600743	0.00	24.10
		3600744	23.90	0.00
		3600759	16.50	0.00
		3600763	14.70	14.90
		3600766	21.70	18.80
		3600767	42.00	0.00
		3600783	42.40	9.20
		3600791	17.60	0.00
		3600794	32.60	0.00
		3600797	18.20	0.00
		3600810	20.50	0.00
		3600811	4.30	0.00

		3600812	19.20	23.50
		3600813	0.00	11.70
		3600814	20.60	0.00
		3600815	24.00	0.00
		3600816	89.90	0.00
		3600819	79.90	0.00
		3600838	19.50	45.50
		3600857	37.80	0.00
		3600858	29.80	0.00
		3600860	16.00	0.00
		3600862	29.20	0.00
		3601805	0.00	11.70
36_ADC018	Blue River abv Green Mountain	3600526	23.90	20.10
		3600567	0.00	25.80
		3600577	20.20	0.00
		3600578	0.00	36.10
		3600633	4.30	2.60
		3600644	27.90	165.00
		3600646	87.80	0.00
		3600647	19.10	0.00
		3600665	0.00	3.30
		3600689	0.00	21.10
		3600691	127.20	134.20
		3600696	18.60	0.00
		3600699	0.00	53.40
		3600702	0.00	63.10
		3600704	189.80	4.60
		3600733	51.00	80.70
		3600788	32.00	0.00
		3600966	29.70	0.00
36_ADC019	Blue River bl Green Mountain	3600514	22.50	18.10
		3600517	18.20	21.60
		3600520	31.90	38.00
		3600545	33.60	21.20
		3600546	0.00	39.00
		3600593	72.20	67.20
		3600594	33.60	29.80
		3600595	64.20	84.90
		3600596	86.50	53.80
		3600604	25.10	0.00
		3600643	269.00	209.80
		3600651	0.00	23.10
		3600652	18.80	32.30
		3600653	45.30	48.90
		3600675	0.00	26.50
		3600697	11.20	0.00
		3600758	0.00	53.20
		3600775	127.80	85.70
		3600776	123.70	242.20

		3600777	158.70	84.20
		3600803	141.10	686.50
		3600820	18.30	31.90
		3600821	42.70	17.40
		3600822	44.90	0.00
		3600827	70.90	67.80
		3600828	42.20	46.10
		3600876	52.00	46.50
		3600910	0.00	5.90
50_ADC020	Colorado River bl Kremmling	5000566	88.30	0.00
		5000602	40.70	0.00
		5000608	324.60	381.80
		5000614	0.00	45.90
		5000651	52.90	36.60
		5000755	152.20	332.40
		5100925	21.20	0.00
		5100926	24.40	0.00
		5100927	22.30	0.00
		5101148	136.60	183.00
		5101196	6.50	0.00
		5101197	47.90	0.00
		5101274	83.10	81.90
		5300614	0.00	25.90
		5300651	287.70	0.00
		5300694	106.00	120.60
		5300816	20.60	40.00
		5301068	0.00	391.00
		5301112	0.00	3.90
		5301144	56.40	0.00
52_ADC021	Black Tail & Sheephorn Creeks	5200505	18.80	8.40
		5200507	14.10	0.00
		5200514	17.70	43.20
		5200515	0.00	37.50
		5200516	30.90	0.00
		5200523	35.20	39.20
		5200524	93.50	85.80
		5200530	29.50	16.60
		5200531	246.20	228.20
		5200540	27.10	0.00
		5200545	3.70	0.00
		5200551	0.00	10.30
		5200552	12.00	0.00
		5200554	3.10	0.00
		5200563	365.30	0.00
		5200564	74.30	0.00
		5200565	7.50	0.00
		5200566	22.80	44.70
		5200573	38.80	0.00
		5200577	0.00	66.50

		5200583	36.90	88.60
		5200587	37.20	16.70
		5200589	16.00	9.90
		5200590	49.40	0.00
		5200591	121.90	0.00
		5200592	0.00	9.60
		5200596	7.00	0.00
		5200597	38.00	0.00
		5200605	21.30	13.80
		5200607	109.10	39.10
		5200608	7.80	9.60
		5200609	53.70	0.00
		5200612	25.00	51.80
		5200621	49.30	44.30
		5200624	57.50	60.50
		5200635	0.00	58.40
		5200637	11.80	0.00
		5200640	24.30	32.50
		5200641	22.20	0.00
		5200649	103.60	0.00
		5200656	0.00	6.80
		5200659	39.40	0.00
		5200660	26.30	210.90
		5200668	47.40	0.00
		5200685	110.20	0.00
		5200691	0.00	3.10
		5200692	4.10	9.80
		5200696	42.00	0.00
		5200702	0.00	10.70
		5200741	0.00	71.80
		5200745	0.00	23.80
		5300508	42.60	57.20
		5300513	56.90	43.80
		5300526	52.90	44.20
		5300564	56.10	0.00
		5300612	0.00	130.10
		5300637	12.90	0.00
		5300695	0.00	25.80
		5300696	14.60	0.00
		5300713	19.20	0.00
		5300714	13.20	25.60
		5300748	11.10	0.00
		5300749	7.10	0.00
		5300758	53.70	54.50
		5300759	79.30	83.60
		5300845	0.00	37.60
		5300848	113.00	0.00
		5300873	0.00	7.70
		5300891	49.20	22.90

		5301065	50.30	0.00
		5301151	0.00	16.60
53_ADC022	Upper Egeria Creek	5300532	43.90	0.00
		5300603	12.60	157.40
		5300682	0.00	70.80
		5300733	33.50	0.00
		5300782	54.40	0.00
		5300829	162.20	79.40
		5301079	87.00	0.00
53_ADC023	King Creek	5300518	0.00	116.70
		5300540	0.00	83.00
		5300596	205.10	38.40
		5300660	0.00	79.10
		5300729	40.70	131.70
		5300732	86.00	14.90
		5300756	0.00	375.20
		5300760	160.10	0.00
		5300766	44.10	216.60
		5300825	223.90	124.10
		5300833	48.80	197.10
53_ADC024	Egeria Creek abv Toponas	5300505	381.70	182.00
		5300533	157.00	0.00
		5300562	129.80	15.50
		5300571	78.10	97.60
		5300648	664.10	431.20
		5300664	0.00	35.40
		5300763	332.10	420.10
		5300887	0.00	80.60
		5304715	706.80	0.00
53_ADC025	Toponas Creek	5300534	27.80	22.40
		5300653	52.80	63.60
		5300722	71.00	96.60
		5300723	86.50	51.60
		5300776	24.10	0.00
		5300777	9.10	14.30
		5300797	13.30	0.00
		5300817	78.60	82.90
		5300818	49.80	55.20
		5300878	183.20	284.40
		5301034	85.80	0.00
		5301083	160.30	127.10
		5301117	87.40	0.00
		5301137	0.00	24.00
53_ADC026	Colorado River abv Alkali	5300504	5.70	0.00
		5300557	6.50	0.00
		5300569	12.80	13.20
		5300570	12.00	22.40
		5300573	28.30	0.00
		5300578	76.20	0.00

		5300592	0.00	43.30
		5300607	11.50	9.80
		5300625	3.60	0.00
		5300628	115.30	151.70
		5300629	12.70	0.00
		5300647	0.00	15.10
		5300650	0.00	35.20
		5300666	0.00	48.70
		5300667	25.50	0.00
		5300668	12.30	0.00
		5300680	0.00	45.90
		5300698	17.10	21.00
		5300703	4.20	24.40
		5300735	0.00	48.20
		5300746	0.00	11.80
		5300747	7.00	0.00
		5300750	4.20	2.50
		5300761	29.10	42.60
		5300764	53.00	87.90
		5300785	0.00	43.60
		5300805	9.90	0.00
		5300831	51.70	104.70
		5300836	14.50	19.20
		5300851	6.20	0.00
		5300852	248.00	0.00
		5300871	21.10	0.00
		5300886	99.50	115.50
		5300899	0.00	27.30
		5301069	0.00	4.80
		5301131	6.00	4.50
		5301139	37.90	0.00
		5301172	0.00	14.60
52_ADC027	Colorado River abv Derby	5200526	68.70	56.00
		5200527	0.00	24.00
		5200528	9.90	8.80
		5200529	86.30	82.20
		5200532	134.60	35.30
		5200534	117.30	143.70
		5200537	17.50	0.00
		5200538	7.20	0.00
		5200544	274.20	208.00
		5200556	0.00	75.80
		5200602	30.10	0.00
		5200633	116.40	116.50
		5200653	15.40	10.30
		5200665	33.00	51.90
		5200666	21.50	17.60
		5200730	0.00	18.10
		5300627	108.10	94.80

		5300665	2.90	0.00
		5300683	28.60	27.00
53_ADC028	Derby Creek	5300510	52.70	0.00
		5300527	84.80	0.00
		5300528	68.50	0.00
		5300546	150.20	135.50
		5300558	203.80	124.90
		5300626	317.20	531.90
		5300701	28.70	13.80
		5300702	167.60	190.80
		5300737	14.30	84.90
		5300739	30.40	0.00
		5300745	122.60	259.80
		5300820	34.20	48.80
		5300822	0.00	128.00
		5300837	48.20	0.00
		5300889	6.50	0.00
37_ADC029	Eagle River abv Brush Creek	3700502	114.60	183.50
		3700505	4.90	7.50
		3700506	12.30	0.00
		3700520	6.20	0.00
		3700521	97.60	0.00
		3700534	31.60	25.20
		3700537	184.80	0.00
		3700557	52.60	0.00
		3700597	76.00	55.00
		3700598	6.70	0.00
		3700599	0.00	55.00
		3700614	229.50	158.20
		3700632	0.00	53.50
		3700634	31.50	0.00
		3700654	4.60	0.00
		3700659	16.90	0.00
		3700662	63.10	45.10
		3700683	76.10	0.00
		3700714	15.20	0.00
		3700722	10.30	11.70
		3700732	86.20	0.00
		3700736	34.00	0.00
		3700779	47.40	0.00
		3700788	15.00	0.00
		3700798	0.00	58.90
		3700801	25.70	19.20
		3700809	7.30	0.00
		3700817	48.10	0.00
		3700833	49.20	0.00
		3700834	20.00	20.20
		3700853	74.10	50.50
		3700854	11.70	0.00

		3700855	0.00	39.20
		3700858	55.00	0.00
		3700906	140.70	352.40
		3701084	185.30	16.50
		3701092	17.20	0.00
		3701156	0.00	68.10
		3701167	4.70	0.00
		3705023	69.00	0.00
		3705076	218.80	0.00
		3705077	70.30	0.00
		3705078	636.70	0.00
37_ADC030	Brush Creek	3700510	17.50	4.90
		3700517	19.50	0.00
		3700559	6.70	5.10
		3700583	368.80	0.00
		3700585	46.80	84.40
		3700588	18.80	0.00
		3700604	32.50	42.20
		3700605	309.60	0.00
		3700610	0.00	25.20
		3700612	0.00	15.70
		3700643	89.90	52.90
		3700644	0.00	74.60
		3700685	70.20	67.50
		3700704	236.50	109.50
		3700741	42.60	0.00
		3700751	21.80	0.00
		3700753	48.30	0.00
		3700756	24.50	0.00
		3700778	9.10	0.00
		3700785	39.90	2.70
		3700786	42.00	0.00
		3700799	16.50	0.00
		3700811	4.00	0.00
		3700818	3.10	14.50
		3700819	21.30	0.00
		3700820	314.40	0.00
		3700822	214.80	0.00
		3700831	70.90	0.00
		3700856	253.50	0.00
		3700857	105.10	0.00
		3700871	138.80	100.10
		3701007	17.10	0.00
37_ADC031	Eagle River bl Gypsum	3700533	0.00	8.50
		3700535	0.00	65.80
		3700544	0.00	6.60
		3700545	150.10	0.00
		3700550	17.80	9.30
		3700551	137.60	0.00

		3700552	46.70	0.00
		3700594	12.90	2.70
		3700595	7.80	8.10
		3700619	0.00	21.00
		3700620	54.60	0.00
		3700640	21.70	10.60
		3700699	214.50	183.40
		3700712	79.70	97.30
		3700718	2.30	0.00
		3700724	0.00	28.60
		3700725	0.00	51.70
		3700728	40.70	0.00
		3700731	50.90	0.00
		3700761	220.40	145.50
		3700776	25.20	163.50
		3700793	120.00	123.20
		3700796	77.90	0.00
		3700806	11.90	0.00
		3700832	176.50	0.00
		3700841	46.80	0.00
		3700863	5.50	0.00
		3700868	30.90	33.00
		3700891	18.20	0.00
		3700939	4.10	0.00
		3700943	7.90	0.00
		3701111	0.00	4.90
		3701236	0.00	7.30
53_ADC032	Colorado River abv Glenwood	3700503	1.70	21.70
		3700601	21.90	0.00
		3700622	53.60	0.00
		5200502	10.10	5.70
		5200503	28.70	9.30
		5200519	4.20	16.40
		5200525	18.50	0.00
		5200541	0.00	52.10
		5200543	0.00	38.20
		5200546	0.00	5.60
		5200553	0.00	19.70
		5200611	35.60	0.00
		5200614	7.30	0.00
		5200617	0.00	8.10
		5200618	0.00	24.00
		5200643	0.00	23.10
		5200644	0.00	50.90
		5200645	0.00	23.30
		5200646	0.00	45.40
		5200661	0.00	32.40
		5200711	0.00	6.80
		5200734	0.00	64.00

		5300501	10.50	0.00
		5300502	8.90	0.00
		5300503	15.30	25.70
		5300529	9.20	3.10
		5300530	9.30	7.50
		5300542	74.20	0.00
		5300548	28.70	27.30
		5300549	106.80	102.60
		5300565	44.20	0.00
		5300579	87.20	76.70
		5300580	41.60	0.00
		5300582	28.40	0.00
		5300586	15.60	0.00
		5300597	0.00	10.00
		5300598	11.40	11.00
		5300600	0.00	7.90
		5300638	18.40	0.00
		5300662	63.70	57.50
		5300687	8.00	23.10
		5300688	0.00	25.10
		5300690	14.50	113.90
		5300700	14.40	13.80
		5300706	51.90	49.60
		5300710	56.70	54.00
		5300721	66.90	0.00
		5300734	6.00	32.60
		5300744	0.00	50.00
		5300757	0.00	3.50
		5300772	38.00	20.10
		5300781	63.00	146.00
		5300793	123.30	0.00
		5300810	0.00	18.70
		5300838	11.70	24.80
		5300842	15.70	143.50
		5300892	39.50	22.30
		5301032	17.10	10.90
		5301047	91.60	180.30
		5301059	92.50	98.70
		5301062	24.50	0.00
		5301101	91.30	0.00
		5301159	50.10	45.90
		5305086	0.00	15.20
38_ADC033	Upper Roaring Fork	3800524	0.90	0.00
		3800537	7.30	0.00
		3800556	198.90	197.70
		3800558	0.00	26.80
		3800563	69.30	0.00
		3800571	18.50	7.80
		3800575	402.90	0.00

		3800576	23.20	0.00
		3800580	82.60	34.90
		3800590	28.50	20.20
		3800594	6.50	0.00
		3800610	1.80	0.00
		3800627	69.20	0.00
		3800636	10.70	0.00
		3800649	21.00	0.00
		3800653	17.60	0.00
		3800666	122.10	0.00
		3800728	23.50	0.00
		3800749	95.00	0.00
		3800766	0.00	3.10
		3800769	29.30	0.00
		3800783	1.30	0.00
		3800813	60.40	22.80
		3800814	62.90	12.40
		3800853	18.20	0.00
		3800859	12.10	0.00
		3800895	40.70	0.00
		3800900	3.60	0.00
		3800901	20.40	0.00
		3800911	0.00	62.70
		3800919	24.60	0.00
		3800924	58.50	0.00
		3800951	44.10	10.40
		3800965	14.20	0.00
		3800992	36.50	0.00
		3801006	39.40	0.00
		3801025	38.40	0.00
		3801026	63.80	0.00
		3801028	36.20	0.00
		3801029	6.70	0.00
		3801042	36.90	0.00
		3801050	12.80	0.00
		3801059	63.60	0.00
		3801060	30.80	0.00
		3801084	77.10	48.90
		3801085	58.30	0.00
		3801090	90.60	34.50
		3801091	36.00	0.00
		3801109	24.90	19.00
		3801110	42.70	0.00
		3801145	112.30	67.20
		3801181	6.20	0.00
		3801272	2.90	0.00
		3801485	28.50	0.00
		3801490	54.10	55.50
		3801496	23.40	21.70

		3801497	20.60	4.10
		3801549	51.60	40.30
		3801561	4.90	0.00
		3801818	1.90	0.00
		3801870	30.00	13.60
38_ADC034	Snowmass Creek	3800554	32.10	10.50
		3800578	0.00	59.90
		3800646	0.00	2.30
		3800660	180.30	17.30
		3800761	94.80	87.30
		3800767	141.40	79.60
		3800785	48.30	45.80
		3800788	42.90	4.70
		3800821	29.20	0.00
		3800824	82.90	56.60
		3800825	12.30	7.10
		3800830	312.00	191.70
		3800844	19.30	5.90
		3800896	109.70	52.40
		3800937	40.40	10.50
		3800938	21.70	12.40
		3800941	12.50	0.00
		3800946	92.00	45.20
		3800974	86.80	44.90
		3800984	31.10	50.40
		3801011	163.20	145.20
		3801023	170.50	203.30
		3801041	14.40	13.40
		3801076	0.00	3.80
		3801079	197.80	109.00
		3801096	291.00	178.40
		3801097	16.60	0.00
		3801098	123.00	73.50
		3801099	9.20	0.00
		3801289	25.00	20.20
		3801578	64.60	0.00
		3801583	0.00	13.60
		3801704	0.90	0.00
		3801904	6.30	0.00
38_ADC035	Frying Pan River	3800502	0.00	15.40
		3800503	1.40	0.00
		3800506	61.30	43.00
		3800539	22.70	0.00
		3800601	40.70	22.70
		3800622	12.00	0.00
		3800629	20.20	0.00
		3800642	53.00	28.00
		3800668	108.00	0.00
		3800696	104.90	60.00

		3800727	18.70	0.00
		3800762	5.70	0.00
		3800805	16.20	0.00
		3800875	16.10	0.00
		3800988	131.50	81.10
		3800999	16.30	0.00
		3801000	4.20	0.00
		3801004	3.30	0.00
		3801005	17.90	0.00
		3801009	24.20	0.00
		3801020	8.30	0.00
		3801146	4.40	0.00
		3801160	20.80	22.50
		3801161	0.00	34.70
		3801673	0.00	26.50
		3801778	23.40	0.00
		3801779	15.30	24.20
38_ADC036	West Sopris Creek	3800583	60.60	36.70
		3800616	36.10	9.60
		3800628	31.60	0.00
		3800630	21.90	0.00
		3800652	15.50	0.00
		3800664	10.90	11.50
		3800684	95.20	0.00
		3800713	48.30	0.00
		3800742	37.80	30.30
		3800752	46.30	47.50
		3800780	107.70	83.10
		3800781	29.30	25.70
		3800784	37.10	5.30
		3800819	128.50	116.50
		3800820	84.70	29.10
		3800858	21.40	0.00
		3800873	32.30	0.00
		3801015	202.80	79.80
		3801035	16.50	7.40
		3801149	115.00	117.50
		3801271	6.20	0.00
		3801668	9.30	0.00
38_ADC037	Roaring Fork abv Crystal River	3800508	27.50	8.60
		3800518	28.80	0.00
		3800599	0.00	19.00
		3800625	65.00	29.50
		3800638	26.50	0.00
		3800681	152.30	0.00
		3800714	90.40	1.80
		3800716	93.70	5.60
		3800731	63.60	52.20
		3800754	15.20	0.00

		3800791	182.40	183.20
		3800792	37.90	0.00
		3800798	25.80	13.10
		3800868	106.40	96.40
		3800882	0.00	2.90
		3800885	25.30	9.40
		3800908	117.50	47.10
		3800920	80.30	149.20
		3800931	118.80	48.40
		3801043	6.30	0.00
		3801125	81.40	27.80
		3801361	37.10	0.00
		3801399	141.10	55.70
		3801563	23.40	0.00
		3801652	112.30	95.00
		3803744	318.10	264.50
		3805009	51.40	6.60
		3805991	11.10	0.00
		3806160	116.60	40.30
38_ADC038	Crystal River	3800522	138.90	127.60
		3800531	30.80	0.00
		3800600	73.90	7.90
		3800602	13.70	11.20
		3800604	3.70	0.00
		3800607	33.70	25.10
		3800631	35.10	11.60
		3800633	0.00	14.60
		3800640	17.20	15.60
		3800644	123.40	0.00
		3800655	10.30	0.00
		3800656	192.50	161.00
		3800670	17.50	0.00
		3800747	151.70	96.80
		3800816	17.20	0.00
		3800847	3.20	0.00
		3800909	34.00	26.60
		3800945	0.00	47.90
		3800948	0.00	33.50
		3800950	62.20	0.00
		3800960	34.20	0.00
		3801032	10.50	10.50
		3801069	0.00	12.90
		3801075	69.50	15.00
		3801077	101.60	110.70
		3801131	47.40	21.00
		3801141	54.20	0.00
		3801254	6.30	0.00
		3801295	0.00	7.90
		3801372	103.00	104.60

		3801478	89.20	31.20
		3801480	4.50	0.00
		3801511	9.30	0.00
		3801519	0.00	121.90
		3801575	93.40	0.00
		3801674	0.00	6.00
		3805140	18.90	0.00
38_ADC039	Cattle Creek	3800568	67.50	36.30
		3800613	64.90	68.60
		3800615	36.30	0.00
		3800637	8.70	4.40
		3800683	12.70	17.60
		3800725	21.40	44.70
		3800726	0.00	58.70
		3800750	42.40	16.40
		3800807	44.70	29.70
		3800860	43.30	19.10
		3800878	113.50	0.00
		3800894	27.50	18.20
		3800933	125.80	166.80
		3800949	56.30	24.90
		3800987	27.70	3.80
		3801014	35.30	0.00
		3801027	64.70	54.00
		3801046	181.50	37.40
		3801088	117.80	84.50
		3801133	29.50	20.40
		3801134	281.40	256.60
		3801148	55.00	29.50
		3801177	22.90	24.00
		3801867	21.00	9.70
38_ADC040	Lower Roaring Fork	3800557	114.00	97.70
		3800635	24.20	24.50
		3800654	50.40	0.00
		3800679	74.50	0.00
		3800691	0.00	30.80
		3800695	19.70	21.60
		3800705	251.10	232.40
		3800724	11.80	8.70
		3800732	153.70	133.40
		3800793	0.00	49.50
		3800799	380.50	275.10
		3800823	23.10	24.60
		3800845	21.70	20.80
		3800961	130.30	98.50
		3800997	8.50	6.80
		3801074	54.50	82.10
39_ADC041	Elk Creek	3900500	3.00	3.90
		3900501	2.70	3.10

		3900503	4.30	0.00
		3900504	2.30	0.00
		3900510	41.10	41.20
		3900525	72.10	74.10
		3900530	19.60	31.60
		3900531	85.30	54.60
		3900536	31.40	0.00
		3900542	0.00	103.30
		3900556	7.90	6.40
		3900579	2.30	0.00
		3900592	55.00	67.90
		3900593	65.00	67.50
		3900598	34.50	37.90
		3900603	10.30	29.00
		3900615	31.00	0.00
		3900626	0.00	13.60
		3900633	59.70	61.90
		3900654	15.20	16.30
		3900655	3.50	7.10
		3900656	60.10	74.90
		3900657	235.50	186.80
		3900660	161.80	21.30
		3900661	241.30	189.40
		3900662	0.00	3.90
		3900667	0.00	12.40
		3900673	45.30	3.90
		3900674	80.30	74.80
		3900676	16.90	21.30
		3900679	0.00	2.20
		3900688	4.30	0.00
		3900689	45.10	51.00
		3900810	9.20	2.10
		3900852	18.30	0.00
		3900863	36.20	36.50
		3900934	14.00	16.30
		3900983	1.30	0.00
		3903507	0.00	116.00
45_ADC042	Colorado River bl Garfield	3900506	0.00	17.00
		3900507	0.00	10.70
		3900521	32.90	1.00
		3900545	17.60	111.70
		3900560	0.00	3.20
		3900569	52.20	59.10
		3900591	0.00	22.40
		3900599	0.00	18.60
		3900601	49.50	15.90
		3900608	0.00	8.60
		3900632	20.60	0.00
		3900641	0.00	1.20

		3900642	0.00	5.10
		3900659	11.10	17.30
		3900675	6.30	13.60
		3900680	0.00	19.30
		3900690	7.80	6.20
		3900697	29.60	0.00
		3900827	152.70	103.70
		3900892	14.70	0.00
		3905033	0.00	2.70
		3905647	0.00	2.70
		4500504	67.80	0.00
		4500521	0.00	23.70
		4500530	13.50	78.10
		4500531	14.70	46.40
		4500532	21.70	6.70
		4500548	277.70	46.50
		4500554	21.70	20.40
		4500555	26.60	25.80
		4500556	24.50	1.70
		4500572	135.40	102.20
		4500590	0.00	3.10
		4500612	0.00	1.60
		4500621	8.40	9.30
		4500642	0.00	11.20
		4500648	0.00	46.20
		4500665	68.70	51.20
		4500695	2.70	1.50
		4500740	17.70	0.00
		4500779	76.40	45.80
		4500780	0.00	62.40
		4500791	105.90	0.00
		4500809	78.00	33.60
		4500823	23.90	19.90
		4500824	27.20	0.00
		4500825	9.40	0.00
		4500826	0.00	49.90
		4500827	3.60	1.80
		4500834	52.10	54.40
		4500836	148.40	149.90
		4500837	23.50	15.70
		4500893	0.00	6.90
		4501055	83.30	50.30
45_ADC043	Colorado River bl Divide Creek	3900568	27.10	37.00
		3900652	121.00	0.00
		4500501	0.00	48.20
		4500534	16.00	5.40
		4500535	27.30	0.00
		4500536	22.30	1.80
		4500550	256.80	264.70

		4500561	0.00	13.20
		4500564	112.90	5.50
		4500580	16.40	16.20
		4500594	0.00	11.40
		4500596	40.10	0.00
		4500597	0.00	612.10
		4500605	4.60	27.70
		4500615	5.60	0.00
		4500618	29.50	47.00
		4500628	41.80	110.10
		4500630	6.50	14.40
		4500639	17.50	4.20
		4500649	60.60	0.00
		4500655	36.50	2.00
		4500656	307.30	356.70
		4500660	41.10	41.00
		4500661	74.60	89.80
		4500666	0.00	1.40
		4500673	59.40	0.00
		4500699	27.00	0.00
		4500702	0.00	19.50
		4500703	6.20	3.80
		4500719	168.10	167.30
		4500724	0.00	27.50
		4500728	60.60	20.90
		4500761	161.60	0.00
		4500816	7.40	7.60
		4500820	11.20	0.00
		4500828	0.00	195.50
		4500843	12.10	33.90
		4500846	36.30	21.90
		4500849	39.30	0.00
		4500934	30.40	0.00
		4500935	2.30	0.00
		4500936	18.50	0.00
		4500940	12.40	8.70
		4501095	0.00	24.20
		4501111	14.60	0.00
		4501144	0.00	25.40
45_ADC044	Colorado R bl Mamm Creek	3900524	4.00	0.00
		3900575	21.80	0.00
		3900619	202.40	0.00
		3900668	33.80	0.00
		3900980	0.00	12.60
		4500519	1,365.10	0.00
		4500528	121.90	180.30
		4500544	18.60	34.40
		4500585	0.00	21.60
		4500592	30.40	101.20

		4500593	80.80	120.90
		4500637	407.90	397.60
		4500653	87.10	56.00
		4500664	28.10	42.10
		4500710	211.00	381.00
		4500742	29.70	0.00
		4500755	0.00	68.60
		4500764	140.50	116.40
		4500800	183.60	163.60
		4500842	4.10	9.70
		4500885	0.00	9.70
		4500985	6.80	0.00
		4501079	83.30	0.00
		4501127	260.00	356.90
		4501135	0.00	18.50
		4501146	8.00	0.00
		4504722	0.00	60.80
		7200735	134.70	23.70
39_ADC045	Rifle Creek	3900508	0.00	10.20
		3900516	14.50	21.70
		3900529	30.20	27.30
		3900543	0.00	18.50
		3900566	119.80	91.20
		3900567	0.00	4.30
		3900578	90.30	59.10
		3900582	74.90	41.90
		3900588	18.90	88.10
		3900602	30.20	19.60
		3900614	78.40	68.50
		3900616	160.40	92.00
		3900617	57.50	96.10
		3900625	89.30	83.10
		3900627	7.10	13.00
		3900637	0.00	10.10
		3900639	58.80	0.00
		3900646	49.90	51.10
		3900658	61.30	34.20
		3900683	6.70	0.00
		3900695	187.90	169.30
		3900698	206.70	159.90
		3900699	13.60	3.10
		3900702	112.80	38.60
		3900706	0.00	106.30
		3900713	23.20	0.00
		3900723	24.20	0.00
		3900805	0.00	12.00
		3900845	10.00	0.00
		3900900	14.40	4.70
45_ADC046	Colorado River bl Beaver Creek	3900550	0.00	1.10

		3900604	113.90	10.80
		3900640	37.90	27.80
		4500518	23.00	0.00
		4500525	12.60	0.00
		4500549	57.80	49.30
		4500562	24.20	73.30
		4500567	112.90	0.00
		4500608	35.70	0.00
		4500629	69.10	133.50
		4500636	44.60	0.00
		4500641	0.00	134.20
		4500670	145.80	121.20
		4500713	0.00	91.10
		4500730	91.80	237.70
		4500741	13.40	0.00
		4500751	86.70	0.00
		4500766	94.90	123.20
		4500768	73.00	61.50
		4500835	47.20	40.80
		4500870	0.00	8.90
		4500901	5.90	0.00
		4500954	13.10	0.00
		4500961	16.30	0.00
		4505166	0.00	47.60
		4505309	0.00	4.90
		4505310	0.00	4.90
45_ADC047	Colorado River bl Cache Creek	3900653	48.30	32.90
		3900789	0.00	96.50
		4500523	85.90	79.60
		4500526	132.30	0.00
		4500538	294.50	293.90
		4500539	35.40	0.00
		4500541	0.00	6.00
		4500558	0.00	169.60
		4500611	13.50	16.40
		4500640	0.00	11.50
		4500645	149.90	115.90
		4500689	180.00	447.40
		4500694	0.00	36.30
		4500711	248.20	50.80
		4500738	16.40	0.00
		4500772	54.60	82.40
		4500783	36.80	0.00
		4500801	18.10	0.00
		4500902	17.00	18.80
		4500903	0.90	18.80
		4500948	0.00	5.90
		4500949	0.00	41.60
		4500950	0.00	11.90

		4500957	16.00	0.00
		4501072	58.50	27.20
		4501073	0.00	27.20
		4501085	8.10	0.00
		4501107	5.30	0.00
		4501133	0.00	19.30
45_ADC048	Colorado River nr De Beque	3900509	55.00	44.20
		3900534	0.00	1.30
		3900535	87.80	0.00
		3900544	89.90	82.40
		3900546	110.80	46.90
		3900549	74.10	42.80
		3900558	35.90	14.50
		3900564	16.60	0.00
		3900565	32.80	8.70
		3900594	85.50	109.00
		3900611	37.50	17.80
		3900643	23.20	18.00
		3900666	0.00	4.90
		3900669	0.00	27.10
		3900681	8.10	0.00
		3900691	6.80	8.80
		3900989	0.00	12.90
		4500509	0.00	232.60
		4500511	63.50	59.50
		4500570	19.30	48.40
		4500582	138.00	0.00
		4500588	0.00	39.10
		4500625	70.30	104.60
		4500633	32.70	150.10
		4500658	16.70	7.30
		4500662	0.00	15.70
		4500674	157.40	218.30
		4500688	0.00	121.40
		4500691	0.00	189.10
		4500706	80.00	118.80
		4500708	106.50	285.30
		4500712	0.00	17.00
		4500714	309.60	475.20
		4500721	56.30	3.50
		4500731	34.00	40.90
		4500732	13.70	9.30
		4500758	13.80	0.00
		4500782	0.00	54.80
		4500792	13.40	0.00
		4500796	202.70	63.30
		4500808	126.80	31.60
		4500813	17.50	0.00
		4500925	0.00	6.50

		4501046	0.00	1.70
		4501048	11.20	8.80
		4505002	34.30	52.80
70_ADC049	Upper Roan Creek	7000500	21.90	58.00
		7000502	80.50	60.40
		7000504	122.30	50.70
		7000509	9.20	0.00
		7000510	97.40	28.70
		7000511	186.30	114.30
		7000512	113.10	175.40
		7000513	20.00	0.00
		7000514	13.30	17.30
		7000516	98.20	15.90
		7000517	60.10	114.70
		7000526	15.20	0.00
		7000538	50.50	0.00
		7000539	42.60	66.60
		7000541	0.00	23.40
		7000542	56.20	74.00
		7000545	51.20	50.20
		7000546	0.00	2.80
		7000548	22.20	0.00
		7000549	27.00	63.10
		7000551	26.60	0.00
		7000555	27.80	0.00
		7000556	24.70	39.00
		7000559	6.30	23.00
		7000561	14.50	73.20
		7000562	27.10	0.00
		7000563	34.10	0.00
		7000566	26.70	23.20
		7000567	20.40	39.10
		7000568	22.30	28.40
		7000572	145.90	179.30
		7000573	24.00	61.30
		7000578	25.10	29.30
		7000579	15.60	0.00
		7000588	13.60	0.00
		7000589	11.40	14.00
		7000591	0.00	14.40
		7000592	11.50	51.10
		7000595	55.30	43.60
		7000597	110.30	59.00
		7000598	0.00	43.40
		7000639	11.50	0.00
		7000642	50.60	88.50
		7005085	18.20	0.00
70_ADC050	Colorado River nr Cameo	7000501	24.40	24.20
		7000503	40.20	0.00

		7000505	113.90	100.90
		7000508	27.50	0.00
		7000518	27.90	7.20
		7000519	29.10	22.10
		7000527	100.30	119.40
		7000529	43.80	100.40
		7000533	77.00	72.30
		7000534	78.70	195.40
		7000535	82.40	81.30
		7000536	63.20	20.00
		7000547	32.50	0.00
		7000552	41.60	9.00
		7000565	74.30	78.30
		7000575	56.90	26.90
		7000587	144.70	143.50
		7000593	47.80	0.00
		7000594	69.40	62.00
		7000630	18.30	0.00
		7005112	59.50	0.00
		7205001	60.00	0.00
72_ADC051	Plateau Creek abv Vega Rsvr	7200538	0.00	28.70
		7200615	188.20	329.20
		7200699	134.20	0.00
		7200928	685.50	10.40
		7200943	0.00	24.80
		7200953	0.00	18.30
		7201252	0.00	18.30
		7201253	0.00	18.30
		7201254	0.00	18.30
72_ADC052	Plateau Creek bl Vega Rsvr	7200662	454.40	329.00
		7200750	19.10	19.80
		7200752	218.10	151.00
		7200822	200.10	179.60
		7200858	0.00	90.30
		7200880	2.50	0.00
		7201023	0.00	4.50
72_ADC053	Salt Creek	7200522	80.90	83.60
		7200540	379.80	225.50
		7200566	54.30	47.00
		7200573	16.50	0.00
		7200588	12.30	0.00
		7200605	11.10	0.00
		7200622	171.60	17.70
		7200694	59.20	93.90
		7200697	76.10	56.00
		7200723	80.40	105.10
		7200728	269.50	193.90
		7200785	0.00	1.90
		7200810	30.30	18.80

		7200830	20.80	17.30
		7200863	154.50	129.80
		7200902	10.70	11.40
		7200914	84.70	40.00
		7200936	12.80	0.00
		7200944	109.50	56.10
		7201132	0.00	6.40
		7201148	5.80	11.70
		7201549	0.00	3.60
72_ADC054 [1]	Upper Buzzard Creek	7200502	83.10	90.50
		7200503	240.60	4.00
		7200565	76.90	79.10
		7200569	8.70	110.90
		7200578	15.60	0.00
		7200582	136.00	116.70
		7200614	144.00	50.10
		7200650	17.20	0.00
		7200652	213.60	155.90
		7200653	13.20	0.00
		7200686	36.90	0.00
		7200733	129.70	48.30
		7200749	166.90	0.00
		7200790	77.30	103.20
		7200791	0.00	348.00
		7200925	19.40	11.20
		7200926	258.90	0.00
		7200937	72.10	26.20
		7200949	100.20	0.00
		7201083	23.60	0.00
		7201226	75.60	0.00
		7201338	57.90	55.60
		7204065	97.50	0.00
72_ADC055 [2]	Plateau Creek bl Buzzard Creek	7200545	0.00	1.10
		7200550	0.00	5.30
		7200604	234.80	202.70
		7200675	230.90	21.90
		7200739	147.30	63.70
		7200774	0.00	30.20
		7200775	71.10	280.80
		7200811	171.60	146.70
		7200845	95.70	72.10
		7200896	0.00	30.00
		7200906	30.10	23.10
		7200931	9.90	27.90
		7200940	5.10	0.00
		7201350	14.50	13.80
		7201661	0.00	8.90
72_ADC056	Upper Grove Creek	7200594	0.00	18.20
		7200631	0.00	10.20

		7200655	109.60	21.40
		7200734	16.90	18.80
		7200751	494.70	127.90
		7200757	208.90	177.10
		7200848	0.00	53.80
		7200854	286.10	250.90
		7200887	17.10	23.90
		7200904	18.90	10.80
		7200929	40.70	34.60
		7200951	7.40	18.90
		7201181	25.20	26.30
		7201451	0.00	79.10
72_ADC057	Lower Grove Creek	7200505	184.70	104.20
		7200532	180.00	178.30
		7200617	118.10	151.20
		7200618	0.00	10.40
		7200619	32.30	0.00
		7200637	359.80	137.80
		7200805	139.50	116.10
		7200833	8.70	0.00
		7200846	174.00	151.50
		7200917	3.60	0.00
		7200981	0.00	31.40
		7201047	10.50	0.00
		7201347	2.10	0.00
72_ADC058	Kimball Creek	7200515	96.50	56.80
		7200691	215.90	183.60
		7200722	136.80	112.10
		7200742	9.80	2.60
		7200761	0.00	12.70
		7200777	75.20	79.10
		7200808	48.00	47.40
		7200876	83.70	0.00
		7200956	31.60	15.50
		7201075	0.00	10.30
		7201443	24.40	3.90
72_ADC059	Big Creek	7200504	40.00	0.00
		7200525	52.20	46.40
		7200554	0.00	52.50
		7200572	0.00	8.30
		7200627	0.00	29.10
		7200633	7.70	0.00
		7200659	42.00	115.90
		7200673	14.40	23.70
		7200711	37.20	5.60
		7200767	3.70	10.70
		7200814	0.00	2.00
		7200824	73.20	60.60
		7200828	33.10	22.00

		7200835	35.10	51.20
		7200861	9.00	6.90
		7200864	30.80	0.00
		7200869	135.00	136.30
		7200890	0.00	7.20
		7200891	16.80	15.20
		7201008	74.60	12.20
		7201041	0.00	171.00
		7201179	43.40	62.90
		7201249	5.80	0.00
		7201388	0.00	93.60
		7201417	37.40	19.70
		7201424	18.60	16.80
72_ADC060	Cottonwood Creek	7200591	92.90	67.30
		7200621	17.00	0.00
		7200809	33.20	26.20
		7200865	84.40	48.60
		7200867	323.50	643.40
		7200945	79.80	30.10
72_ADC061	Bull Creek	7200602	6.30	0.00
		7200620	0.00	53.90
		7200625	35.20	0.00
		7200656	183.70	148.20
		7200718	196.60	92.40
		7200756	61.70	57.20
		7200838	28.40	42.50
		7200850	33.30	26.80
		7200877	20.20	0.00
		7200878	116.40	117.30
		7200894	21.30	14.00
		7200895	47.80	59.50
72_ADC062	Coon Creek	7200526	94.30	142.30
		7200527	13.20	0.00
		7200581	247.60	0.00
		7200600	171.50	0.00
		7200663	66.40	0.00
		7200680	41.50	0.00
		7200682	57.30	0.00
		7200719	83.40	0.00
		7200776	35.50	117.50
		7200779	168.40	73.70
		7200829	212.60	213.10
		7200834	20.00	0.00
		7200862	0.00	13.10
		7200882	128.40	52.90
		7200885	0.00	88.40
		7200932	13.70	6.30
		7200946	20.80	22.00
		7201118	85.20	0.00

		7201512	80.90	0.00
		7201513	28.00	14.60
		7203894	19.00	14.50
		7203902	27.40	0.00
		7204906	0.00	47.40
72_ADC063	Mesa Creek	7200516	117.00	143.70
		7200517	0.00	27.30
		7200518	41.30	71.60
		7200519	66.00	72.10
		7200529	104.90	0.00
		7200586	67.00	0.00
		7200587	17.80	0.00
		7200712	179.20	930.30
		7200714	0.00	45.10
		7200715	0.00	13.60
		7200763	78.40	0.00
		7200832	33.30	8.00
		7200853	149.50	0.00
		7200873	6.90	0.00
		7200892	63.00	12.40
		7200934	210.10	0.00
		7200939	51.60	308.50
		7201060	10.00	10.30
		7201078	40.70	6.90
		7201448	168.60	0.00
72_ADC064	Plateau Creek	7200521	19.50	36.10
		7200584	12.80	8.10
		7200667	78.30	0.00
		7200668	6.70	0.00
		7200672	33.50	0.00
		7200677	6.40	0.00
		7200678	21.10	0.00
		7200716	11.80	0.00
		7200717	15.60	0.00
		7200782	142.90	55.40
		7200868	28.30	22.70
		7200889	165.50	38.20
		7200903	110.30	0.00
		7200909	24.70	0.00
		7200935	27.50	0.00
		7201112	6.10	0.00
		7201151	13.20	50.70
		7201202	16.20	0.00
		7201392	4.90	11.30
		7201452	0.00	18.40
		7201635	0.00	8.50
		7201636	0.00	4.20
		7203864	15.60	0.00
		7203866	7.40	0.00

		7203870	25.20	0.00
72_ADC065	Colorado River nr State Line	7200535	0.00	1.20
		7200585	108.10	112.70
		7200590	36.20	77.30
		7200595	137.70	171.50
		7200608	5.10	0.00
		7200613	12.90	0.00
		7200629	106.30	159.40
		7200630	0.00	82.00
		7200636	60.40	11.70
		7200641	0.40	0.00
		7200642	2.90	0.00
		7200647	41.50	25.70
		7200661	13.40	0.00
		7200705	44.70	66.50
		7200708	49.00	0.00
		7200709	0.00	40.70
		7200727	200.80	202.20
		7200732	101.60	80.70
		7200738	0.00	4.30
		7200753	67.10	0.00
		7200770	54.50	0.00
		7200771	23.50	0.00
		7200788	4.40	0.00
		7200792	0.00	25.50
		7200812	8.10	0.00
		7200857	0.00	56.40
		7200860	16.20	0.00
		7200872	41.40	23.10
		7200875	60.60	46.50
		7200908	69.90	58.20
		7200918	68.30	0.00
		7200919	0.00	158.60
		7200941	131.50	57.80
		7201024	187.40	141.50
		7201051	29.00	32.80
		7201070	0.00	10.70
		7201076	11.70	0.00
		7201101	0.00	43.40
		7201107	52.30	0.00
		7201190	0.00	14.00
		7201200	0.00	49.80
		7201225	0.00	20.80
		7201289	0.00	8.70
		7201299	0.00	24.70
		7201313	0.00	40.40
		7201477	33.30	0.00
		7201484	0.00	23.20
		7201525	3.20	0.00

		7201565	25.80	3.80
		7201571	0.00	5.40
		7201682	0.00	69.50
		7203920	0.00	57.80
		7205348	0.00	24.80
		7205349	0.00	16.50
Total			**92,571**	**74,206**

[1] For aggregate 72_ADC054 acreage has been added to the 2000 coverage value for WDID 7200652 in the amount of 6.00 acres that was associated incorrectly to WDID 7200820.

[2] For aggregate 72_ADC055 acreage has been added to the 2000 coverage value for WDID 7200811 in the amount of 3.80 acres that was associated incorrectly to WDID 7200819.

Section D.3
Final

TO: File

FROM: Erin M. Wilson

SUBJECT:

Subtask 5.05 - Upper Colorado River Basin Define Water Right Classes

Introduction

This memo describes the results of Subtask 5.05, Define Water Right Classes. The objective of this task is as follows:

Define approximately 10 classes or divisions of the domain of water right administration numbers, such that water rights within a class may be administered together in the model. Thus class divisions should be selected judiciously to reduce error introduced by allocating water to a right under a class-average administration number rather than the right's actual priority.

Results

Exhibit 1 was generated with the following procedures (top to bottom):

- Line 1, Net Absolute Diversion Water Rights

  This list was obtained by executing **watright**, a Data Management Interface that extracts all net absolute water rights associated with the direct flow diversions from the CRDSS database for the Colorado River Basin (Division 5). The following command was used:

  watright basin=coloup -rightsd -sortaa -report

  After this file was parsed into the spreadsheet, it was sorted by administration number.

- Line 2, Phase IIIa Model

  This list is the combination of the water rights modeled in Phase II (coloup.ddr) and those water rights associated with the irrigated lands to be aggregated and modeled in Phase IIIa (/usr2/crdss/crdssdem/pcarcview/irr_land_ph3.dbf).

- Line 3, Phase II Model

  This list is all water rights associated with the structures modeled in the Phase II model (coloup.ddr).

- Diamond Symbols, Key Rights Administered in the Colorado basin

  These symbols indicate the administrative "location" of the key rights administered on the Upper Colorado. These rights were provided by the Division 5 office and are shown in **Table 1.**

Call Information

Boyle contacted the Division 5 office on April 30, 1997, to discuss key controlling or "swing" rights on the system. The Division office responded by sending a spreadsheet of rights that typically call on the Colorado. This list included a total of 90 direct flow diversion and reservoir storage rights. The list can be combined by project (i.e. Grand Valley Project has 6 associated rights with administration numbers from 2279.12922 to 22792.21241) and equivalent administration number (i.e. Climax has key rights on three tributaries all with administration number of 29228.28840) into the 30 rights shown in **Table 1**. These rights are also plotted as a diamond symbols in Exhibit 1. This exhibit, with potential water class breakdowns, was sent to the Division office for further input on June 6, 1997. The Division office indicated that **Table 1** can be reduced to five controlling calls on the Upper Colorado and the water class breakdowns need to take these into account. **Table 2** shows these five controlling rights.

Table 1
Rights Typically Administered on the Upper Colorado

River	Diverson or Project Name	Administration Number
Tribs to N. Fork Colorado	Grand River Ditch	14854.00000
Colorado	Shoshone Power Plant - Senior Right	20427.18999
Fraser and Tribs	Berthoud Canal Tunnel	20676.19173
Piney Creek	Ewing Placer Ditch	22435.20605
Colorado	Grand Valley Project	22729.22116
Ivanhoe,Lyle,Pan,Hidden L	Ivanhoe Reservoir Tunnel	28394.28365
McNulty,Tenmile,Clinton	Climax Diversions	29228.28840
Hoosier,Fraser,Williams F	Con-Hoosier System	30184.29071
Fraser,Williams Fork	Denver Water Fraser and Williams Fork Diversions	30870.26117
Bennet,Mitchel,E.Fk.Eagle	Pueblo Supply-Warren E. Wurts and Columbine Ditch	30894.29013
Colorado	Grande Valley Project	30895.21241
Lincoln	Independence Pass TM Diversion System	30941.29454
Blue,N.Fk.Colorado,Willow	CBT and Green Mountain Exchange	31258.00000
Meadow Creek	Englewood TM Diversion via Moffat	31259.00000
Williams Fork Reservoir	Denver Water Ex. For Fraser and Williams Fk Divers.	31359.00000
Colorado	Shoshone Power Plant - Junior Right	33023.28989
Blue,Tenmile,Snake	Denver Water Blue River Diversion Project	35238.00000
Blue,Crystal;Hoosier,Spruce	Con-Hoosier System	35927.00000
Plateau	Vega Reservoir	37486.00000
Rifle	Rifle Gap Reservoir	37503.36899
Yoder & Rule	Pueblo Supply-Warren E. Wurts Ditch	38753.37478
Williams Fork	Denver Water Williams Fork Diversion Project	39095.38998
Hunter,Fryingpan	Fry-Ark Project and Ruedi Reservoir	39291.00000
Homestake	Homestake Project	39650.37520
Fraser & Tribs	Denver Water Moffat Tunnel System	41514.00000
Willow,Colorado	Windy Gap Project	43621.42906
Fryingpan	Ruedi Reservoir Power Plant	45950.00000
Colorado	Windy Gap Project Pump & Pl	46751.46211
Colorado	Windy Gap Project Pump & Pl	47602.00000
Fryingpan	Ruedi Reservoir	47869.00000

Table 2

Key Rights Typically Administered on the Upper Colorado

WDID	Diversion or Project Name	Appropriated Amount (cfs)	Administration Number
530584	Shoshone Power Plant-Senior Rights	1250.00	20427.18999
720646	Grand Valley Project	730.00	22729.21241
720646	Grand Valley Project Power	400.00	30895.21241
720646	Grand Valley Irrigation Canal	119.47	30895.24988
530584	Shoshone Power Plant-Junior Rights	158.00	32023.28989

Another significant water rights issue in the Upper Colorado basin is related to Senate Document 80. This allows water rights senior to October 15, 1977 (administration number 46674.00000) to benefit from Green Mountain Reservoir storage if direct flow diversions are unavailable. However, January 24, 1984 (administration number 48966.00000) has been used as the cutoff date for beneficiaries of Green Mountain Reservoir historically, and is used in the CRDSS historical model simulation.

Water Right Groups

Water right classes were defined by starting with the operationally significant rights listed in **Table 2** and the two Senate Document 80 dates as class boundaries. Other major projects identified in **Table 1** where used to further break down large classes. These major projects represent significant breaks in the curves of Exhibit 1. The resulting eleven water right classes are presented in **Table 3.**

Table 3
Water Right Classes

Class Number	From Administration Number	To Administration Number	Cumulative Right (From Line 2) (cfs)	Incremental Right (cfs)
1	1.00000	14854.00000	2651.22	2651.22
2	14854.00000	20427.18999	6540.94	3889.72
3	20427.18999	22729.21241	10367.18	3826.24
4	22729.21241	30895.21241	15590.14	5222.96
5	30895.21241	31258.00000	21283.55	5693.41
6	31258.00000	32023.28989	22555.94	1272.39
7	31258.00000	39095.38998	26430.97	3875.03
8	39095.38998	43621.42906	29558.12	3127.15
9	43621.42906	46674.00000	29909.09	350.97
10	46674.00000	48966.00000	30693.13	784.04
11	48966.00000	Infinity	30783.11	89.98

Comments

The relative position of the three lines in **Exhibit 1** is the same as it was in similar exhibits for the White, Yampa, and San Juan/Dolores River basins. A large percentage of the diversions in the Upper Colorado basin are transmountain diversions.

Boyle checked the water rights to determine the difference between the "Net Absolute Diversion Water Rights" (line 1) and the "Phase IIIa Model" water rights (line 2). The "Net Absolute Diversion Water Rights" includes rights which no longer operate, are associated with non-consumptive activities, and relatively small municipal and industrial rights. Examples of these differences include the following:

- The 32.646 cfs right for the Keystone Ditch (360683) is included in the "Net Absolute Diversion Water Rights", but has been abandoned and therefore is not included in the Phase II or Phase IIIa model.

- The 90 cfs right for the East Rifle Creek Plant Number 2 (390649) is included in the "Net Absolute Diversion Water Rights", but is non-consumptive and therefore is not included in the Phase II or Phase IIIa model.

- The 200 cfs right for the Willcox Canal (390752) is included in the "Net Absolute Diversion Water Rights", but is associated with a structure that is non-existent and therefore is not included in the Phase II or Phase IIIa model.

The conclusion based on the checks performed is that the Phase IIIa model does estimate 100 percent of consumptive use by irrigation, as defined by the 1993 survey of irrigated lands.

Appendix B

Aggregation of Non-Irrigation Structures

1. CDSS Memorandum 5.10
Colorado River Basin Aggregated Municipal and Industrial Use

2. CDSS Memorandum 5.11
Colorado River Basin Aggregated Reservoirs and Stock Ponds

Final
Memorandum

TO: File

FROM: Ray R. Bennett

SUBJECT: **Subtask 5.10 - Colorado River Basin Aggregated Municipal and Industrial Use**

Introduction

This memo describes the results of Sub task 5.10 Colorado River Basin Aggregated Municipal and Industrial Use. The objective of this task was as follows:

> *Aggregate municipal and industrial uses not explicitly modeled in Phase II to simulate their depletive effects in the basin.*

Approach and Results

Phase II Modeled M&I Use. Table 1 presents the 1975 to 1991 average annual Municipal and Industrial depletions modeled in Phase II. These were identified by evaluating Appendix C8.8, Municipal Diversions, of the Phase II Documentation, structures with no irrigated acreage, and structures with a non-agricultural return flow pattern. Note, transmountain diversions are not shown because they are modeled explicitly in the Phase II model. Also, hydropower and M&I carrier ditches (ID 381170, 720814, 720920, 721339, and 950030) are not shown because they are non consumptive.

Table 1
Phase II Explicitly Modeled M&I Consumptive Use (acre-feet)

Id	Name	Serving	Total
360784	Rankin No 1	Dillon	89
360908	Keystone Snowline Ditch	Keystone	43
361008	Breckenridge Pipeline	Breckenridge	326
361016	Copper Mt. Snowmaking	Copper Mt.	33
370708	Metcalf Ditch	Upper Eagle	681
380854	Maroon Ditch	Aspen	1,243
380869	Midland Flume Ditch	Aspen	1,841
381052	Carbondale Water System & PL	Carbondale	381
390967	Rifle Town of Pump & PL	Rifle	483
420520	Grand Junction Gunnison PL	Grand Jct.	501
511070	Henderson Mine Water System	Industrial	1,887
530585	Glenwood L Water Co. System	Glenwood Sp.	1,425
531051	Glenwood L Water Co. System	Glenwood Sp.	113
720644	Grand Junction Colo. R PL	Grand Jct.	551
720816	Palisade Town Pipeline	Palisade	257
950020	Ute Water Treatment	Ute	1594
950051	Grand Junction Demands	Grand Jct.	2,680
955001	Vail Valley Consolidated	Vail	715
955003	Vail Valley Consolidated	Vail	123
955002	Keystone Municipal	Keystone	99
Total			**15,065**

Phase II Consumptive Uses and Loss Estimates. Table 2 presents the categories and values of M&I consumptive use presented in the task memorandum 2.09-10, Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Colorado River Basin (01/21/97).

Table 2
Phase II Consumptive Use and Loss M&I Consumptive Use (acre-feet)

Category	Total
Municipal	8,481
Mineral	1,019
Livestock	1,462
Thermal	39
Total	**11,001**

Aggregated M&I Diversion. Based on the above, the Phase II model includes more M&I CU (**15,065 ac-ft**) than the data prepared for the Consumptive Uses and Losses report (**11,001 ac-ft**). This discrepancy might be attributed to the efficiency assigned to municipal users in the Phase II model (36%), the per capita use assigned to urban and rural users in the Consumptive Uses and Losses report (120 gal/person/day), etc. Because the amount of consumptive use is relatively small, no refinement of either estimate is proposed. Rather for Phase IIIa, it is recommended that one aggregated M&I demand be included at the bottom of the system for consistency with other basins and for potential use at a later date should the basic data be refined. As presented in **Table 3** below, for the Phase IIIa analysis, this aggregated M&I structure should be assigned an annual demand of 0 ac-ft/yr. and a water right of 0 cfs.

Table 3
Phase III Colorado River Aggregated M&I Consumptive Use Summary

Basin	Aggregated M&I ID	Depletive Demand AF/yr.	Water Right cfs
Colorado	72_AMC001	0	0

A monthly aggregated demand files with 0 ac-ft/yr was built in an editor using a StateMod format. It is named 72_AMC001.stm and is stored in the directory /crdss/tmp on cando.

Section D.5
Final

TO: File

FROM: Ray Alvarado

SUBJECT: **Subtask 5.11-Colorado River Basin Aggregate Reservoirs and Stock Ponds**

Introduction

This memorandum describes the approach and results obtained under Subtask 5.11, Aggregate Reservoirs and Stock Ponds. The objective of this task was as follows:

> *Aggregates and stock ponds not explicitly modeled in Phase II to allow simulation of effects of minor reservoirs and stock ponds in the basin.*

Approach and Results

Reservoirs and Stock Ponds: Table 1 presents the net absolute storage rights that were modeled in Phase II, those to be added as aggregated reservoirs in Phase IIIa, and stock ponds to be added as aggregated stock ponds in Phase IIIa. The Phase II reservoir information was obtained from the Phase II reservoir rights file, *coloup.rer*. The absolute decree amount presented in **Table 1** for "Total Aggregated Reservoirs " was produced by running **watright** with command file *aggres.com* (see **Exhibit 1**). The storage presented in **Table 1** for the "Total Aggregated Stock Ponds" was taken from the year 2 Task Memorandum 2.09-10 "Consumptive Use Model Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Upper Colorado River Basin" (11/26/96).

Table 1
Net Absolute Water Rights

Phase	Reservoir	Absolute Decree (af)	% Total
Phase II	GREEN MOUNTAIN RESERV	160,961	10%
Phase II	CLINTON GULCH RESERVOIR	4,250	<1%
Phase II	DILLON RESERVOIR	252,678	16%
Phase II	HOMESTAKE PROJ	43,505	3%
Phase II	GRASS VALLEY RESERVOIR	6,889	<1%
Phase II	RIFLE GAP RESERVOIR	13,601	1%
Phase II	MEADOW CREEK RESERVOIR	5,100	<1%
Phase II	CBT SHADOW MTN GRAND L	19,669	1%
Phase II	WILLIAMS FORK RESERVOIR	187,274	12%
Phase II	CBT WILLOW CREEK RES	10,553	1%
Phase II	CBT GRANBY RESERVOIR	543,758	35%
Phase II	VEGA RESERVOIR	33,500	2%
Phase II	RUEDI RESERVOIR	102,369	7%
Phase II	WOLFORD MOUNTAIN RES	65,985	4%
Phase II	BONHAM AGGREGATED RES	6,778	<1%
Phase II	COTTONWOOD AGGREG RES	3,812	<1%
Phase II	CONT. HOOSIER RES	2,140	<1%
Subtotal		1,462,822	94%
Phase IIIa	Total Aggregated Reservoirs	92,505	6%
Phase IIIa	Total Aggregated Stock Ponds	2,661	<1%
Subtotal		94,766	6%
Total		**1,557,588**	**100%**

Number of Structures and Locations: Based on general location, the Phase IIIa reservoirs and stock ponds were incorporated into the model as 11 aggregated structures within each water district. Ten non-operational reservoirs were used to model the net absolute decreed storage. Storage was assigned to the ten nodes as shown in **Table 2**. One non-operational reservoir was used to model the stock ponds, also shown in **Table 3**.

Each aggregated reservoir and stock pond was assigned one account and an initial storage equal to their capacity. Each aggregated reservoir and stock pond was assumed to be 10 foot deep. Each aggregated reservoir and stock pond was assigned a 2 point area-capacity curve. The first curve point is zero capacity and zero area. The second point on the area-capacity table is total capacity with the area equal to the total capacity divided 10. The net evaporation station as described in Phase II Colorado River basin documentation (Section 4.3.2.1 “Estimation of Annual Net Evaporation") was assigned to each structure at 100 percent. All other parameters were left as the default to each structure.

Table 2
Non-operational Reservoirs

Model ID	Name	Capacity (AF)	Percent
36_ARC001	36_ARC001	8,702	9
37_ARC002	37_ARC002	6,671	7
38_ARC003	38_ARC003	13,074	14
39_ARC004	39_ARC004	2,236	2
45_ARC005	45_ARC005	2,054	2
50_ARC006	50_ARC006	11,481	12
51_ARC007	51_ARC007	8,480	9
52_ARC008	52_ARC008	821	1
53_ARC009	53_ARC009	8,389	9
72_ARC010	72_ARC010	30,597	33
	Total	92,505	100

Table 3
Non-operational Stock Pond

Model ID	Name	Capacity (AF)	Percent
72_ASC001	72_ACS_001	2,261	100
	Total	94,766	100

Target Contents, and End-of-Month Data: Each aggregate reservoir and stock pond was designed to maintain maximum volume, filling to account for evaporation losses,
The end-of-month data used in the baseflow calculations was set to the target values.

Water Rights: Water rights associated with each aggregated reservoir and stock pond were assigned an administration number equal to 1.

EXHIBIT 1

```
basin=coloup
-rightss
-report
#Included in Phase II
ignore(363543)
ignore(364512)
ignore(374516)
ignore(383713)
ignore(393505)
ignore(393508)
ignore(513686)
ignore(513695)
ignore(513709)
ignore(513710)
ignore(723844)
ignore(363575)
ignore(503657)
ignore(514620)
ignore(363570)
#Part of Cottonwood Res. Aggregation in Phase II
ignore(723933)
ignore(723934)
ignore(723932)
ignore(723926)
ignore(723931)
ignore(723925)
ignore(723923)
ignore(723924)
#Part of Bonham Res. Aggregation in Phase II
ignore(723837)
ignore(723910)
ignore(723908)
ignore(723904)
ignore(723906)
ignore(723907)
ignore(723909)
ignore(723905)
```

Appendix C

Pattern Stream Gages

1. CDSS Daily Colorado River Model –Recommendation of Pattern Stream Gages

Upper Colorado River Basin Model Memorandum
Final

To: Ray Alvarado, CWCB and Ray Bennett, SEO

From: James Heath and Erin Wilson

Subject: CDSS Daily Upper Colorado River Model – Task 2.1 Recommendation of Pattern Stream Gages

Date: February 8, 2006

Introduction

The purpose of this memorandum is to outline the approach used to select pattern stream gages within the Upper Colorado River basin for the daily model. The objective of Task 2.1 was to "select stream gages with good daily records to represent appropriate sub-basins or model areas." These pattern gages were then used to distribute monthly baseflow estimate results to daily baseflows at nearby gages.

Background

Boyle Engineering completed a pilot study for the CDSS Daily Yampa Model, in which they determined that the best approach to creating a daily model was to use the daily pattern approach (see September 28, 2001 "CDSS Daily Yampa Model – Task 2 Pilot Study" by Meg Frantz and Linda Williams).

The daily pattern approach can be described as distributing monthly baseflows to daily baseflows based on the daily distribution of selected historical gages, or pattern gages. StateMod is used to disaggregate the monthly baseflows by multiplying the daily historical gage flow QD_{gage} by the factor QM_{bf}/QM_{gage}, where QM_{bf} is the monthly baseflow and QM_{gage} is the monthly historical gage flow.

For this approach, monthly demands are disaggregated to daily demands by connecting the midpoints of the monthly data. Reservoir targets are disaggregated by connecting the endpoints of end-of-month contents. Instream flow demands are disaggregated by setting them to the average daily value.

The Scope of Work for the Upper Colorado River Basin StateMod Update defined the daily model simulation study period to be 1975 through 2005. LRE reviewed streamflow records for the model gages and found that streamflow records for potential pattern gages were consistently available back to 1956 without significant filling. Therefore, LRE recommends the development of pattern gages for the model period of 1956 through 2005. Note that calibration and documentation efforts will focus on the original study period from 1975 through 2005.

Approach

The daily streamflow pattern gages were selected for use in the Upper Colorado River Model by using the following approach:

1) ***Review Completeness of Daily Records*** - The stream gages within the Upper Colorado River Model were reviewed for completeness of daily records over the 1975 through 2005 study period.
2) ***Select Representative Gages*** - Representative gages were selected based on the location and minimal upstream effects.
3) ***Remove Upstream Effects –*** Many of the gages selected are below transbasin diversions or imports. Daily exports were added to and imports were subtracted from the historic gaged flows to more closely represent baseflow stream conditions.
4) ***Fill Missing Daily Baseflow Data*** – Selected pattern gages missing daily data over the 1956 through 2005 model period were filled using the monthly logarithmic regression command within TSTool.
5) ***Generate the Daily Pattern Gage File –*** The daily pattern gage file, *cm2005.rbd*, was created using the command file r*bd.commands.TSTool* in TSTool.

1) Review Completeness of Daily Records

Within the Monthly Upper Colorado River Model, a total of 88 stream gages are used. These gages were reviewed to determine which would be selected as daily pattern gages. Two primary criteria were used in the selection of daily pattern gages:

(1) Completeness of the daily data set over the study period (1975 – 2005),
(2) Location of the gage.

Of the 88 gages in the Upper Colorado River Model, only 29 gages had a complete daily data set over the 1975 through 2005 study period. Additionally, one gage was missing 1%, two gages were missing 7%, and one gage was missing 10% of the daily data over the study period. The remaining 55 gages were missing more than 10% of the daily data over the 1975 through 2005 study period, which was considered to be an unreasonably high amount of missing data to serve as a pattern gage. The 33 gages with a complete or near complete data set are listed below:

- 09010500 Colorado River below Baker Gulch, near Grand Lake, CO
- 09024000 Fraser River at Winter Park
- 09025000 Vasquez Creek at Winter Park
- 09026500 St. Louis Creek near Fraser
- 09032000 Ranch Creek near Fraser
- 09034900 Bobtail Creek near Jones Pass
- 09035500 Williams Fork River below Steelman Creek
- 09036000 Williams Fork River near Leal, CO
- 09037500 Williams Fork River near Parshall
- 09038500 Williams Fork River Below Williams Fork Reservoir
- 09046600 Blue River near Dillon
- 09047500 Snake River near Montezuma, CO
- 09050100 Tenmile Creek at Frisco

- 09050700 Blue River below Dillon Reservoir
- 09058000 Colorado River near Kremmling
- 09063000 Eagle River at Red Cliff, CO
- 09064000 Homestake Creek at Gold Park
- 09065100 Cross Creek near Minturn
- 09065500 Gore Creek at Upper Station, near Minturn
- 09070000 Eagle River below Gypsum
- 09070500 Colorado River near Dotsero
- 09073400 Roaring Fork River near Aspen (missing 1% of daily data during study period)
- 09074000 Hunter Creek near Aspen
- 09078600 Fryingpan River near Thomasville (missing 10% of daily data during study period)
- 09080400 Fryingpan River near Ruedi
- 09081600 Crystal River above Avalanche Creek near Redstone
- 09085000 Roaring Fork River at Glenwood Springs
- 09085100 Colorado River below Glenwood springs
- 09089500 West Divide Creek near Raven (missing 7% of daily data during study period)
- 09095500 Colorado River near Cameo
- 09105000 Plateau Creek near Cameo (missing 7% of daily data during study period)
- 09152500 Gunnison River near Grand Junction
- 09163500 Colorado River near Colorado-Utah State Line

2) Select Representative Gages

The location of the gage was the second criterion for selecting pattern gages. It was determined that to best match the baseflows of other gages, the historic flows at the selected pattern gages needed to be as close to baseflow conditions as possible. Gages located downstream of key reservoirs, imports, or gages affected by large upstream diversions were not as favorable for pattern gages as gages located above these structures. Gages located downstream of such structures are impacted by the fluctuations of reservoirs, the amount of water imported, or quantities and timing of diversions and associated return flows, therefore the historic flows are not representative of baseflow conditions. Unfortunately, in the Upper Colorado River basin many of the headwaters of tributaries contain transbasin diversions. Therefore these diversions needed to be added back into the historic gage flow to evaluate the baseflow conditions.

Seven stream gages from the list above were identified as being located where historic flows would be similar to baseflow conditions. These gages are as follows:

- 09010500 Colorado River below Baker Gulch, near Grand Lake, CO
- 09024000 Fraser River at Winter Park
- 09036000 Williams Fork River near Leal, CO
- 09047500 Snake River near Montezuma, CO
- 09063000 Eagle River at Red Cliff, CO
- 09081600 Crystal River above Avalanche Creek near Redstone
- 09089500 West Divide Creek near Raven

Gage 09089500 - West Divide Creek near Raven is missing 7% of the data set over the study period. The missing data occurs during the winters of USGS water years 2000 through 2005 and was filled using the monthly logarithmic regression capability in TSTool utilizing gage 09081600 - Crystal River above Avalanche Creek near Redstone. The Crystal River gage was selected because of the high correlation for the missing months throughout the study period. Once the missing data was filled, gage 09089500 - West Divide Creek near Raven was used as a pattern gage.

Gage 09024000 – Fraser River at Winter Park requires daily data from Denver for the Jim Creek collection location within the Fraser Collection System. Data throughout the study period was not yet available at the time of this model update and therefore the gage was removed from the list of pattern gages.

Gage 09152500 – Gunnison River near Grand Junction was used to represent inflows from the Gunnison River basin.

The sub-basins in the Upper Colorado River Model have been represented by one or more of the seven selected pattern gages. The major tributaries have a pattern gage located along its main stem except for the Blue River, Fraser River, and Plateau Creek. **Table 1** summarizes the pattern gages selected for each sub-basin in the Upper Colorado River Model.

Table 1
Recommended Daily Pattern Gages for Colorado River Sub-basins

Basin Subdivision	Recommended Pattern Gage
Upper Colorado, Willow Creek, Corral Creek, and Troublesome Creek (Districts 51 and part of 50) and the Main Stem of the Colorado from the headwaters to the Dotsero Gage	09010500 - Colorado River below Baker Gulch, near Grand Lake, CO
Williams Fork River (Part of District 51)	09036000 - Williams Fork River near Leal, CO
Blue River (District 36)	09047500 - Snake River near Montezuma, CO
Eagle River (Districts 37 and 52) and the Main Stem of the Colorado from the Dotsero Gage to the end of the model	09063000 - Eagle River at Red Cliff, CO
Roaring Fork (District 38)	09081600 - Crystal River above Avalanche Creek near Redstone
Divide Creek, Plateau Creek, Muddy Creek, and North Side Tributaries (Districts 39, 45, 50 (part), 53, 70, and 72)	09089500 - West Divide Creek near Raven
Gunnison River (District 42)	09152500 – Gunnison River near Grand Junction

Figure 1, attached, illustrates the gages within the Upper Colorado River Model and the recommended pattern gages that will be used to represent them in the daily model.

A brief description of why each pattern gage was chosen to represent the corresponding sub-basins:

- Gage 09010500 - Colorado River below Baker Gulch, near Grand Lake, CO was selected to represent the Upper Colorado River and its tributaries because the gage is located above Northern Colorado Water Conservancy Districts' transbasin diversions. However, it is below the Grand River Ditch (WDID 51004601) transbasin diversion. Corral Creek, Troublesome Creek, and Willow Creek are well represented by this gage because they have similar South facing aspects, headwaters located at elevations exceeding 10,000 ft, and steep sloping drainages. The Fraser River Basin will be represented by this gage due to a higher statistical correlation than the Williams Fork gage listed below. This gage has also been chosen to represent the mainstem of the Colorado River from the headwaters to gage 09070500 – Colorado River near Dotsero based on regression analyses between mainstem and pattern gages.
- Gage 09036000 - Williams Fork River near Leal, CO was selected to represent Williams Fork River and its tributaries. This gage is not the highest gage in the system but was chosen because of its extensive period of record, 1933 through 2005, and baseflows can be determined by accounting for transbasin diversions through the Gumlick Tunnel near Jones Pass.
- Gage 09047500 - Snake River near Montezuma, CO was selected to represent all of District 36, Blue River, because it has a complete and lengthy period of record (1942-2005) and because it only has one minor transbasin diversion above it in the Vidler Tunnel. The two gages near Dillon were not combined and utilized due to the multiple upstream transbasin diversions, Breckenridge diversions, and the Con-Hoosier reservoir.
- Gage 09063000 - Eagle River at Red Cliff, CO was selected to represent all of Districts 37 and 52 (Eagle River, Piney Creek, and Cottonwood Creek). This gage is the upper most gage in the basin and has three transbasin diversions above it: Columbine Ditch, Ewing Ditch, and Wurtz Ditch. District 52 is represented by this gage because of close proximity and similar topography to the Eagle River; additionally there are no gages along the modeled tributaries within District 52. This gage also best represents the mainstem of the Colorado River from gage 09070500 – Colorado River near Dotsero to the end of the model based on regression analyses between mainstem and pattern gages.
- Gage 09081600 - Crystal River above Avalanche Creek near Redstone was selected to represent all of District 38, Roaring Fork River Basin, because there are no reservoirs or transbasin diversions above this gage. Additionally, Crystal Creek provides nearly a quarter of the baseflow observed in the basin.
- Gage 09089500 - West Divide Creek near Raven was selected to represent all of Districts 39, 45, 53, 70, and 73 along with Muddy Creek in District 50. The primary reasons this gage is used for such a broad area are because there are no other gages in the lower portion of the Upper Colorado River basin with records encompassing the entire study period and located above reservoirs and/or significant diversions. This gage is representative of the North side tributaries up to Muddy Creek due to the topography of the drainage basins. Muddy Creek and other North side tributaries primarily have broad gently sloping drainage basins with headwaters located at elevations below 10,000 ft.
- Gage 09152500 – Gunnison River near Grand Junction was selected to represent inflows from the Gunnison River into the Upper Colorado River model. Daily data is complete throughout the model period.

3) Remove Upstream Effects

In order to create base flows from the historic flows recorded at the gages transbasin diversions must be added and transbasin imports must be subtracted from the historic gage records. TSTool was utilized to make these manipulations and are described below in detail for each gage.

- Gage 09010500 - Colorado River below Baker Gulch, near Grand Lake, CO is located below the Grand River Ditch (WDID 51004601) transbasin diversion. The Grand River Ditch is represented in HydroBase as Stream Flow station 09010000 – Grand River Ditch at La Poudre Pass @ 10 ft Parshall Flume. The transbasin diversions were added to the historic gage records to generate baseflows at the gage's location.
- Gage 09036000 - Williams Fork River near Leal, CO is located below the transbasin diversions through the August P. Gumlick Tunnel. The Gumlick Tunnel is represented in HydroBase as Stream Flow station APGTUNCO - August P. Gumlick Tunnel near Jones Pass. Data for this stream flow station is missing data for USGS water years 2000-2005 which have been filled with data from the diversion structure 5104603 – Williams Fork Tunnel. The transbasin diversions were added to the historic gage records to generate baseflows at the gage's location.
- Gage 09047500 - Snake River near Montezuma, CO is located below the transbasin diversions at the Vidler Tunnel. The Vidler Tunnel is represented in HydroBase as Stream Flow station 09047300 – Vidler Tunnel near Argentine Pass. The transbasin diversions were added to the historic gage records to generate baseflows at the gage's location.
- Gage 09063000 - Eagle River at Red Cliff, CO is located below three transbasin diversions at the Columbine Ditch, Ewing Ditch, and Wurtz Ditch. The diversions are represented in HydroBase as Stream Flow stations 09061500 – Columbine Ditch near Freemont Pass, 09062000 – Ewing Ditch at Tennessee Pass, and 09062500 – Wurtz Ditch near Tennessee Pass. The Ewing Ditch is missing records for USGS water years 1975-1979 which have been filled by a monthly logarithmic regression in TSTool utilizing gage 09062500 – Wurtz Ditch near Tennessee Pass as the independent data set. The transbasin diversions were added to the historic gage records to generate baseflows at the gage's location.
- Gage 09081600 - Crystal River above Avalanche Creek near Redstone does not have diversions, imports, or reservoirs located above it within the model therefore the historic gage records are also baseflows.
- Gage 09089500 - West Divide Creek near Raven is located below the transbasin import from the Gunnison River Basin through Divide Creek Highline Feeder Ditch. The imports is represented in HydroBase as diversion 4004657 – Divide Cr Hl Feeder D. Data is missing for 4004657 – Divide Cr Hl Feeder D which is filled from the following two diversions: 4500576 – Divide Creek Highline D (S:1 F:4657 U:1), and 4500576 – Divide Creek Highline D (S:4 F:4657 U:1). The transbasin imports were subtracted from the historic gage records to generate baseflows at the gage's location.

4) *Fill Missing Daily Baseflow Data*

Gage 09089500 - West Divide Creek near Raven, is missing 7% of the daily data over the 1975 through 2005 study period. The missing daily data was filled using TSTool's monthly regression model. Gage 09081600 - Crystal River above Avalanche Creek near Redstone was selected as the independent gage for correlating to gage 09089500 - West Divide Creek near Raven because of the highest correlation coefficients for November, December, January, February, and March as determined using TSTool. The monthly correlation coefficients between gage 09089500 - West Divide Creek near Raven and gage 09081600 - Crystal River above Avalanche Creek near Redstone were 0.87, 0.85, 0.82, 0.78, and 0.91. The following command was used in TSTool to fill the missing daily data in gage 09089500 - West Divide Creek near Raven:

- FillRegression() – used to fill in the missing daily data for gage 09089500 - West Divide Creek near Raven with monthly logarithmic regression equations using gage 09081600 - Crystal River above Avalanche Creek near Redstone.

5) *Generate the Daily Pattern Gage File*

The daily historic baseflow file was created using the command file, r*bd.commands.TSTool*, in TSTool. The resulting output file, *cm2005.rbd*, contains the historic daily baseflows for the seven pattern gages in the basin for the model period of 1956 through 2005. Additionally, the TSTool command file, *rid.commands.TSTool,* was utilized to create the historic streamflow file, *cm2005.rid*. The historic streamflow file, *cm2005.rid*, contains data for the seven pattern gages along with 14 other gages within the basin chosen to review during calibration.

Conclusions

The Daily Pattern approach was used to develop the daily model for the Upper Colorado River basin. Seven stream gages within the basin were selected as pattern gages, which will be used to represent the remaining gages in the daily model. These seven stream gages were selected based on the completeness of the daily data set over the modeled period (1956 – 2005), and the location of the stream gage. The stream gages selected and the sub-basin that they will represent are summarized in Table 1 and illustrated in Figure 1.

Comments and Concerns

A pattern gage was not selected in the Fraser River basin due to data limitations. Available gages on the Fraser River require that the upstream effects of transbasin diversions be considered. Daily data for the Fraser collection system diversions are not directly measured but are calculated by Denver Water based on Moffat Tunnel diversions and gaged bypasses. Daily data from 1992 through 2005 is not available at this time and according to Denver Water, will not be available this year. Therefore, the Colorado River below Baker Gulch gage was selected to represent the Fraser River basin, based on good correlation to Fraser gages.

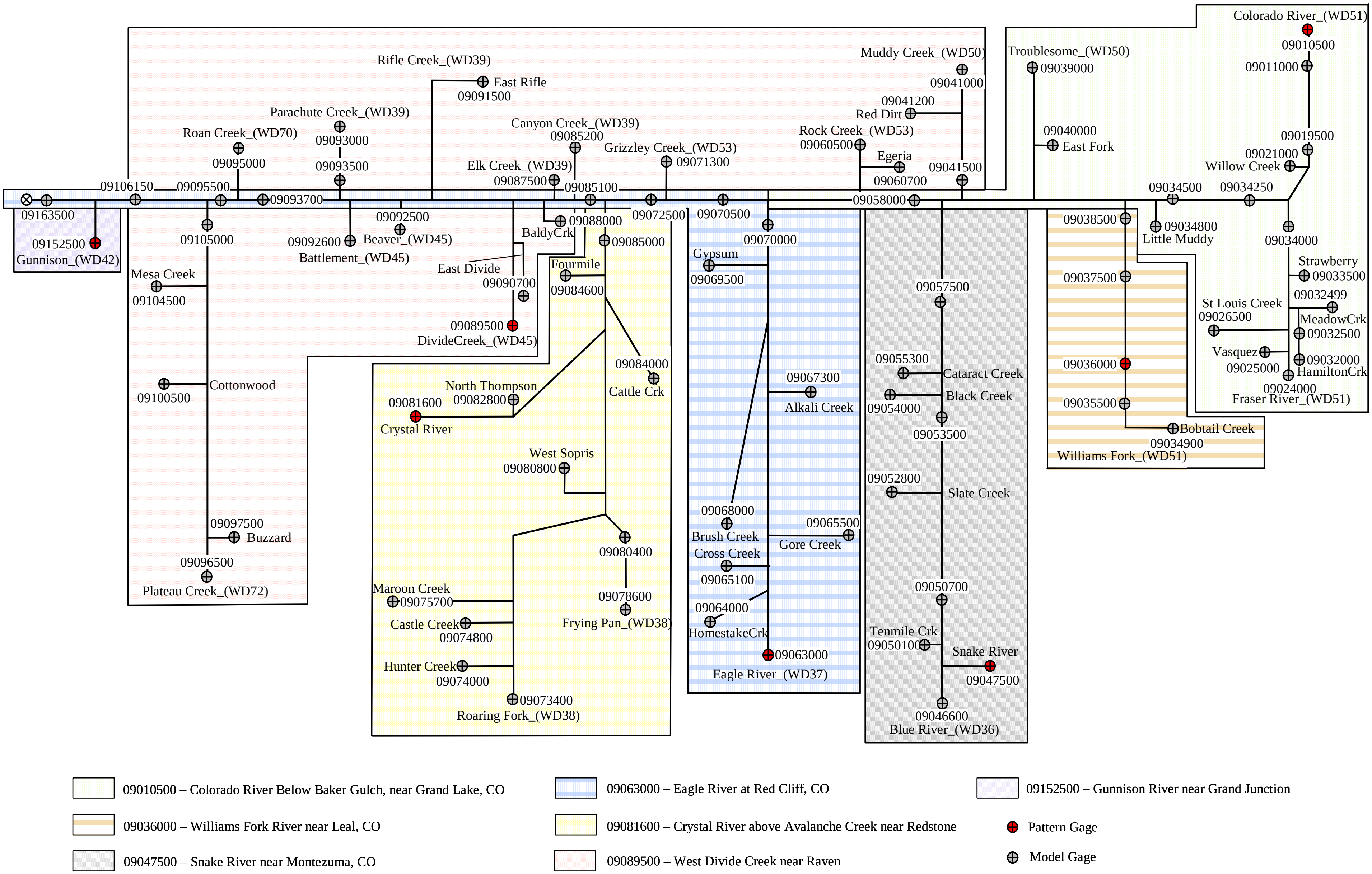


Figure 1 – Recommended Application of Daily Pattern Gages

Appendix D

Simulation Results with Calculated Irrigation Demand

Calculated Data Set

Note: This section describes a Calculated Data Set that was completed in January 2007. The monthly Upper Colorado Model Historical (calibration), Calculated and Baseline data files were updated in October 2009, and the 2009 calibration and Baseline data sets are described in this user manual. Inconsistencies between the 2008 and 2009 Calculated Data Set are minor, and include:

1) maximum irrigation efficiency set to 0.60 in 2008, and set to 0.54 in 2009
2) differences in IWR for fields below 6,500 ft in elevation, because an elevation adjustment was applied to crop coefficients in the Blaney-Criddle analysis in the 2009 model
3) updated baseline demands for several transbasin diversions, including Roberts Tunnel, Adams Tunnel, and Con-Hoosier Tunnel, and
4) revision to the representation of the Ute Water Conservancy District system.

The approach described for the Calculated Data Set is accurate, except for the items listed above. Table values in this appendix are similar to, but not exactly, what is produced by the 2009 Calculated Data Set.

The “Calculated Data Set” is a data set that was created to further look at simulation of the Upper Colorado River Model. The unique characteristic of this data set is the demand file. Demand for irrigation users in this scenario is estimated outside the model, based on crop consumptive use of historical acreage and historical efficiency. Unlike the Baseline data set, the scenario is historical in the sense that is uses historical operating rules, and reservoirs come on-line when they did historically, but the irrigation demand is not strictly historical. In the Historical calibration run, demand was set to historical diversions, so that it reflects an irrigator’s operational decisions or circumstances that are unrelated to use by crops. For example, if a headgate was damaged in spring flooding and didn’t become usable until several weeks into the normal irrigation season, it would be reflected in historical diversions and therefore in the Historical calibration data set. Demand in the Calculated data set reflects the theoretical crop needs – that is the amount that needs to be diverted if the crop is to acquire a full supply.

Calculated Demand

Calculated demands must account for both crop needs and irrigation practices. Monthly calculated demand for 1975 through 2005 was generated within StateDMI, by taking the maximum of crop irrigation water requirement divided by average monthly irrigation efficiency, and historic diversions. The irrigation efficiency may not exceed the defined maximum efficiency (60 percent), which represents an estimated practical upper limit on efficiency for flood irrigation systems in the Colorado basin. Thus calculated demand for a consistently shorted structure, and demand for months when a structure historically operated more efficiently than the average, will be greater than the historical diversion. By estimating demand to be the maximum of calculated demand and historical diversions, such irrigation practices as diverting to fill the soil moisture zone or diverting for stock watering can be mimicked more accurately.

Calculated demands were filled using the automated time series filling technique described in Section 4.4.2 for the time period prior to 1975. This is done because historical diversion records are generally not available until 1975 in the Colorado River basin. Basin wide calculated demand over the calibration period (1975-2005) amounts to 4,551,889 acre-feet per year on average. This compares with historical diversion which averaged 4,082,716 acre-feet per year over the same period. The Calculated demand represents an increase of 11 percent over historical diversions. Note that historical diversions for carriers and feeder canals, set to zero in the Calculated data set because demand is placed at the destination, are not included in the historical diversion average presented here.

Demands are calculated using the same methodology as the Baseline demands except Calculated demands are limited to historical acreage; whereas Baseline demands are estimated as if current irrigated acreage was in place over the entire study period.

Calculated Data Set Calibration Efforts

In previous modeling phases, calculated demands were calculated as irrigation water requirement divided by average efficiency. As noted above, this did not account for certain irrigation practices, such as spring diversions to fill the soil reservoir or “wet” canals. This method was also unable to account for winter diversions for stock watering. Calculate demands for the current model are calculated as the maximum of irrigation water requirement divided by average efficiency and historical diversion. This allowed better calibration of diversions and streamflow gages in the winter and early spring.

Calculated Data Set Simulation Results

Simulation of the Calculated Upper Colorado River Model is considered good, with more than half of the streamflow gages deviating less than 1 percent from historical values on an average annual basis. The basin wide shortage in Colorado, determined by comparing simulated diversions to Calculated demand, is about 4 percent per year, on average. In Colorado, 7 percent more water is being diverted during Calculated simulation, determined by comparing simulated diversions to historic diversions. Simulated reservoir contents are representative of historical values.

Water Balance Results

Table D.1 summarizes the water balance for the Upper Colorado River Model, for the calibration period (1975-2005). Following are observations based on the summary table:

- Surface water inflow to the basin averages 5.65 million acre-feet per year, and stream outflow averages 4.54 million acre-feet per year.

- Annual diversions amount to approximately 4.95 million acre-feet on average, which is approximately 7 percent greater than diversions in the historical calibrated simulation.

- Approximately 1.06 million acre-feet per year is consumed in the Calculated simulation. Note that this value is representative of the basin wide consumptive use and losses and includes crop consumptive use, municipal and industrial consumptive use, reservoir evaporation, and 100 percent of exports from the basin.

- The column labeled “Inflow – Outflow” represents the net result of gain (inflow, return flows, and negative change in reservoir and soil moisture contents) less outflow terms (diversions, outflow, evaporation, and positive changes in storage), and indicates that the model correctly conserves mass.

Table D.1
Average Annual Water Balance for Calculated Simulation 1975-2005 (af/yr)

Month	Stream Inflow	Return	From Soil Moisture	Total Inflow	Diversions	Resvr Evap	Stream Outflow	Resvr Change	To Soil Moisture	Soil Moisture Change	Total Outflow	Inflow - Outflow	CU
OCT	264,547	378,373	392	643,312	418,459	2,512	260,076	-38,126	936	-544	643,313	0	42,953
NOV	199,000	211,369	10	410,379	183,556	536	256,874	-30,596	357	-347	410,379	0	25,676
DEC	185,276	227,501	0	412,777	219,105	-932	232,932	-38,328	203	-203	412,777	0	31,497
JAN	178,357	210,642	0	389,000	213,122	-894	218,028	-41,257	145	-145	389,000	0	31,730
FEB	173,751	186,172	0	359,923	193,499	191	202,805	-36,571	112	-112	359,923	0	28,637
MAR	235,762	198,338	35	434,135	218,637	1,489	250,414	-36,440	239	-204	434,135	0	32,457
APR	405,783	264,355	79	670,216	333,001	3,250	329,392	4,530	1,268	-1,190	670,251	-35	45,509
MAY	1,181,351	390,061	460	1,571,873	593,539	7,232	822,511	148,130	4,209	-3,748	1,571,873	0	138,555
JUN	1,471,198	482,911	1,877	1,955,986	787,081	10,209	983,167	173,651	1,802	75	1,955,986	0	241,041
JUL	741,376	476,270	5,291	1,222,937	709,688	9,658	495,134	3,166	244	5,048	1,222,938	-1	214,275
AUG	343,777	434,391	3,802	781,970	578,341	6,946	247,904	-55,001	226	3,577	781,992	-22	141,340
SEP	271,133	418,151	2,014	691,298	503,190	4,652	237,221	-55,779	411	1,604	691,298	0	86,062
AVG	5,651,306	3,878,534	13,962	9,543,809	4,951,216	44,849	4,536,457	-2,621	10,151	3,811	9,543,867	-58	1,059,733

Note: Consumptive Use (CU) = Diversion (Divert) * Efficiency + Reservoir Evaporation (Evap)

Streamflow Results

Table D.2 summarizes the average annual streamflow for water years 1975 through 2005, as estimated in the Calculated simulation. It also shows average annual values of actual gage records for comparison. Both numbers are based only on years for which gage data are complete. Figures D.1 through D.14 (at the end of this appendix) graphically present monthly streamflow estimated by the model compared to historical observations at key streamflow gages in both time-series format and as scatter graphs. When only one line appears on the time-series graph, it indicates that the simulated and historical results are the same at the scale presented. The "goodness of fit" is indicated by the R^2 value shown on each scatter graph.

Calculated simulation streamflow is generally very good in terms of both annual volume and monthly pattern, and similar to the historical calibration results. As expected with higher demands, there is slightly less simulated flow at many gages. An example is Redtop Valley Ditch above Grand Lake diverted 4,145 acre-feet per year more in the Calculated simulation compared with historical diversions affecting downstream flows. In the Calculated simulation, the Moffat Tunnel system demand is placed at the Moffat Tunnel node and diversions from each tributary are met by operating rules, whereas in the historical scenario demand is placed at the individual diversions. Even though the same priority is given to the operating rules, more of the demand is met from St. Louis Creek and less from the other tributaries, than in the historical simulation. This affects the flows on both the tributaries of the Fraser River and Williams Fork. Similarly, the Fryingpan-Arkansas Boustead Tunnel transbasin diversion is placed at a summary node which receives more water from the Fryingpan River than from Hunter Creek, when compared to the historic diversions, affecting the flows on both of these streams.

Table D.2
Historical and Simulated Average Annual Streamflow Volumes (1975-2005)
Calculated Simulation (acre-feet/year)

Gage ID	Historical	Simulated	Historical -Simulated Volume	Historical -Simulated Percent	Gage Name
09010500	45,792	45,792	0	0%	Colorado R Below Baker Gulch, Nr Grand Lake, CO.
09011000	57,764	53,291	4,473	8%	Colorado River Near Grand Lake, CO.
09019500	39,532	36,482	3,050	8%	Colorado River Near Granby
09021000	31,132	30,484	648	2%	Willow Creek Below Willow Creek Reservoir
09024000	13,309	12,392	917	7%	Fraser River At Winter Park
09025000	10,289	13,124	-2,836	-28%	Vasquez Creek At Winter Park, CO.
09026500	15,221	6,032	9,189	60%	St. Louis Creek Near Fraser, CO.
09032000	8,860	12,641	-3,780	-43%	Ranch Creek Near Fraser, CO.
09032499	8,064	8,064	0	0%	Meadow Creek Reservoir Inflow
09032500	Missing gage data during calibration period				Ranch Creek Near Tabernash, CO.
09033500	Missing gage data during calibration period				Strawberry Creek Near Granby, CO.
09034250	183,828	174,290	9,538	5%	Colorado River At Windy Gap, Near Granby, CO.
09034500	168,786	162,516	6,271	4%	Colorado River At Hot Sulphur Springs, CO.
09034800	Missing gage data during calibration period				Little Muddy Creek Near Parshall, CO.
09034900	7,564	7,564	0	0%	Bobtail Creek Near Jones Pass, CO.
09035500	14,124	15,133	-1,009	-7%	Williams Fork Below Steelman Creek, CO.
09036000	72,517	73,527	-1,009	-1%	Williams Fork River Near Leal, Co
09037500	79,248	74,204	5,044	6%	Williams Fork River Near Parshall, Co
09038500	92,719	90,334	2,384	3%	Williams Fork River Below Williams Fork Reservoir
09039000	22,365	22,840	-476	-2%	Troublesome Creek Near Pearmont, CO.
09040000	22,498	20,904	1,594	7%	East Fork Troublesome C Near Troublesome, CO.
09041000	49,395	48,679	716	1%	Muddy Creek Near Kremmling, CO.
09041200	Missing gage data during calibration period				Red Dirt Creek Near Kremmling, CO.
09041500	66,565	60,535	6,030	9%	Muddy Creek At Kremmling, CO.
09046600	69,345	69,144	201	0%	Blue River Near Dillon, CO.
09047500	45,449	45,454	-5	0%	Snake River Near Montezuma, CO.
09050100	75,063	75,203	-140	0%	Tenmile Creek Below North Tenmile Creek At Frisco
09050700	146,624	146,900	-276	0%	Blue River Below Dillon Reservoir
09052800	18,677	18,677	0	0%	Slate Creek At Upper Station, Near Dillon, CO.
09053500	312,566	321,061	-8,494	-3%	Blue River Above Green Mountain Reservoir, CO.
09054000	22,776	22,776	0	0%	Black Creek Below Black Lake, Near Dillon, CO.
09055300	14,558	14,558	0	0%	Cataract Creek Near Kremmling, CO.
09057500	301,300	299,328	1,972	1%	Blue River Below Green Mountain Reservoir
09058000	718,265	702,113	16,152	2%	Colorado River Near Kremmling
09060500	24,031	24,031	0	0%	Rock Creek Near Toponas, CO.
09060700	Missing gage data during calibration period				Egeria Creek Near Toponas, CO.
09063000	28,262	28,295	-33	0%	Eagle River At Red Cliff, CO.
09064000	19,824	20,451	-627	-3%	Homestake Creek At Gold Park, CO.
09065100	37,802	37,802	0	0%	Cross Creek Near Minturn
09065500	22,232	22,232	0	0%	Gore Creek At Upper Station, Near Minturn, CO.
09067300	Missing gage data during calibration period				Alkali Creek Near Wolcott, CO.
09068000	Missing gage data during calibration period				Brush Creek Near Eagle, CO.
09069500	Missing gage data during calibration period				Gypsum Creek Near Gypsum, CO.

Gage ID	Historical	Simulated	Historical -Simulated Volume	Historical -Simulated Percent	Gage Name
09070000	407,419	406,092	1,327	0%	Eagle River Below Gypsum
09070500	1,455,699	1,433,926	21,773	1%	Colorado River Near Dotsero
09071300	9,755	9,755	0	0%	Grizzly Creek Near Glenwood Springs, CO.
09072500	Missing gage data during calibration period				Colorado River At Glenwood Springs, CO.
09073400	71,114	71,428	-315	0%	Roaring Fork River Near Aspen
09074000	30,203	35,661	-5,458	-18%	Hunter Creek Near Aspen
09074800	31,675	31,675	0	0%	Castle Creek Above Aspen, CO.
09075700	50,076	50,076	0	0%	Maroon Creek Above Aspen, CO.
09078600	76,881	71,928	4,953	6%	Fryingpan River Near Thomasville
09080400	123,912	119,221	4,691	4%	Fryingpan River Near Ruedi
09080800	Missing gage data during calibration period				West Sopris Creek Near Basalt, CO.
09081600	215,575	215,575	0	0%	Crystal River Above Avalanche Creek Near Redstone
09082800	10,923	10,923	0	0%	North Thompson Creek Near Carbondale, CO.
09084000	Missing gage data during calibration period				Cattle Creek Near Carbondale, CO.
09084600	Missing gage data during calibration period				Fourmile Creek Near Glenwood Springs, CO.
09085000	860,602	855,436	5,166	1%	Roaring Fork River At Glenwood Springs
09085100	2,370,982	2,343,856	27,127	1%	Colorado River Below Glenwood Springs
09085200	40,635	40,222	413	1%	Canyon Creek Above New Castle, CO.
09087500	Missing gage data during calibration period				Elk Creek At New Castle, CO.
09088000	Missing gage data during calibration period				Baldy Creek Near New Castle
09089500	30,280	30,280	0	0%	West Divide Creek Near Raven
09090700	Missing gage data during calibration period				East Divide Creek Near Silt, CO.
09091500	Missing gage data during calibration period				East Rifle Creek Near Rifle, CO.
09092500	3,591	3,591	0	0%	Beaver Creek Near Rifle
09092600	Missing gage data during calibration period				Battlement Creek Near Parachute
09093000	35,518	35,518	0	0%	Parachute Creek Near Parachute CO.
09093500	22,997	23,138	-141	-1%	Parachute Creek At Parachute, CO.
09093700	2,816,135	2,779,010	37,126	1%	Colorado River Near De Beque
09095000	38,970	39,379	-410	-1%	Roan Creek Near De Beque, CO.
09095500	2,726,210	2,687,654	38,556	1%	Colorado River Near Cameo
09096500	22,259	14,314	7,946	36%	Plateau Creek Near Collbran, CO.
09097500	30,446	29,294	1,153	4%	Buzzard Creek Near Collbran
09100500	Missing gage data during calibration period				Cottonwood Creek At Upper Sta, Near Molina, CO.
09104500	Missing gage data during calibration period				Mesa Creek Near Mesa, CO.
09105000	154,723	149,453	5,270	3%	Plateau Creek Near Cameo
09152500	1,841,072	1,841,070	2	0%	Gunnison River Near Grand Junction
09163500	4,585,370	4,536,457	48,913	1%	Colorado River Near Colorado-Utah State Line

Diversion Results

Table D.3 summarizes the average annual simulated diversions, by tributary or sub-basin, compared to historical diversions for water years 1975 through 2005. Table D.5 (at the end of this appendix) shows the average annual shortages for water years 1975 through 2005 by structure. On a basin wide basis, average annual diversions in the basin are greater than historical diversions by about 7 percent in the Calculated simulation run. Note that total diversions shown in Table D.3 and D.5 are not the same as total diversions shown in Table D.1. Diversions in Table D.1 include diverted amounts both at carriers and their destination.

Table D.3
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2005)
Calculated Simulation (acre-feet/year)

			Historical minus Simulated	
Tributary or Sub-basin	**Historical**	**Simulated**	**Volume**	**Percent**
Colorado Main Stem	3,099,388	3,249,347	-149,959	-5%
Fraser River	88,352	99,363	-11,011	-12%
Williams Fork River	36,498	45,581	-9,084	-25%
Blue River	157,539	175,387	-17,848	-11%
Eagle River	121,772	138,680	-16,908	-14%
Roaring Fork River	454,984	509,705	-54,721	-12%
Plateau Creek	124,182	139,882	-15,700	-13%
Basin Total	**4,082,716**	**4,357,946**	**-275,230**	**-7%**

Note that historical diversions are grouped differently than shown in Table 7.4 due to demand located at summary nodes in the Calculated simulation and at the carrier structures in the Historic simulation. Specifically, the Ute Water Conservancy District has a summary node on Rapid Creek, which is grouped with the Colorado Main Stem, while the carrier structures are located on Plateau Creek. Similarly, the Moffat Tunnel is operated as a summary node on the Fraser River but has a carrier located on Williams Fork.

As noted previously, the Calculated demand (not shown in Table D.3) represents an increase of 11 percent over historical diversions, compared to the Calculated simulated diversions shown in Table D.3, which represents a 7 percent increase over historical diversion. In general, calculated demands are being met. Shortage based on Calculated demand, intended to better estimate crop needs, is 4 percent.

Reservoir Results

Figures D.15 through D.29 (located at the end of this appendix) present reservoir end-of-month contents estimated by the model using the Calculated data set compared to historical observations at selected reservoirs. Most reservoirs exhibit slightly more use than in the

Historical calibration simulation, as a result of higher Calculated demands. Vega Reservoir shows significant increase in use, as a result of higher irrigation demands.

Consumptive Use Results

Crop consumptive use is estimated by StateMod and reported in the consumptive use summary file (*.xcu) for each diversion structure in the scenario. This file also includes consumptive use for municipal and industrial diversions. The crop consumptive use estimated by StateCU is reported in the water supply-limited summary file (*.wsl) for each agricultural diversion structure in the basin. Therefore, to provide a one-to-one comparison, only structures in the StateCU analysis are included.

Table D.4 shows the comparison of StateCU estimated potential crop consumptive use, StateCU estimated water-supply limited crop consumptive use, and StateMod simulated crop consumptive use for the Calculated simulation. Table D.4 presents these values for explicit structures, aggregated structures, and total for the model. Percent shortage values represent the difference between the amount of water the crops need to meet full demands (potential consumptive use) and what they received based on either historical diversions (StateCU results), or simulated diversions (Calculated StateMod results).

In the Calculated simulation, more of the potential consumptive use (crop demand) is met than in the StateCU analysis. Historical diversions are used by StateCU to estimate water supply-limited (actual) consumptive use. In the Calculated simulation, where demands are essentially set to meet potential CU, more water is being diverted compared to historical diversion. The approximate 9 percent increase in CU between StateCU results and Calculated simulation results could indicate any or a combination of the following:

- Historical irrigation practices do not take full advantage of water supply
- Historical irrigation practices do not utilize the entire potential growing season
- Blaney-Criddle methodology does not accurately reflect true crop demands

Table D.4
Average Annual Crop Consumptive Use Comparison (1975-2004)
Calculated Simulation

Comparison	StateCU Potential CU (af/yr)	StateCU CU Results (af/yr)	StateCU Shortage (%)	Calculated Run CU Results (af/yr)	Calculated Run Shortage (%)
Explicit Structures	353,846	309,868	12%	328,017	7%
Aggregate Structures	172,066	144,444	16%	165,682	4%
Basin Total	525,912	454,321	14%	493,699	6%

Not that the simulated crop consumptive use presented here represents only a portion of the approximately 1.06 million acre-feet per year consumed in the basin, and reported above in Table D.1. The consumptive use reported in Table D.1 is representative of the total basin-wide consumptive use and losses in the basin, and includes municipal and industrial consumptive use, reservoir evaporation, and exports from the basin in addition to crop consumptive use.

Table D.5
Historical and Simulated Average Annual Diversions (1975-2005)
Calculated Simulation (acre-feet/year)

WDID	Historical	Simulated	Historical - Simulated Volume	Historical - Simulated Percent	Name
360606	0	0	0	0%	ELLIOTT CREEK FEEDER [1]
360645	4,175	4,847	-672	-16%	GUTHRIE THOMAS DITCH
360649	6,002	7,695	-1,693	-28%	Hamilton Davidson Div Sy
360660	2,429	3,320	-891	-37%	HIGH MILLER DITCH
360662	6,232	8,465	-2,233	-36%	Hoagland Div Sys
360671	2,374	3,344	-970	-41%	INDEPENDENT BLUE DITCH
360687	1,340	1,279	61	5%	KIRKWOOD DITCH
360709	5,821	7,790	-1,969	-34%	LOBACK DITCH
360725	579	511	68	12%	MARY DITCH
360728	956	922	33	3%	MAT NO 1 DITCH
360729	1,062	1,024	39	4%	MAT NO 2 DITCH
360734	1,242	1,507	-265	-21%	MCKAY DITCH
360765	2,184	2,055	129	6%	PALMER-MCKINLEY DITCH
360780	1,168	1,034	134	11%	PLUNGER DITCH
360784	588	588	0	0%	RANKIN NO 1 DITCH
360796	1,501	1,946	-445	-30%	SAUMS DITCH
360800	1,678	1,671	7	0%	SLATE CREEK DITCH
360801	3,088	3,553	-465	-15%	SMITH DITCH
360829	474	473	1	0%	STRAIGHT CREEK DITCH
360841	1,907	1,779	128	7%	TENMILE DIVERSION NO 1
360868	2,150	2,697	-547	-25%	WESTLAKE DITCH
360881	0	0	0	0%	GREEN MTN HYDRO-ELECTRIC [4]
360908	355	283	72	20%	KEYSTONE SNOWLINE DITCH
360989	0	0	0	0%	MAGGIE POND (SNOWMAKING)
361008	1,433	1,059	374	26%	BRECKENRIDGE PIPELINE
361016	126	112	13	11%	COPPER MTN SNOWMAKING
364626	521	515	5	1%	VIDLER TUNNEL COLL SYS
364683	0	0	0	0%	CON-HOOSIER SYS BLUE R D [1]
364684	63,515	63,515	0	0%	BLUE RIVER DIVR PROJECT
364685	91	91	0	0%	BOREAS NO 2 DITCH
364699	0	0	0	0%	CON-HOOSIER TUNNEL [1]
36_ADC017	17,637	21,940	-4,303	-24%	Upper Blue River
36_ADC018	7,371	9,054	-1,684	-23%	Blue River abv Green Mou
36_ADC019	7,761	10,637	-2,876	-37%	Blue River bl Green Moun
370519	1,436	1,204	232	16%	BRAGG NO 1 DITCH
370539	3,936	4,888	-952	-24%	CHATFIELD BARTHOLOMEW D
370548	2,960	3,451	-491	-17%	C M STREMME GATES DITCH
370560	1,873	2,394	-521	-28%	CREAMERY DITCH
370561	3,113	3,781	-668	-21%	DAGGETT AND PARKER DITCH
370571	2,283	2,198	84	4%	J M DODD DITCH
370635	1,022	1,509	-487	-48%	HERNAGE DITCH
370642	4,403	5,247	-844	-19%	HOLLINGSWORTH DITCH
370655	1,709	2,303	-594	-35%	H O R DITCH
370658	2,249	2,563	-314	-14%	HOWARD DITCH
370686	1,843	2,581	-739	-40%	LOVE AND WHITE DITCH
370694	2,546	3,178	-633	-25%	MATHEWS DITCH
370708	2,138	2,137	1	0%	METCALF DITCH
370723	1,010	968	42	4%	NEILSON SOUTH DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
370743	2,842	3,587	-745	-26%	ONEILL AND HOLLAND DITCH
370823	6,594	8,057	-1,464	-22%	STRATTON AND CO DITCH
370830	1,860	2,539	-679	-37%	TERRELL AND FORD DITCH
370843	1,146	1,656	-509	-44%	UPPER FROST DITCH
370848	4,233	4,042	190	4%	WARREN DITCH
371091	1,032	1,012	20	2%	EWING PLACER DITCH
371146	0	0	0	0%	WOLCOTT PUMP PIPELINE
374614	24,674	24,674	0	0%	HOMESTAKE PROJ TUNNEL
374641	1,731	1,725	6	0%	COLUMBINE DITCH
374643	0	0	0	0%	HOMESTAKE PROJ CONDUIT [1]
374648	2,758	2,751	6	0%	WARREN E WURTS DITCH
37_ADC029	15,160	18,349	-3,189	-21%	Eagle River abv Brush Cr
37_ADC030	15,010	17,964	-2,955	-20%	Brush Creek
37_ADC031	9,442	11,163	-1,721	-18%	Eagle River bl Gypsum
380516	1,665	1,379	286	17%	ATKINSON DITCH
380517	2,250	3,382	-1,132	-50%	ATKINSON CANAL
380528	8,951	8,713	238	3%	BASIN DITCH
380545	1,636	2,020	-384	-23%	BORAM AND WHITE DITCH
380547	4,321	5,449	-1,128	-26%	BOWLES AND HOLLAND DITCH
380569	1,801	2,265	-464	-26%	C AND M DITCH
380572	2,548	2,384	164	6%	CAPITOL FALLS DITCH
380573	1,433	1,688	-255	-18%	CAPITOL PARK DITCH
380574	7,867	9,157	-1,290	-16%	CARBONDALE DITCH
380606	1,050	1,301	-251	-24%	COLLINS CREEK DITCH
380618	5,429	6,193	-763	-14%	CRANE AND PEEBLES DITCH
380639	1,453	1,889	-436	-30%	DESERT DITCH
380651	10,731	11,452	-721	-7%	EAST MESA DITCH
380659	2,380	3,358	-978	-41%	ELI CERISE DITCH
380663	5,748	5,508	239	4%	ELLA DITCH
380667	500	409	91	18%	EUREKA NO 1 DITCH
380688	809	982	-174	-21%	FOUR MILE DITCH
380712	14,105	16,171	-2,066	-15%	GLENWOOD DITCH
380715	6,586	7,056	-470	-7%	GRACE AND SHEHI DITCH
380720	3,456	4,455	-1,000	-29%	GREEN MEADOW DITCH
380740	5,115	6,125	-1,011	-20%	HARRIS & REED DITCH
380755	3,491	3,957	-466	-13%	HOLDEN DITCH
380757	18,668	21,719	-3,051	-16%	HOME SUPPLY DITCH
380800	4,319	5,076	-757	-18%	KESTER DITCH
380822	277	260	17	6%	LIGNITE DITCH
380838	1,631	1,989	-358	-22%	LOWER DITCH
380840	11,877	12,883	-1,007	-8%	LOWLINE DITCH
380854	3,372	3,347	25	1%	MAROON DITCH
380861	1,207	1,476	-269	-22%	MAURIN DITCH
380869	4,445	4,437	9	0%	MIDLAND FLUME DITCH
380879	854	1,287	-432	-51%	MONARCH DITCH
380880	2,717	3,140	-423	-16%	Mt. Sopris Div Sys
380881	6,554	4,788	1,766	27%	MOUNTAIN MEADOW DITCH
380890	1,289	1,863	-574	-45%	MCKENZIE WILDCAT DITCH
380893	1,698	1,505	194	11%	MCKOWN DITCH
380902	2,578	2,750	-172	-7%	NEEDHAM DITCH
380925	3,235	4,246	-1,012	-31%	PARK DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
380930	17,500	18,386	-886	-5%	PATERSON D JACOB EXT
380939	2,885	2,880	5	0%	PIONEER DITCH
380959	2,776	3,705	-930	-33%	RED ROCK BLUFF DITCH
380966	4,222	5,408	-1,186	-28%	ROBERTSON DITCH
380968	13,877	15,203	-1,325	-10%	ROBINSON DITCH
380970	8,214	9,553	-1,339	-16%	ROCKFORD DITCH
380981	7,383	9,604	-2,221	-30%	SALVATION DITCH
380989	917	938	-22	-2%	SHIPPEE DITCH
380994	929	1,042	-114	-12%	SLOSS DITCH
380996	7,582	7,422	160	2%	SLOUGH D AND BANNING LAT
381012	2,980	3,595	-615	-21%	SNOWMASS DIVIDE DITCH
381018	4,973	6,108	-1,135	-23%	SOUTHARD AND CAVANAUGH
381038	13,525	15,512	-1,987	-15%	SWEET JESSUP CANAL
381052	1,202	1,079	123	10%	CARBONDALE WTR SYS & PL
381062	3,535	3,530	4	0%	UNION DITCH
381066	358	528	-170	-48%	VAN CLEVE NO 1 DITCH
381073	5,032	5,743	-711	-14%	WACO DITCH
381078	5,861	5,485	376	6%	WALKER WONDER DITCH
381095	1,322	1,947	-626	-47%	WILLIAMS NO 1 D CAP CR
381101	2,387	3,042	-655	-27%	WILLOW CREEK DITCH
381104	857	1,422	-565	-66%	WILLOW AND OWL DITCH
381121	1,168	1,455	-287	-25%	ALEXIS ARBANEY DITCH
381132	1,627	1,906	-279	-17%	WALTHEN DITCH
381147	5,337	6,664	-1,327	-25%	KAISER AND SIEVERS DITCH
381441	1,229	1,229	0	0%	EAST SNOWMASS BRUSH C PL
381481	566	772	-206	-36%	VAN CLEVE-FISHER FDR D
381594	0	0	0	0%	FRY ARK PR HUNTER TUNNEL
381661	1,146	1,150	-4	0%	SALVATION DITCH VAGN EXT
381790	3,331	3,710	-379	-11%	RED MOUNTAIN EXT DITCH
384613	5,338	5,335	3	0%	IVANHOE RESERVOIR TUNNEL
384617	38,188	37,873	315	1%	IND P TM DVR TUNNEL NO 1
384625	0	0	0	0%	FRY ARK PR BOUSTEAD TUNL
384717	256	198	58	23%	WEST THREE MILE DITCH [1]
38_ADC033	21,654	25,159	-3,505	-16%	Upper Roaring Fork
38_ADC034	12,597	17,352	-4,755	-38%	Snowmass Creek
38_ADC035	7,056	9,023	-1,967	-28%	Frying Pan River
38_ADC036	11,243	13,976	-2,733	-24%	West Sopris Creek
38_ADC037	13,756	16,725	-2,969	-22%	Roaring Fork abv Crystal
38_ADC038	8,594	11,006	-2,413	-28%	Crystal River
38_ADC039	5,406	6,482	-1,076	-20%	Cattle Creek
38_ADC040	1,848	3,884	-2,037	-110%	Lower Roaring Fork
390532	2,688	3,406	-718	-27%	CLOUGH NO 1 DITCH
390537	1,313	1,614	-301	-23%	CORNELL DITCH
390539	1,904	2,140	-236	-12%	CORYELL DITCH
390540	1,299	1,403	-104	-8%	CORYELL JOINT STOCK IRRI
390547	1,381	2,284	-904	-65%	DAVIE DITCH
390548	2,009	2,298	-289	-14%	DEWEESE DITCH
390562	1,922	1,366	556	29%	GRANLEE DITCH
390563	0	0	0	0%	GRASS VALLEY CANAL [1]
390574	6,003	6,920	-917	-15%	GRAND TUNNEL DITCH
390585	1,129	1,321	-192	-17%	HIBSCHLE BENBOW DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
390590	1,842	1,215	627	34%	JANGLE DITCH
390610	3,782	3,623	159	4%	LOW COST DITCH
390612	15,934	17,634	-1,700	-11%	LOWER CACTUS VALLEY D
390635	1,626	2,004	-378	-23%	PARACHUTE DITCH
390638	790	942	-152	-19%	PIERSON AND HARRIS DITCH
390645	9,310	10,229	-919	-10%	RIFLE CREEK CANON DITCH
390663	0	0	0	0%	SILT PUMP CANAL [1]
390672	5,789	5,691	98	2%	THOMPKINS DITCH
390687	11,785	13,547	-1,762	-15%	WARE AND HINDS DITCH
390701	1,174	1,278	-104	-9%	RED ROCK DITCH
390825	7,024	7,622	-598	-9%	WILLIAMS CANAL
390967	1,444	1,398	45	3%	RIFLE TOWN OF PUMP & PL
390990	1,434	1,697	-263	-18%	WEST LAT RIFLE CR CANON
394725	1,325	1,544	-219	-17%	Vulcan Ditch Div Sys
39_ADC041	16,300	18,059	-1,759	-11%	Elk Creek
39_ADC045	4,724	6,372	-1,648	-35%	Rifle Creek
420520	162	162	0	0%	GRAND JCT GUNNISON PL
420541	414,884	414,864	20	0%	REDLANDS POWER CANAL
450514	2,564	2,606	-42	-2%	BATTLEMENT DITCH
450576	9,010	9,777	-767	-9%	DIVIDE CREEK HIGHLINE D
450584	1,836	1,579	257	14%	EAST DIVIDE CREEK DITCH
450616	1,399	1,786	-387	-28%	H AND S DITCH
450632	1,068	1,660	-592	-55%	HOLMES DITCH
450635	618	760	-142	-23%	HUDSON & SULLIVAN DITCH
450638	1,252	1,257	-5	0%	HUNTLEY DITCH
450668	9,842	11,473	-1,631	-17%	LAST CHANCE DITCH
450675	559	822	-264	-47%	LOUIS REYNOLDS DITCH
450685	851	1,259	-408	-48%	MAMM CREEK DITCH
450693	2,251	2,691	-440	-20%	MINEOTA DITCH
450704	4,321	4,265	57	1%	MULTA-TRINA DITCH
450705	857	931	-74	-9%	MURRAY AND YULE DITCH
450725	4,146	4,229	-82	-2%	PORTER DITCH
450743	5,903	7,241	-1,337	-23%	RISING SUN DITCH
450749	419	702	-283	-68%	RODERICK DITCH
450788	596	436	160	27%	SYKES AND ALVORD DITCH
450790	2,063	2,163	-100	-5%	TALLMADGE AND GIBSON D
450793	1,706	2,366	-660	-39%	TAUGHENBAUGH DITCH
450810	725	978	-253	-35%	WARD AND REYNOLDS DITCH
450818	1,608	1,926	-318	-20%	WEST DIVIDE CREEK DITCH
450861	8,379	10,019	-1,640	-20%	LARKIN DITCH
450969	29,177	32,561	-3,385	-12%	BLUESTONE VALLEY DITCH
45_ADC042	8,187	9,797	-1,610	-20%	Colorado River bl Garfie
45_ADC043	6,412	9,167	-2,756	-43%	Colorado River bl Divide
45_ADC044	4,321	9,492	-5,171	-120%	Colorado R bl Mamm Creek
45_ADC046	3,786	5,100	-1,314	-35%	Colorado River bl Beaver
45_ADC047	5,242	7,276	-2,034	-39%	Colorado River bl Cache
45_ADC048	11,123	14,291	-3,167	-28%	Colorado River nr De Beq
500526	1,321	1,802	-481	-36%	BLICKLEY DITCH
500539	1,009	1,318	-309	-31%	CLIFF DITCH
500574	2,633	3,470	-837	-32%	HARDSCRABBLE DITCH
500576	4,313	5,552	-1,240	-29%	HAYPARK CANAL HGT NO 1

WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
500582	1,430	2,108	-678	-47%	HERDE DITCH
500585	872	1,344	-472	-54%	HOGBACK DITCH
500593	5,368	6,038	-670	-12%	KIRTZ DITCH NO 2
500598	805	896	-92	-11%	LANDSLIDE DITCH
500601	1,122	1,605	-483	-43%	MARTIN NO 1 DITCH
500606	4,131	4,843	-712	-17%	MISSOURI DITCH
500612	1,014	1,257	-243	-24%	MCELROY NO 1 DITCH
500613	743	1,047	-305	-41%	MCELROY NO 2 DITCH
500617	3,411	3,582	-171	-5%	MCMAHON DITCH
500627	972	1,293	-320	-33%	PASS CREEK DITCH
500628	1,123	645	478	43%	PICKERING DITCH
500632	747	1,048	-301	-40%	PLEASANT VIEW DITCH
500653	2,625	3,811	-1,187	-45%	TOM ENNIS DITCH
500654	2,968	3,669	-701	-24%	TROUBLESOME DITCH
500656	919	1,217	-299	-32%	TYLER DITCH
500731	833	1,472	-640	-77%	CLIFF DITCH HGT NO 2
500734	5,284	6,517	-1,233	-23%	Deberard Div Sys
50_ADC012	7,197	8,830	-1,633	-23%	Troublesome Creek
50_ADC013	5,264	5,485	-221	-4%	Upper Muddy Creek
50_ADC014	5,780	6,887	-1,107	-19%	Muddy Creek abv Tyler Di
50_ADC015	3,259	4,476	-1,217	-37%	Muddy Creek abv Red Dirt
50_ADC016	2,326	4,689	-2,363	-102%	Lower Muddy Creek
50_ADC020	6,978	8,605	-1,627	-23%	Colorado River bl Kremml
510529	25,800	31,088	-5,287	-20%	Big Lake Div Sys
510546	6,819	7,928	-1,109	-16%	BUNTE HIGHLINE DITCH
510585	3,479	4,341	-861	-25%	COFFEE MCQUEARY DITCH
510594	2,118	3,118	-1,000	-47%	CROOKED CREEK DITCH NO 1
510629	1,782	2,178	-396	-22%	FARRIS SOUTH SIDE DITCH
510639	0	0	0	0%	Jim_Creek [1]
510660	547	731	-184	-34%	GASKILL DITCH
510699	2,440	3,032	-593	-24%	HAMMOND NO 1 DITCH
510700	821	1,636	-816	-99%	HAMMOND NO 2 DITCH
510728	0	0	0	0%	HAMILTON-CABIN CR DITCH [1]
510763	7,628	9,240	-1,612	-21%	KINNEY BARRIGER DITCH
510788	2,072	2,876	-804	-39%	LYMAN DITCH
510810	2,717	3,165	-448	-16%	MUSGRAVE DITCH
510829	225	1,558	-1,334	-594%	PEAVEY NO 2 DITCH
510831	1,121	1,637	-516	-46%	PETERSON DITCH NO 1
510848	11,756	15,901	-4,145	-35%	REDTOP VALLEY DITCH
510858	283	304	-21	-7%	ROCK CREEK DITCH
510876	1,757	2,333	-576	-33%	SCYBERT DITCH
510880	1,674	2,049	-375	-22%	SELAK LARRABEE DITCH
510883	1,755	2,586	-830	-47%	SHERIFF DITCH (156)
510893	4,191	5,308	-1,117	-27%	SOPHRONIA DAY DITCH
510924	2,310	1,647	663	29%	SYLVAN DITCH
510934	1,061	1,813	-753	-71%	TRAIL CREEK DITCH
510939	1,687	2,426	-739	-44%	UTE BILL NO 2 DITCH
510941	3,473	4,462	-989	-28%	Vail Irr Div Sys
510948	1,495	2,164	-669	-45%	WALDON HOLLOW DITCH
510958	0	0	0	0%	CBT WILLOW CREEK FEEDER [1]
511070	2,249	2,187	62	3%	HENDERSON MINE WTR SYS

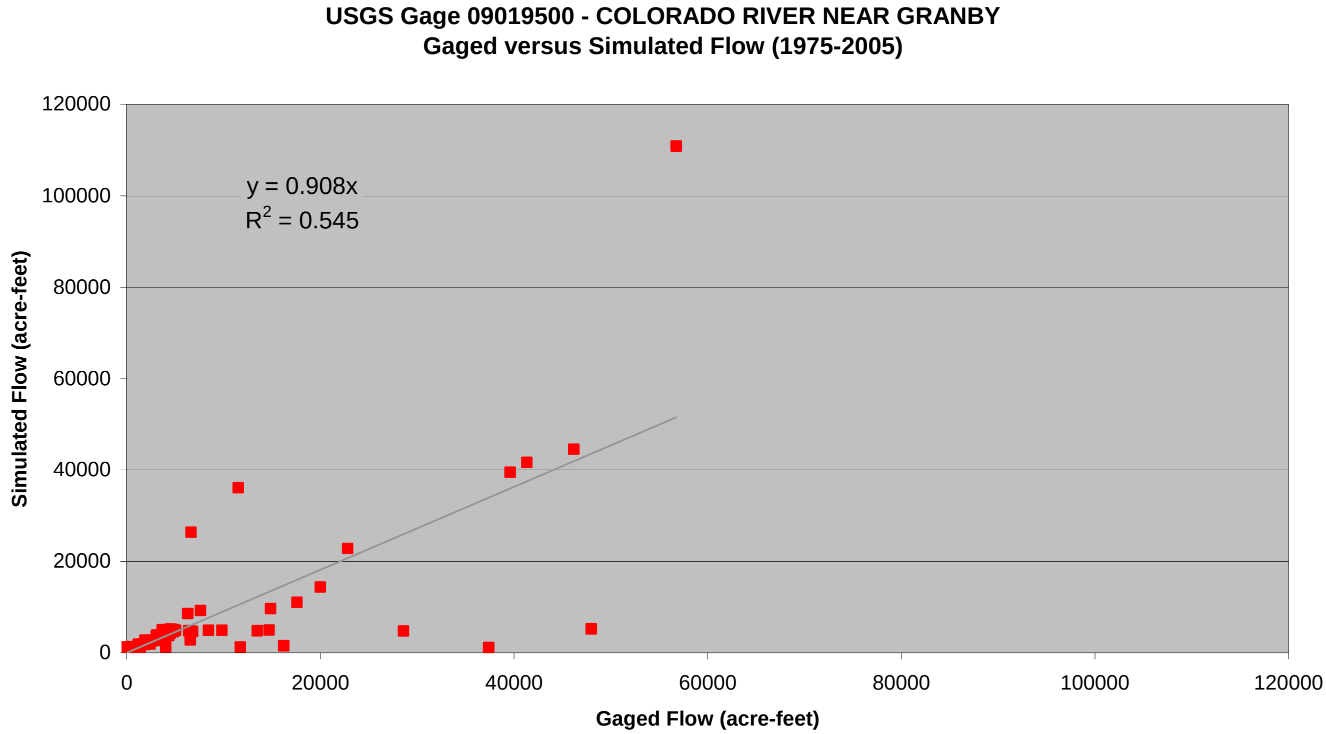
WDID	Historical	Simulated	Historical - Simulated Volume	Percent	Name
511149	1,431	1,519	-88	-6%	THOMPSON PUMP NO 2
511237	0	0	0	0%	WILLIAMS FORK POWER COND
511269	0	0	0	0%	Ranch_Creek [1]
511309	0	0	0	0%	St_Louis_Cr [1]
511310	0	0	0	0%	Vasquez_Creek [1]
514601	18,265	18,265	0	0%	GRAND RIVER DITCH
514603	0	0	0	0%	WILLIAMS FORK TUNNEL [1]
514625	719	699	20	3%	BERTHOUD CANAL TUNNEL
514634	227,477	227,477	0	0%	CBT ALVA B ADAMS TUNNEL
514655	57,268	55,851	1,417	2%	MOFFAT WATER TUNNEL
514700	0	0	0	0%	WINDY GAP PUMP PL CANAL [1]
51_ADC001	2,753	3,334	-581	-21%	Colorado River nr Granby
51_ADC002	2,133	2,990	-857	-40%	Willow Creek
51_ADC003	3,176	4,038	-861	-27%	Ranch Creek
51_ADC004	4,923	5,973	-1,049	-21%	Fraser River bl Crooked
51_ADC005	4,186	6,818	-2,631	-63%	Tenmile Creek
51_ADC006	4,084	5,314	-1,230	-30%	Fraser River at Granby
51_ADC007	7,197	8,745	-1,549	-22%	Colorado River abv Hot S
51_ADC008	5,486	6,685	-1,199	-22%	Colorado River abv Willi
51_ADC009	3,335	4,652	-1,317	-39%	Upper Williams Fork
51_ADC010	3,042	4,778	-1,737	-57%	Lower Williams Fork
51_ADC011	5,327	6,316	-989	-19%	Colorado River abv Troub
520559	995	1,556	-561	-56%	GUTZLER DITCH
520572	684	1,234	-550	-80%	HOG EYE DITCH
520658	1,264	1,216	48	4%	WILMOT DITCH
52_ADC021	15,599	23,772	-8,173	-52%	Black Tail & Sheephorn C
52_ADC027	6,016	8,552	-2,536	-42%	Colorado River abv Derby
530555	7,850	9,741	-1,891	-24%	Derby Div Sys
530584	752,231	745,182	7,049	1%	SHOSHONE POWER PLANT
530585	4,498	4,497	1	0%	GLENWOOD L WATER CO SYS
530621	674	336	338	50%	HIGHWATER DITCH
530632	373	587	-214	-57%	HORSE MEADOWS DITCH
530657	3,428	4,246	-818	-24%	KAYSER DITCH
530678	2,307	3,617	-1,311	-57%	LION BASIN DITCH
530780	2,854	3,282	-427	-15%	ROGERS DITCH
530783	464	182	282	61%	ROYAL FLUSH DITCH
530800	4,586	5,913	-1,327	-29%	SOUTH DERBY DITCH
530883	2,562	2,490	72	3%	WILSON AND DOLL DITCH
531051	0	0	0	0%	GLENWOOD L WATER CO SYS [1]
531082	376	176	200	53%	MACFARLANE DITCH
53_ADC022	1,223	319	905	74%	Upper Egeria Creek
53_ADC023	2,830	2,374	455	16%	King Creek
53_ADC024	4,384	5,801	-1,417	-32%	Egeria Creek abv Toponas
53_ADC025	2,306	4,158	-1,852	-80%	Toponas Creek
53_ADC026	7,424	9,759	-2,335	-31%	Colorado River abv Alkal
53_ADC028	6,959	9,086	-2,127	-31%	Derby Creek
53_ADC032	17,007	21,356	-4,350	-26%	Colorado River abv Glenw
700521	3,568	3,909	-342	-10%	CLEAR CREEK DITCH
700530	3,347	3,846	-499	-15%	CREEK AND NEWMAN DITCH
700550	1,573	1,267	306	19%	H V C AND S DITCH
700571	465	443	22	5%	NEW HOBO DITCH

WDID	Historical	Simulated	Historical - Simulated Volume	Historical - Simulated Percent	Name
700580	5,697	5,838	-141	-2%	RESERVOIR DITCH
700583	2,462	2,725	-263	-11%	ROAN CREEK NO 2 DITCH
700584	1,743	2,123	-381	-22%	ROAN CREEK NO 3 DITCH
700596	1,137	1,257	-121	-11%	UPPER ROAN CREEK DITCH
70_ADC049	13,604	12,869	735	5%	Upper Roan Creek
70_ADC050	2,978	4,854	-1,876	-63%	Colorado River nr Cameo
720512	1,669	2,004	-335	-20%	Arbogast Pump Div Sys
720514	1,581	1,537	44	3%	ARKANSAS DITCH
720533	2,805	3,752	-948	-34%	BERTHOLF LANHAM UPDIKE D
720542	0	0	0	0%	BONHAM BRANCH PIPELINE [1]
720557	453	603	-150	-33%	BULL BASIN HIGHLINE D
720558	3,443	3,204	239	7%	BULL CREEK DITCH
720574	1,771	1,770	0	0%	COAKLEY KIGGINS DITCH
720580	1,274	1,277	-3	0%	COOK DITCH
720583	0	0	0	0%	COTTONWOOD BRANCH PL [1]
720596	852	1,838	-986	-116%	DAVENPORT D (COTTNWD)
720607	720	789	-69	-10%	EAKIN-SMITH DITCH
720616	1,243	1,907	-663	-53%	NEW ERIE CANAL
720628	1,316	1,808	-492	-37%	GALBRAITH DITCH
720643	1,248	1,384	-136	-11%	GOLDEN AGE DITCH
720644	1,914	1,873	41	2%	GRAND JCT COLO R PL
720645	260,410	281,502	-21,092	-8%	GRAND VALLEY CANAL
720646	0	0	0	0%	GRAND VALLEY PROJECT [1]
720649	1,844	2,127	-284	-15%	GROVE CR DITCH CO NO 1 D
720703	4,586	4,694	-107	-2%	HOOSIER DITCH
720721	744	1,018	-274	-37%	JOHNSON AND STUART DITCH
720729	866	1,134	-268	-31%	KIGGINS GOYN DITCH
720730	1,573	2,114	-541	-34%	KIGGINS SALISBURY DITCH
720731	2,704	2,242	462	17%	KING DITCH
720744	381	1,495	-1,114	-293%	LEON DITCH
720746	0	0	0	0%	LEON PARK FEEDER CANAL [1]
720766	1,236	1,396	-159	-13%	Ute WCD Carver Ranch
720784	5,543	6,068	-525	-9%	MESA CREEK DITCH
720799	5,238	6,884	-1,646	-31%	MORMON MESA DITCH
720807	13,247	12,251	996	8%	MOLINA POWER PLANT
720813	63,710	63,710	0	0%	ORCHARD MESA IRR DIS SYS
720816	814	814	0	0%	PALISADE TOWN PL (RAPID)
720818	4,066	3,428	637	16%	PALMER DITCH
720820	0	0	0	0%	Park Creek DivSys [1]
720821	236	1,020	-785	-333%	PARKER DITCH
720823	952	1,195	-243	-26%	PARK VIEW DITCH
720831	1,922	2,171	-249	-13%	PIONEER OF PLATEAU DITCH
720852	667	1,985	-1,318	-198%	RMG Div Sys
720870	3,698	4,478	-780	-21%	SILVER GAUGE DITCH
720879	0	0	0	0%	SOUTHSIDE CANAL [1]
720911	1,192	910	281	24%	TEMS DITCH
720920	0	0	0	0%	UTE PIPELINE HGT NO 2
720933	2,732	2,974	-242	-9%	WEST SIDE DITCH
720938	4,497	4,020	477	11%	WILDCAT DITCH (BIG CR)
721233	1,587	1,743	-156	-10%	UPPER HIGHT DITCH
721329	0	0	0	0%	Rapid Creek PP DivSys

WDID	Historical	Simulated	Historical - Simulated Volume	Historical - Simulated Percent	Name
721330	0	0	0	0%	COLORADO R PUMPING PLANT
721339	0	0	0	0%	COON CREEK PIPELINE
724715	1,676	1,676	0	0%	LEON TUNNEL CANAL
724721	0	0	0	0%	OWENS CREEK DITCH [1]
72_ADC051	1,042	2,516	-1,473	-141%	Plateau Creek abv Vega R
72_ADC052	2,662	3,085	-424	-16%	Plateau Creek bl Vega Rs
72_ADC053	6,364	7,094	-730	-11%	Salt Creek
72_ADC054	2,647	4,796	-2,149	-81%	Upper Buzzard Creek
72_ADC055	3,448	4,790	-1,342	-39%	Plateau Creek bl Buzzard
72_ADC056	2,684	3,233	-549	-20%	Upper Grove Creek
72_ADC057	3,627	3,372	254	7%	Lower Grove Creek
72_ADC058	3,557	4,243	-686	-19%	Kimball Creek
72_ADC059	5,207	3,442	1,765	34%	Big Creek
72_ADC060	2,462	2,463	-1	0%	Cottonwood Creek
72_ADC061	5,038	4,068	970	19%	Bull Creek
72_ADC062	2,894	3,885	-991	-34%	Coon Creek
72_ADC063	2,752	3,112	-359	-13%	Mesa Creek
72_ADC064	1,907	2,890	-983	-52%	Plateau Creek
72_ADC065	4,844	10,711	-5,867	-121%	Colorado River nr State
72_AMC001	0	0	0	0%	72_AMC001 Colorado River
950001	321,667	333,986	-12,319	-4%	Grand Valley Project
950002	215,639	214,616	1,023	0%	USA Power Plant
950003	0	0	0	0%	Orchard Mesa Check [3]
950004	101,018	101,009	9	0%	OMID Hydraulic Pump
950005	0	0	0	0%	OMID Pre-1985 Bypass [3]
950006	0	0	0	0%	OMID Post-1985 Bypass [3]
950007	44,956	44,180	775	2%	USA PP-Winter-OM Stip
950008	44,076	43,766	309	1%	USA PP-Summer-OM Stip
950010	4,232	5,644	-1,413	-33%	Dry Elk Valley Irr
950011	12,812	13,591	-779	-6%	Farmers Irrigation Comp
950020	9,028	6,937	2,091	23%	Ute Water Treatment
950030	0	0	0	0%	Mason Eddy-Ute
950050	77,397	90,900	-13,503	-17%	Redlands Power Canal Irr
950051	6,589	6,274	315	5%	Grand Junction Demands
950060	2,723	2,723	0	0%	Green_Mtn_Contract_Dem.
950061	0	0	0	0%	Green_Mtn_Annual_Rep_Est.
952001	1,642	1,642	0	0%	15-Mile Fish Requirement
953001	658	658	0	0%	Ruedi Rnd 1-Muni Demand
953002	0	0	0	0%	Ruedi Rnd 1-Ind Demand
953003	0	0	0	0%	Ruedi Rnd 2-Muni Demand
953004	0	0	0	0%	Ruedi Rnd 2-Ind Demand
953005	0	0	0	0%	Ruedi Addl Demand
953101	0	0	0	0%	Wolford Fraser Demand
953102	0	0	0	0%	Wolford MidPark Demand
953103	0	0	0	0%	Wolford Market Demand
953668D	0	0	0	0%	HUP Release Node
953709D	0	0	0	0%	HUP Release Node
954512D	0	0	0	0%	HUP Release Node
954516D	0	0	0	0%	HUP Release Node
954683	8,662	8,617	46	1%	Continental_Hoosier_Tunn
954699	48,288	47,614	673	1%	Boustead_Summary

WDID	Historical	Simulated	Historical - Simulated		Name
			Volume	Percent	
955001	1,429	1,429	0	0%	Vail Valley Consolidated
955002	394	338	56	14%	Keystone Municipal
955003	1,345	1,330	15	1%	Vail Valley Consolidated
956001	0	0	0	0%	Future Depletion #1
956002	0	0	0	0%	Future Depletion #2
Basin Total	**4,082,716**	**4,357,946**	**-275,230**	**-7%**	

1) Carrier Structures – demand and use reported at user structure
2) Green Mountain Reservoir modeled operations are based on current operations and differ from historical operations
3) OMID Check and Bypass operations redivert USA Power Plant diversions, so are not reported again here



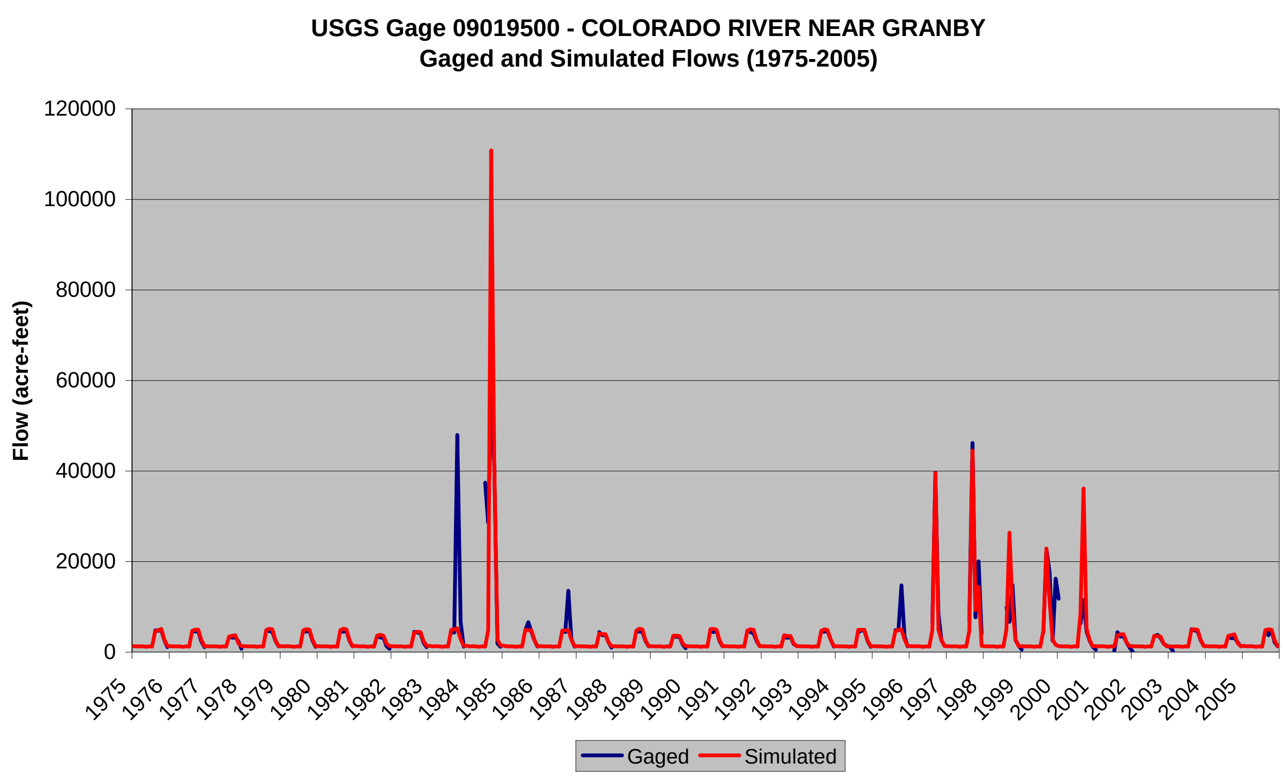
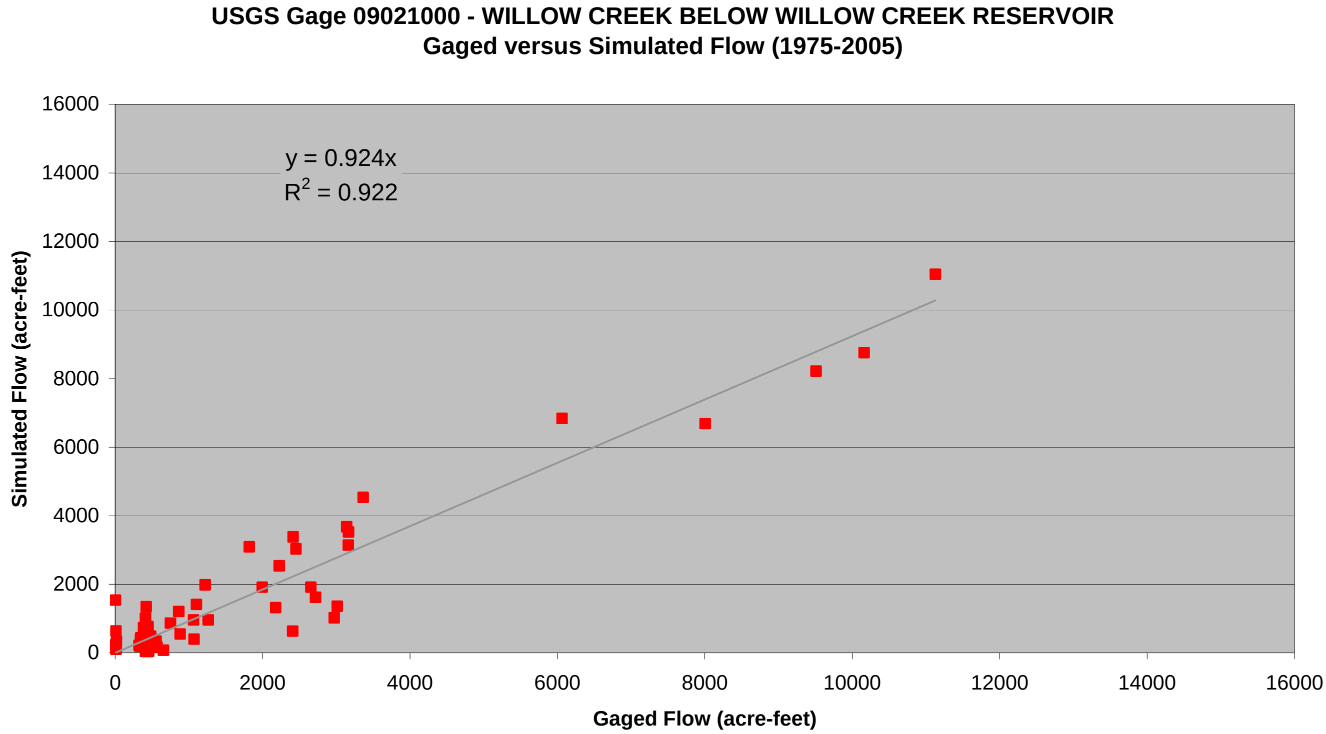


Figure D.1 Calculated Streamflow Simulation – Colorado River near Granby



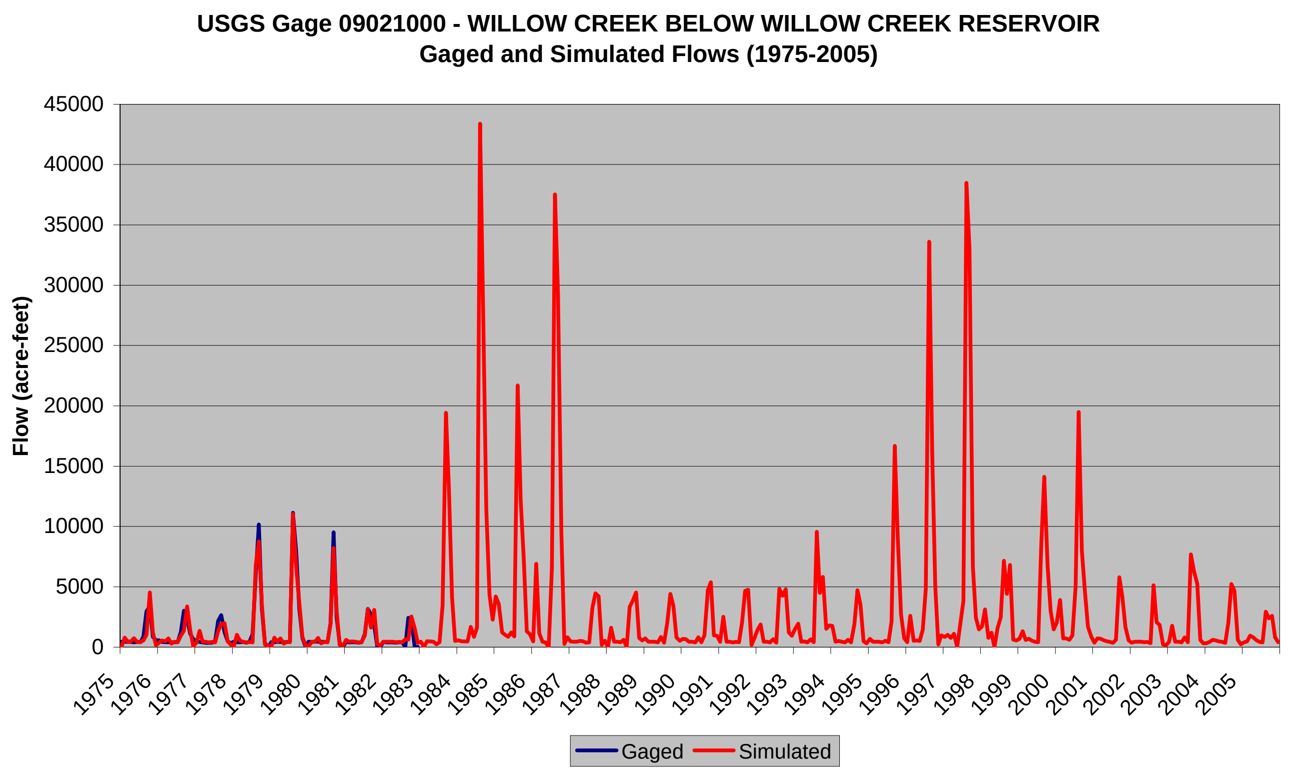
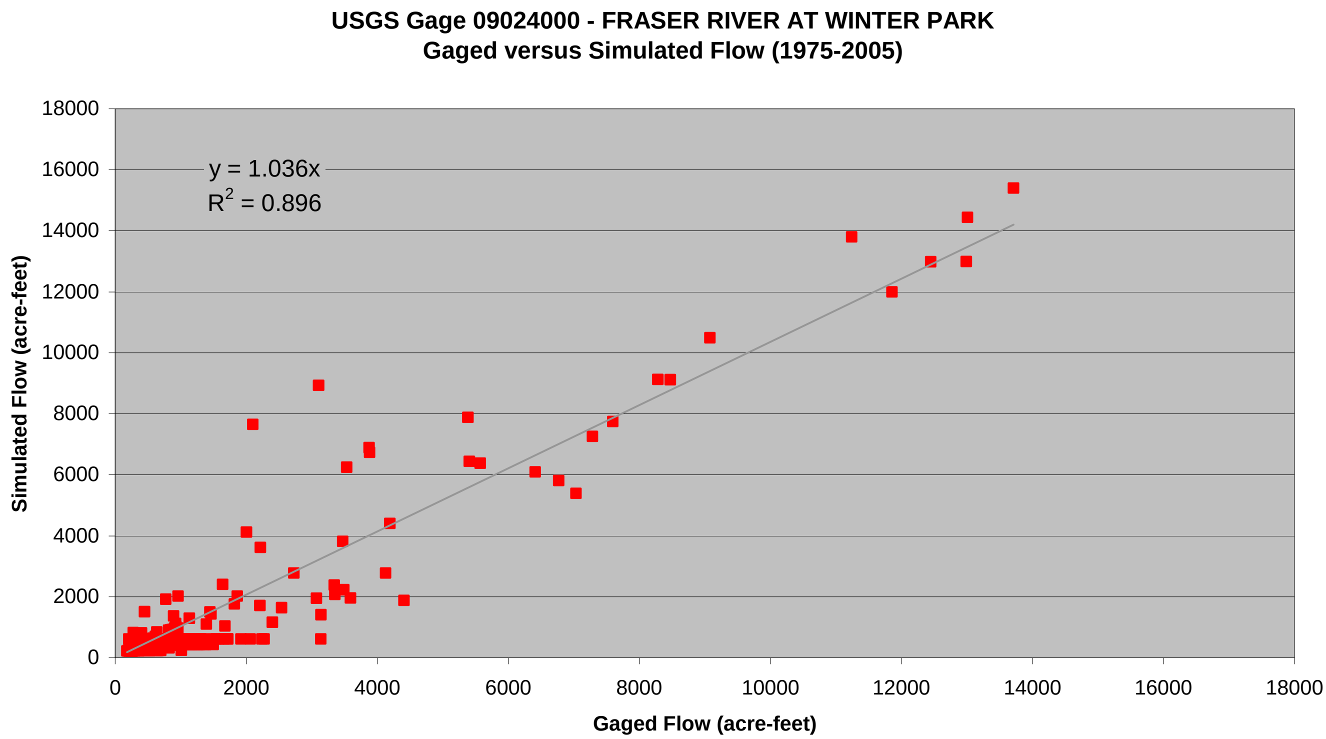


Figure D.2 Calculated Streamflow Simulation – Willow Creek below Willow Creek Reservoir



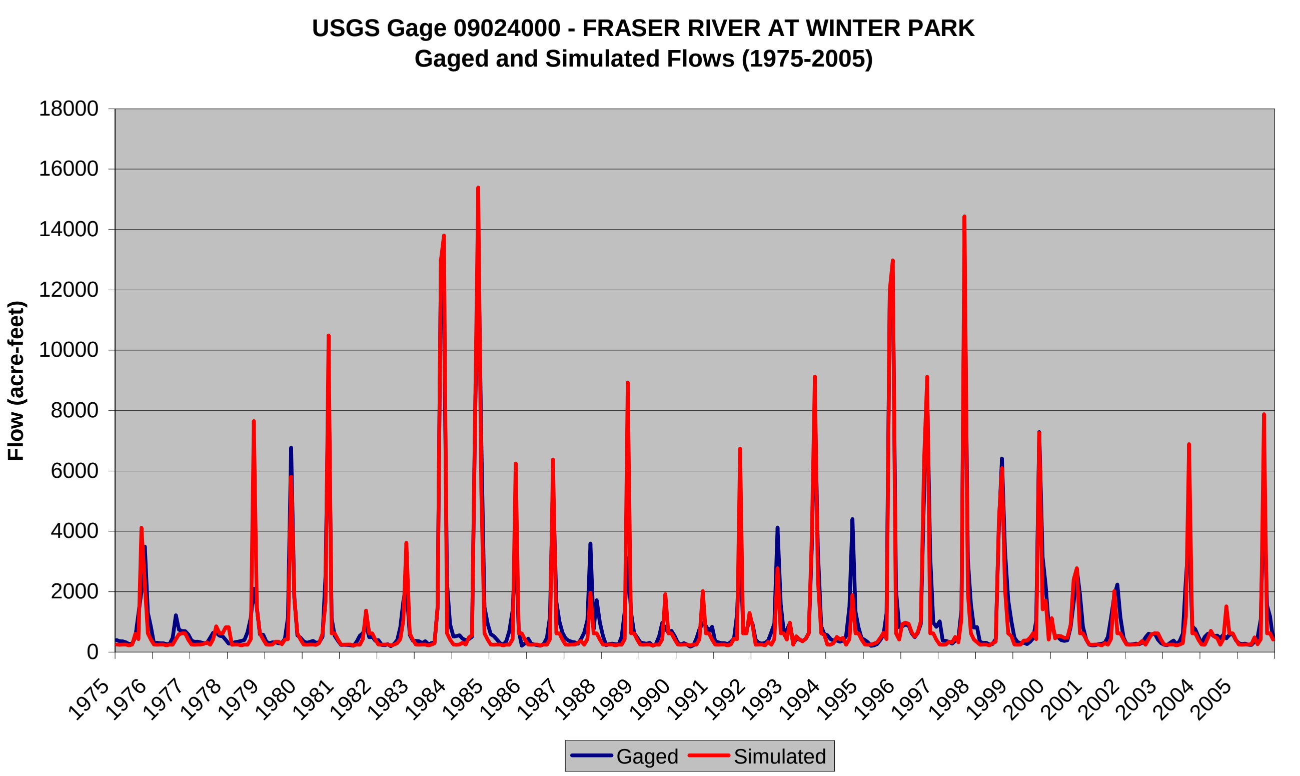
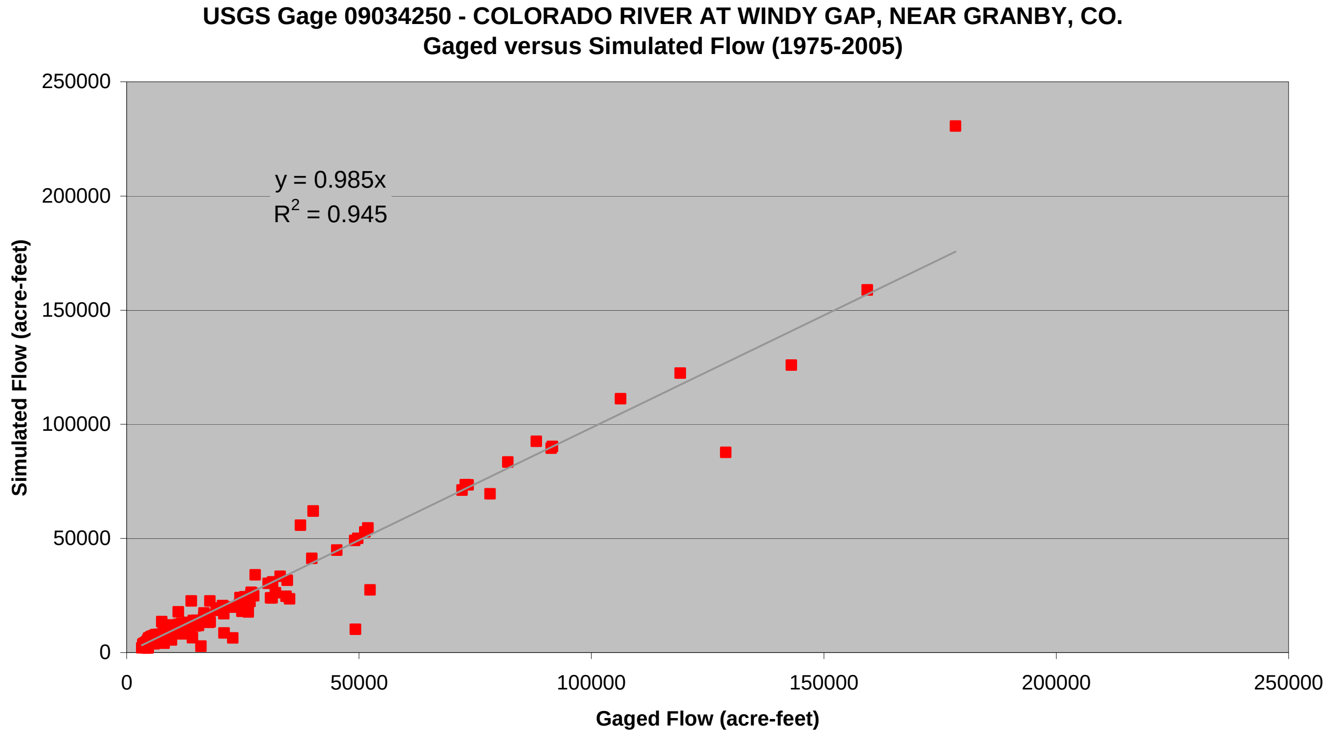


Figure D.3 Calculated Streamflow Simulation – Fraser River at Winter Park



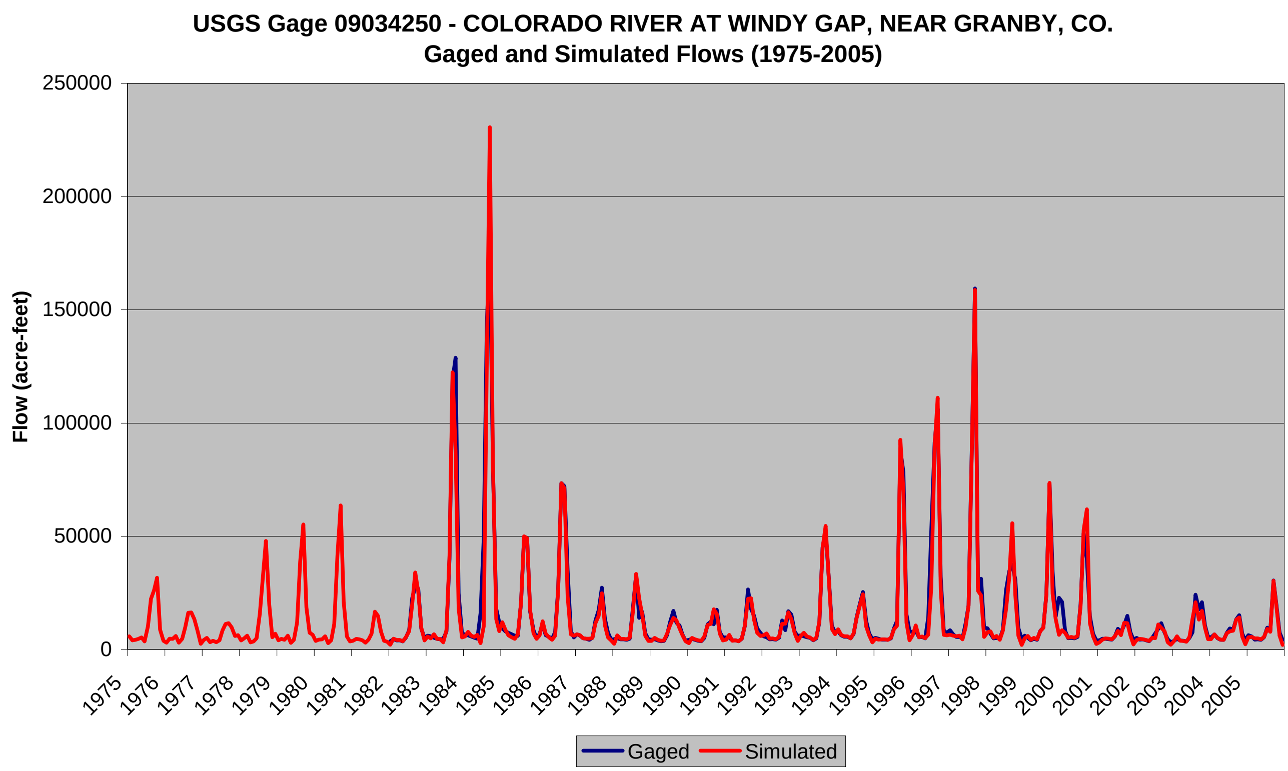
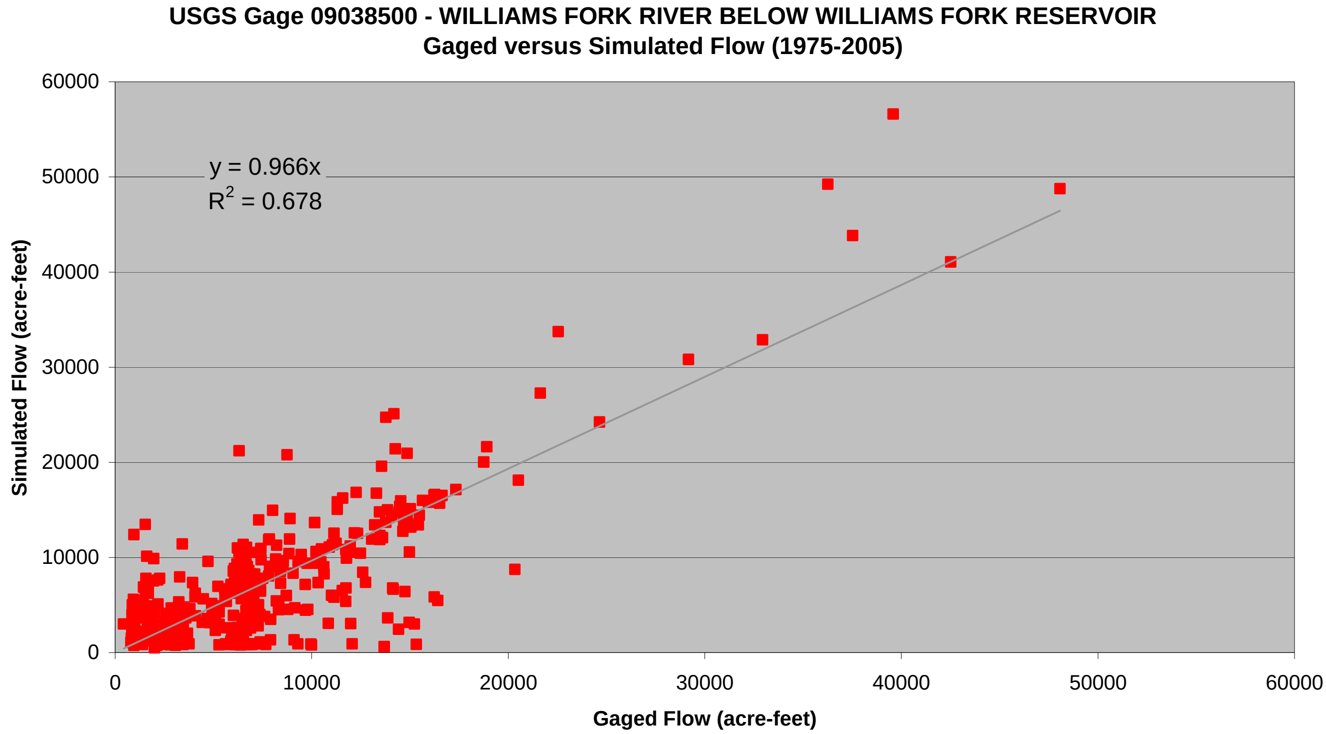


Figure D.4 Calculated Streamflow Simulation – Colorado River at Windy Gap, near Granby, CO.



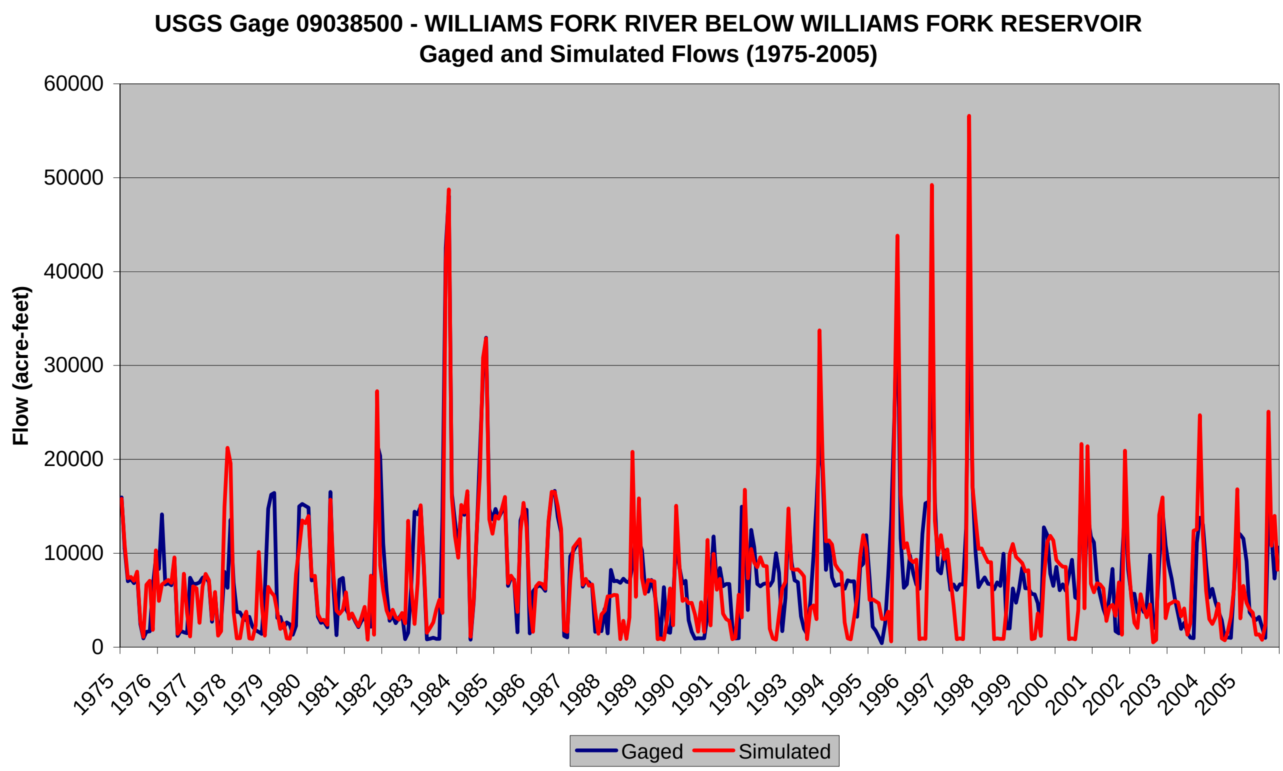
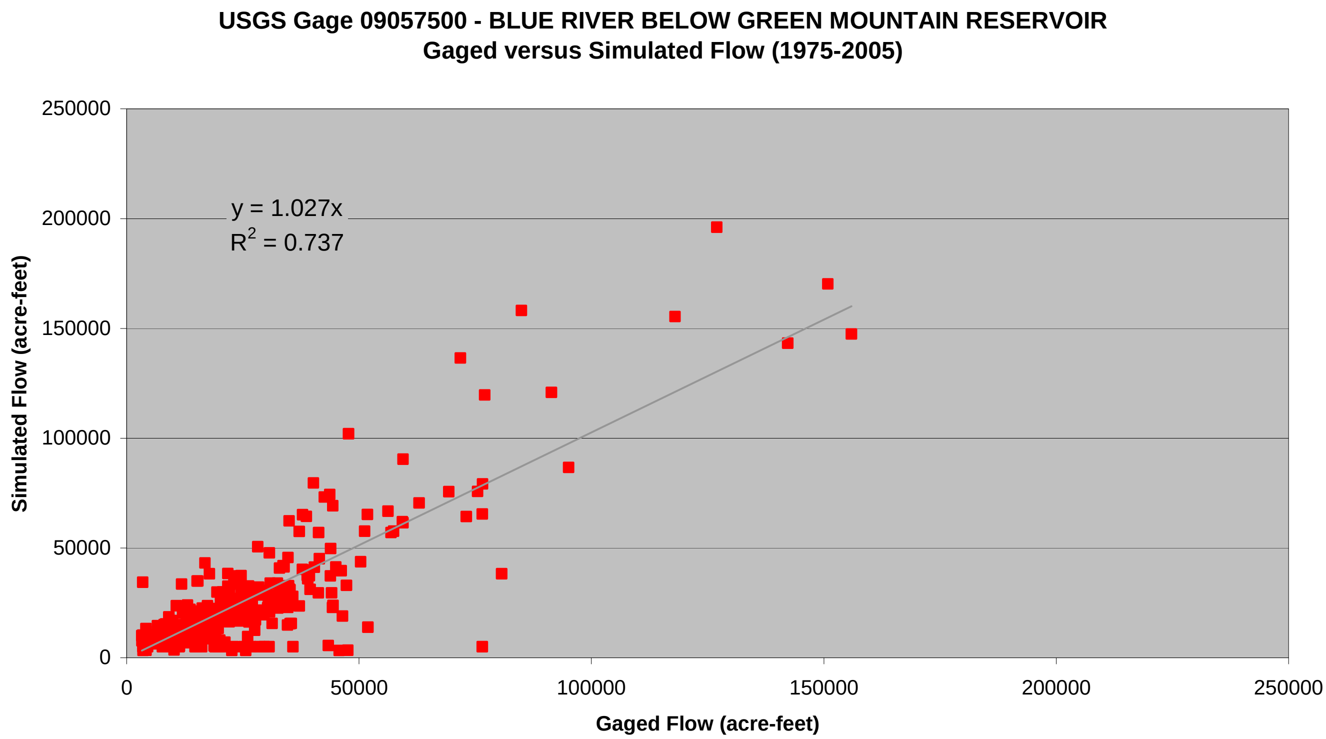


Figure D.5 Calculated Streamflow Simulation – Williams Fork River below Williams Fork Res.



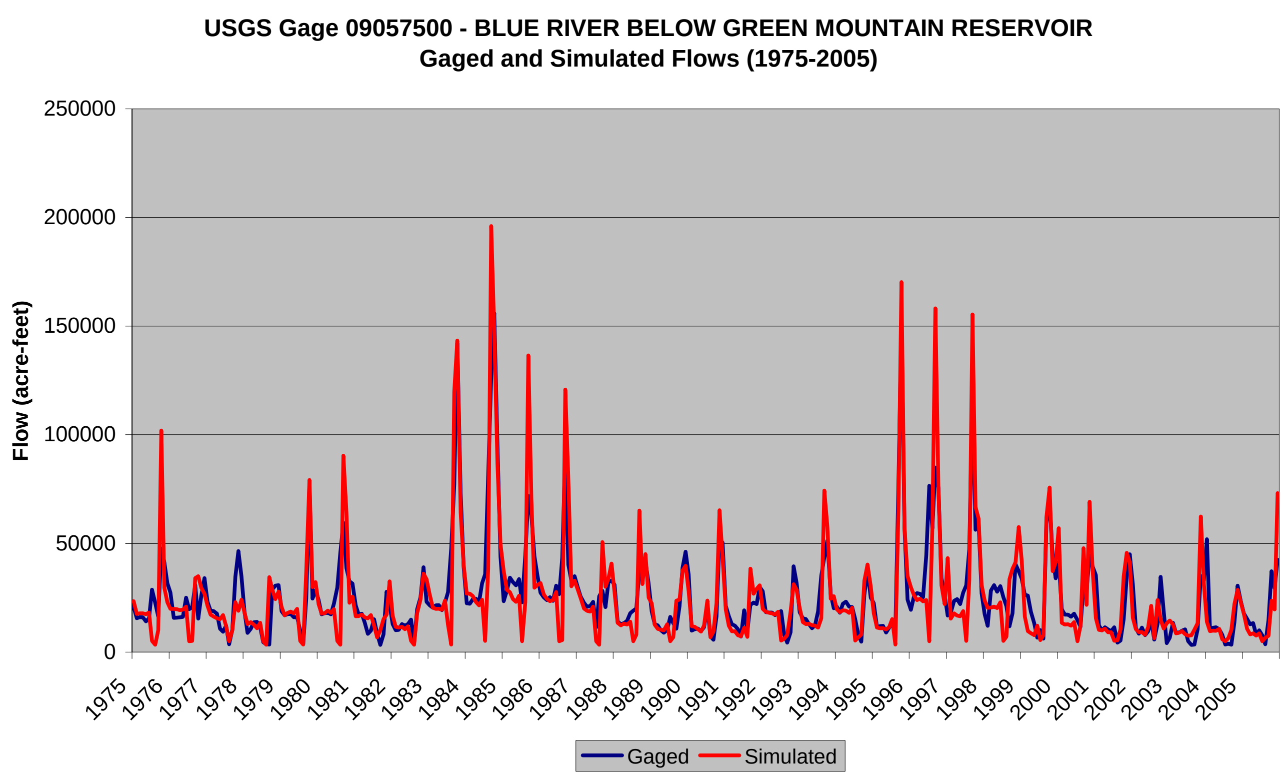
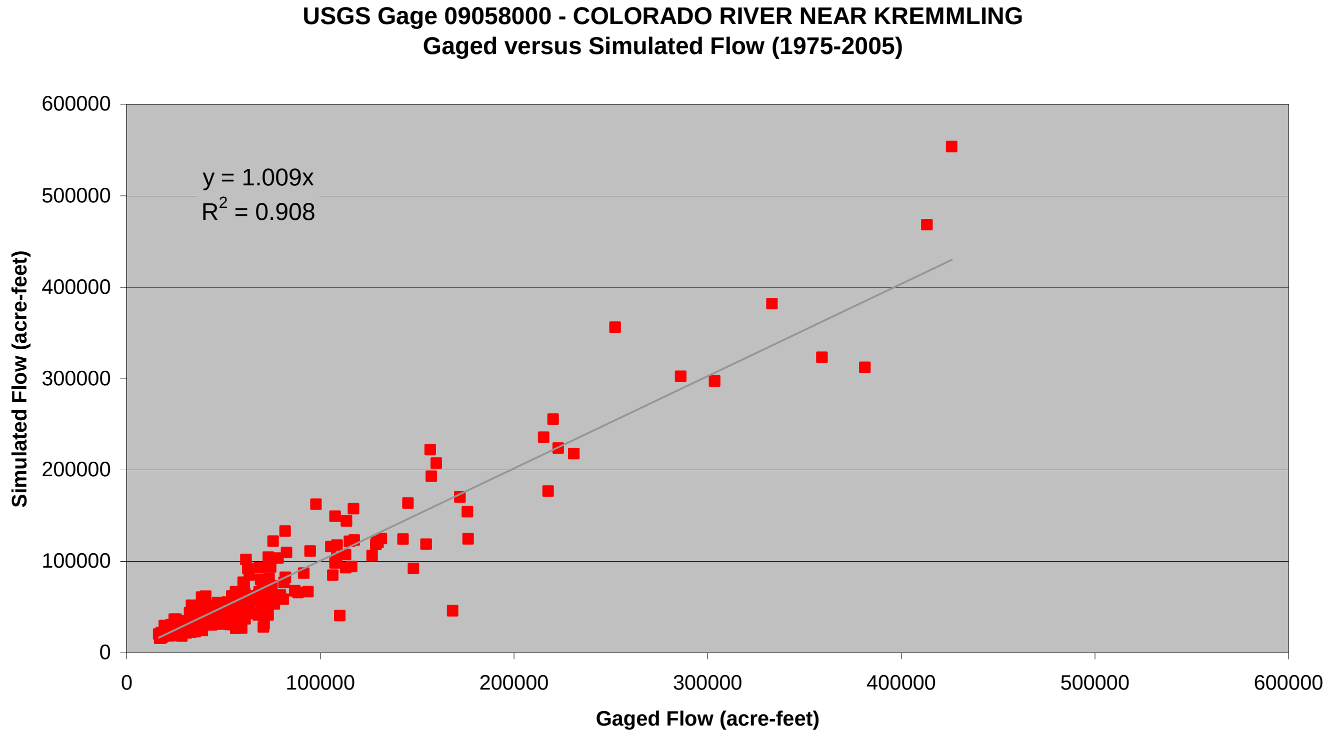


Figure D.6 Calculated Streamflow Simulation – Blue River below Green Mountain Reservoir



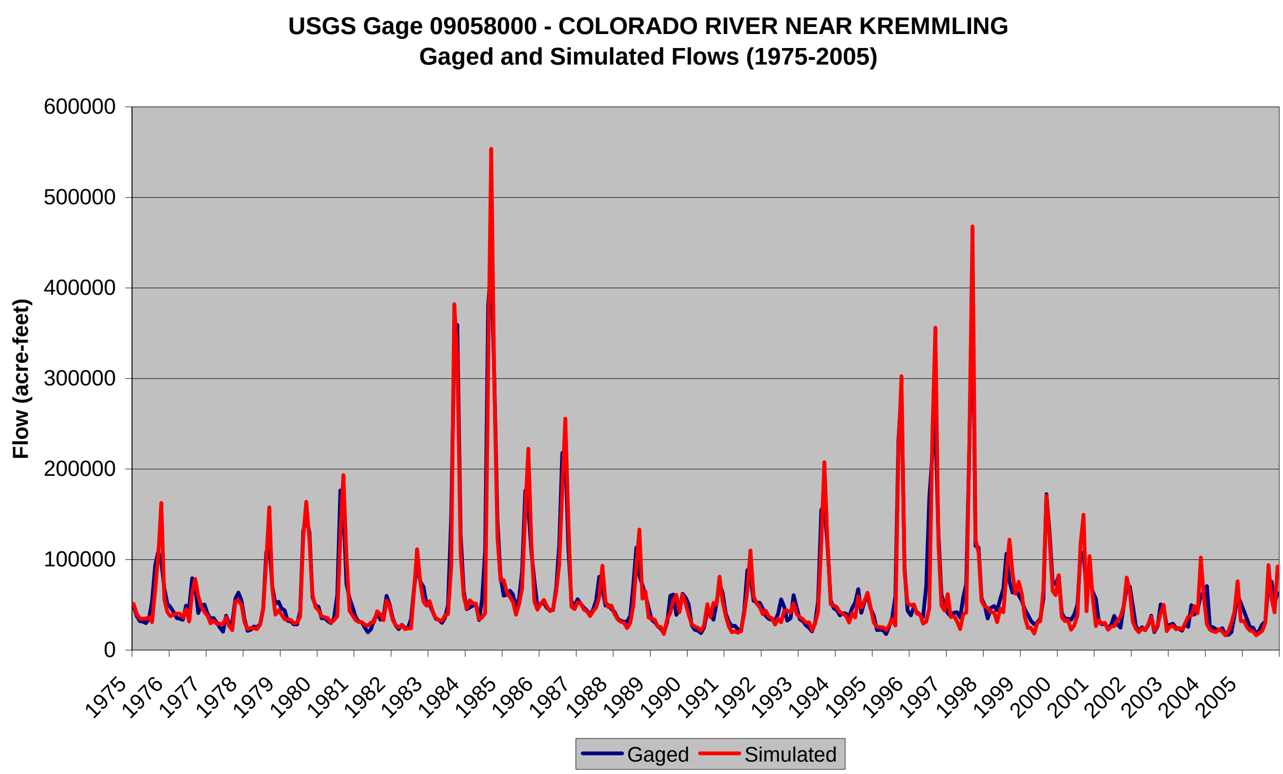
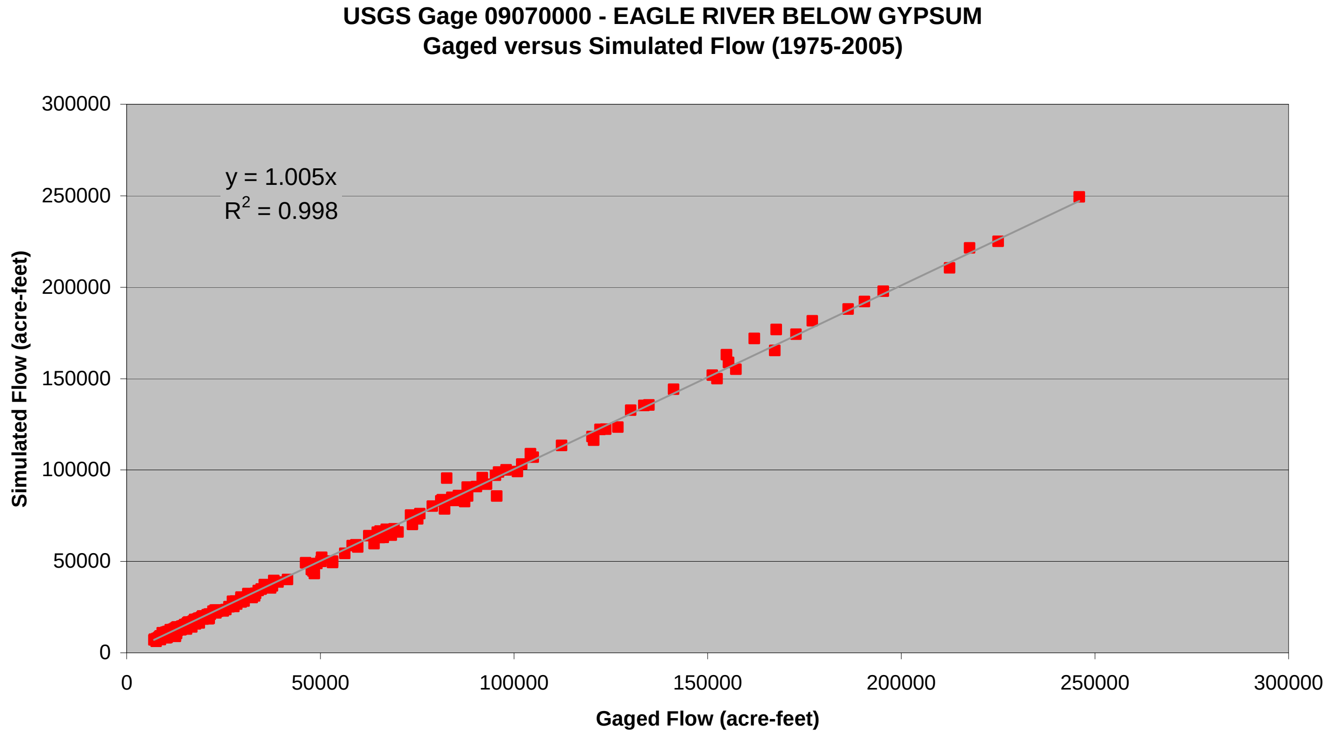


Figure D.7 Calculated Streamflow Simulation – Colorado River near Kremmling



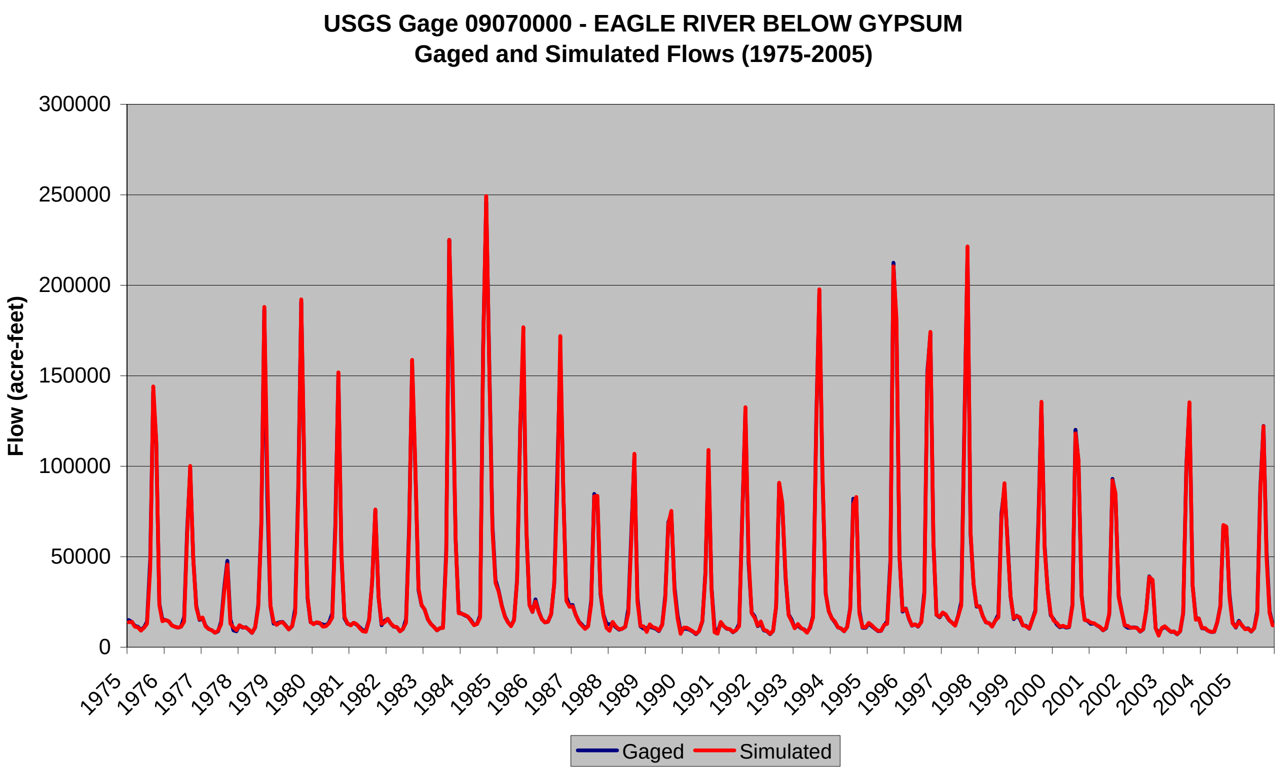
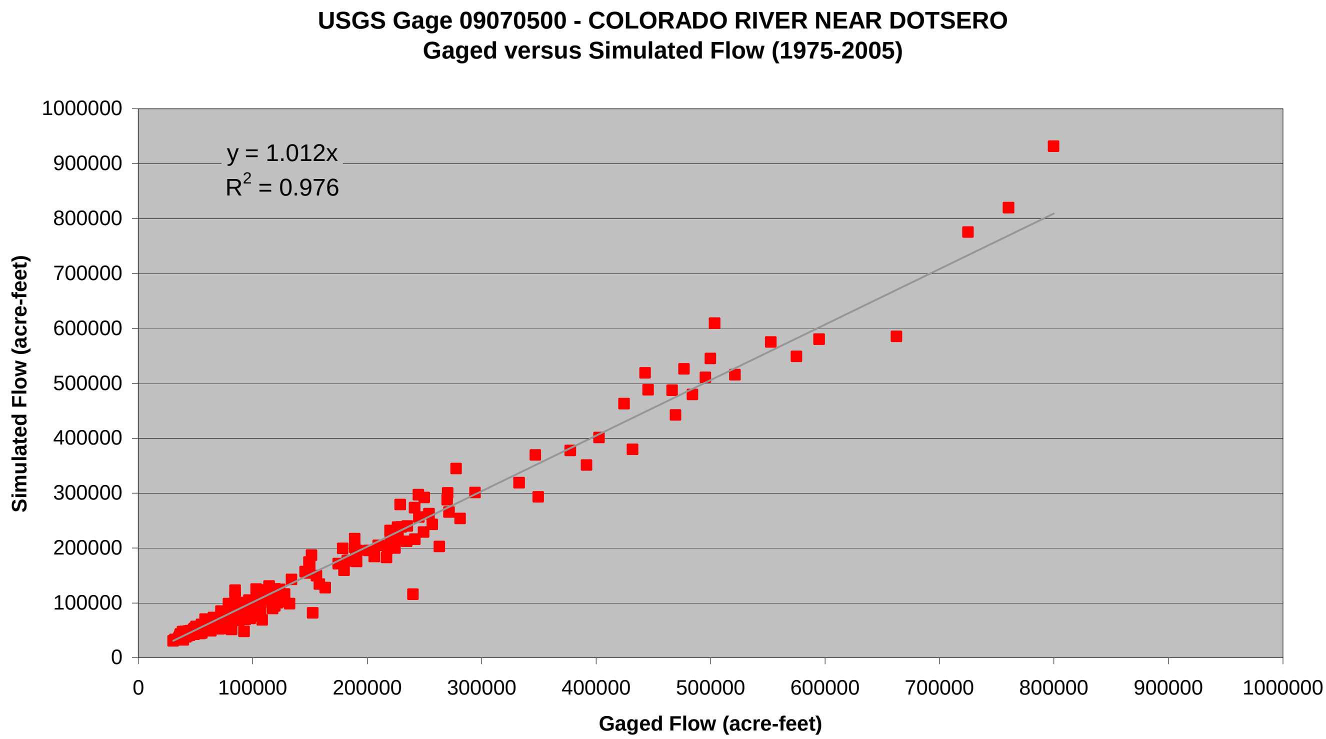


Figure D.8 Calculated Streamflow Simulation – Eagle River below Gypsum



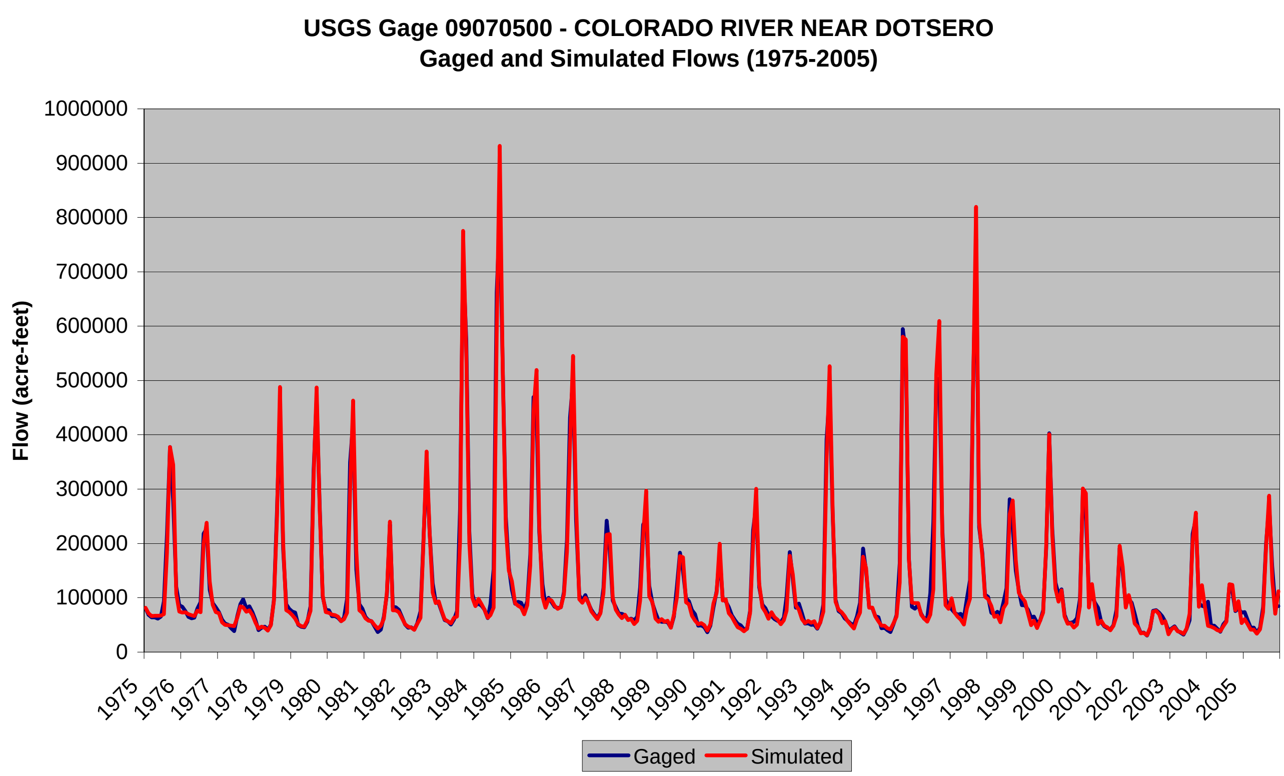
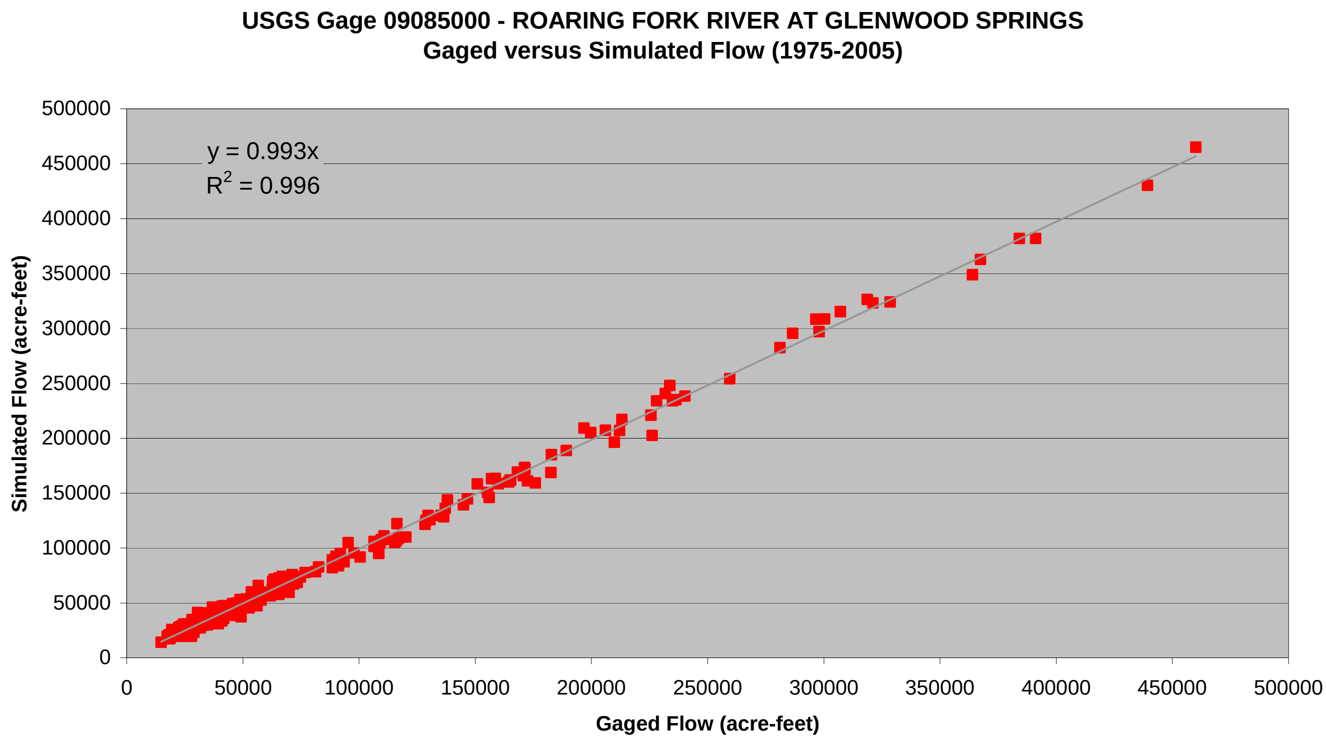


Figure D.9 Calculated Streamflow Simulation – Colorado River near Dotsero



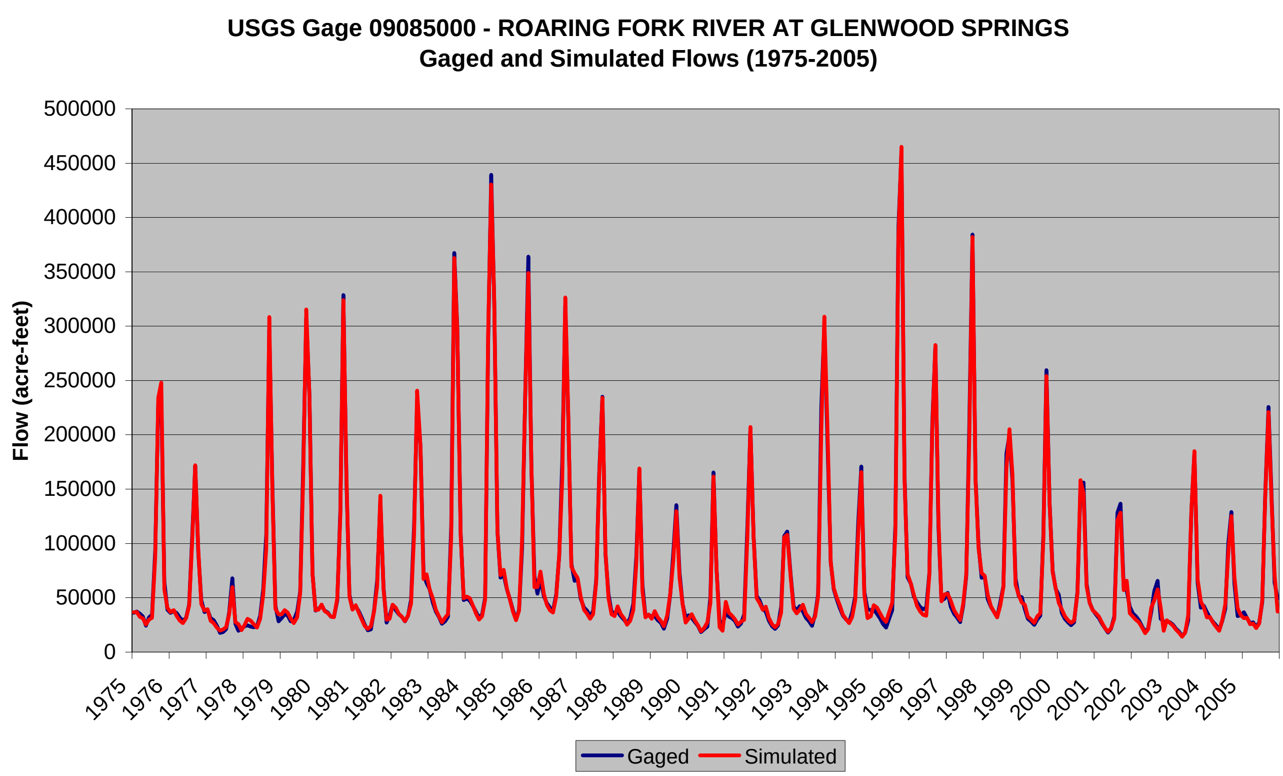
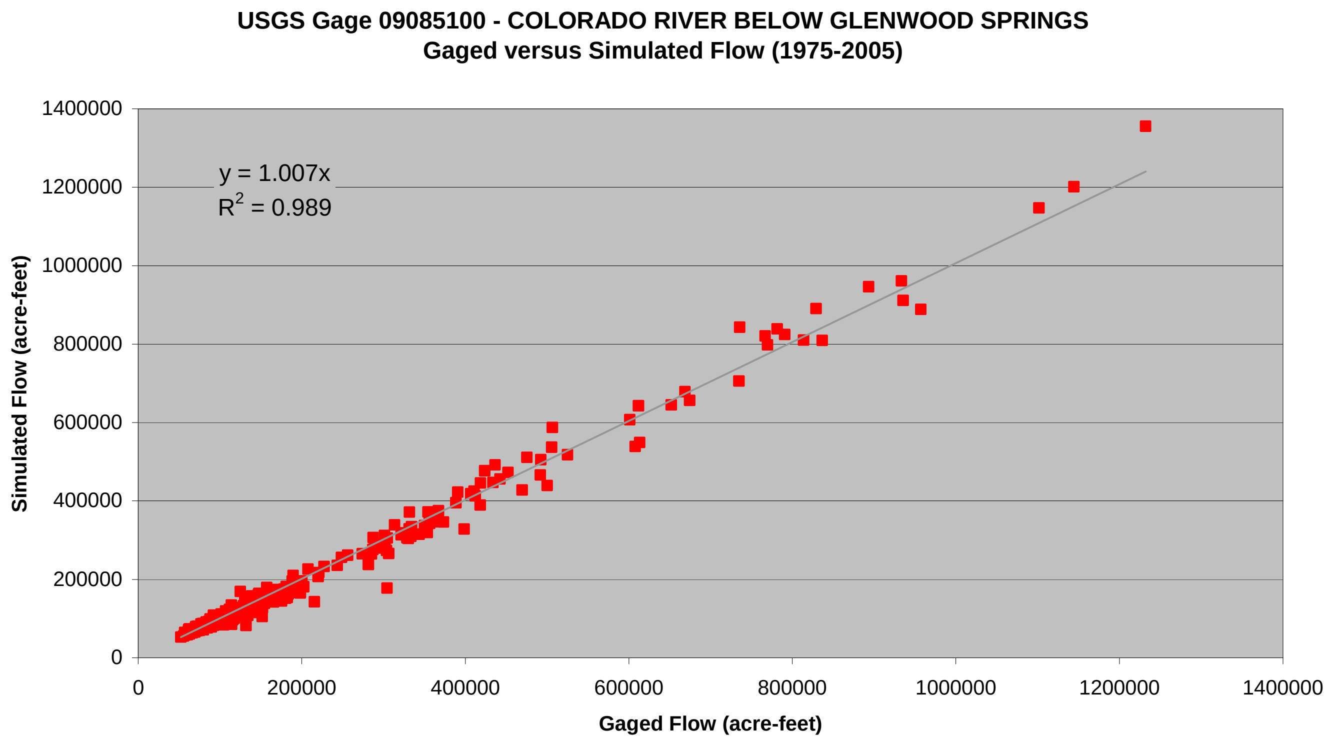


Figure D.10 Calculated Streamflow Simulation – Roaring Fork River at Glenwood Springs



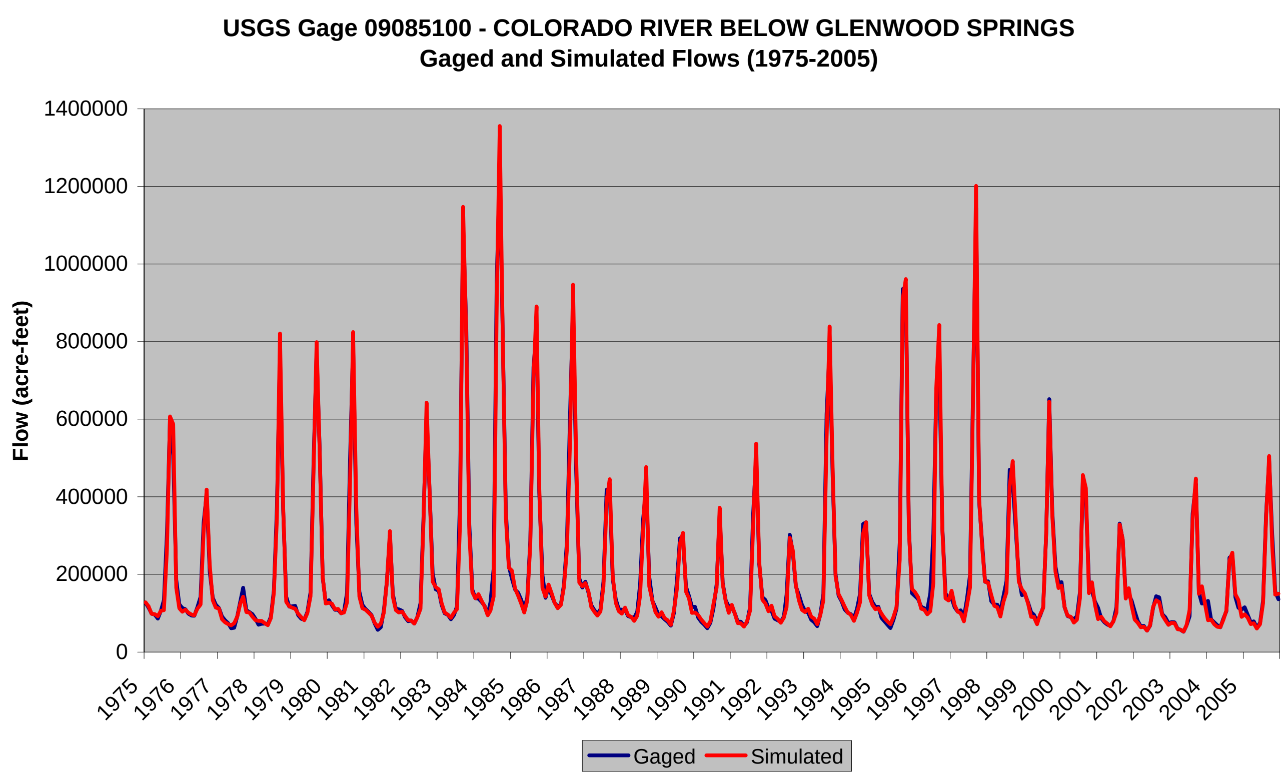
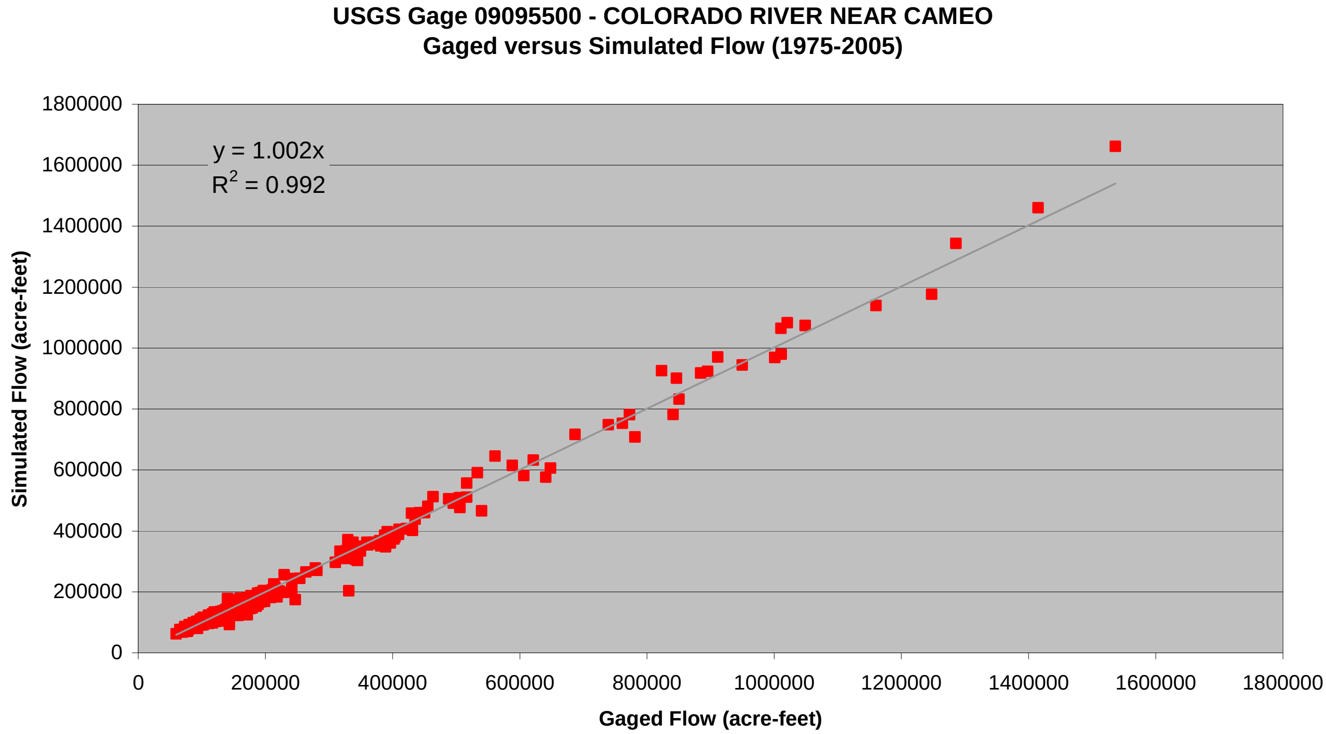


Figure D.11 Calculated Streamflow Simulation – Colorado River below Glenwood Springs



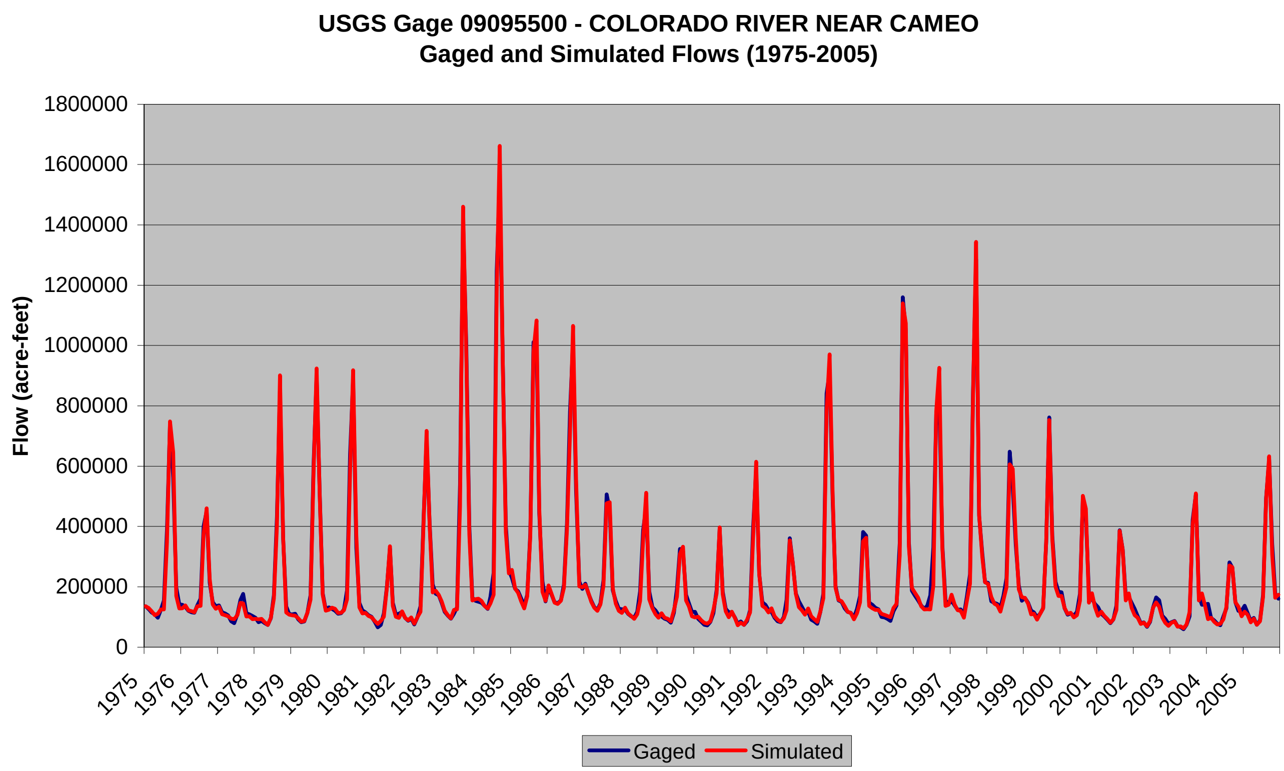
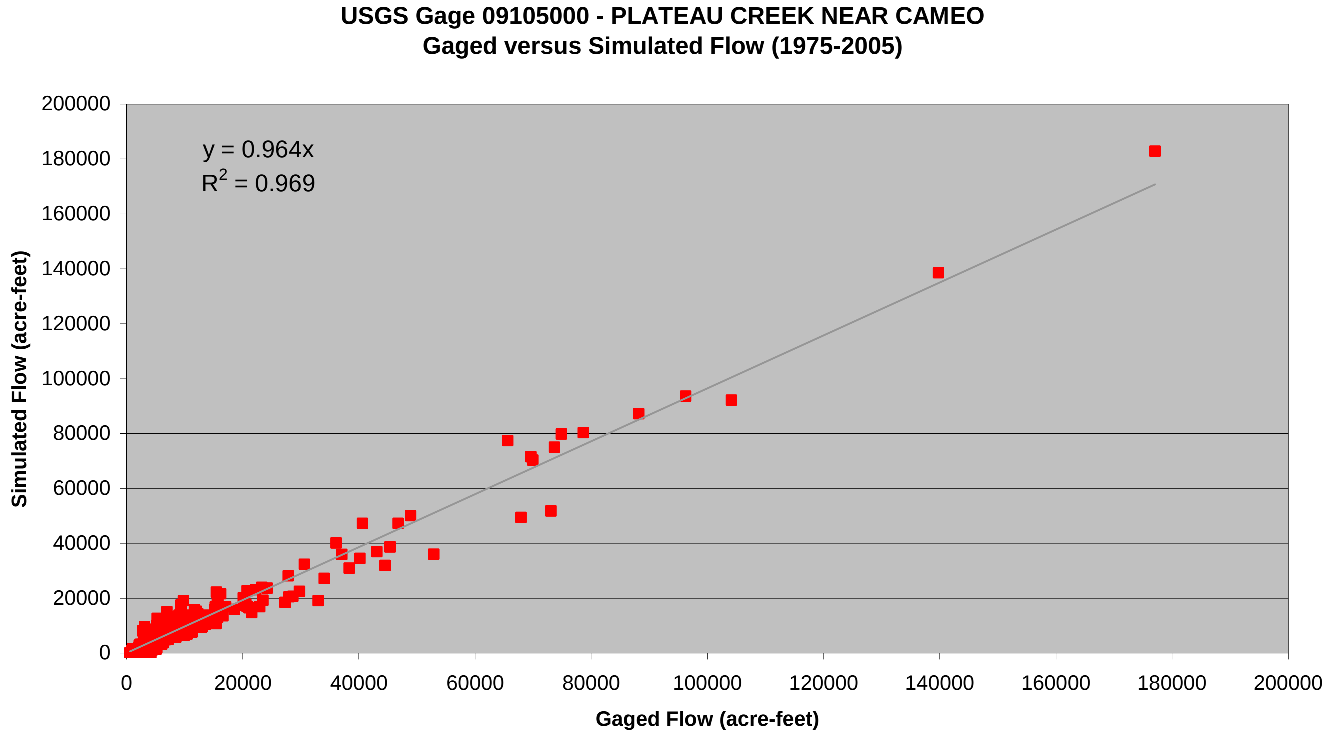


Figure D.12 Calculated Streamflow Simulation – Colorado River near Cameo



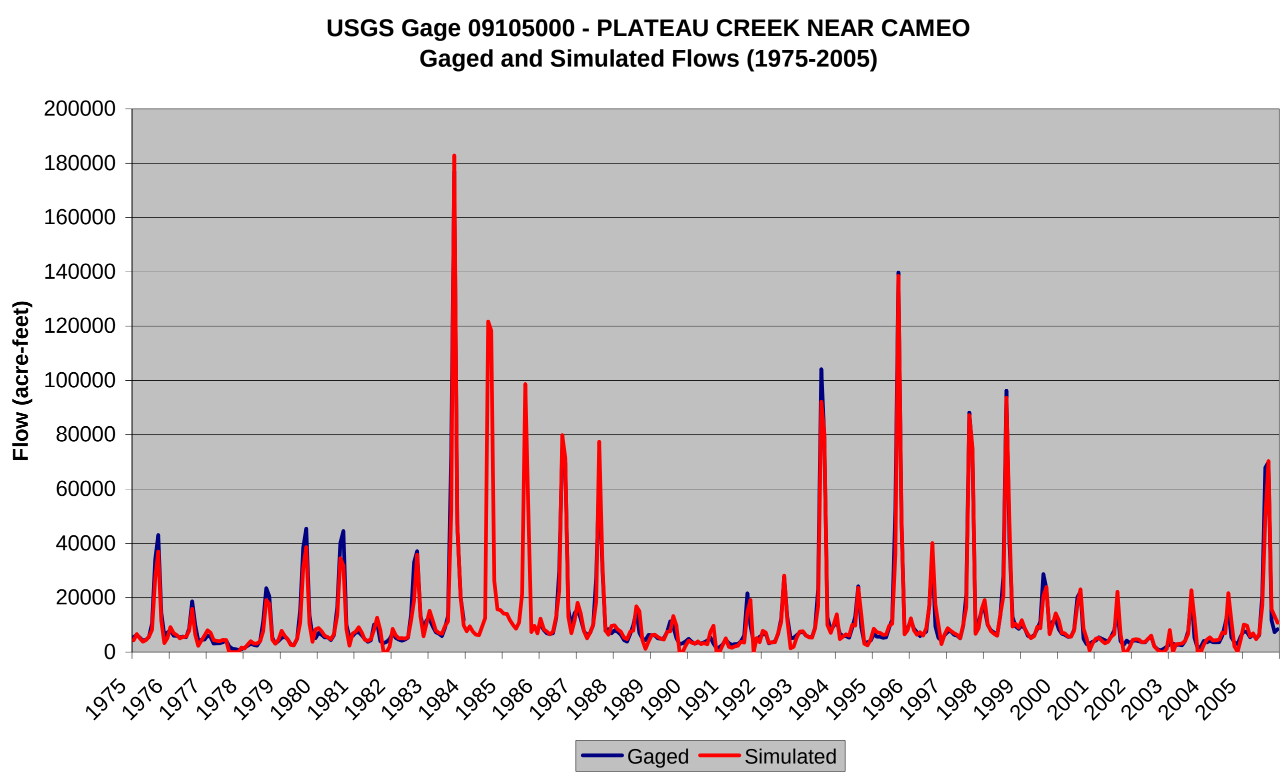
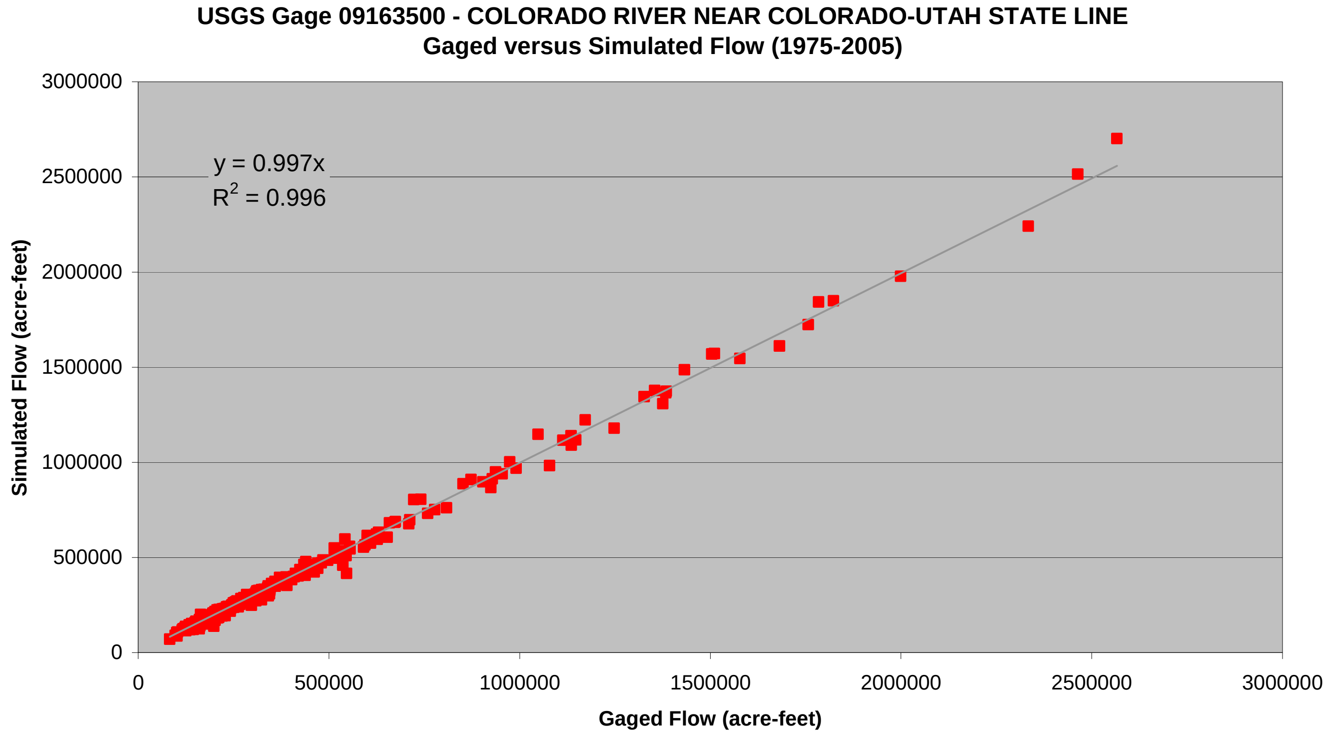


Figure D.13 Calculated Streamflow Simulation – Plateau Creek near Cameo



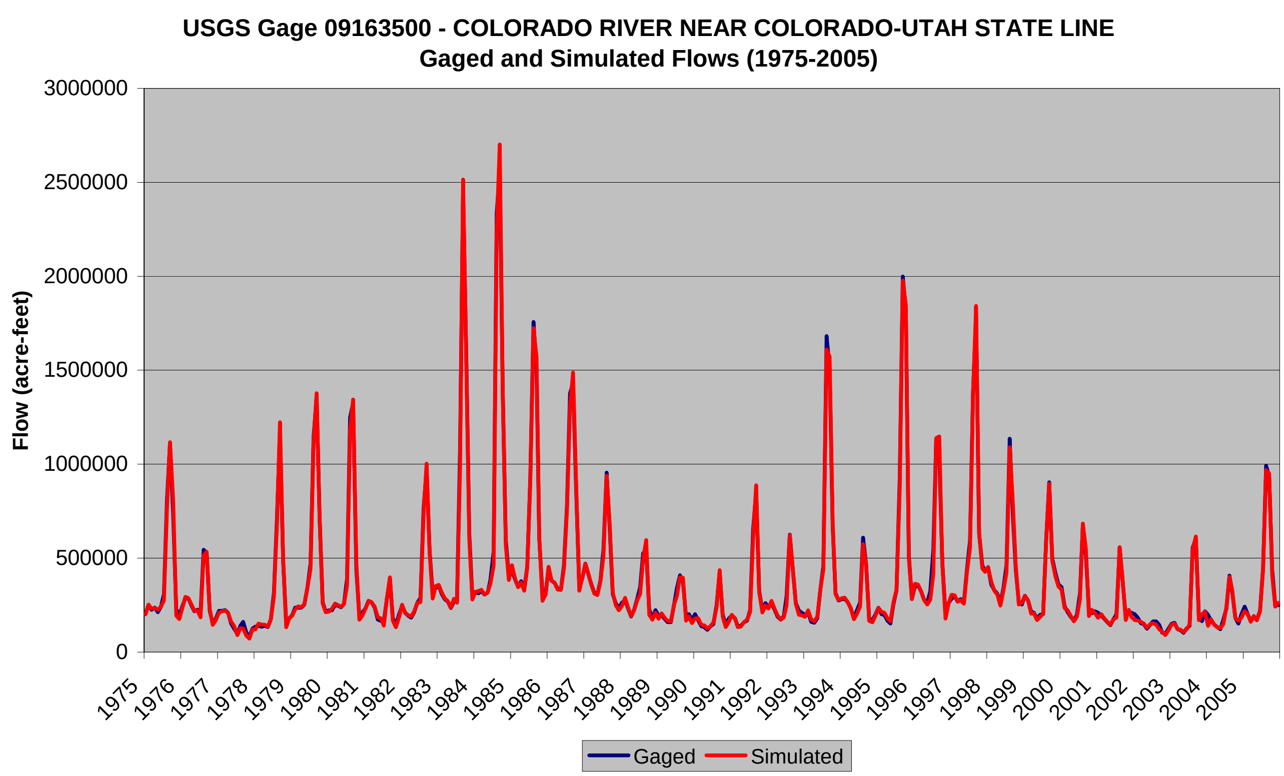


Figure D.14 Calculated Streamflow Simulation – Colorado River near Colorado-Utah State Line

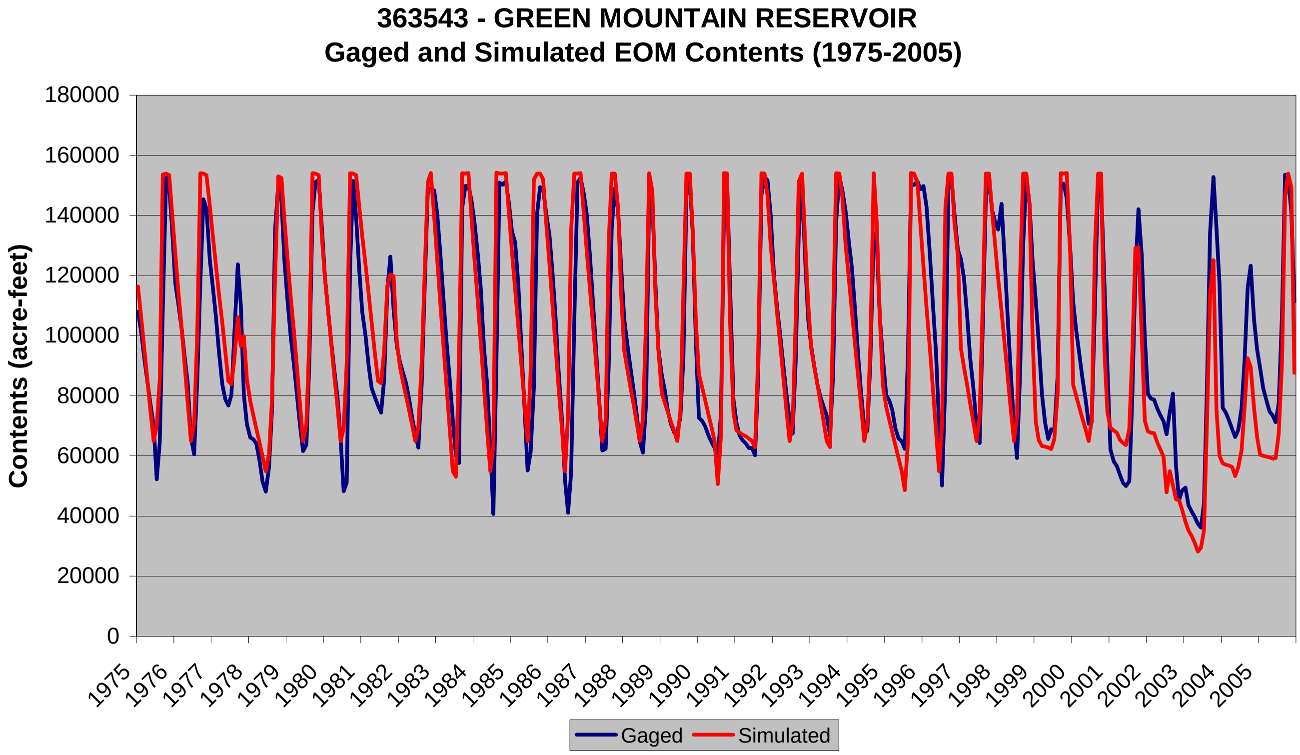


Figure D.15 Calculated Reservoir Simulation – Green Mountain Reservoir

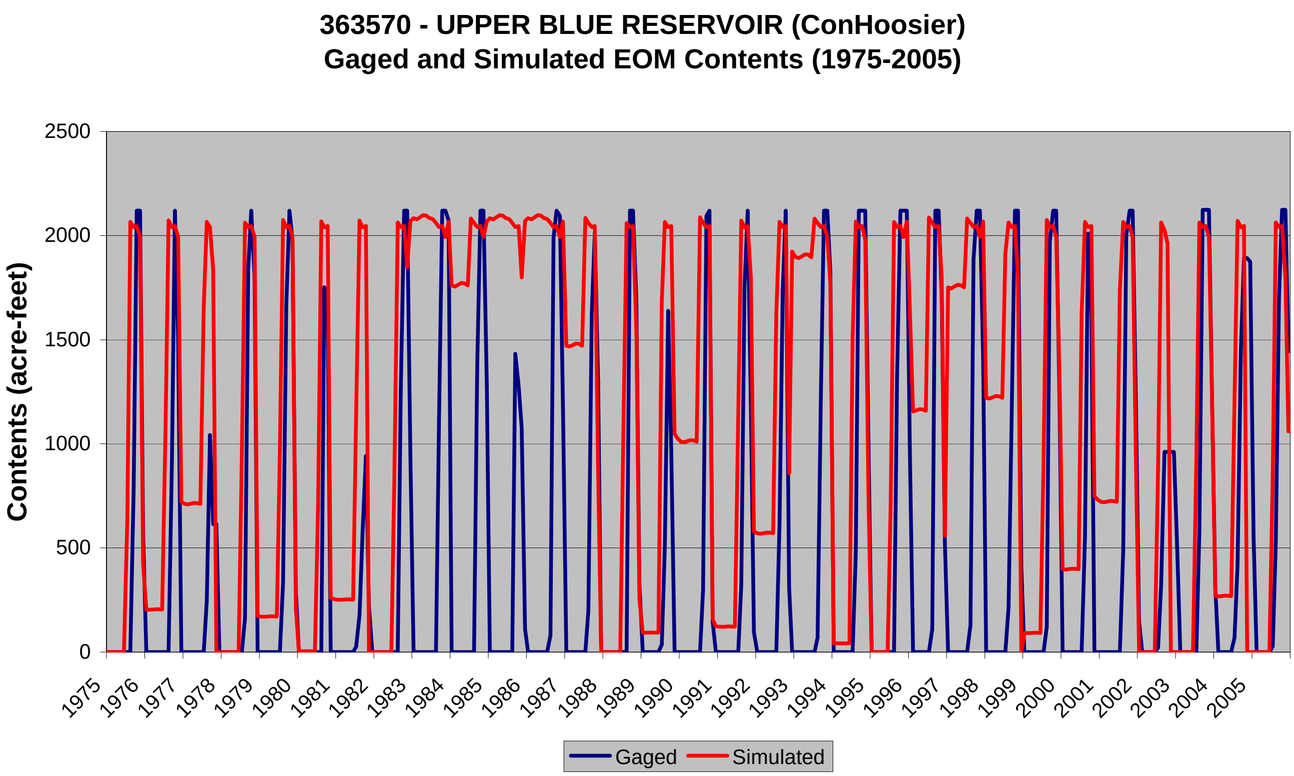


Figure D.16 Calculated Reservoir Simulation – Upper Blue Reservoir (ConHoosier)

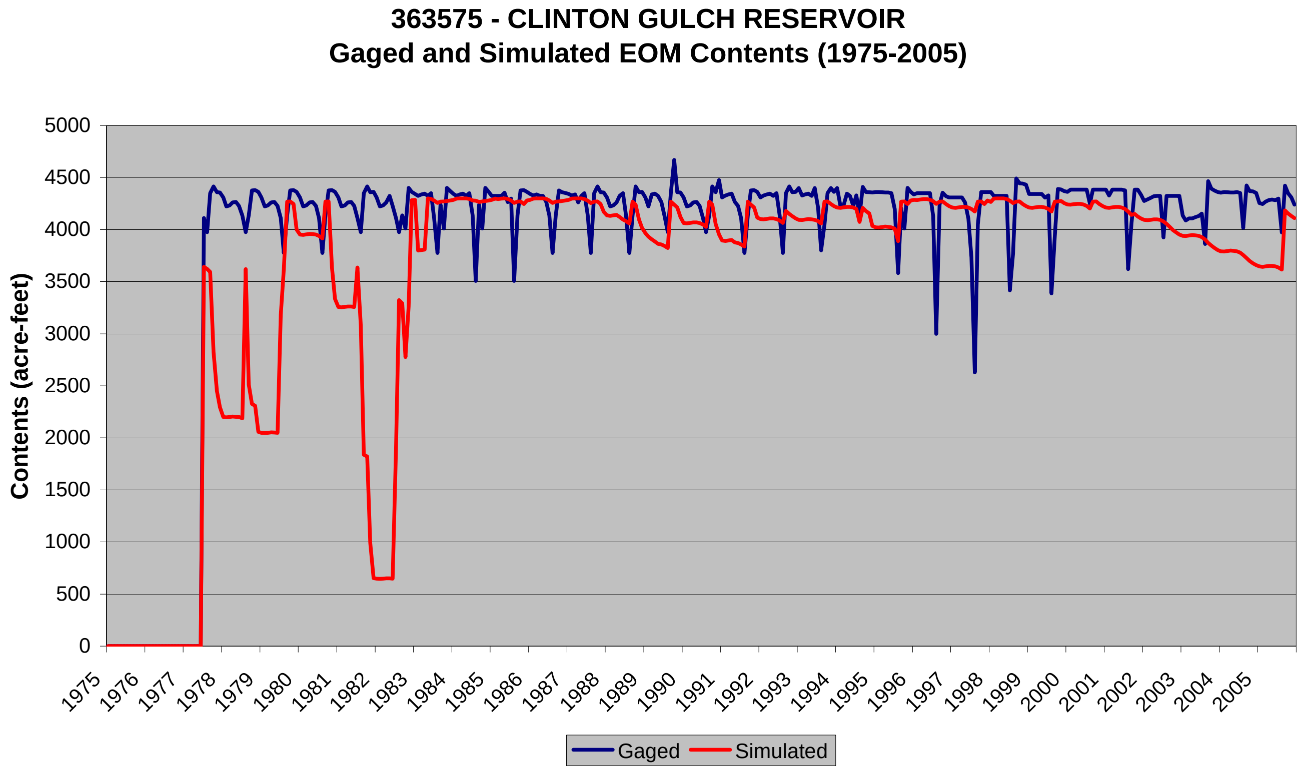


Figure D.17 Calculated Reservoir Simulation – Clinton Gulch Reservoir

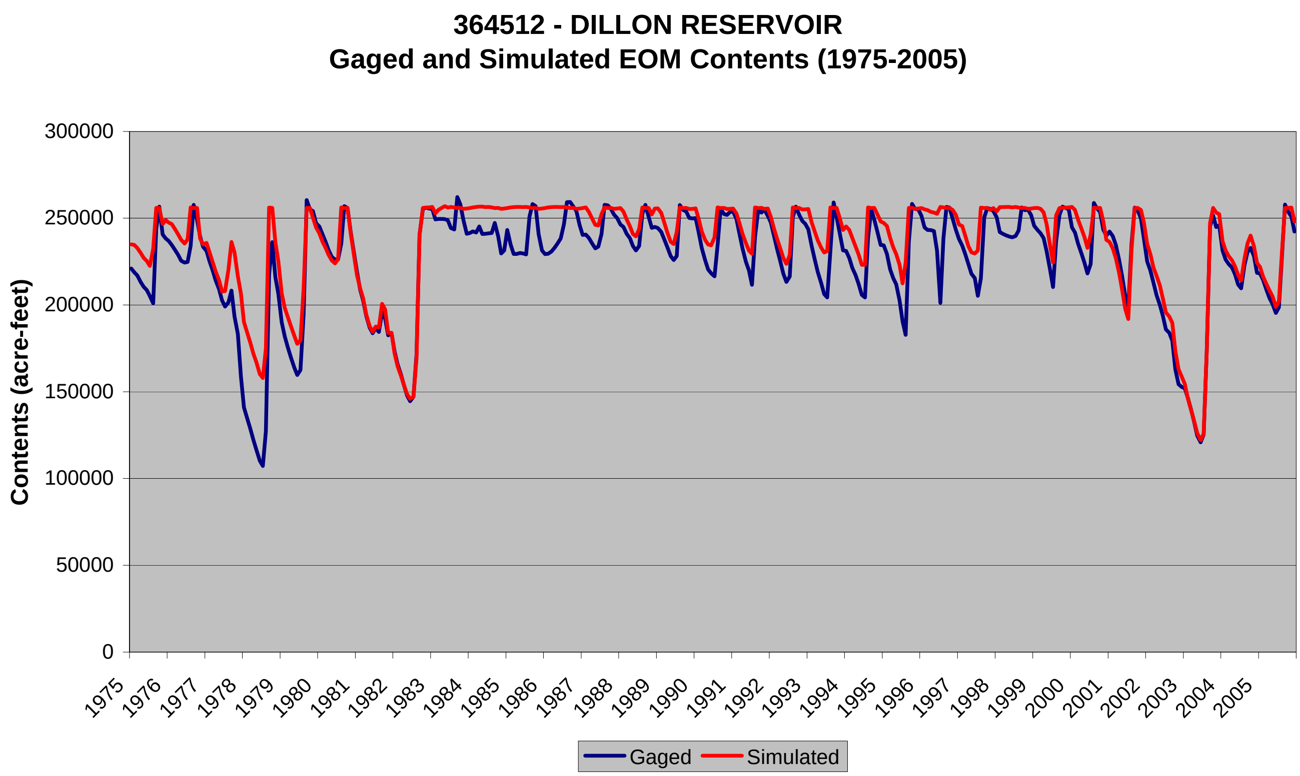


Figure D.18 Calculated Reservoir Simulation – Dillon Reservoir

374516 - HOMESTAKE PROJ RESERVOIR
Gaged and Simulated EOM Contents (1975-2005)

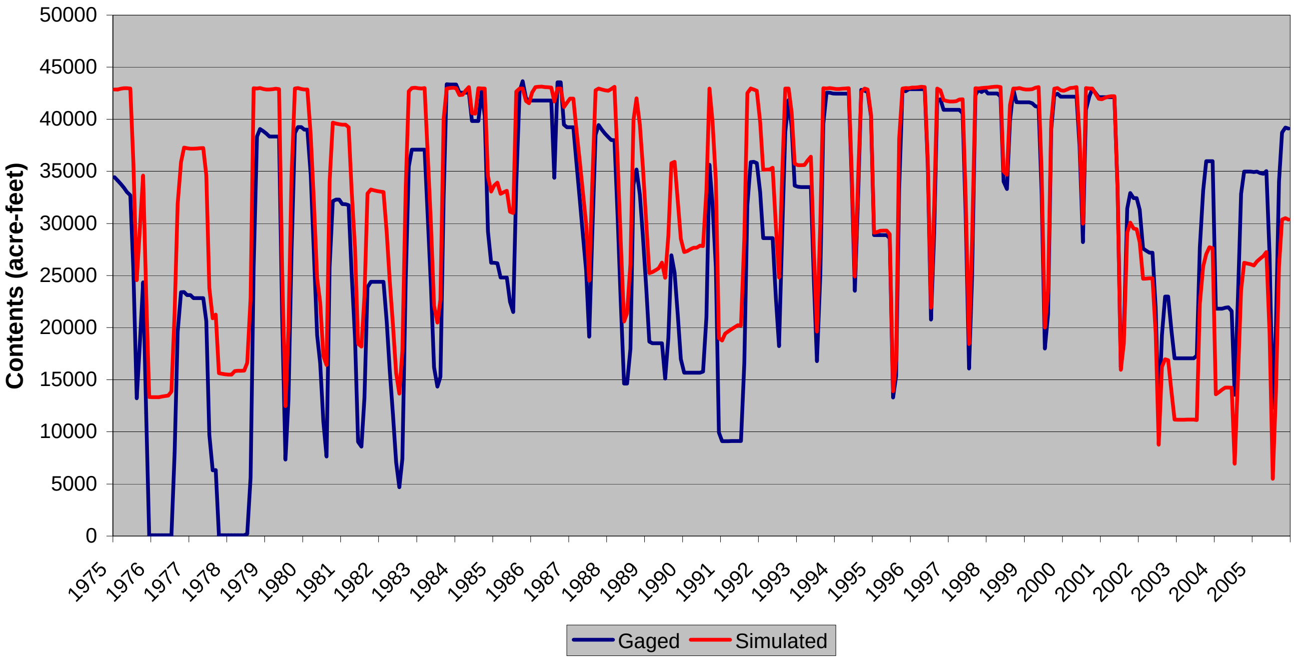


Figure D.19 Calculated Reservoir Simulation – Homestake Proj Reservoir

393505 - GRASS VALLEY RESERVOIR
Gaged and Simulated EOM Contents (1975-2005)

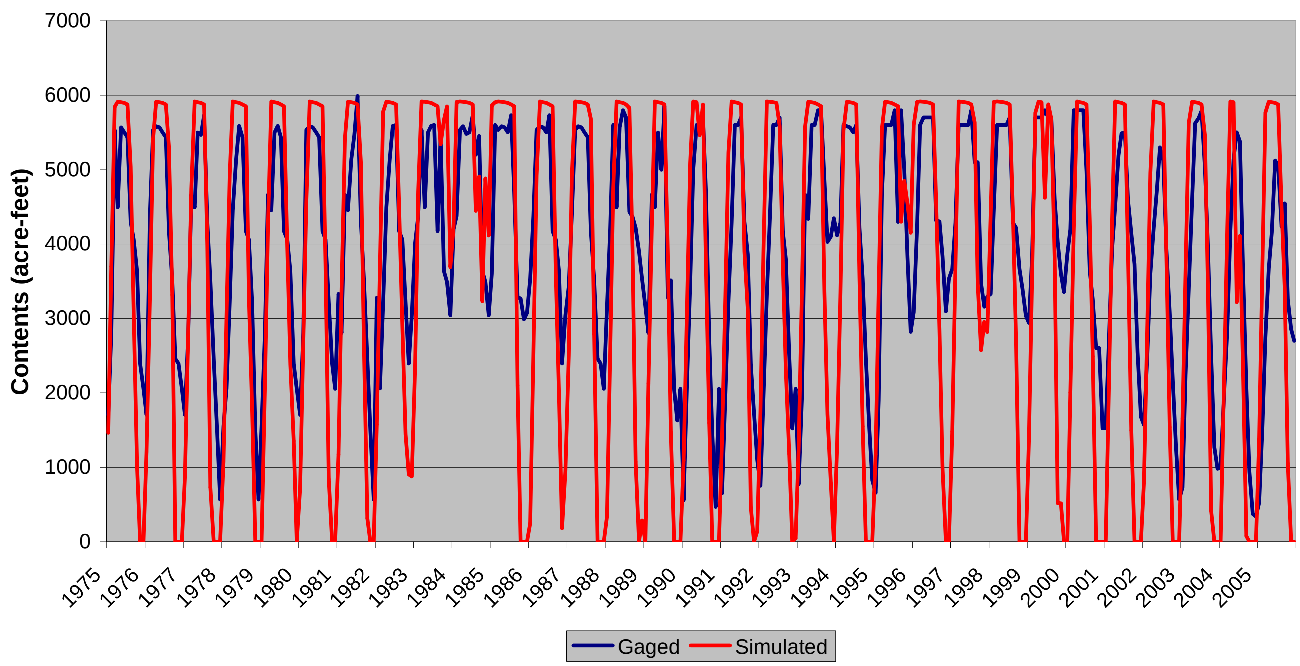


Figure D.20 Calculated Reservoir Simulation – Grass Valley Reservoir

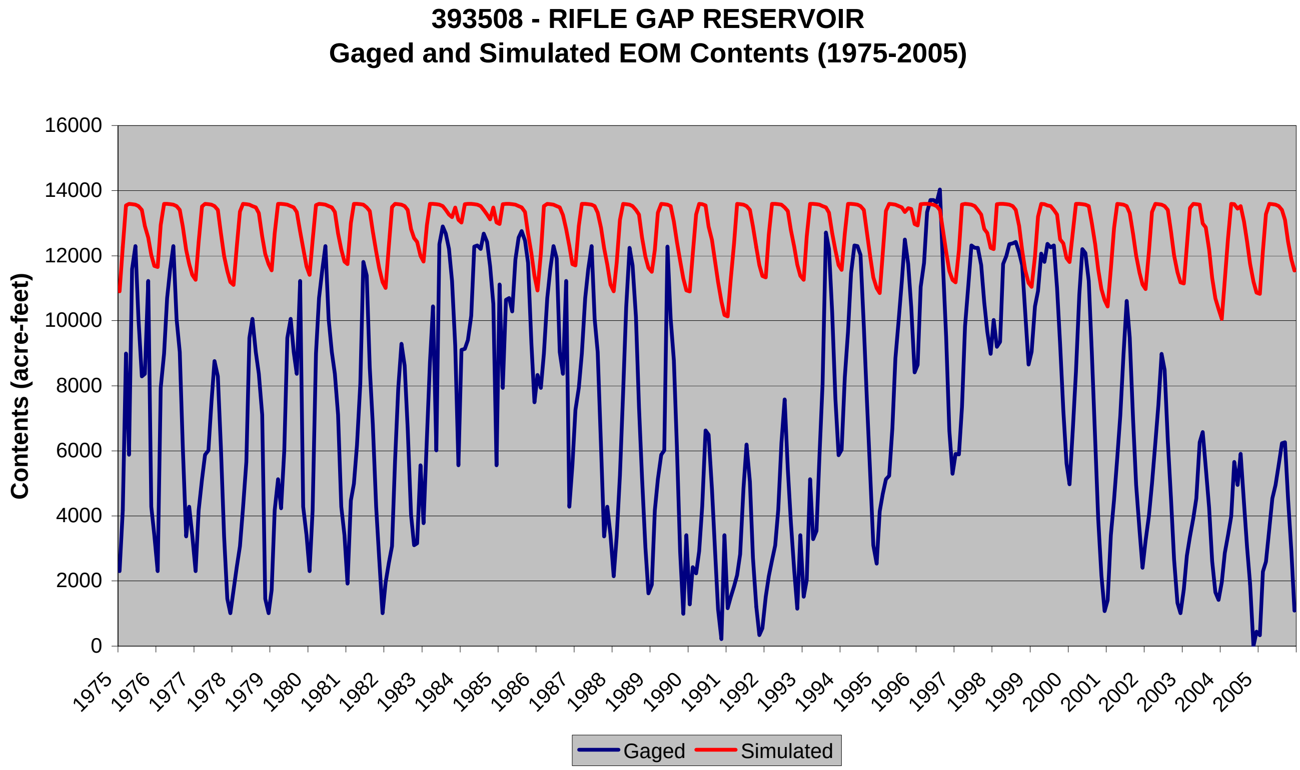


Figure D.21 Calculated Reservoir Simulation – Rifle Gap Reservoir

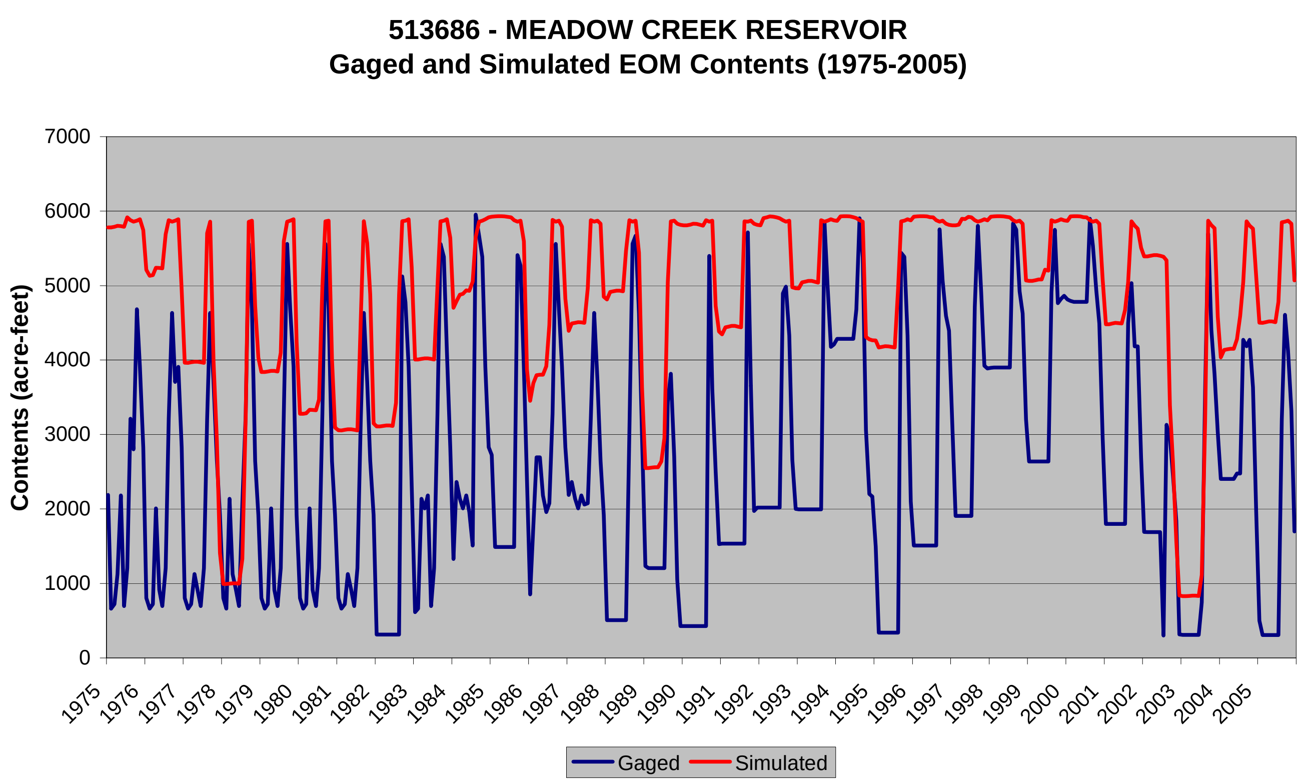


Figure D.22 Calculated Reservoir Simulation – Meadow Creek Reservoir

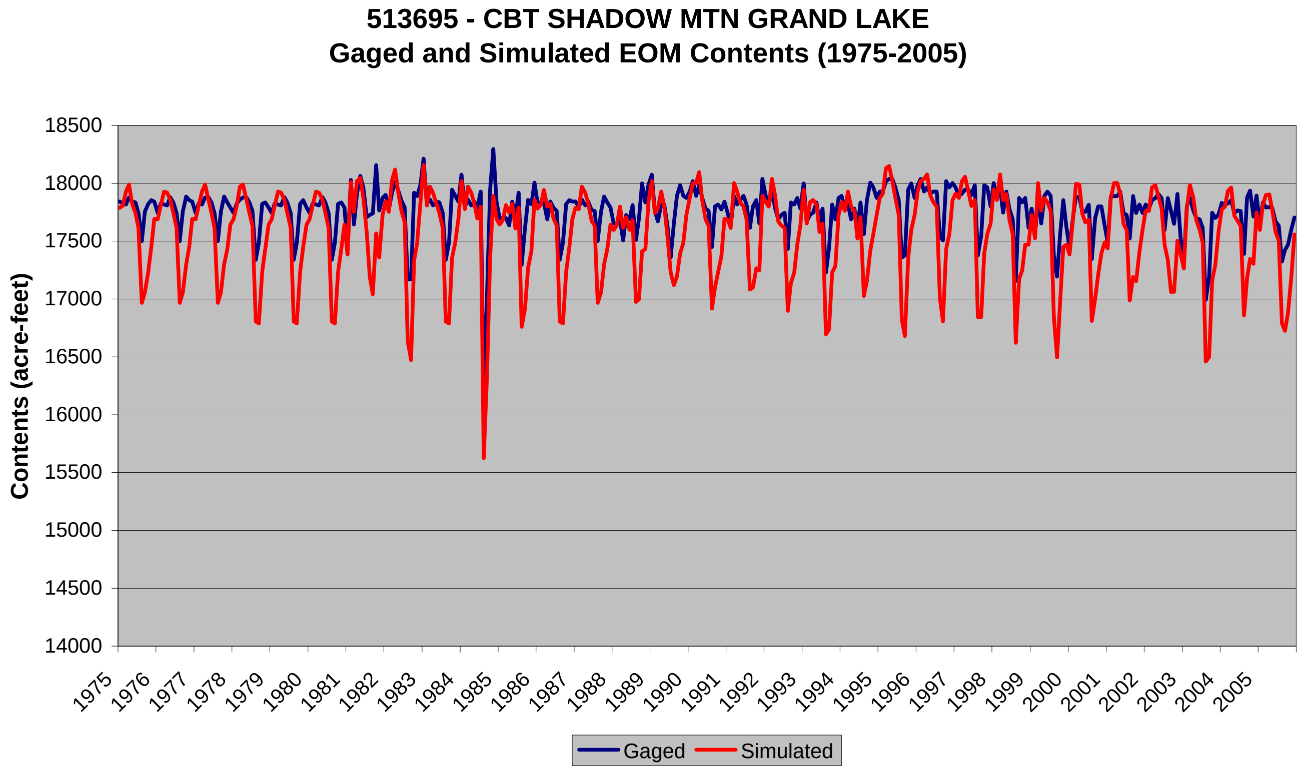


Figure D.23 Calculated Reservoir Simulation – CBT Shadow Mtn Grand Lake

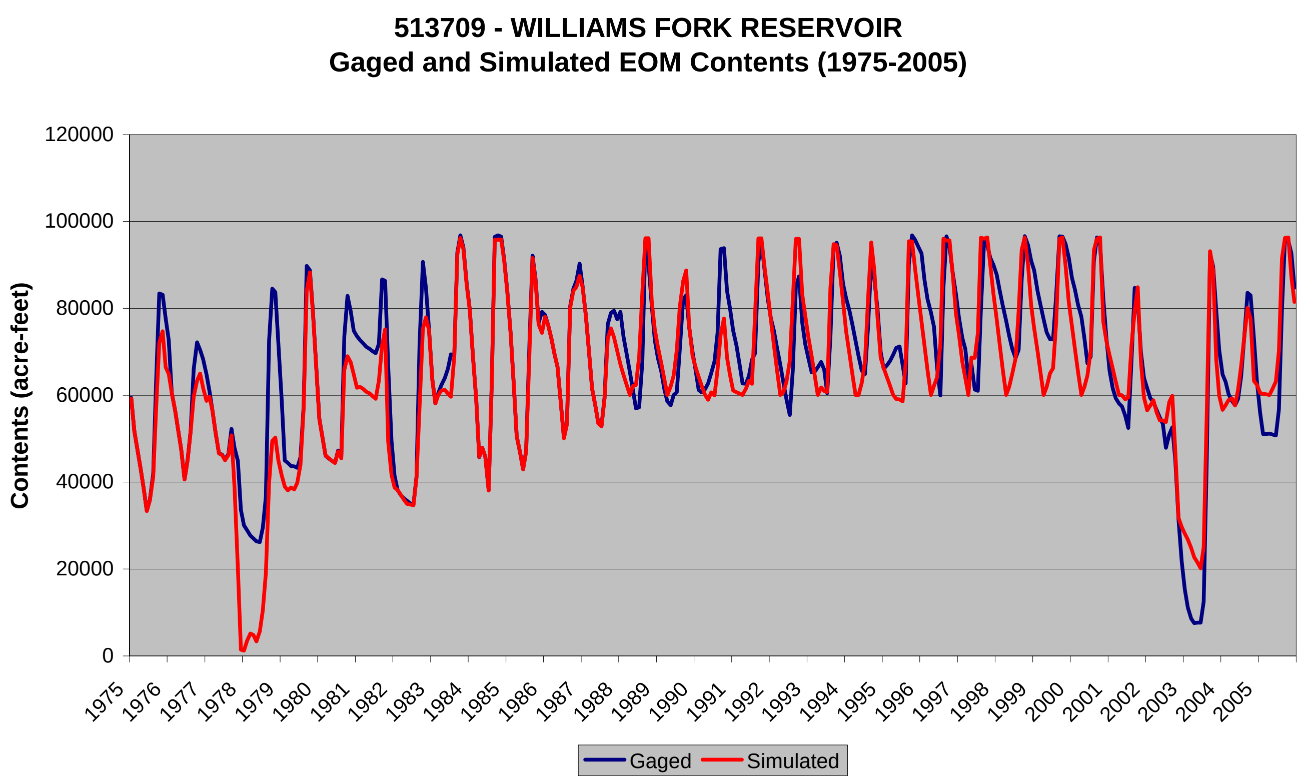


Figure D.24 Calculated Reservoir Simulation – Williams Fork Reservoir

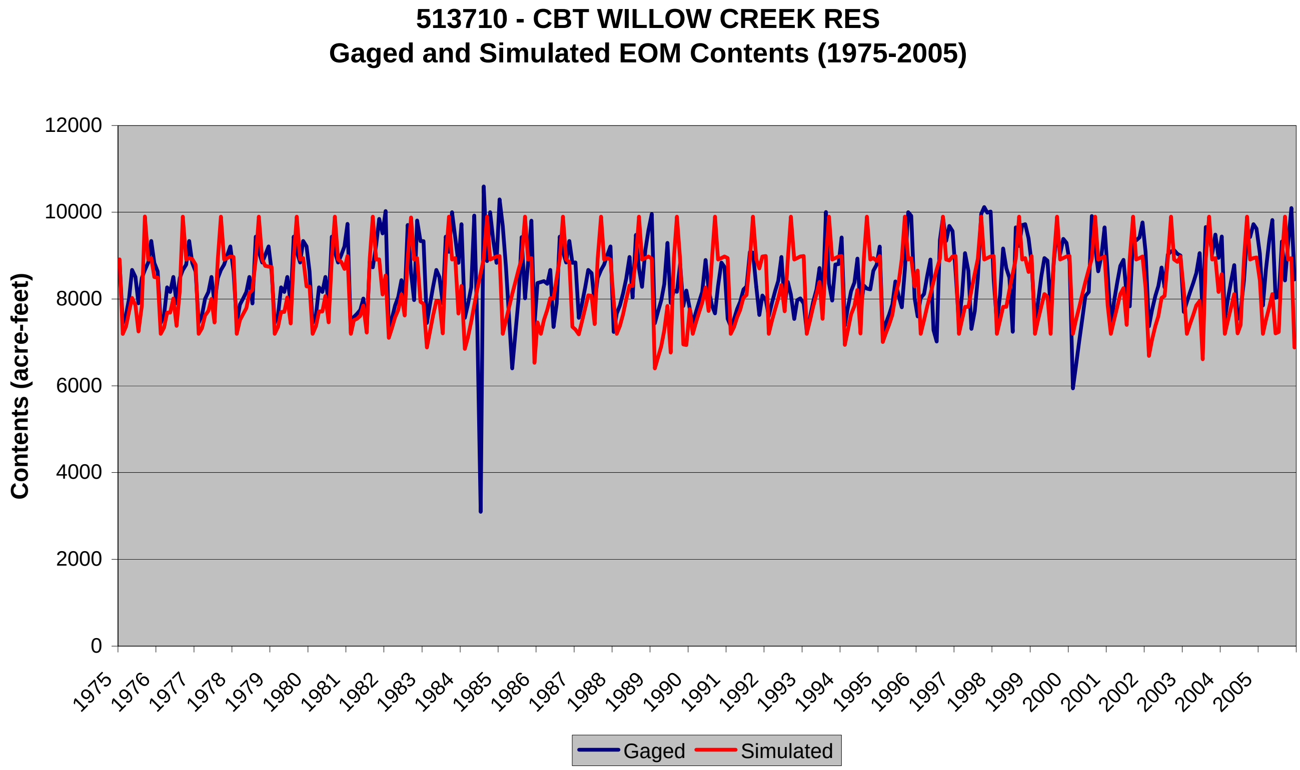


Figure D.25 Calculated Reservoir Simulation – CBT Willow Creek Res

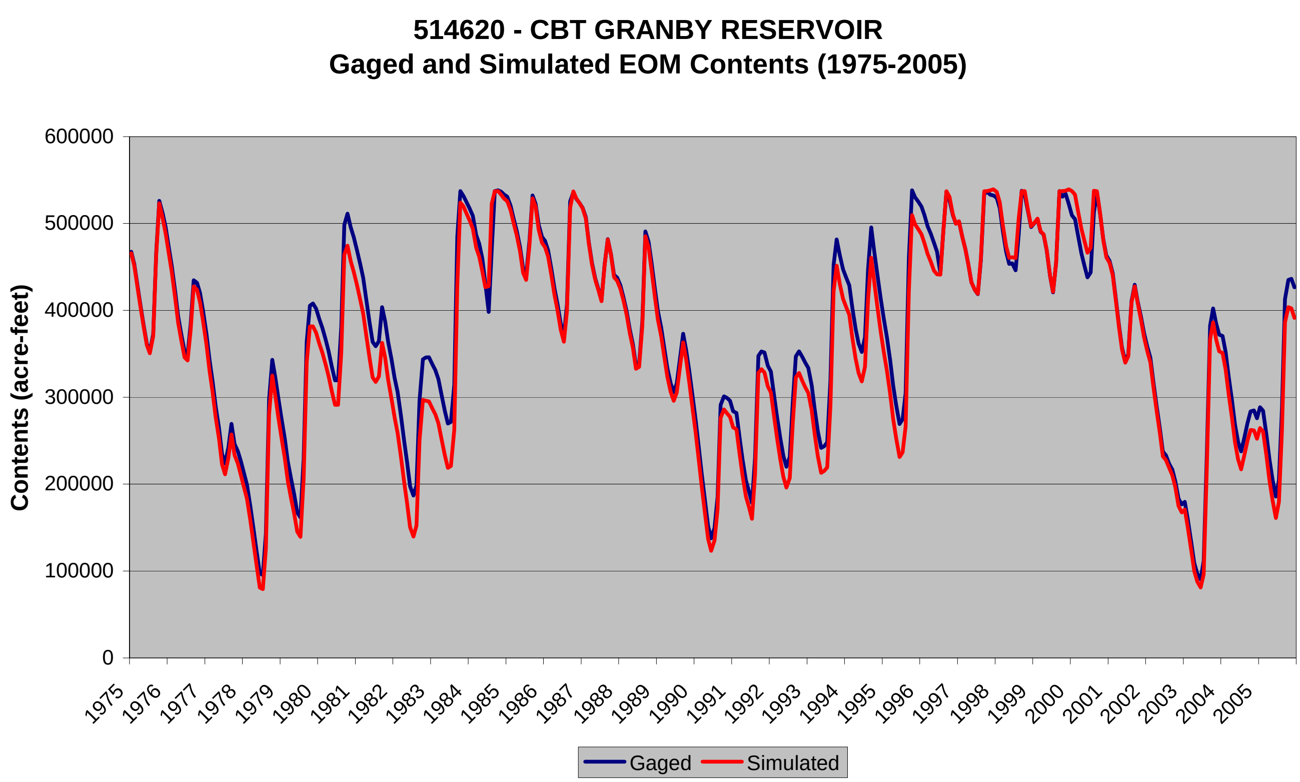


Figure D.26 Calculated Reservoir Simulation – CBT Granby Reservoir

723844 - VEGA RESERVOIR
Gaged and Simulated EOM Contents (1975-2005)

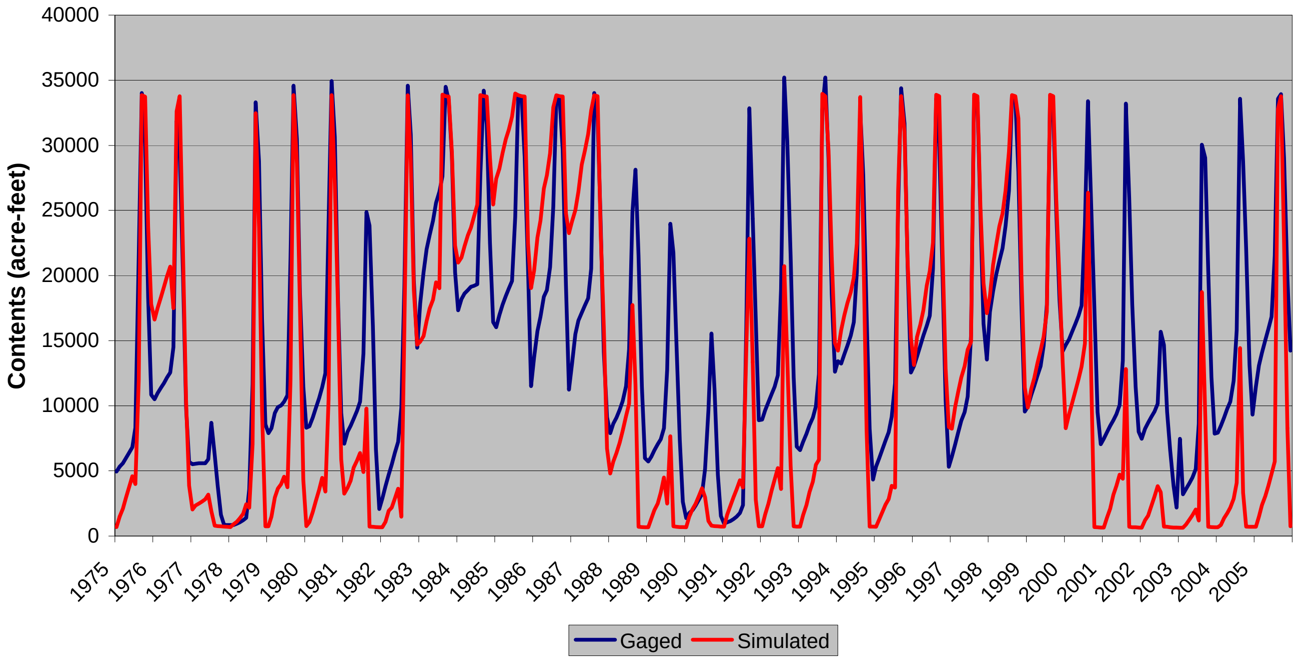


Figure D.27 Calculated Reservoir Simulation – Vega Reservoir

383713 - RUEDI RESERVOIR
Gaged and Simulated EOM Contents (1975-2005)

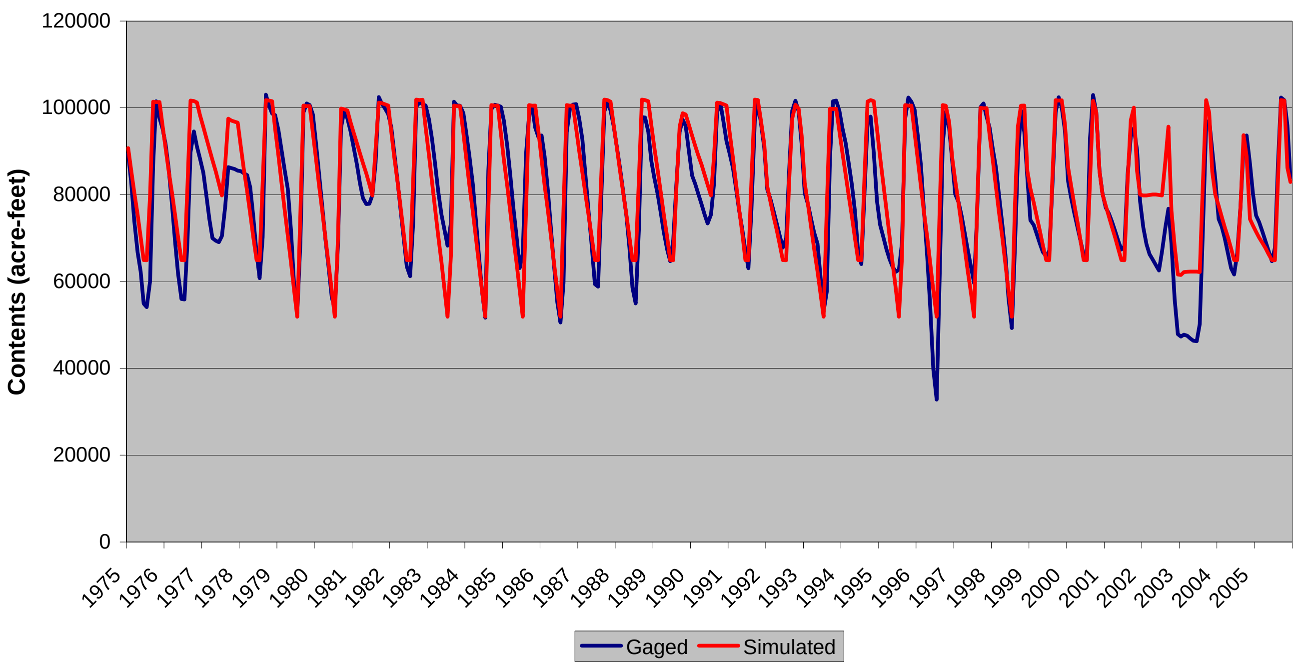


Figure D.28 Calculated Reservoir Simulation – Ruedi Reservoir

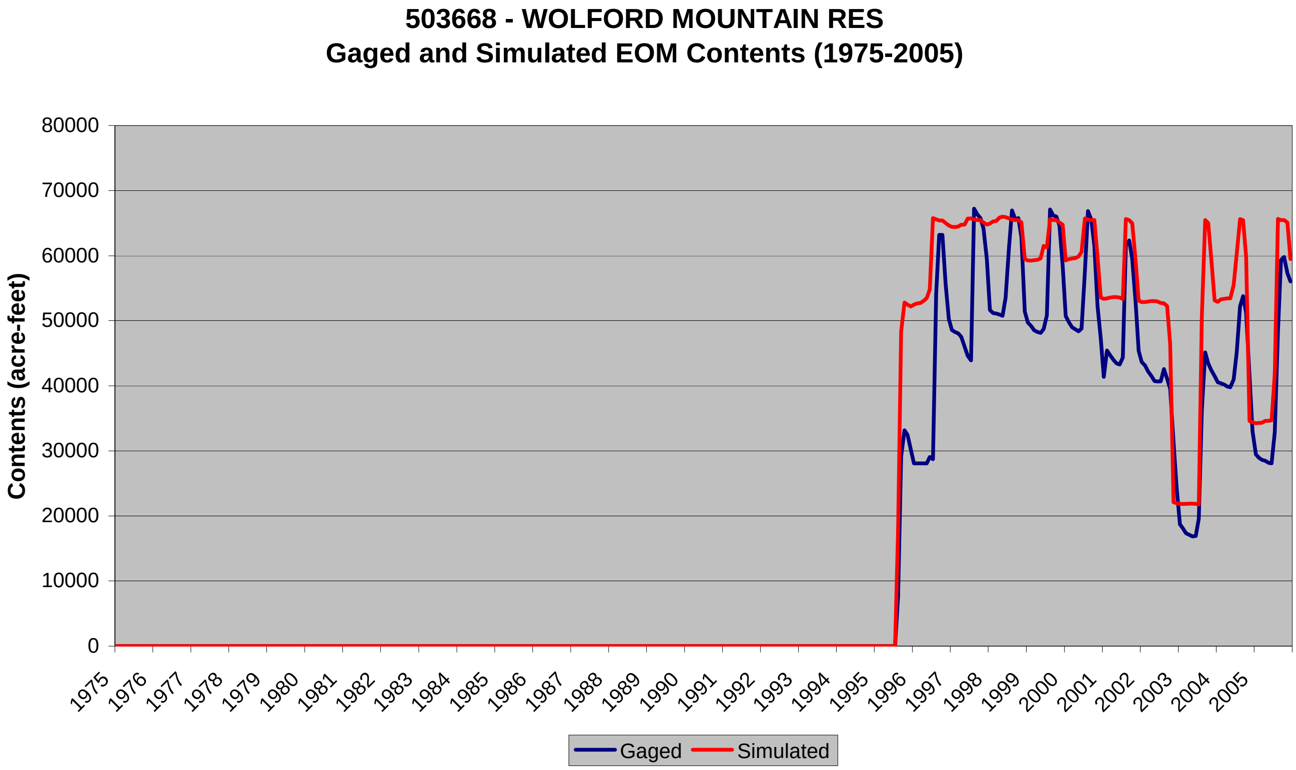


Figure D.29 Calculated Reservoir Simulation – Wolford Mountain Reservoir

Appendix E

Historical Daily Simulation Results

Historical Daily Data Set

Note: This section describes a Historical Daily Data Set that was completed in January 2007. The Upper Colorado Model Historical (calibration), Calculated and Baseline data files were updated in October 2009, and the 2009 calibration and Baseline data sets are described in this user manual. Inconsistencies between the 2008 and 2009 Historical Daily Data Set are minor, and include:

1) maximum irrigation efficiency set to 0.60 in 2008, and set to 0.54 in 2009
2) differences in IWR for fields below 6,500 ft in elevation, because an elevation adjustment was applied to crop coefficients in the Blaney-Criddle analysis in the 2009 model
3) updated baseline demands for several transbasin diversions, including Roberts Tunnel, Adams Tunnel, and Con-Hoosier Tunnel, and
4) revision to the representation of the Ute Water Conservancy District system.

The approach described for the Historical Daily Data Set is accurate, except for the items listed above. Table values in this appendix are expected to be similar to, but not exactly, what would be produced with an updated Historical Daily Data Set.

The “Historical Daily” data set is a data set that was created to run on a daily time-step. The Historical Daily data set simulates the historical demands, infrastructure and projects, and administrative environment. The purpose of the Historical Daily model data set is to capture daily variations in streamflow and call regime. The simulation period for the Historical Daily model is 1975 through 2005. This is the period for which diversion data, and associated irrigation efficiencies, are most complete.

The most difficult part of developing a basin model is understanding the system. By first developing a monthly model, the system operation was investigated without the volume of information ultimately required for a daily model. The Historical Daily model was developed to be able to simulate large and small flow events that occur within a monthly time-step. Therefore, although daily baseflows are used, other terms required for daily analysis, such as diversion demands and reservoir targets, are developed using a simplified approach.

Daily baseflows are estimated using StateMod’s Daily Pattern approach. StateMod calculates each day’s baseflow by disaggregating monthly baseflows using the daily pattern of flow at selected historical gages. These “pattern gages” are representative of baseflows in subbasins throughout the Colorado River basin. The selection and use of pattern gages is discussed in Section 8 Daily Baseline Results.

Historical Daily Data Set Calibration Efforts

The Historical Daily data set uses existing input from the Historical Calibration data set, with pattern gages used in the Daily Baseline data set. No additional calibration efforts were considered necessary for the Historical Daily Upper Colorado River Model.

Historical Daily Simulation Results

Simulation of the Historical Daily Upper Colorado River Model is considered good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. The basin-wide shortage in Colorado, determined to be simulated diversions divided by historical demand, is less than 4 percent per year, on average. Simulated reservoir contents are representative of historical values.

Water Balance Results

Table E.1 summarizes the water balance for the Historical Daily Upper Colorado River Model, for the calibration period (1975-2005). Following are observations based on the summary table:

- Surface water inflow to the basin averages 5.65 million acre-feet per year, and stream outflow averages 4.64 million acre-feet per year.

- Annual diversions amount to approximately 4.52 million acre-feet on average.

- Approximately 989,900 acre-feet per year is consumed in the Historical Daily simulation. Note that this value is representative of the basin-wide consumptive use and losses, and includes crop consumptive use, municipal and industrial consumptive use, reservoir evaporation, and 100 percent of exports from the basin.

- The column labeled “Inflow – Outflow” represents the net result of gain (inflow, return flows, and negative change in reservoir and soil moisture contents) less outflow terms (diversions, outflow, evaporation, and positive changes in storage). The small values are due to rounding on a daily basis, and indicate that the model correctly conserves mass.

Table E.1
Average Annual Water Balance for Historical Daily Simulation 1975–2005 (af/yr)

Month	Stream Inflow	Return	From Soil Moisture	Total Inflow	Diversions	Resvr Evap	Stream Outflow	Resvr Change	To Soil Moisture	Soil Moisture Change	Total Outflow	Inflow - Outflow	CU
OCT	264,547	340,151	1,589	606,287	373,874	2,524	264,006	-35,694	2,942	-1,353	606,298	-11	39,792
NOV	199,000	191,964	50	391,015	176,354	539	246,379	-32,286	827	-777	391,037	-22	25,662
DEC	185,276	214,178	0	399,453	214,564	-929	225,759	-39,907	441	-441	399,486	-33	31,518
JAN	178,357	202,846	0	381,203	211,651	-878	212,278	-41,858	314	-314	381,194	9	31,780
FEB	173,751	178,150	0	351,902	191,910	187	195,575	-35,766	247	-247	351,906	-5	28,637
MAR	235,762	187,036	698	423,495	205,774	1,482	250,906	-35,358	410	287	423,502	-7	31,552
APR	405,783	243,411	2,607	651,800	304,450	3,213	341,020	529	2,768	-162	651,818	-18	42,861
MAY	1,181,351	361,333	5,247	1,547,931	544,044	7,096	854,937	136,615	9,230	-3,983	1,547,937	-6	127,426
JUN	1,471,198	443,881	5,752	1,920,831	723,499	10,167	1,007,830	173,632	6,448	-697	1,920,880	-50	229,064
JUL	741,376	433,481	11,659	1,186,517	631,522	9,648	531,609	2,342	1,665	9,994	1,186,780	-264	198,168
AUG	343,777	384,838	8,960	737,576	502,991	6,944	266,115	-47,221	2,226	6,734	737,790	-214	127,684
SEP	271,133	368,541	4,450	644,124	440,417	4,656	242,187	-47,469	2,935	1,515	644,242	-118	75,801
AVG	5,651,306	3,549,808	41,012	9,242,136	4,521,049	44,648	4,638,602	-2,441	30,455	10,558	9,242,867	-738	989,945

Note: Consumptive Use (CU) = Diversion (Divert) * Efficiency + Reservoir Evaporation (Evap)

Streamflow Results

Table E.2 summarizes the average annual streamflow for water years 1975 through 2005, as estimated in the Historical Daily simulation. It also shows average annual values of actual gage records for comparison. Both numbers are based only on years for which gage data are complete. Calibration based on streamflow simulation is generally very good in terms of both annual volume and monthly pattern. In general, the daily simulation produces slightly poorer calibration on the mainstem and smaller tributaries.

Temporal variability of the Historical Daily simulated flows are illustrated in Figures E.1 through E.45 for three selected years for each of the daily pattern gages and for eight additional downstream gages: Colorado River near Granby, Fraser River at Winter Park, Williams Fork River below Williams Fork Reservoir, Blue River below Green Mountain Reservoir, Eagle River below Gypsum, Roaring Fork River at Glenwood Springs, Plateau Creek near Cameo, and Colorado River near Colorado-Utah State Line. The selected years represent wet (1984), average (2000) and dry (1977) years in the Colorado River basin. The historical gaged streamflow is shown on these graphs for comparison. As shown, daily simulated streamflow represents the daily large and small flow events that occur within a monthly time-step.

As with the monthly historical simulation, daily historical simulation of streamflows on Williams Fork below Williams Fork Reservoir and Blue River below Green Mountain Reservoir accurately model annual volume, but the monthly patterns vary from gaged. Williams Fork and Green Mountain Reservoirs are modeled using forecasting curves provided by the Denver Water Board and USBR that are intended to mimic hydropower and other operations. It appears that the rule curves are used only as guidelines and decisions based on other factors drive actual operations.

Table E.2
Historical and Simulated Average Annual Streamflow Volumes (1975-2005)
Historical Daily Simulation (acre-feet/year)

Gage ID	Historical	Simulated	Historical -Simulated Volume	Historical -Simulated Percent	Gage Name
09010500	45,792	45,908	-115	0%	Colorado R Below Baker Gulch, Nr Grand Lake, CO.
09011000	57,764	59,082	-1,318	-2%	Colorado River Near Grand Lake, CO.
09019500	39,532	39,262	270	1%	Colorado River Near Granby
09021000	31,132	33,475	-2,343	-8%	Willow Creek Below Willow Creek Reservoir
09024000	13,309	15,366	-2,058	-15%	Fraser River At Winter Park
09025000	10,289	11,701	-1,412	-14%	Vasquez Creek At Winter Park, CO.
09026500	15,221	15,712	-491	-3%	St. Louis Creek Near Fraser, CO.
09032000	8,860	9,979	-1,118	-13%	Ranch Creek Near Fraser, CO.
09032499	8,064	8,064	0	0%	Meadow Creek Reservoir Inflow
09032500	-999	-999	-999	0%	Ranch Creek Near Tabernash, CO.
09033500	-999	-999	-999	0%	Strawberry Creek Near Granby, CO.
09034250	183,828	189,672	-5,844	-3%	Colorado River At Windy Gap, Near Granby, CO.
09034500	168,786	178,409	-9,622	-6%	Colorado River At Hot Sulphur Springs, CO.
09034800	-999	-999	-999	0%	Little Muddy Creek Near Parshall, CO.
09034900	7,564	7,564	0	0%	Bobtail Creek Near Jones Pass, CO.
09035500	14,124	14,673	-549	-4%	Williams Fork Below Steelman Creek, CO.
09036000	72,517	73,067	-549	-1%	Williams Fork River Near Leal, Co
09037500	79,248	79,963	-715	-1%	Williams Fork River Near Parshall, Co
09038500	92,719	93,701	-983	-1%	Williams Fork River Below Williams Fork Reservoir
09039000	22,365	22,689	-324	-1%	Troublesome Creek Near Pearmont, CO.
09040000	22,498	23,143	-645	-3%	East Fork Troublesome C Near Troublesome, CO.
09041000	49,395	49,803	-408	-1%	Muddy Creek Near Kremmling, CO.
09041200	-999	-999	-999	0%	Red Dirt Creek Near Kremmling, CO.
09041500	66,565	66,595	-30	0%	Muddy Creek At Kremmling, CO.
09046600	69,345	69,415	-70	0%	Blue River Near Dillon, CO.
09047500	45,449	45,467	-18	0%	Snake River Near Montezuma, CO.
09050100	75,063	75,213	-151	0%	Tenmile Creek Below North Tenmile Creek At Frisco
09050700	146,624	146,729	-105	0%	Blue River Below Dillon Reservoir
09052800	18,677	18,677	0	0%	Slate Creek At Upper Station, Near Dillon, CO.
09053500	312,566	321,786	-9,220	-3%	Blue River Above Green Mountain Reservoir, CO.
09054000	22,776	22,776	0	0%	Black Creek Below Black Lake, Near Dillon, CO.
09055300	14,558	14,558	0	0%	Cataract Creek Near Kremmling, CO.
09057500	301,300	299,947	1,353	0%	Blue River Below Green Mountain Reservoir
09058000	718,265	733,831	-15,566	-2%	Colorado River Near Kremmling
09060500	24,031	23,754	277	1%	Rock Creek Near Toponas, CO.
09060700	-999	-999	-999	0%	Egeria Creek Near Toponas, CO.
09063000	28,262	28,408	-146	-1%	Eagle River At Red Cliff, CO.
09064000	19,824	20,152	-328	-2%	Homestake Creek At Gold Park, CO.
09065100	37,802	37,802	0	0%	Cross Creek Near Minturn
09065500	22,232	22,232	0	0%	Gore Creek At Upper Station, Near Minturn, CO.
09067300	-999	-999	-999	0%	Alkali Creek Near Wolcott, CO.
09068000	-999	-999	-999	0%	Brush Creek Near Eagle, CO.
09069500	-999	-999	-999	0%	Gypsum Creek Near Gypsum, CO.

Gage ID	Historical	Simulated	Historical -Simulated Volume	Percent	Gage Name
09070000	407,419	407,904	-486	0%	Eagle River Below Gypsum
09070500	1,455,699	1,473,808	-18,109	-1%	Colorado River Near Dotsero
09071300	9,755	9,751	4	0%	Grizzly Creek Near Glenwood Springs, CO.
09072500	-999	-999	-999	0%	Colorado River At Glenwood Springs, CO.
09073400	71,114	73,508	-2,395	-3%	Roaring Fork River Near Aspen
09074000	30,203	30,615	-412	-1%	Hunter Creek Near Aspen
09074800	31,675	31,675	0	0%	Castle Creek Above Aspen, CO.
09075700	50,076	50,076	0	0%	Maroon Creek Above Aspen, CO.
09078600	76,881	80,102	-3,221	-4%	Fryingpan River Near Thomasville
09080400	123,912	126,800	-2,887	-2%	Fryingpan River Near Ruedi
09080800	-999	-999	-999	0%	West Sopris Creek Near Basalt, CO.
09081600	215,575	215,575	0	0%	Crystal River Above Avalanche Creek Near Redstone
09082800	10,923	10,923	0	0%	North Thompson Creek Near Carbondale, CO.
09084000	-999	-999	-999	0%	Cattle Creek Near Carbondale, CO.
09084600	-999	-999	-999	0%	Fourmile Creek Near Glenwood Springs, CO.
09085000	860,602	871,066	-10,463	-1%	Roaring Fork River At Glenwood Springs
09085100	2,370,982	2,399,756	-28,774	-1%	Colorado River Below Glenwood Springs
09085200	40,635	40,791	-156	0%	Canyon Creek Above New Castle, CO.
09087500	-999	-999	-999	0%	Elk Creek At New Castle, CO.
09088000	-999	-999	-999	0%	Baldy Creek Near New Castle
09089500	30,280	30,280	0	0%	West Divide Creek Near Raven
09090700	-999	-999	-999	0%	East Divide Creek Near Silt, CO.
09091500	-999	-999	-999	0%	East Rifle Creek Near Rifle, CO.
09092500	3,591	3,571	21	1%	Beaver Creek Near Rifle
09092600	-999	-999	-999	0%	Battlement Creek Near Parachute
09093000	35,518	35,467	52	0%	Parachute Creek Near Parachute CO.
09093500	22,997	23,007	-9	0%	Parachute Creek At Parachute, CO.
09093700	2,816,135	2,845,167	-29,032	-1%	Colorado River Near De Beque
09095000	38,970	39,564	-594	-2%	Roan Creek Near De Beque, CO.
09095500	2,726,210	2,759,528	-33,319	-1%	Colorado River Near Cameo
09096500	22,259	24,413	-2,153	-10%	Plateau Creek Near Collbran, CO.
09097500	30,446	31,150	-704	-2%	Buzzard Creek Near Collbran
09100500	-999	-999	-999	0%	Cottonwood Creek At Upper Sta, Near Molina, CO.
09104500	-999	-999	-999	0%	Mesa Creek Near Mesa, CO.
09105000	154,723	154,078	645	0%	Plateau Creek Near Cameo
09152500	1,841,072	1,841,070	2	0%	Gunnison River Near Grand Junction
09163500	4,585,370	4,639,450	-54,080	-1%	Colorado River Near Colorado-Utah State Line

Diversion Results

Table E.3 summarizes the average annual simulated diversions, by tributary or sub-basin in Colorado, compared to historical diversions for water years 1975 through 2005. On a basin-wide basis, average annual diversions differ from historical diversions by about 4 percent in the daily calibration run. The tributaries showing the greatest simulated variance from historical diversions are also the problematic tributaries in the monthly historical simulation.

Table E.3
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2005)
Historical Daily Simulation (acre-feet/year)

			Historical minus Simulated	
Tributary or Sub-basin	**Historical**	**Simulated**	**Volume**	**Percent**
Colorado Main Stem	3,090,881	2,988,223	102,658	3%
Fraser River	83,553	78,107	5,446	7%
Williams Fork River	41,297	40,051	1,246	3%
Blue River	157,539	152,062	5,476	3%
Eagle River	121,772	117,515	4,258	3%
Roaring Fork River	454,984	425,140	29,844	7%
Plateau Creek	132,689	123,452	9,237	7%
Basin Total	**4,082,716**	**3,924,550**	**158,166**	**4%**

Reservoir Results

Figures E.46 through E.60 (located at the end of this chapter) present reservoir EOM contents estimated by the Historical Daily model simulation compared to historical observations at selected reservoirs. Simulated reservoir end-of-month contents using a daily time-step are very close to simulations using a monthly time-step. The issues identified in Section 7.4.4 are valid on a daily time-step.

Consumptive Use Results

Crop consumptive use is estimated by StateMod and reported in the consumptive use summary file (*.xcu) for each diversion structure in the scenario. This file also includes consumptive use for municipal and industrial diversions. The crop consumptive use estimated by StateCU is reported in the water supply-limited summary file (*.wsl) for each agricultural diversion structure in the basin. Therefore, to provide a one-to-one comparison, only structures in the StateCU analysis are included.

Table E.4 shows the comparison of StateCU estimated crop consumptive use compared to StateMod estimate of crop consumptive use for explicit structures, aggregate structures, and basin total. As shown, both explicit and aggregate structure consumptive use match StateCU results very well. Historical diversions are used by StateCU to estimate supply-limited (actual) consumptive use. The 4 percent difference represents the overall basin diversion shortages simulated by the model.

Table E.4
Average Annual Crop Consumptive Use Comparison (1975-2005)

Comparison	StateCU Results (af/yr)	Daily Run Results (af/yr)	% Difference
Explicit Structures	309,868	297,255	4%
Aggregate Structures	144,444	139,181	4%
Basin Total	454,321	436,436	4%

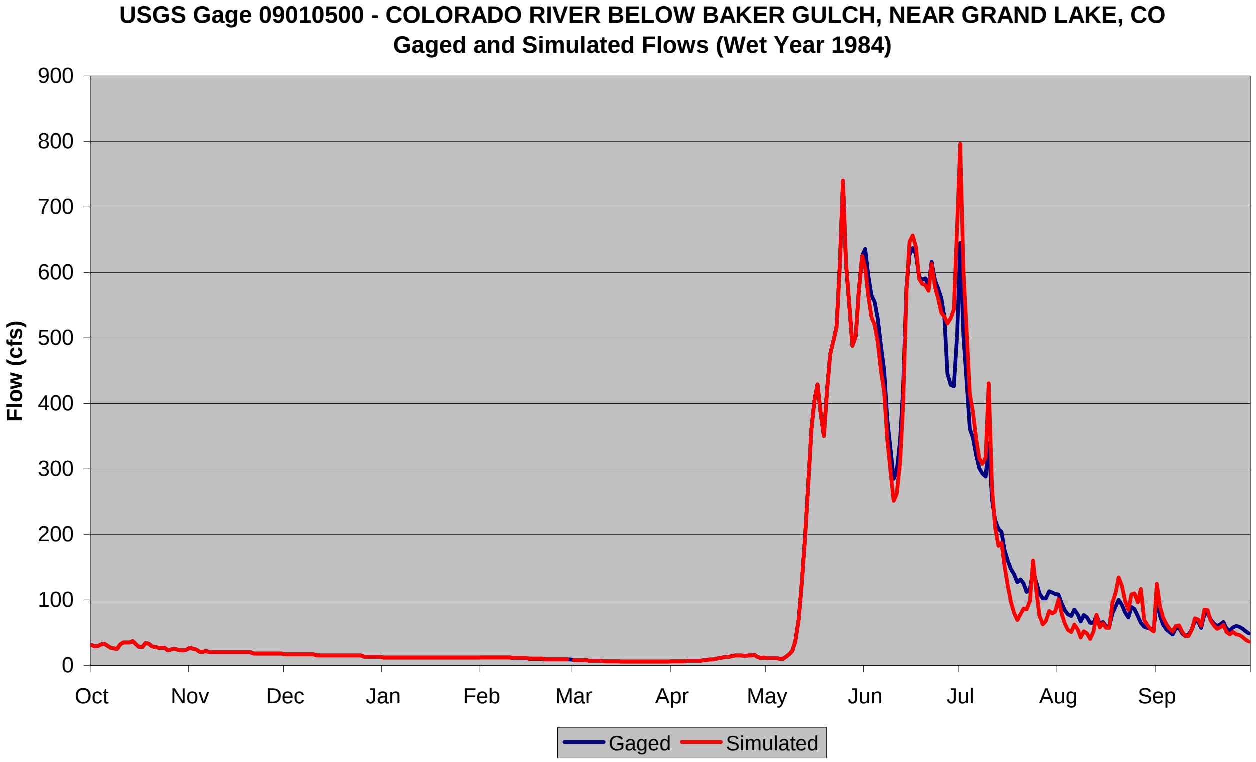


Figure E.1 Historical Daily Comparison, Wet Year – Colorado River below Baker Gulch, near Grand Lake, CO

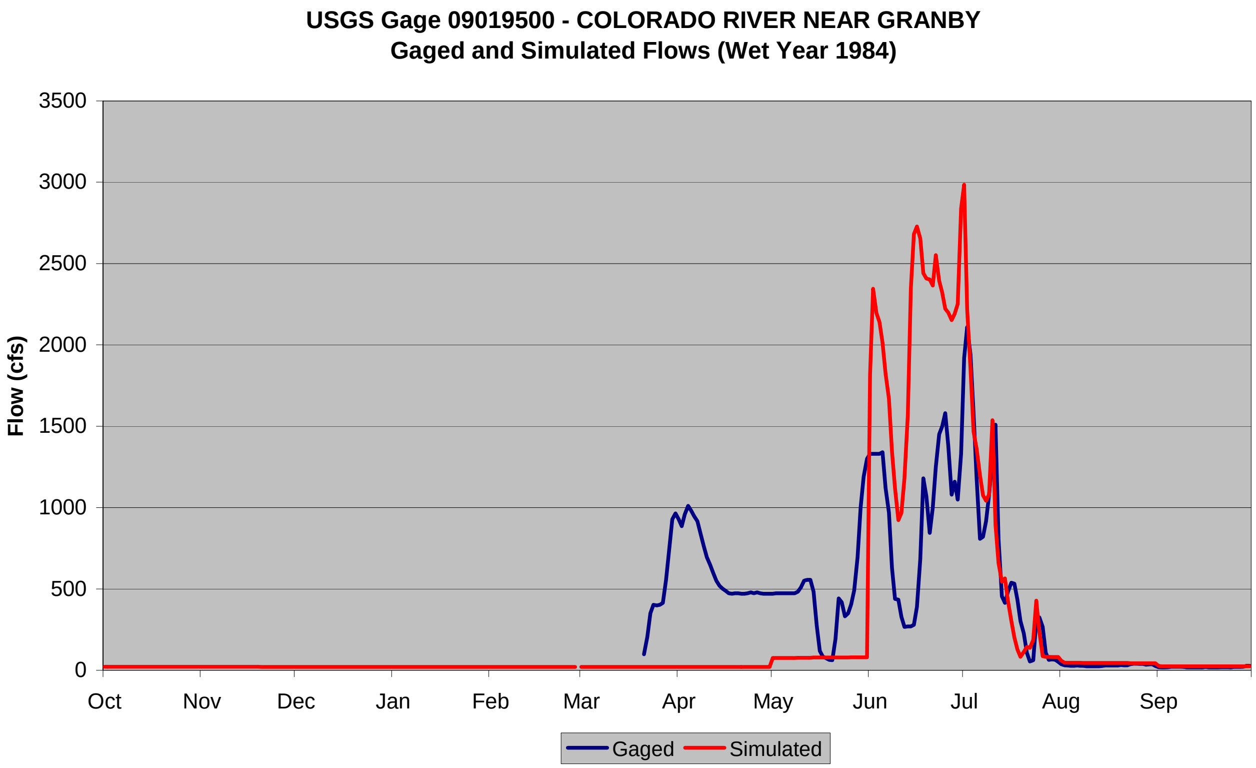


Figure E.2 Historical Daily Comparison, Wet Year – Colorado River near Granby

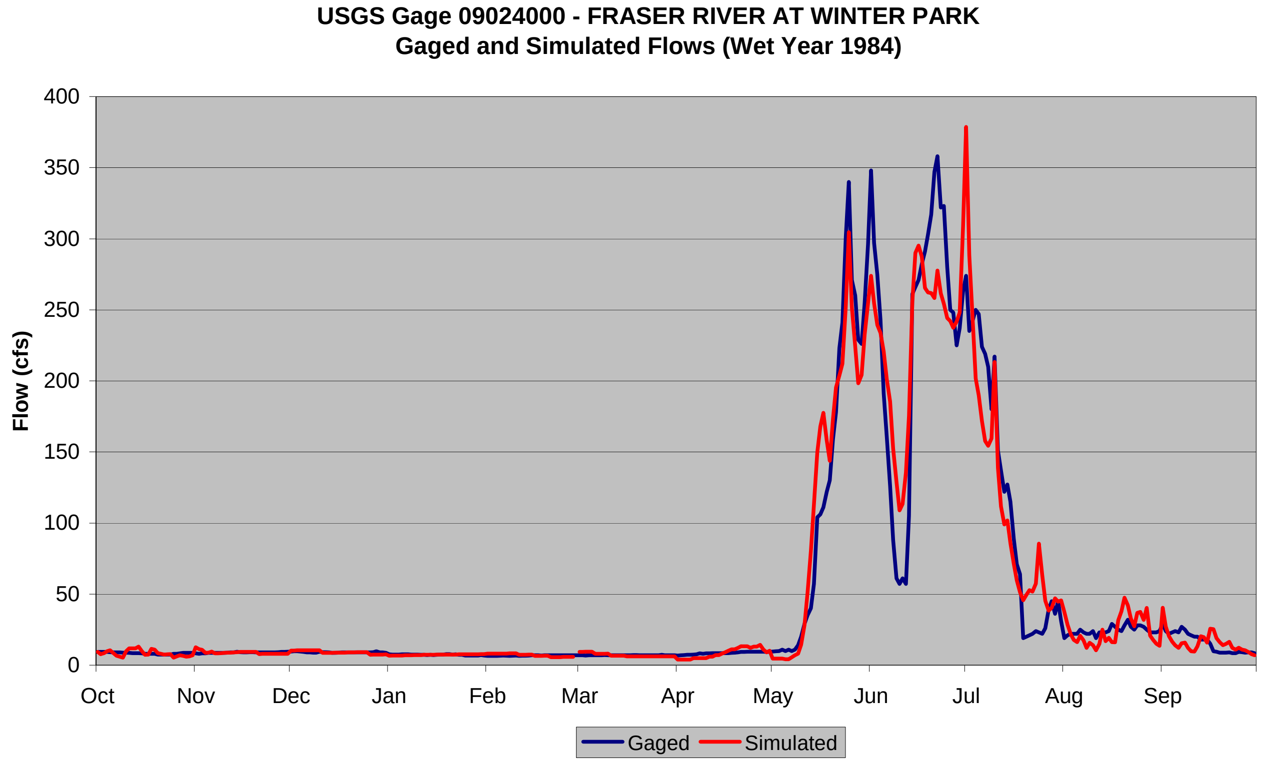


Figure E.3 Historical Daily Comparison, Wet Year – Fraser River at Winter Park

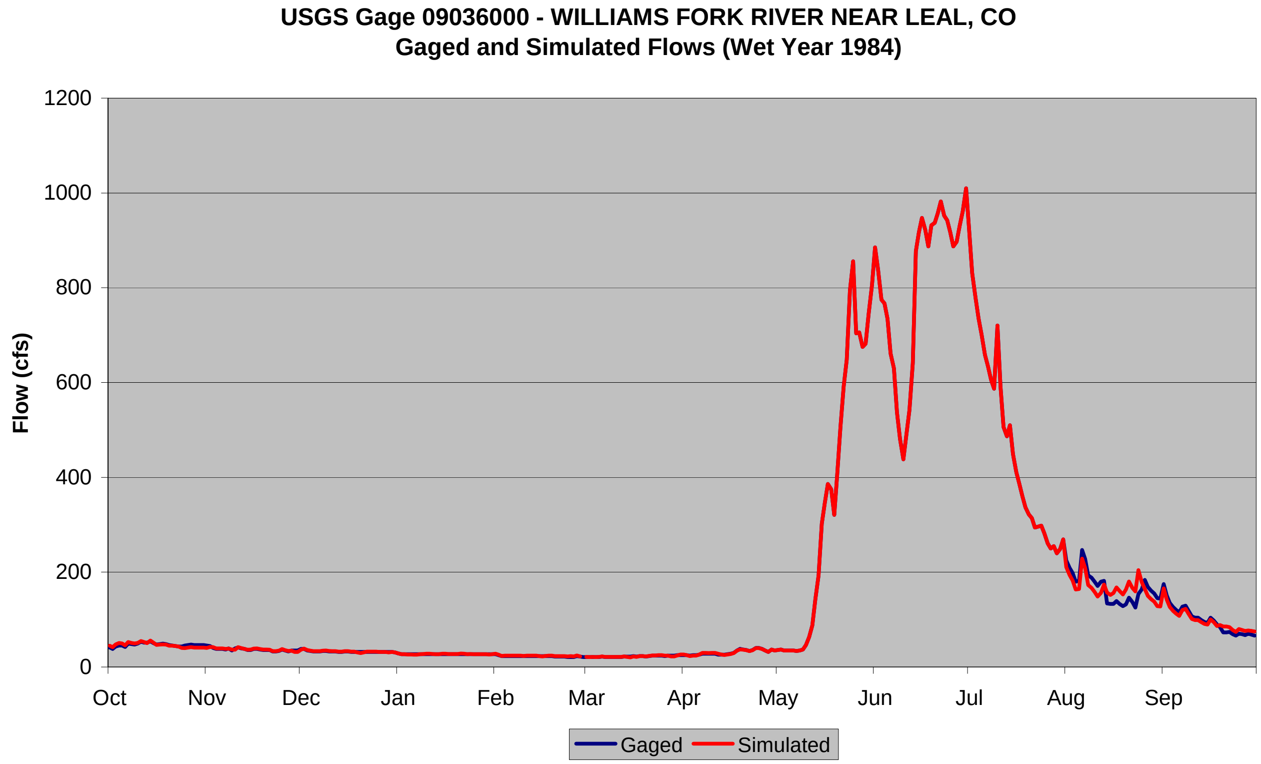


Figure E.4 Historical Daily Comparison, Wet Year – Williams Fork River near Leal, CO

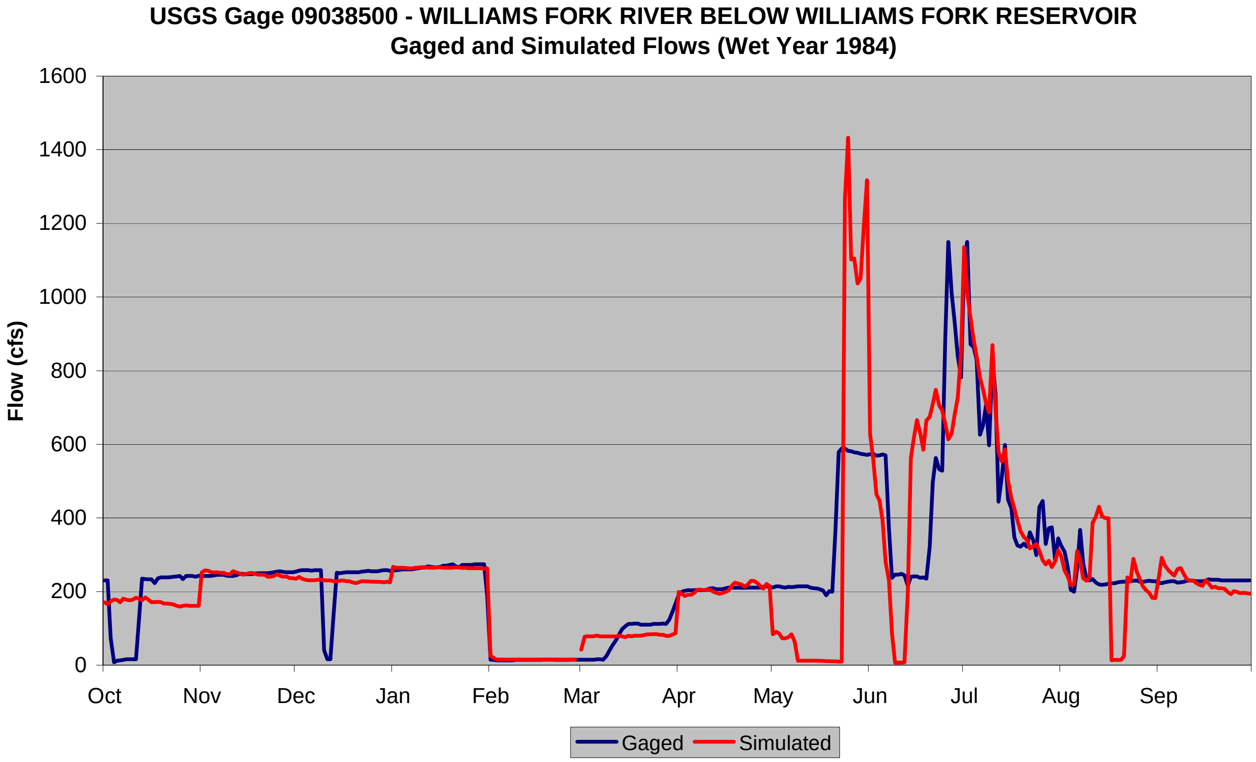


Figure E.5 Historical Daily Comparison, Wet Year – Williams Fork River below Williams Fork Reservoir

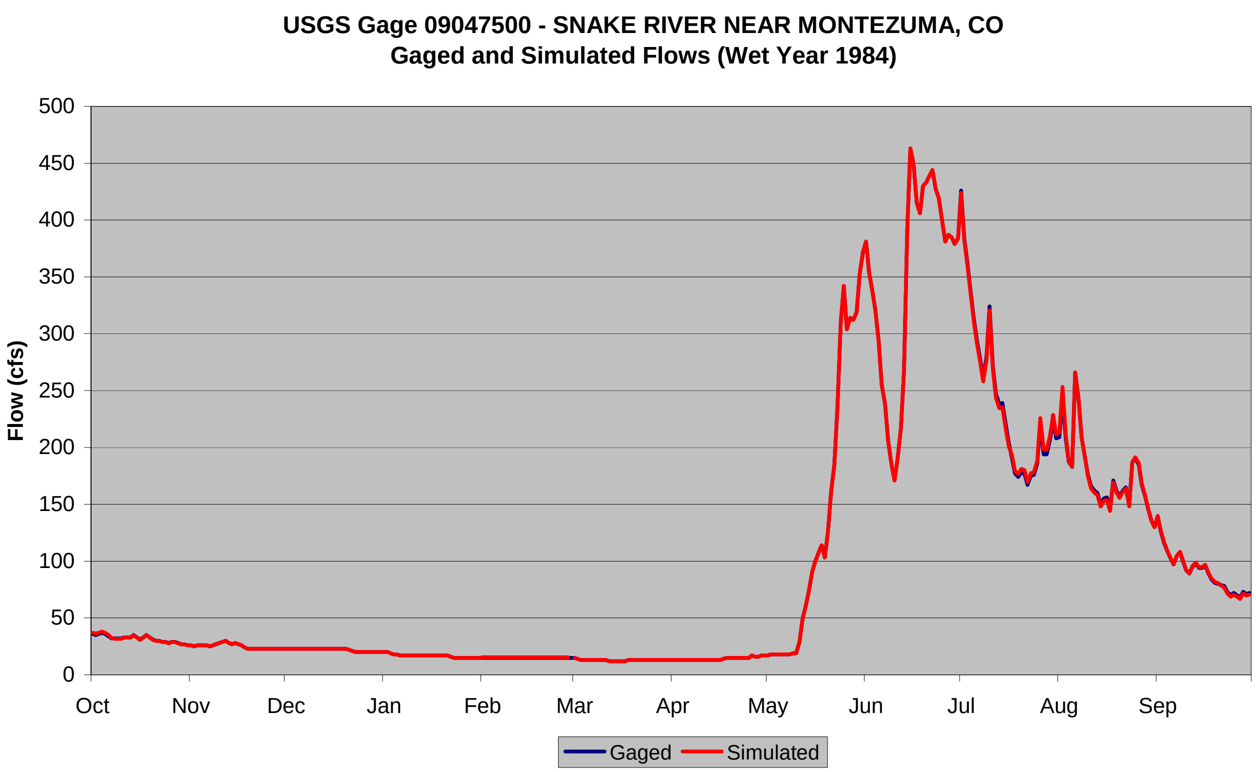


Figure E.6 Historical Daily Comparison, Wet Year – Snake River near Montezuma, CO

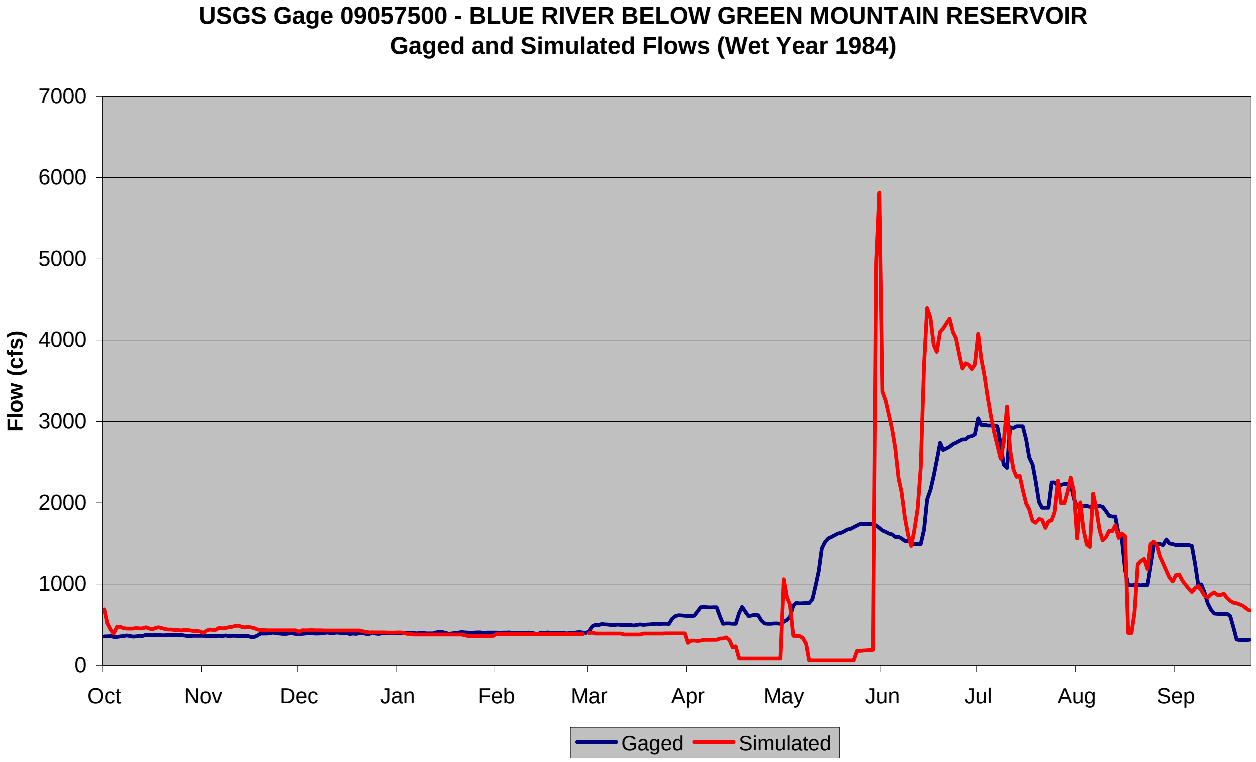


Figure E.7 Historical Daily Comparison, Wet Year – Blue River below Green Mountain Reservoir

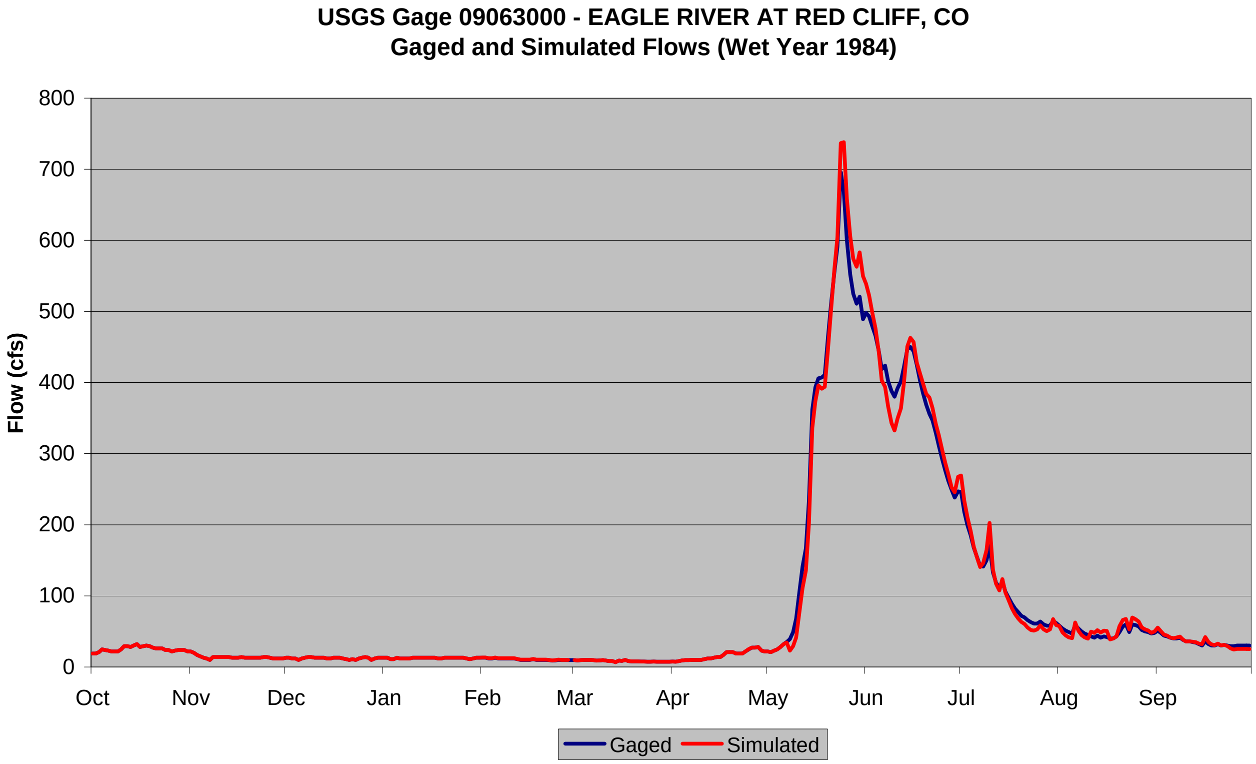


Figure E.8 Historical Daily Comparison, Wet Year – Eagle River at Red Cliff, CO

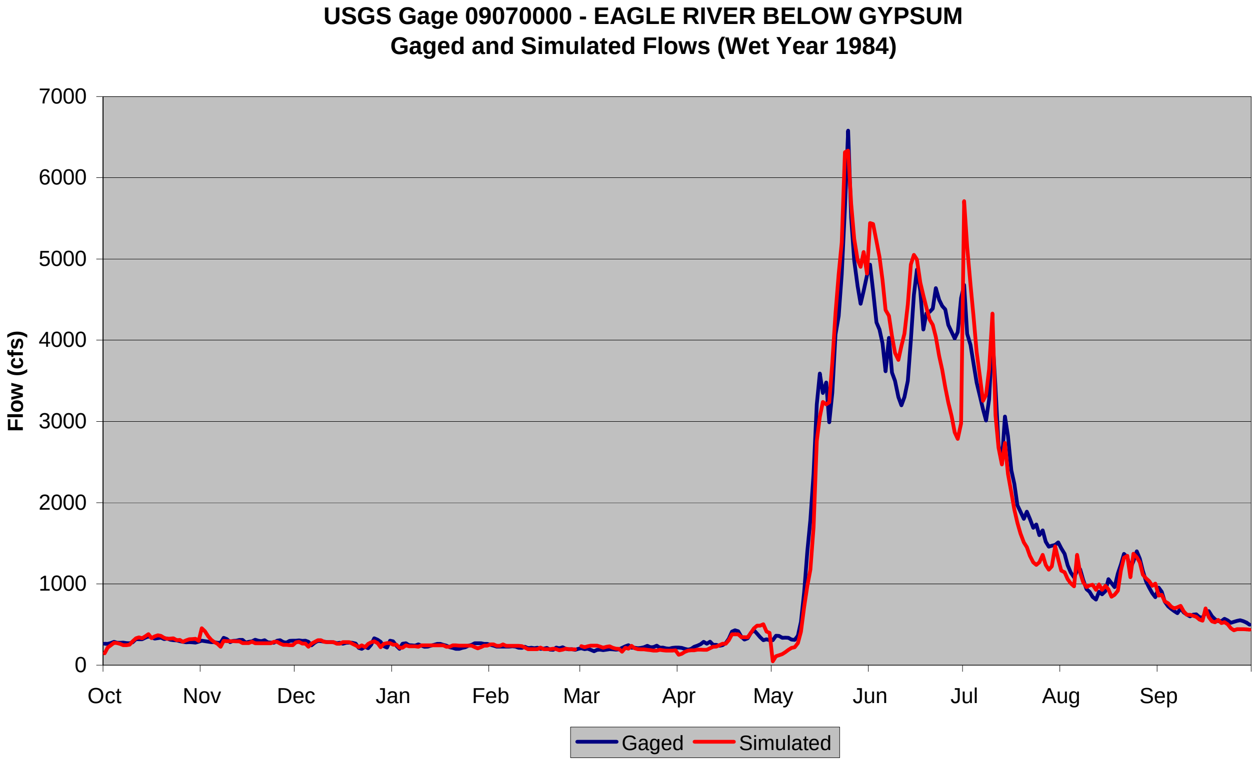


Figure E.9 Historical Daily Comparison, Wet Year – Eagle River below Gypsum

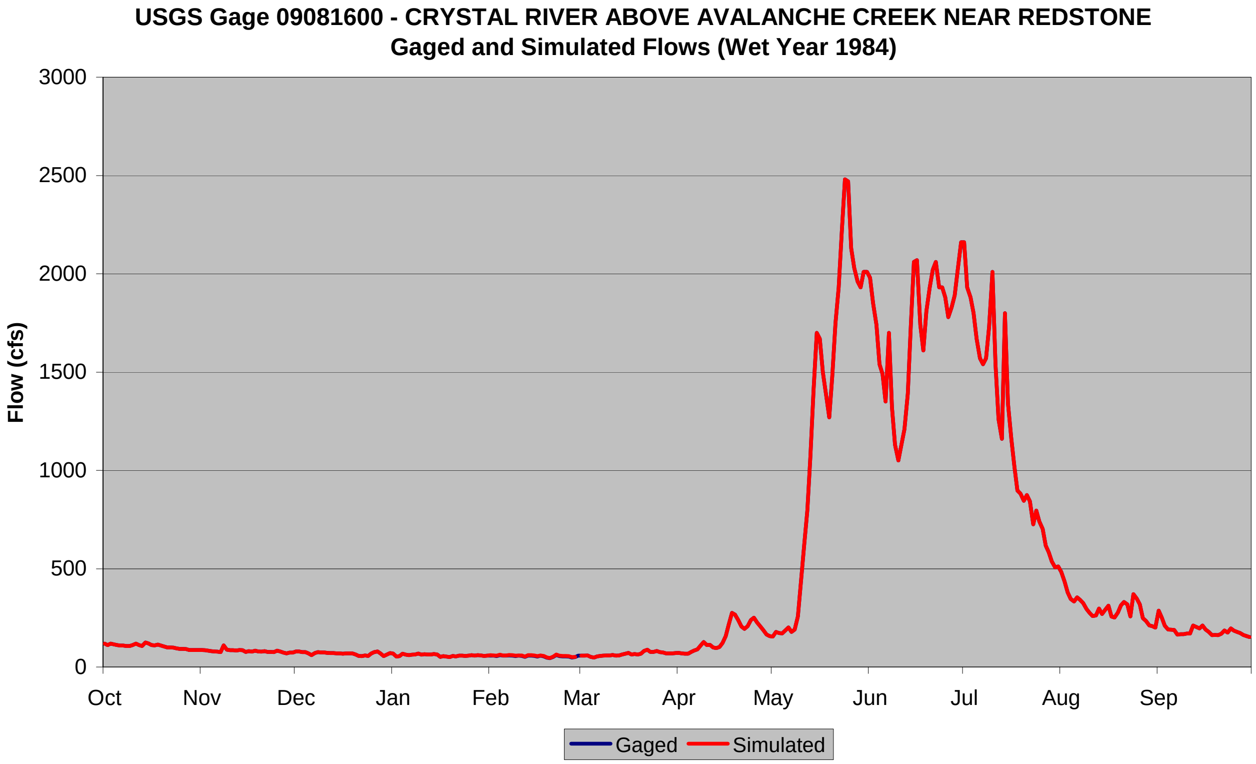


Figure E.10 Historical Daily Comparison, Wet Year – Crystal River above Avalanche Creek near Redstone

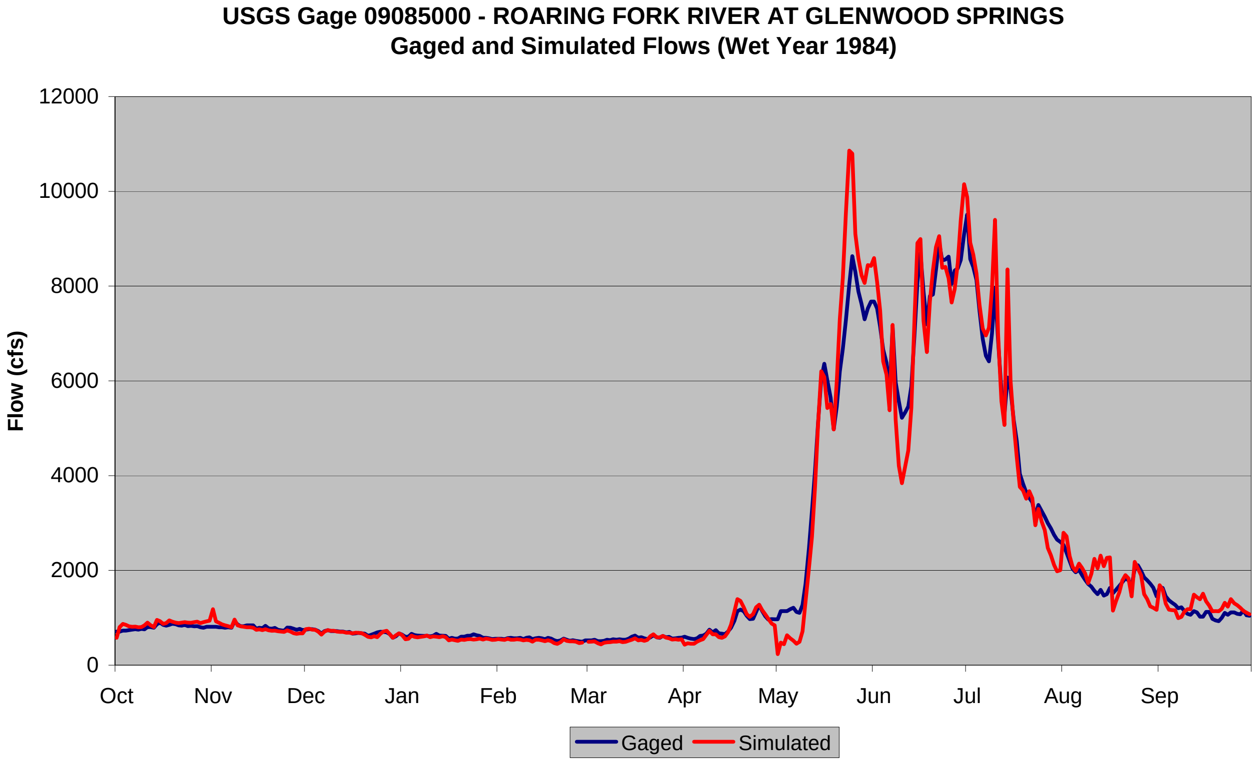


Figure E.11 Historical Daily Comparison, Wet Year – Roaring Fork River at Glenwood Springs

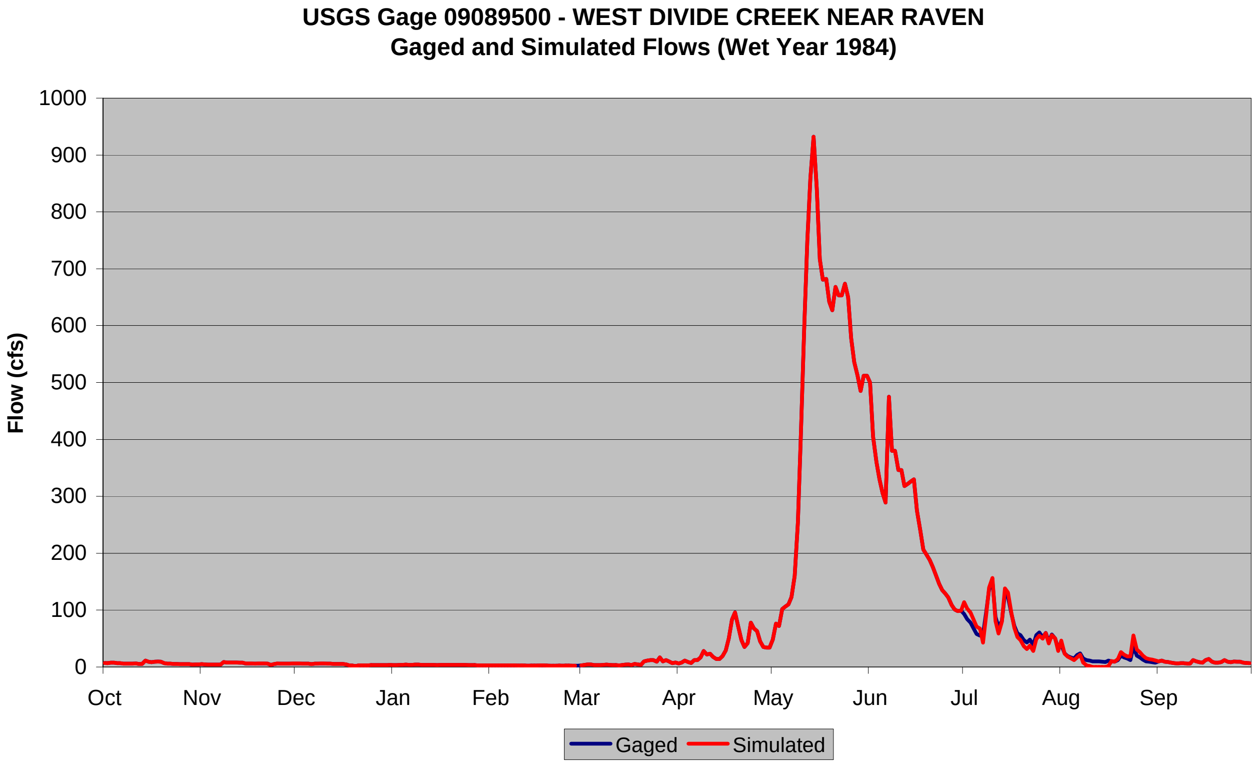


Figure E.12 Historical Daily Comparison, Wet Year – West Divide Creek near Raven

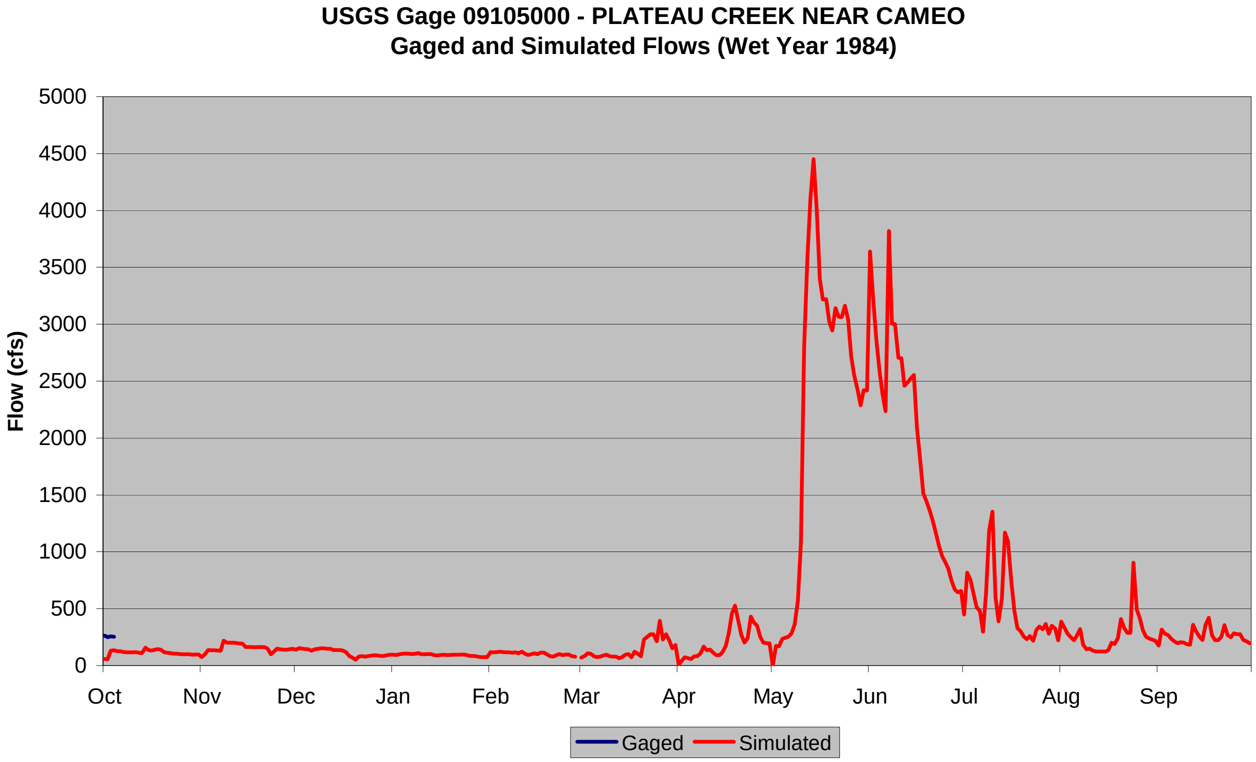


Figure E.13 Historical Daily Comparison, Wet Year – Plateau Creek near Cameo

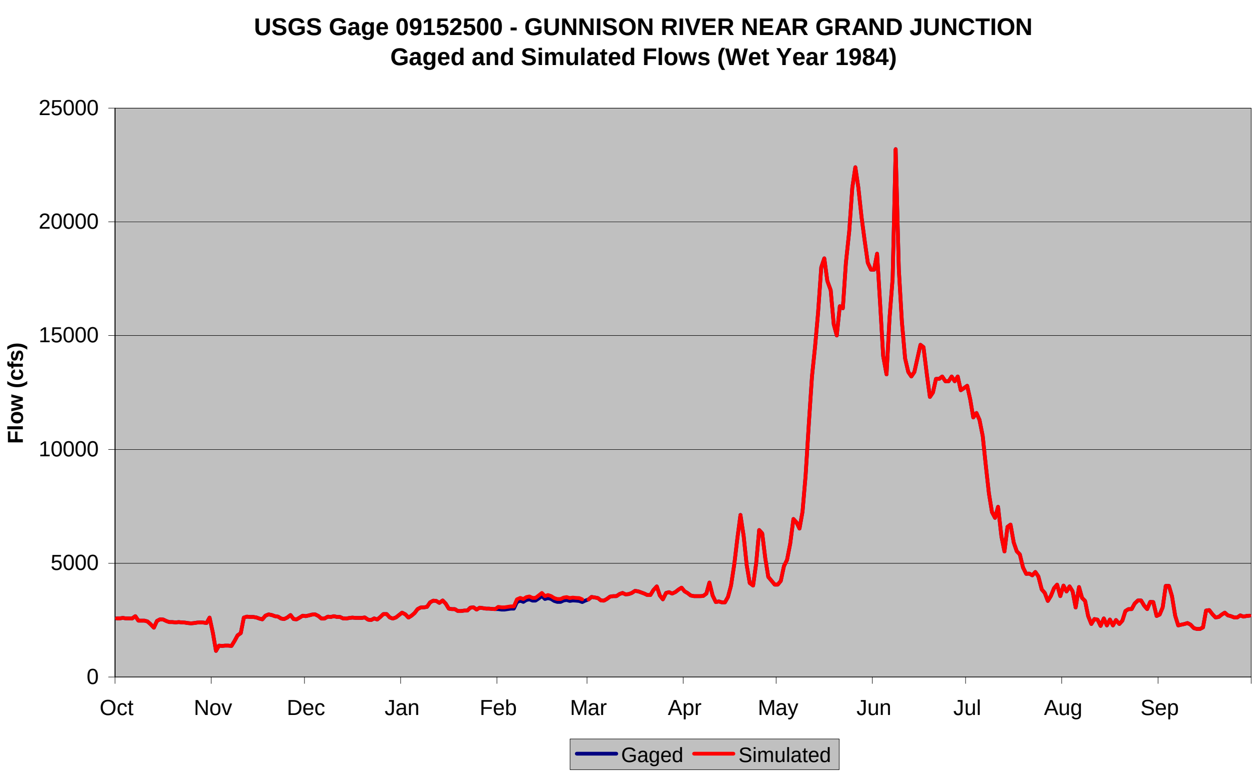


Figure E.14 Historical Daily Comparison, Wet Year – Gunnison River near Grand Junction

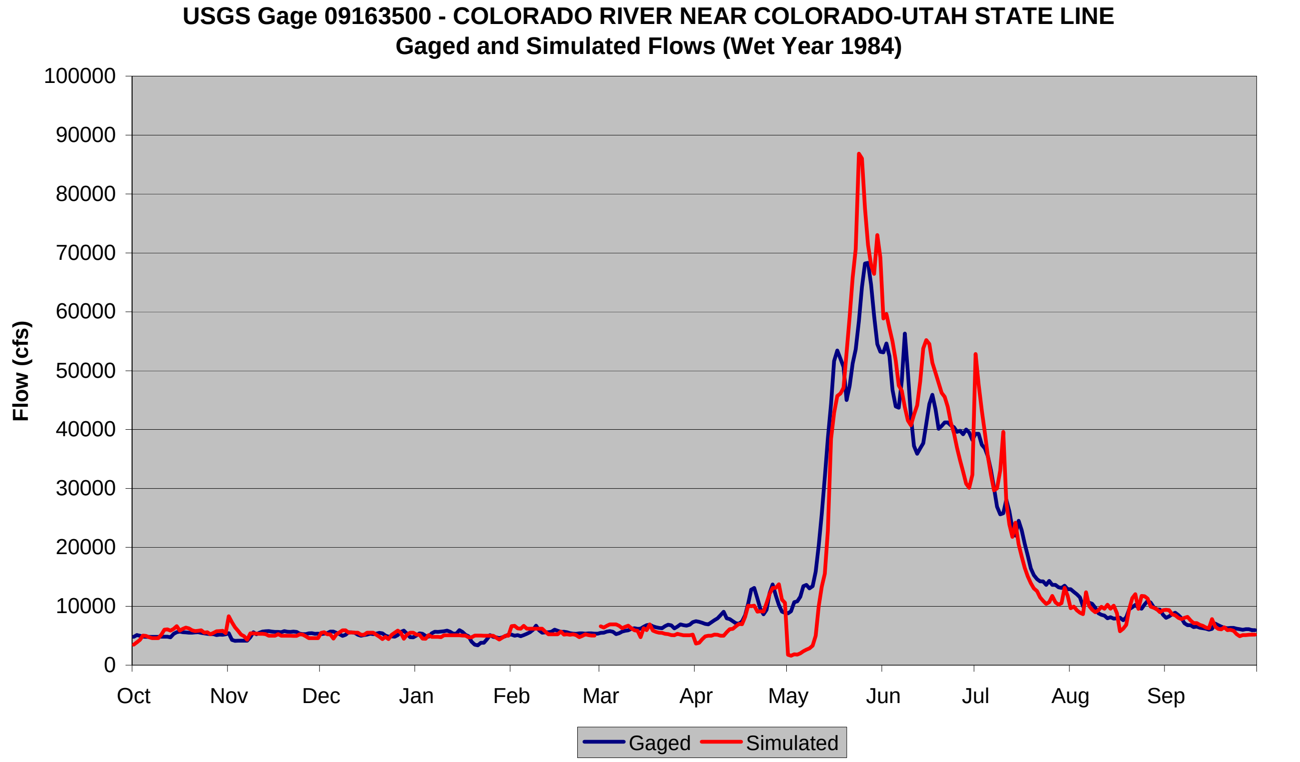


Figure E.15 Historical Daily Comparison, Wet Year – Colorado River near Colorado-Utah State Line

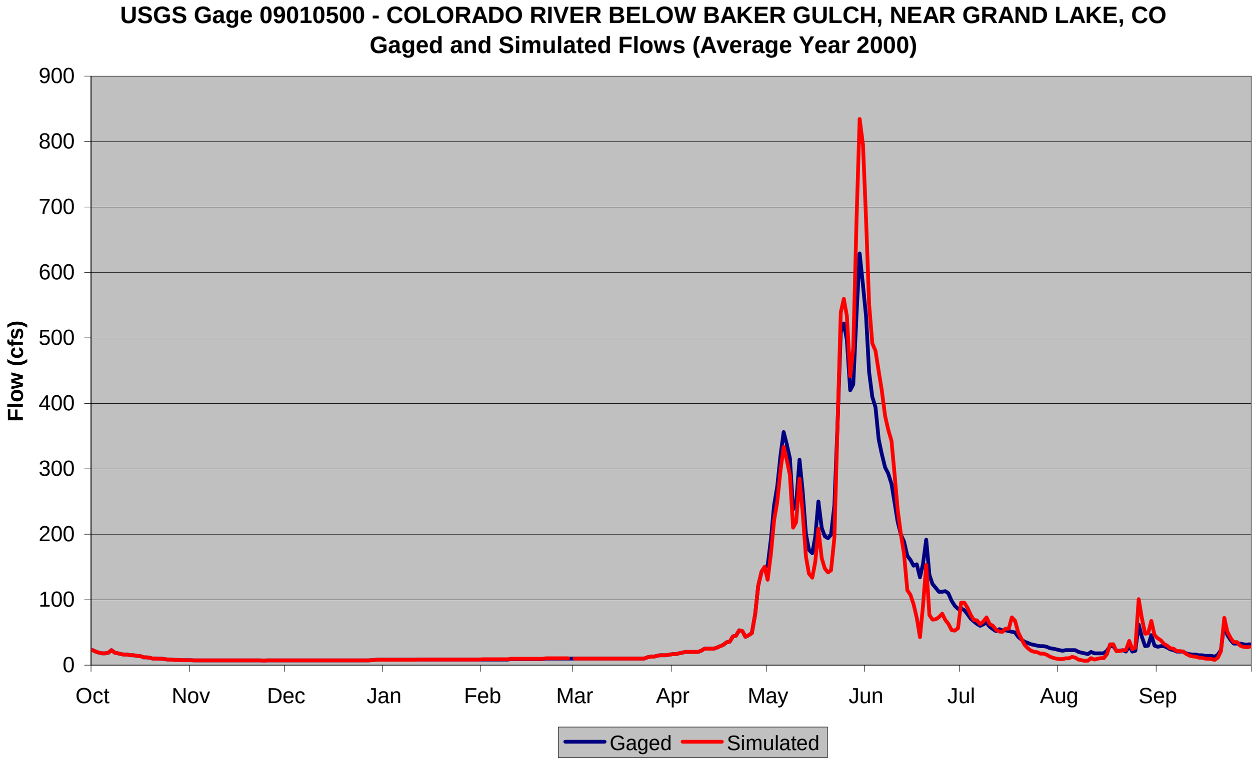


Figure E.16 Historical Daily Comparison, Average Year – Colorado River below Baker Gulch, near Grand Lake, CO

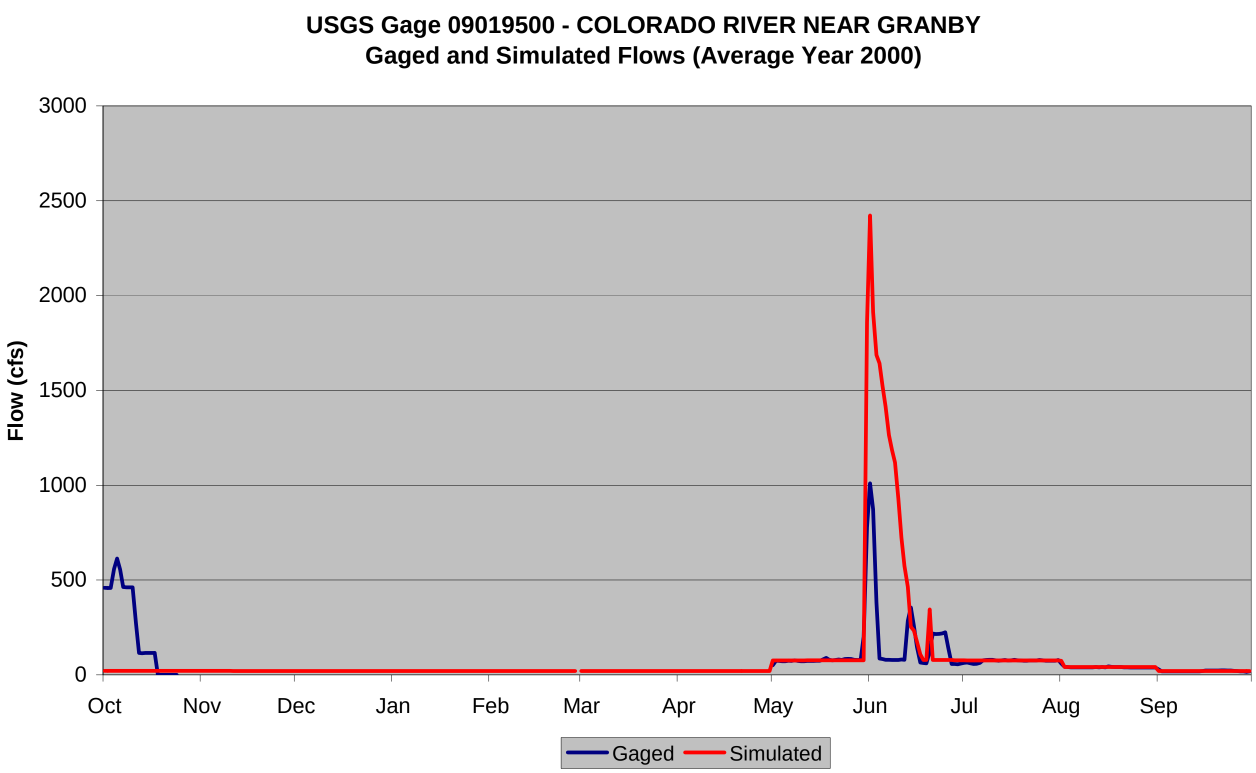


Figure E.17 Historical Daily Comparison, Average Year – Colorado River near Granby

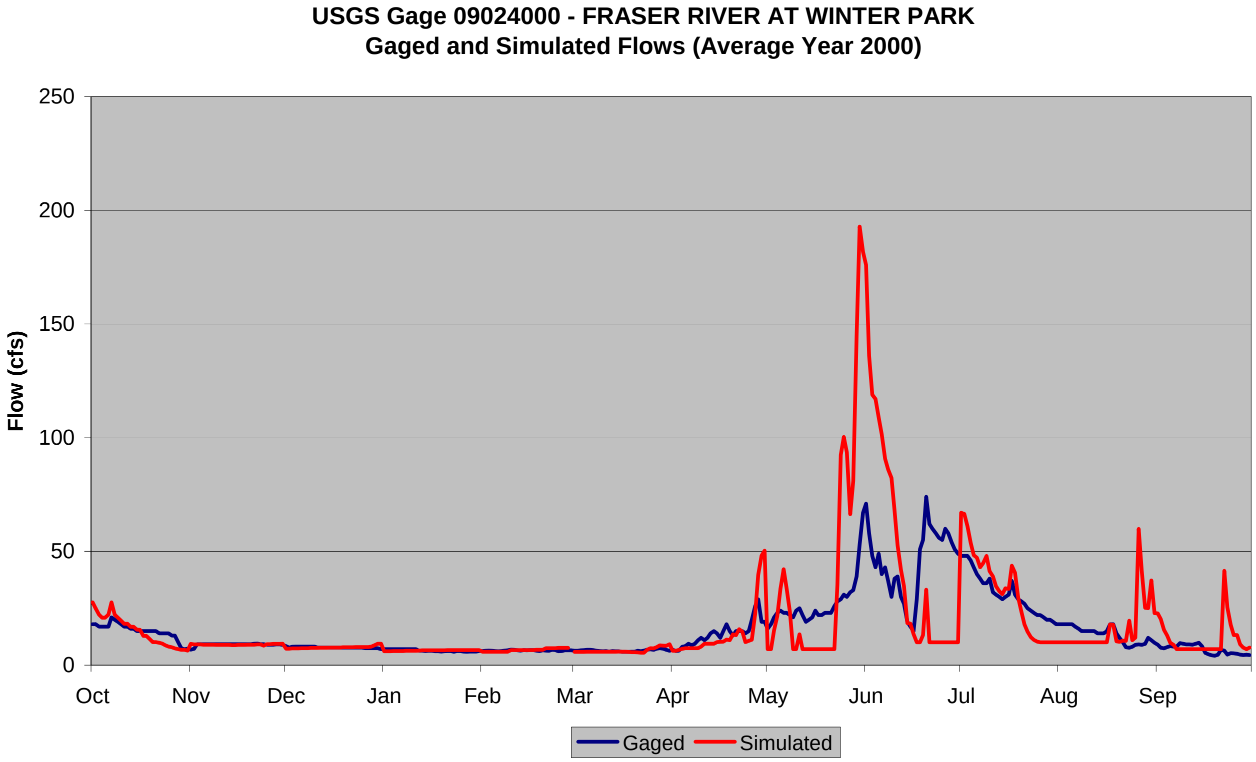


Figure E.18 Historical Daily Comparison, Average Year – Fraser River at Winter Park

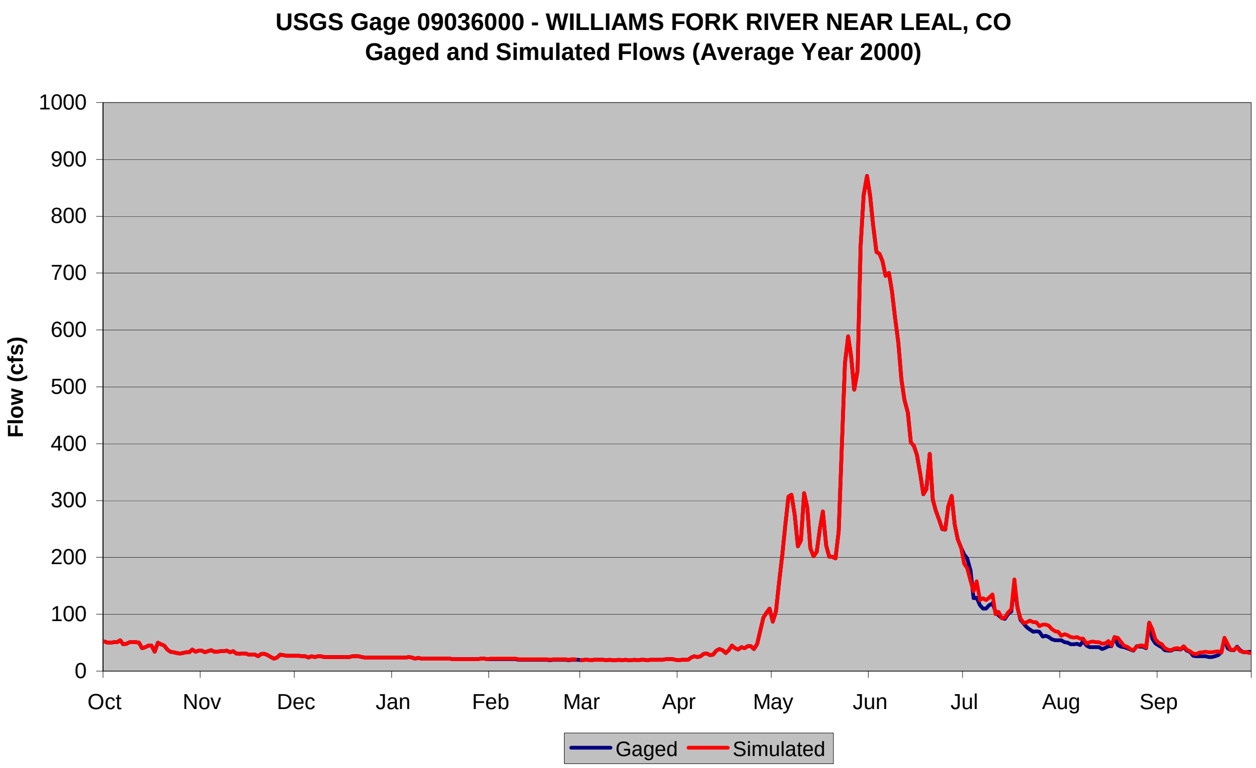


Figure E.19 Historical Daily Comparison, Average Year – Williams Fork River near Leal, CO

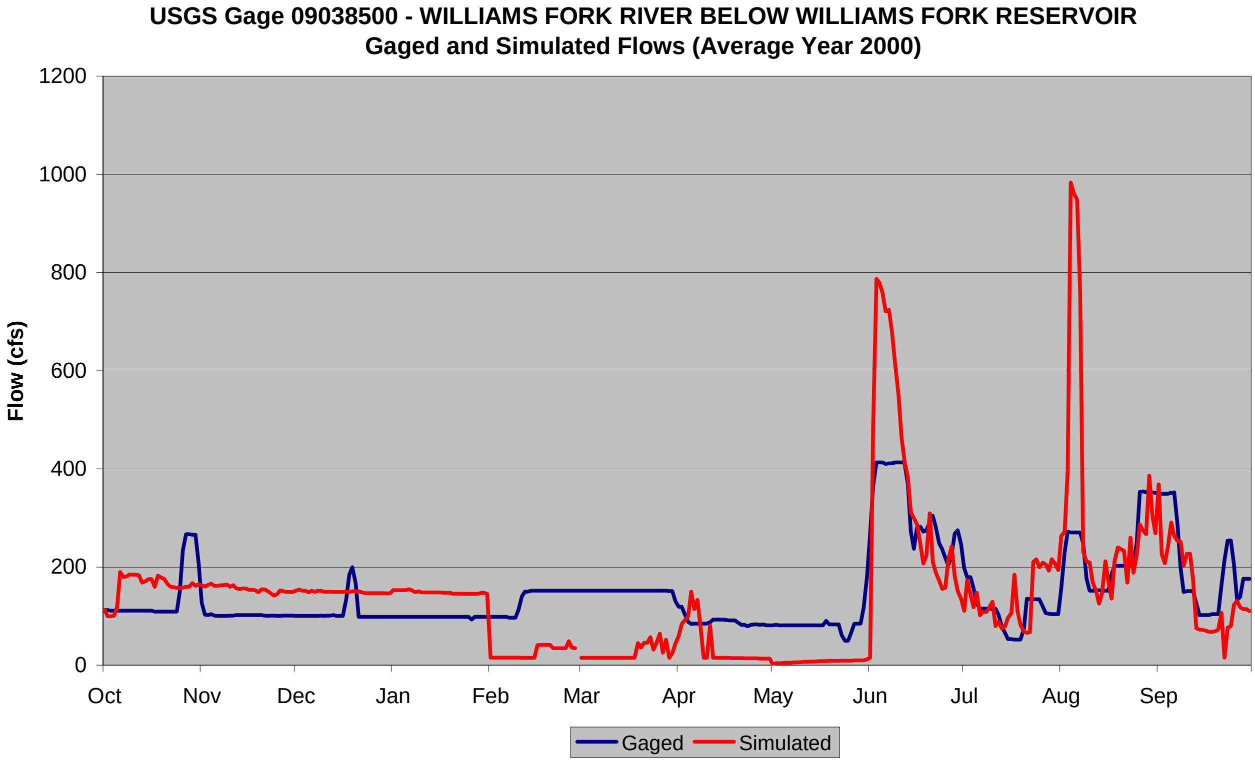


Figure E.20 Historical Daily Comparison, Average Year – Williams Fork River below Williams Fork Reservoir

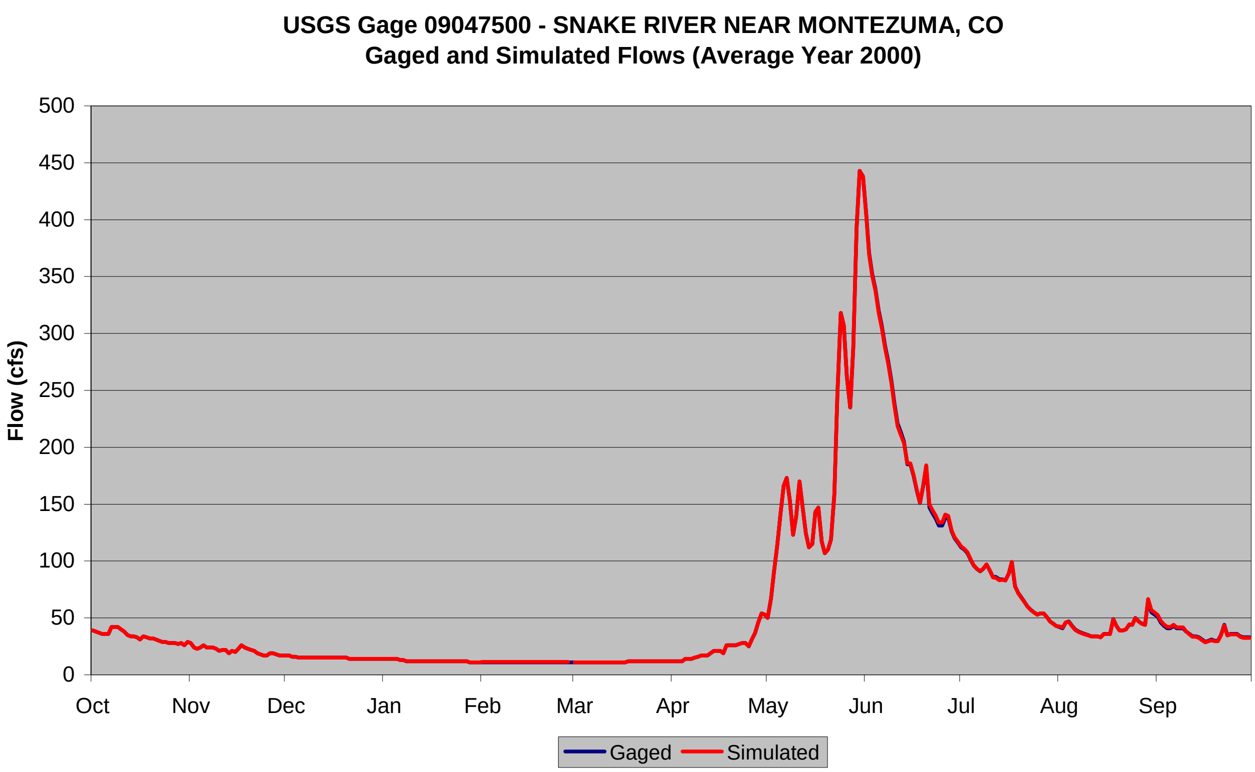


Figure E.21 Historical Daily Comparison, Average Year – Snake River near Montezuma, CO

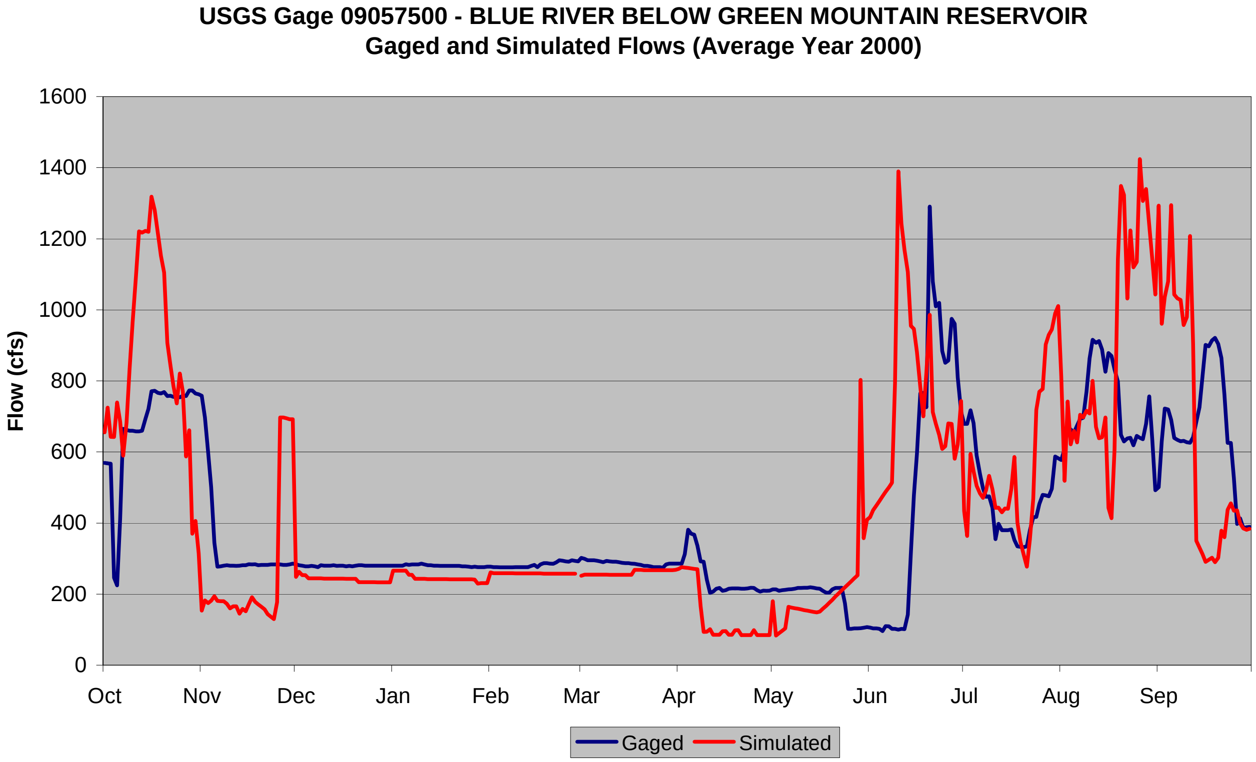


Figure E.22 Historical Daily Comparison, Average Year – Blue River below Green Mountain Reservoir

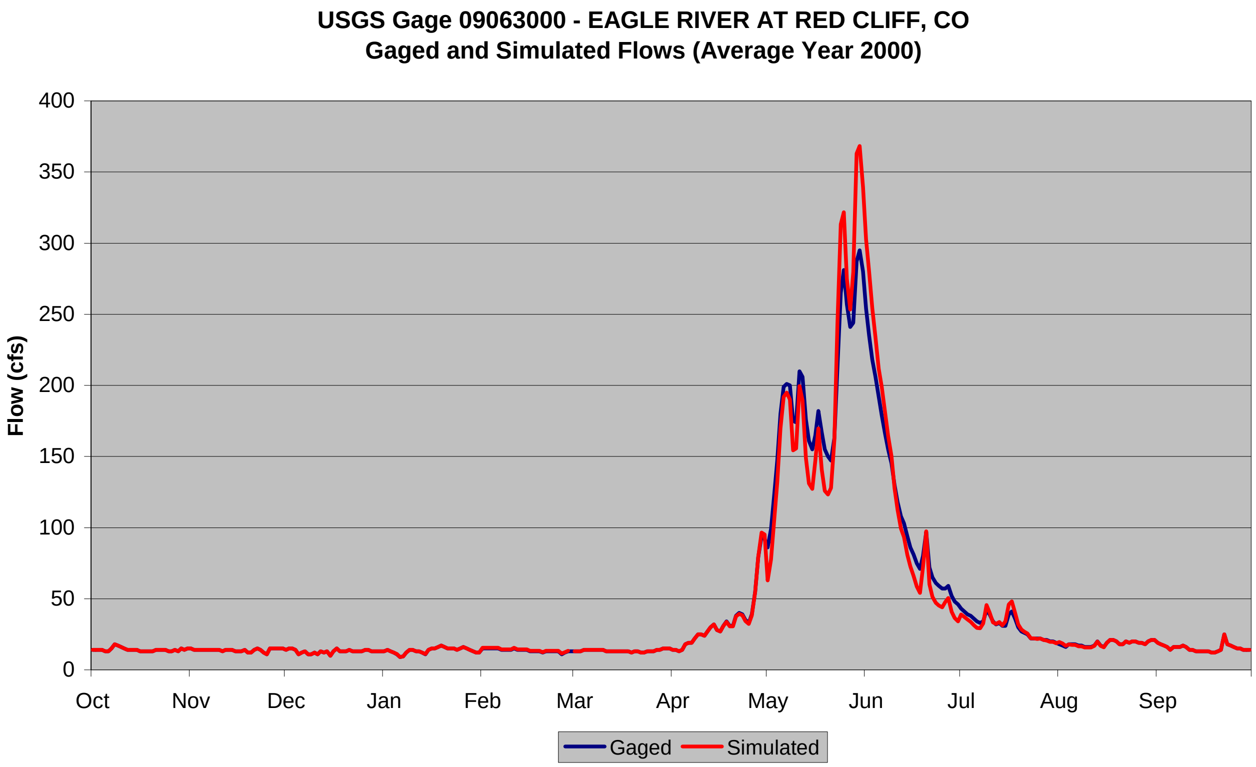


Figure E.23 Historical Daily Comparison, Average Year – Eagle River at Red Cliff, CO

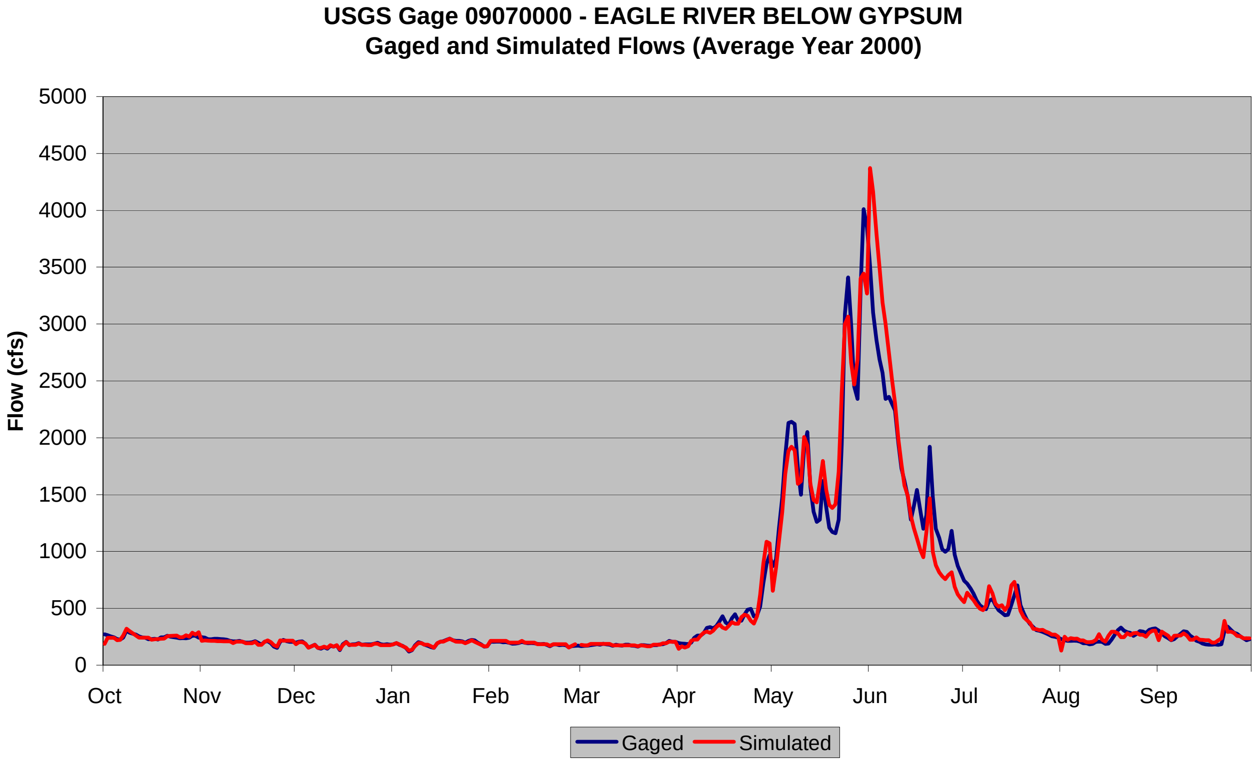


Figure E.24 Historical Daily Comparison, Average Year – Eagle River below Gypsum

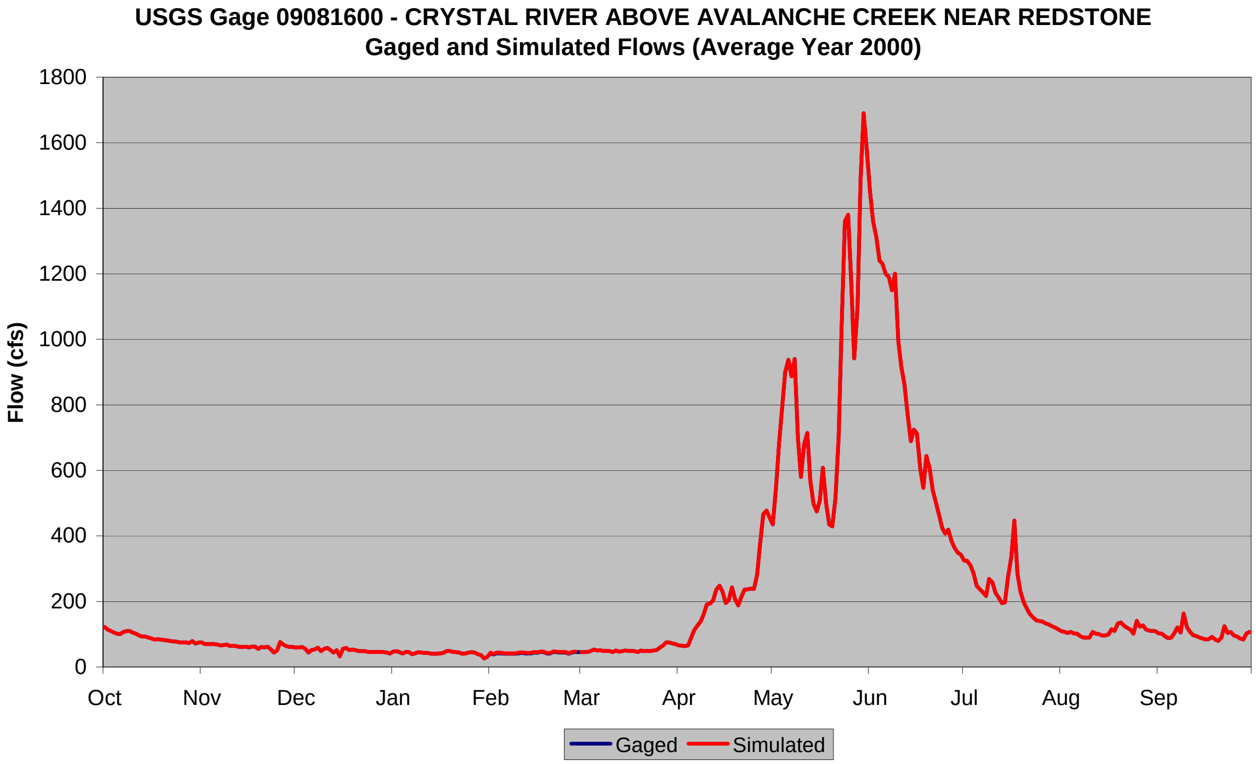


Figure E.25 Historical Daily Comparison, Average Year – Crystal River above Avalanche Creek near Redstone

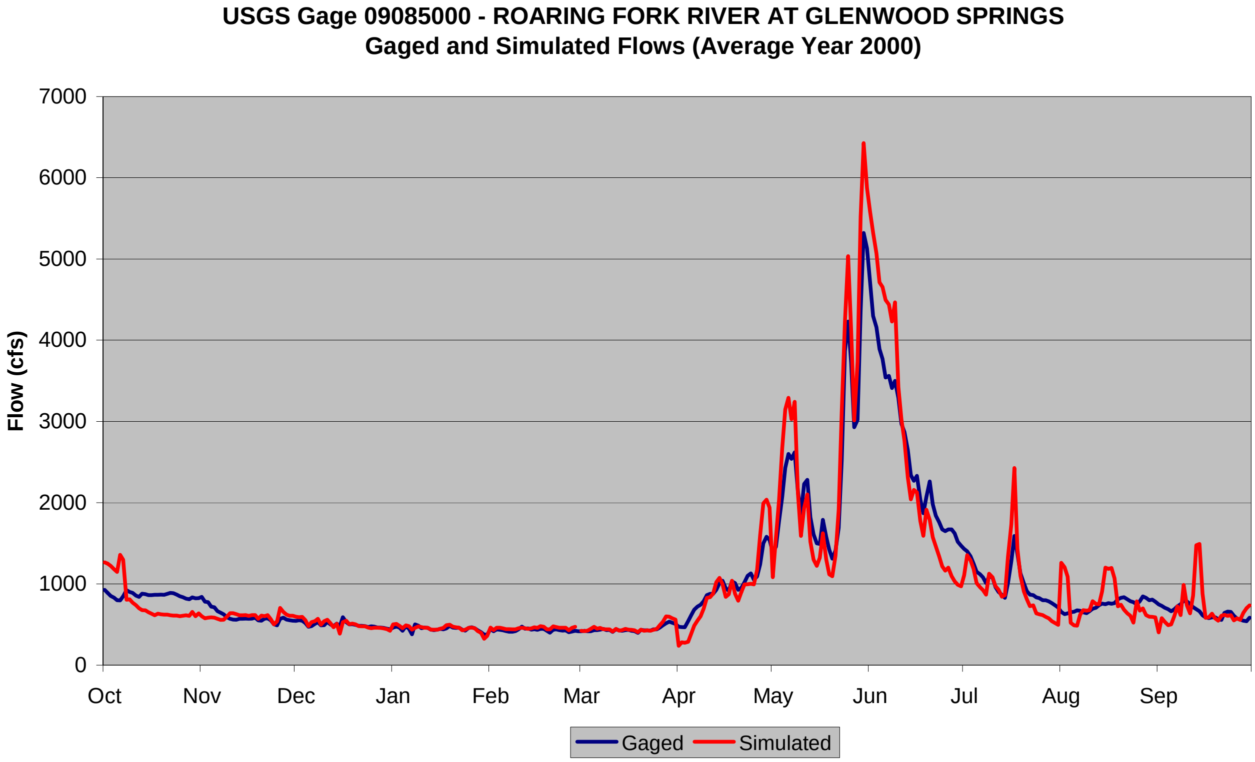


Figure E.26 Historical Daily Comparison, Average Year – Roaring Fork River at Glenwood Springs

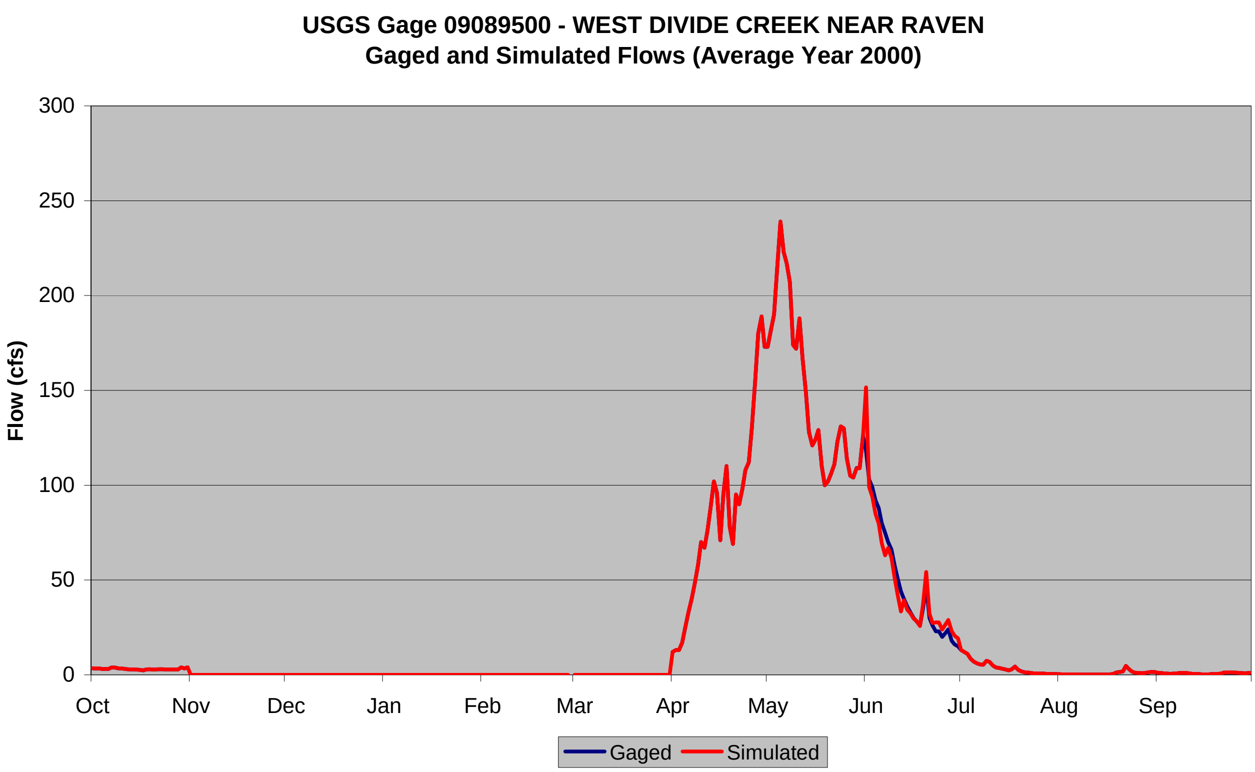


Figure E.27 Historical Daily Comparison, Average Year – West Divide Creek near Raven

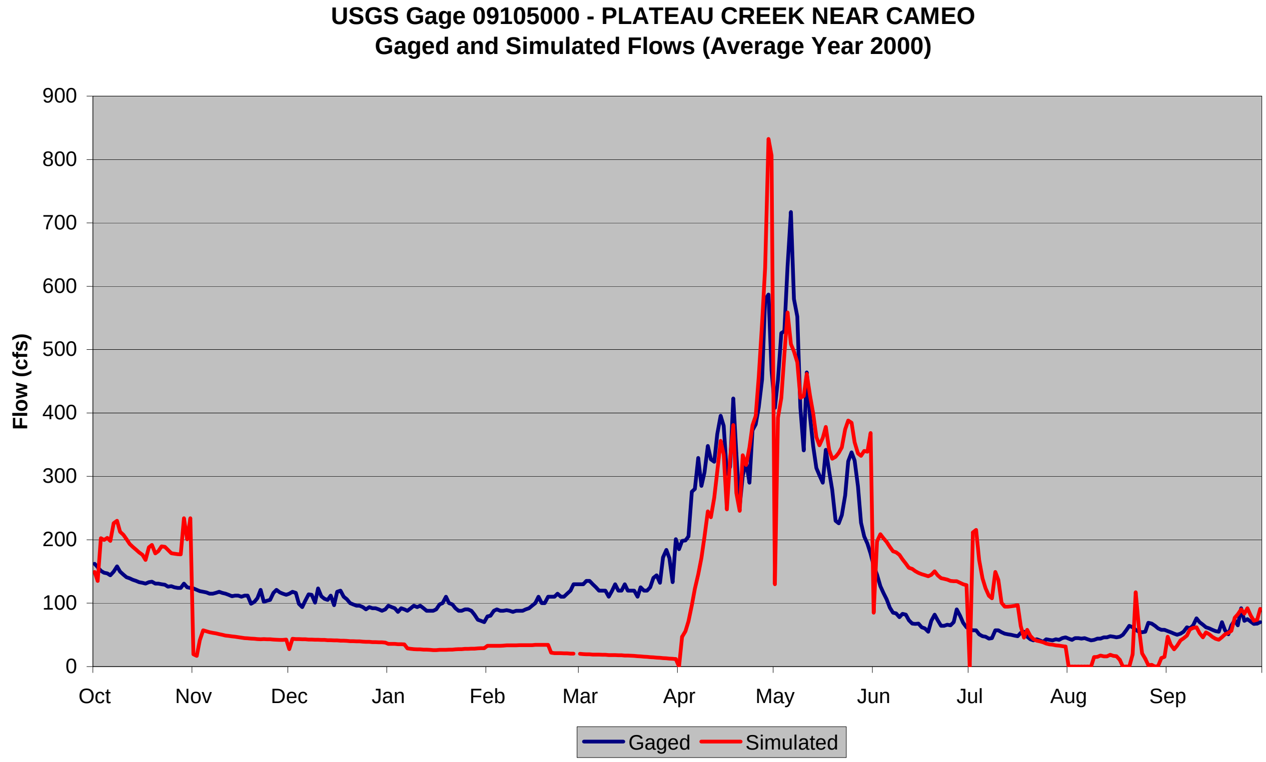


Figure E.28 Historical Daily Comparison, Average Year – Plateau Creek near Cameo

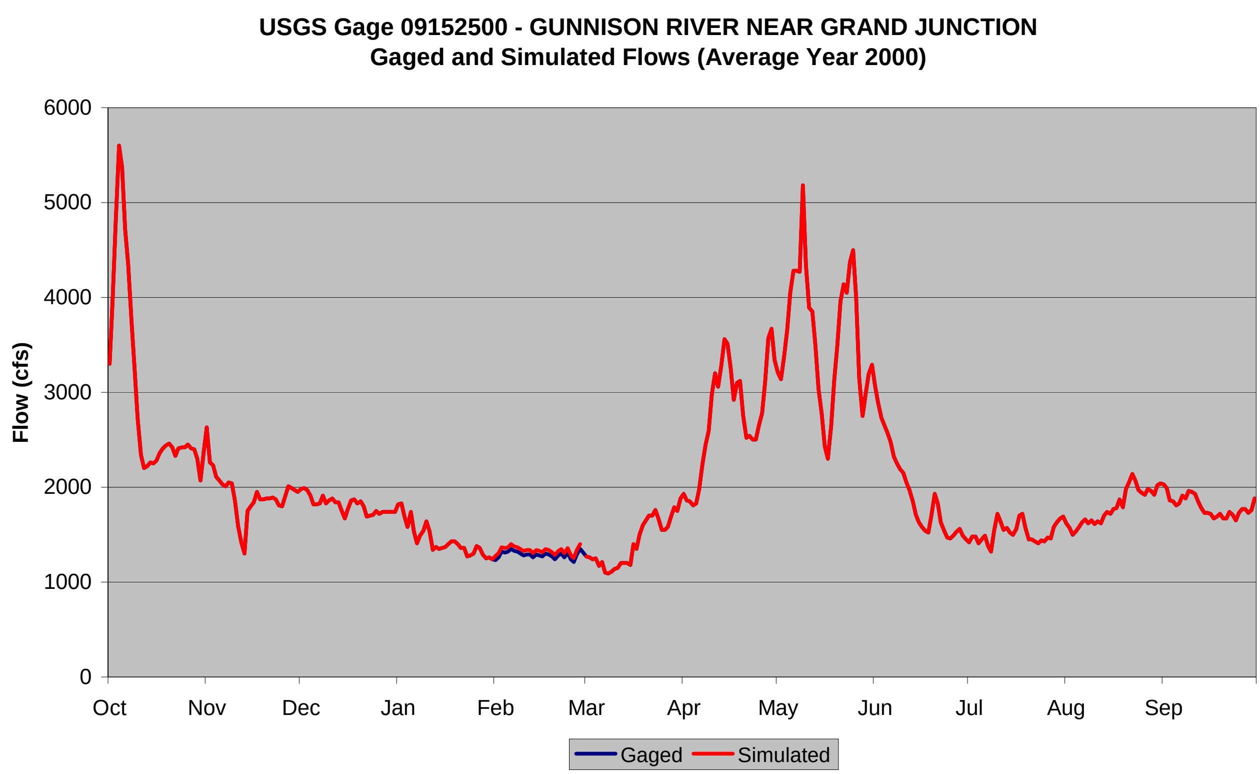


Figure E.29 Historical Daily Comparison, Average Year – Gunnison River near Grand Junction

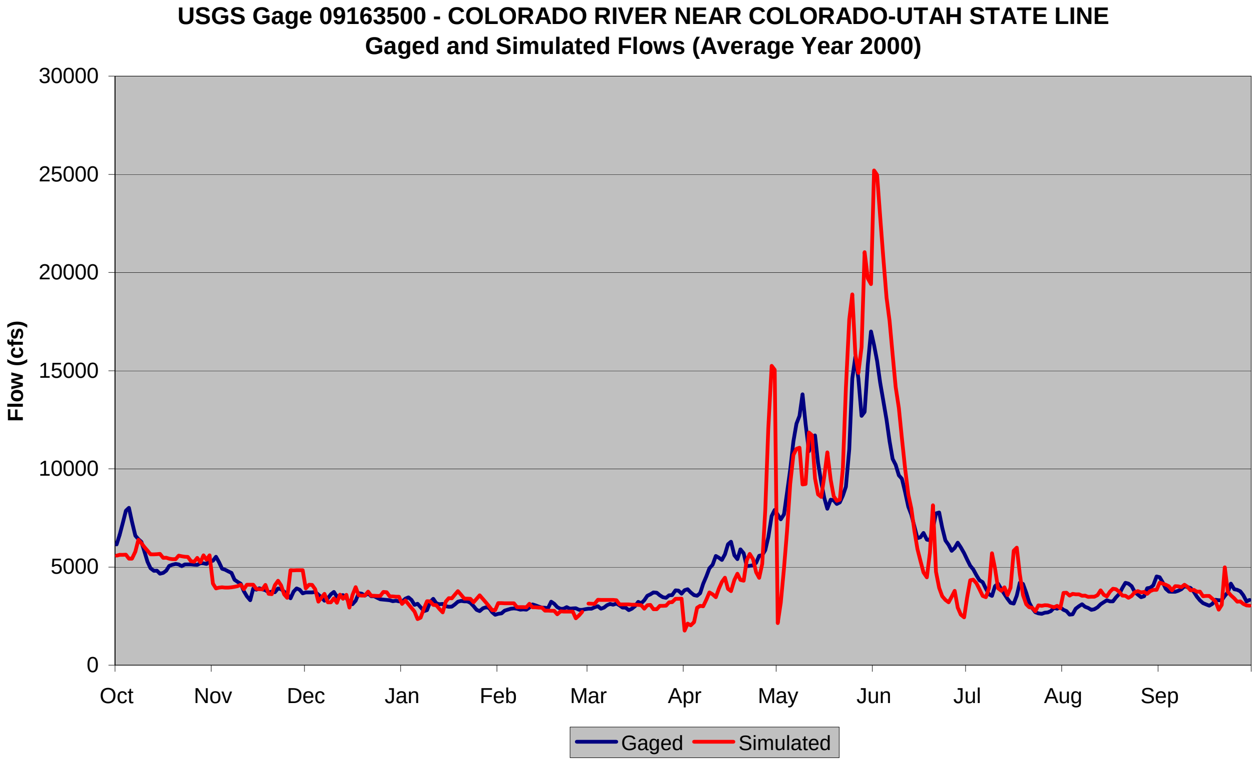


Figure E.30 Historical Daily Comparison, Average Year – Colorado River near Colorado-Utah State Line

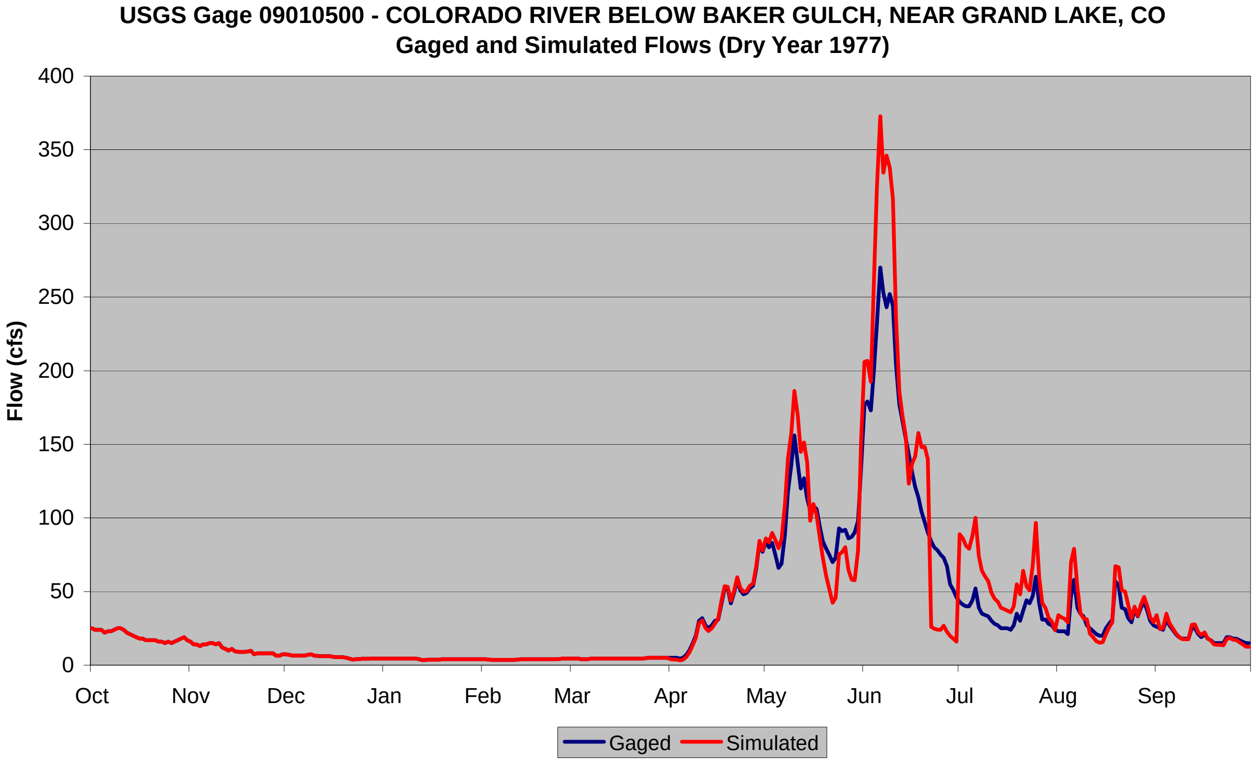


Figure E.31 Historical Daily Comparison, Dry Year – Colorado River below Baker Gulch, near Grand Lake, CO

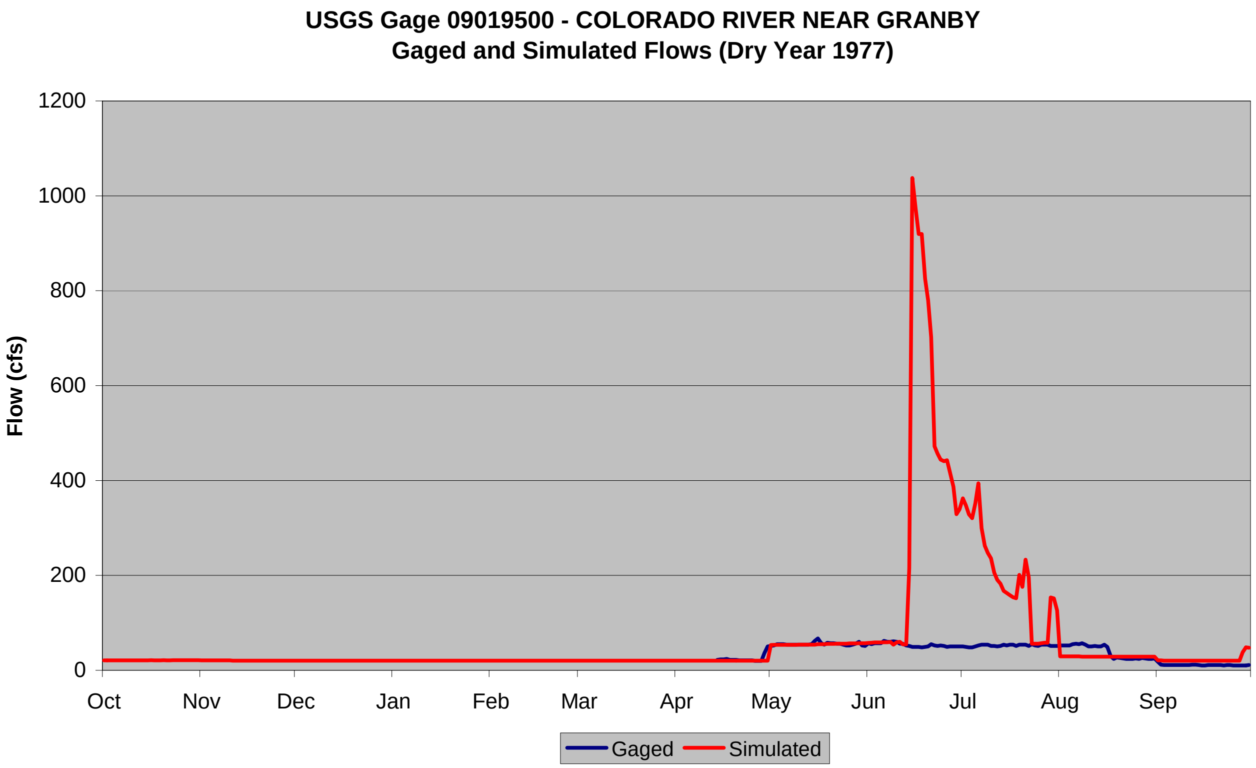


Figure E.32 Historical Daily Comparison, Dry Year – Colorado River near Granby

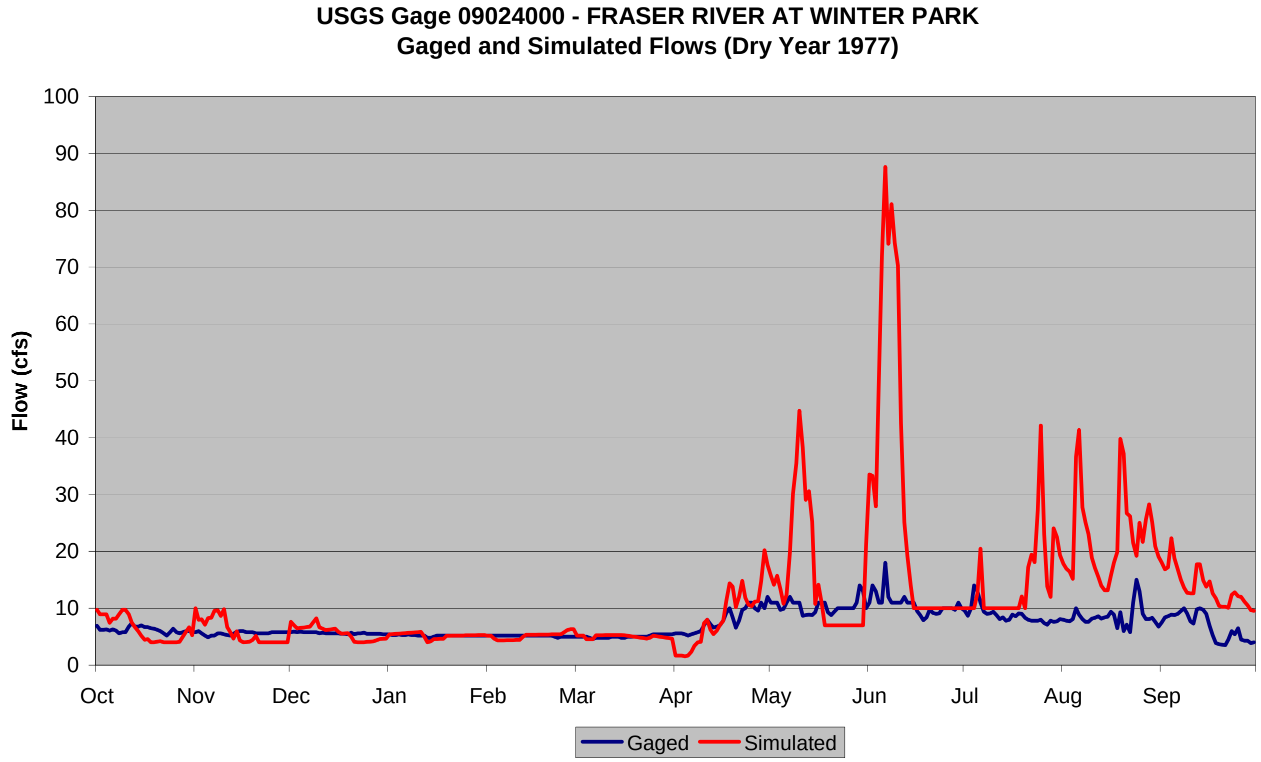


Figure E.33 Historical Daily Comparison, Dry Year – Fraser River at Winter Park

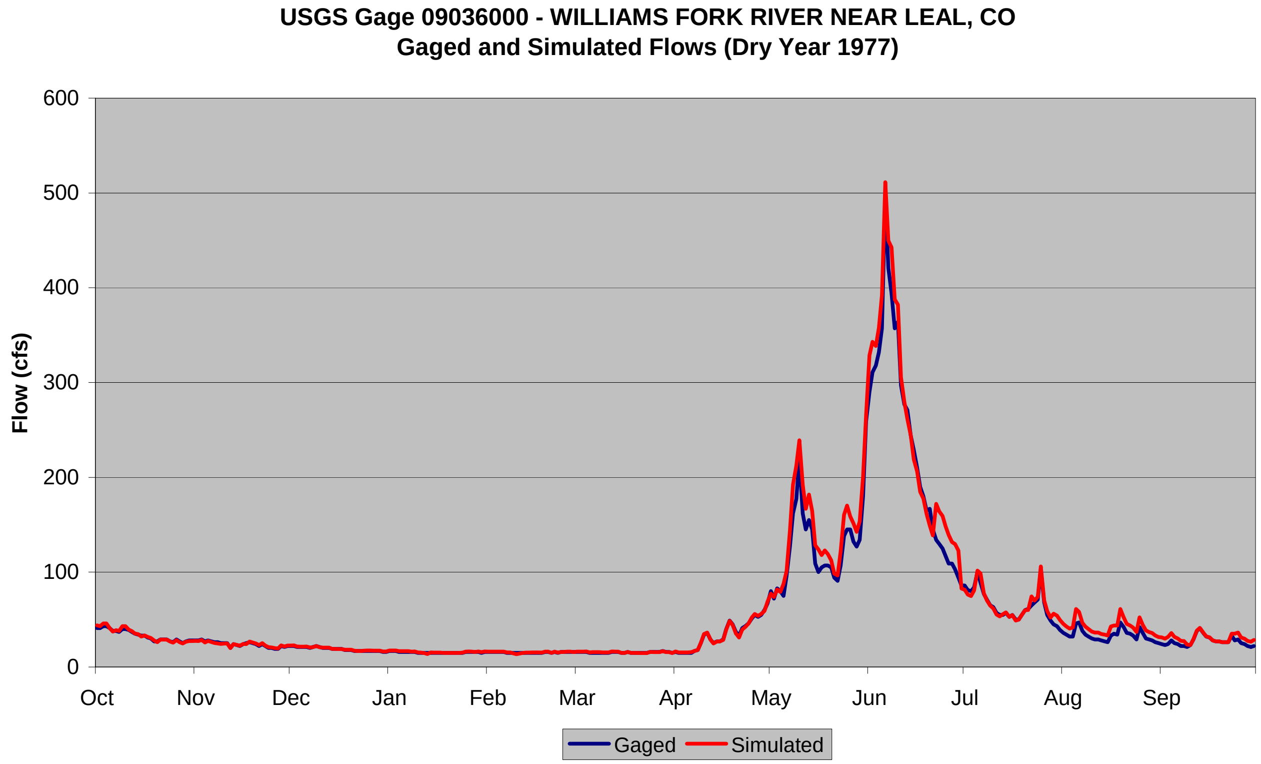


Figure E.34 Historical Daily Comparison, Dry Year – Williams Fork River near Leal, CO

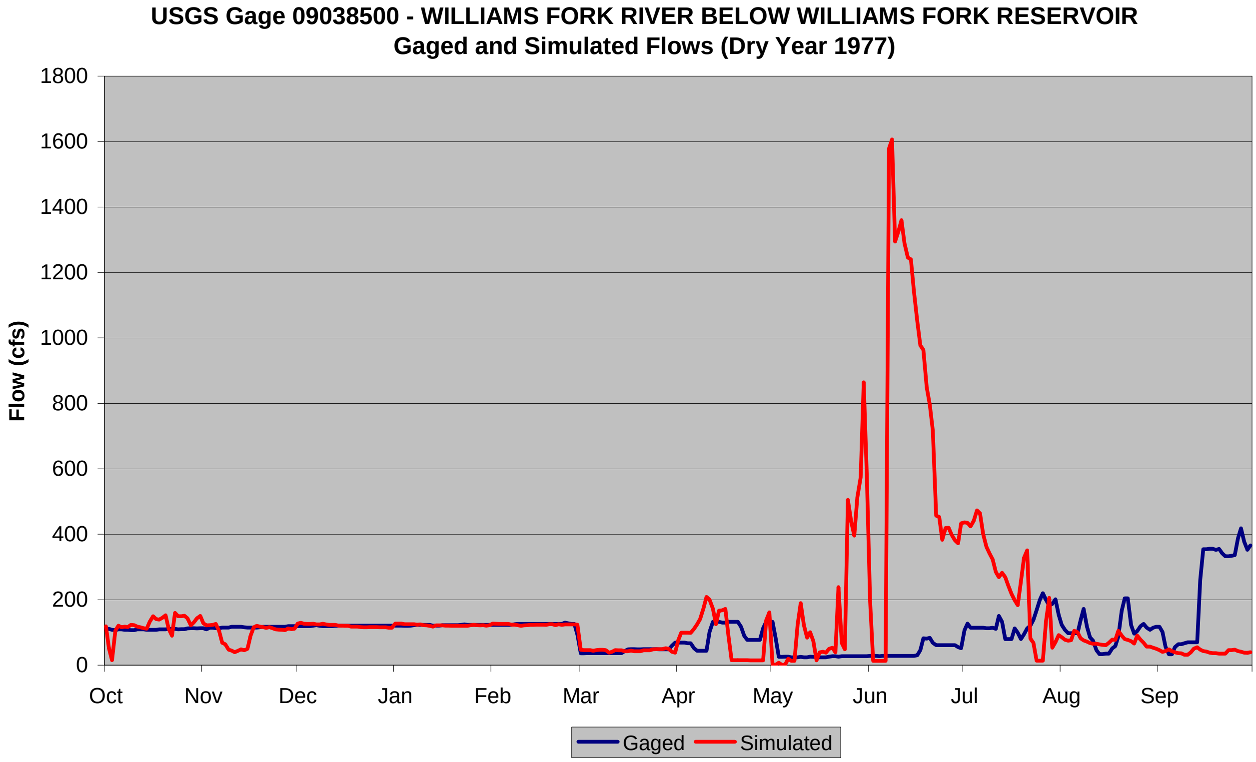


Figure E.35 Historical Daily Comparison, Dry Year – Williams Fork River below Williams Fork Reservoir

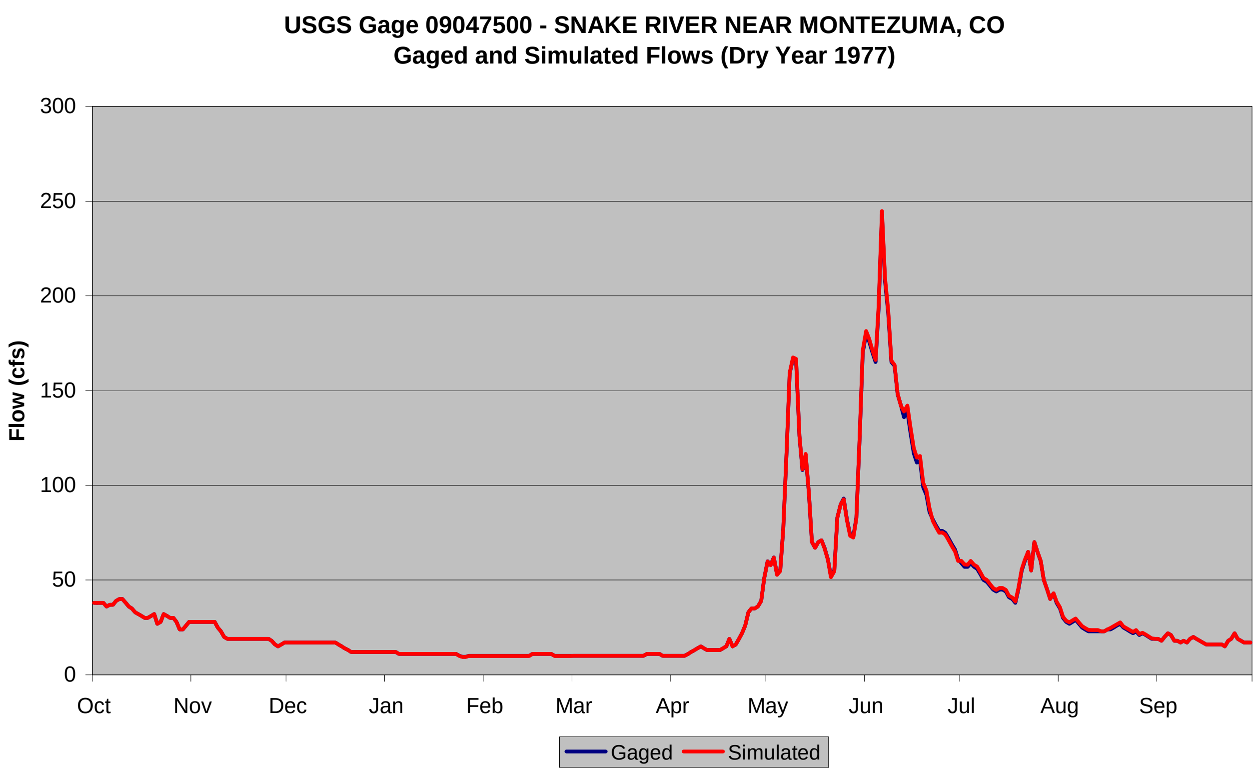


Figure E.36 Historical Daily Comparison, Dry Year – Snake River near Montezuma, CO

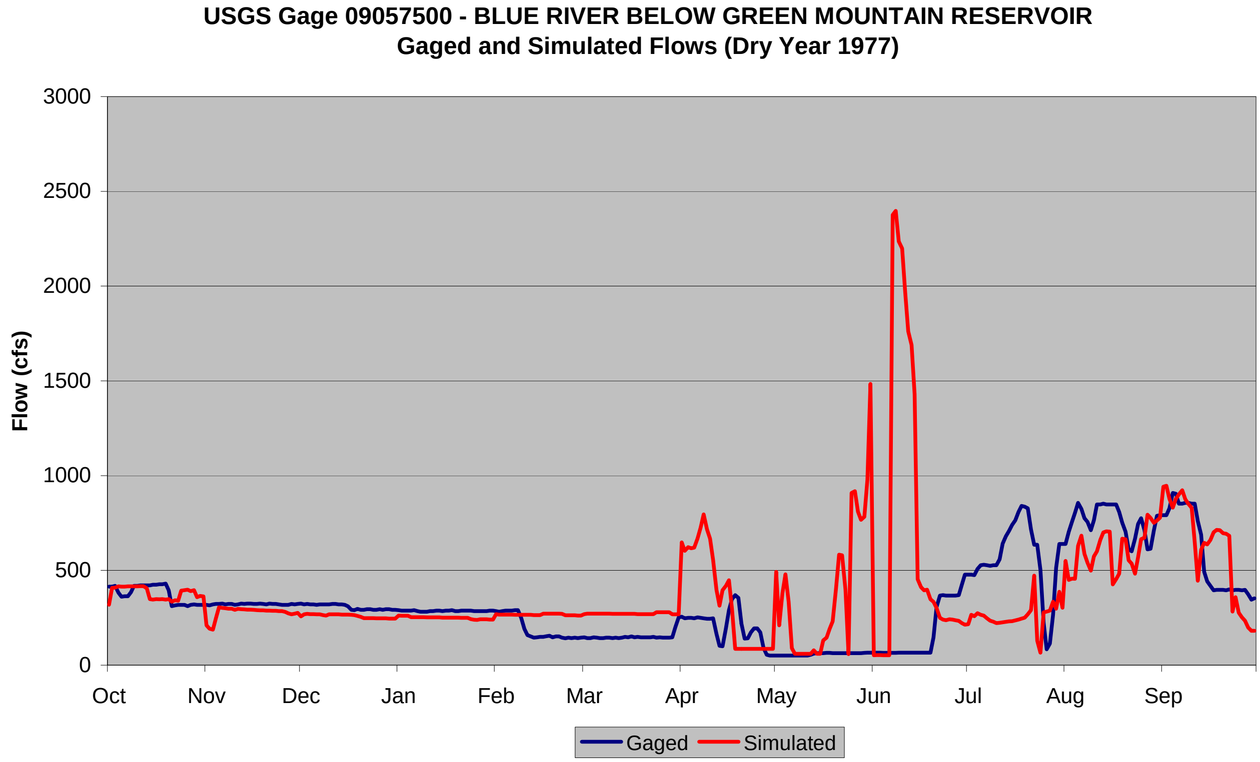


Figure E.37 Historical Daily Comparison, Dry Year – Blue River below Green Mountain Reservoir

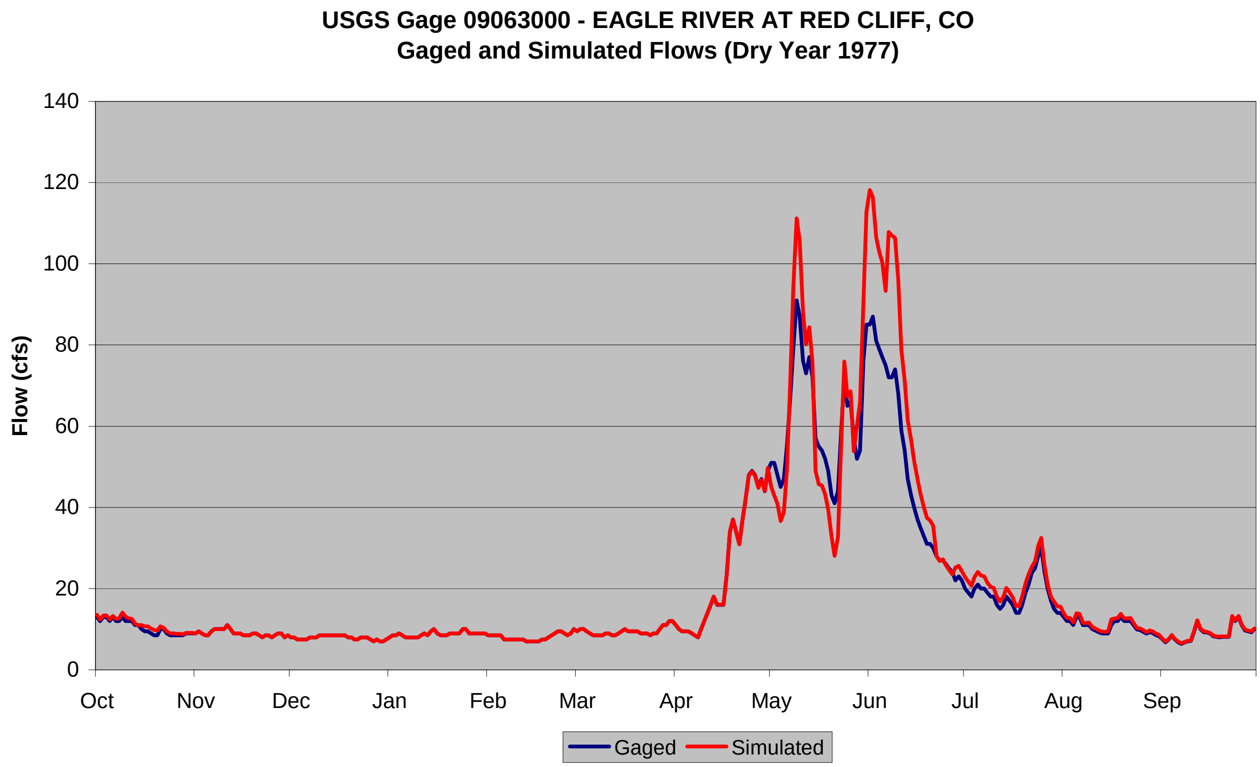


Figure E.38 Historical Daily Comparison, Dry Year – Eagle River at Red Cliff, CO

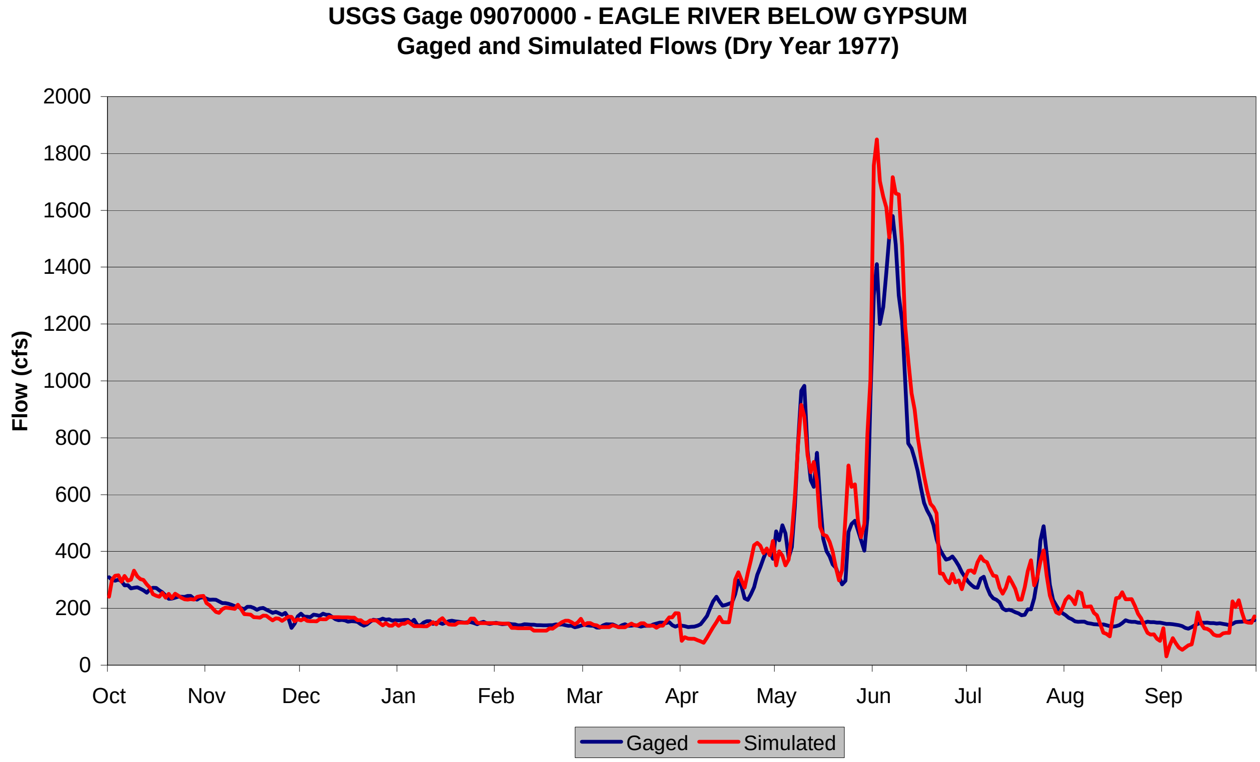


Figure E.39 Historical Daily Comparison, Dry Year – Eagle River below Gypsum

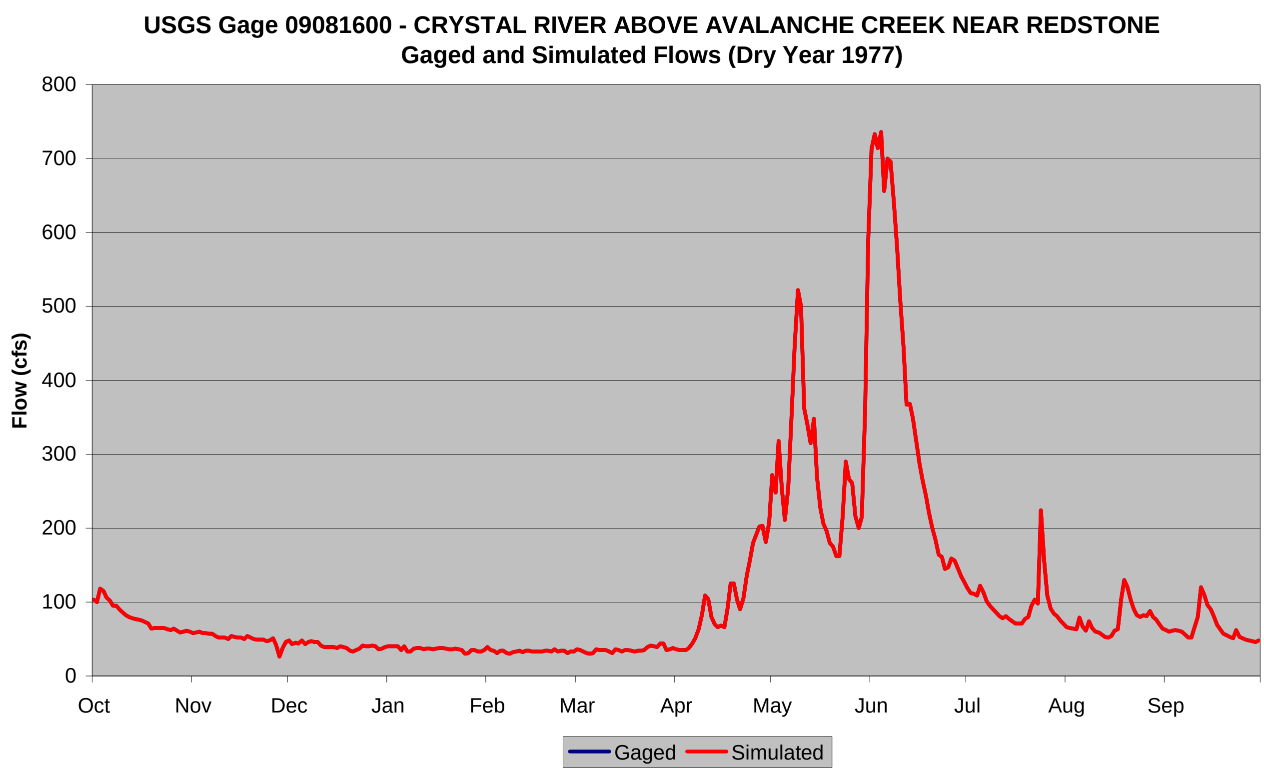


Figure E.40 Historical Daily Comparison, Dry Year – Crystal River above Avalanche Creek near Redstone

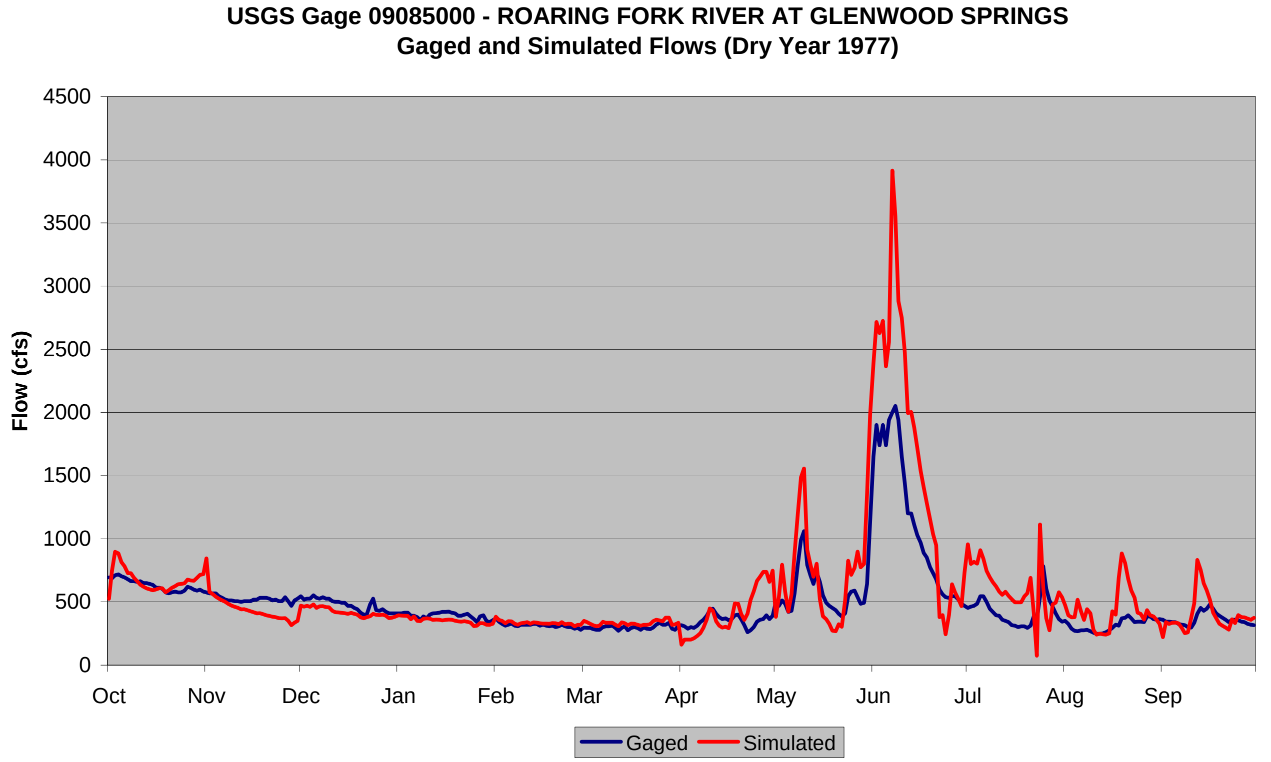


Figure E.41 Historical Daily Comparison, Dry Year – Roaring Fork River at Glenwood Springs

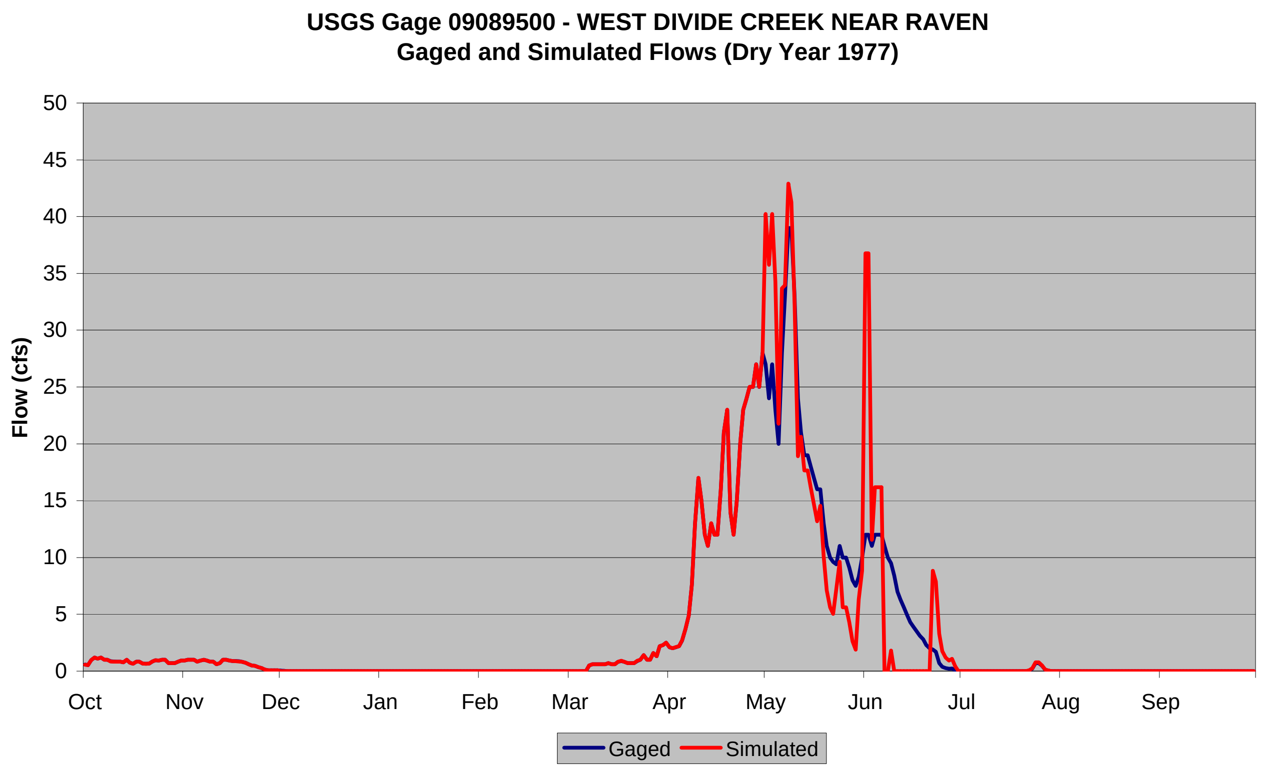


Figure E.42 Historical Daily Comparison, Dry Year – West Divide Creek near Raven

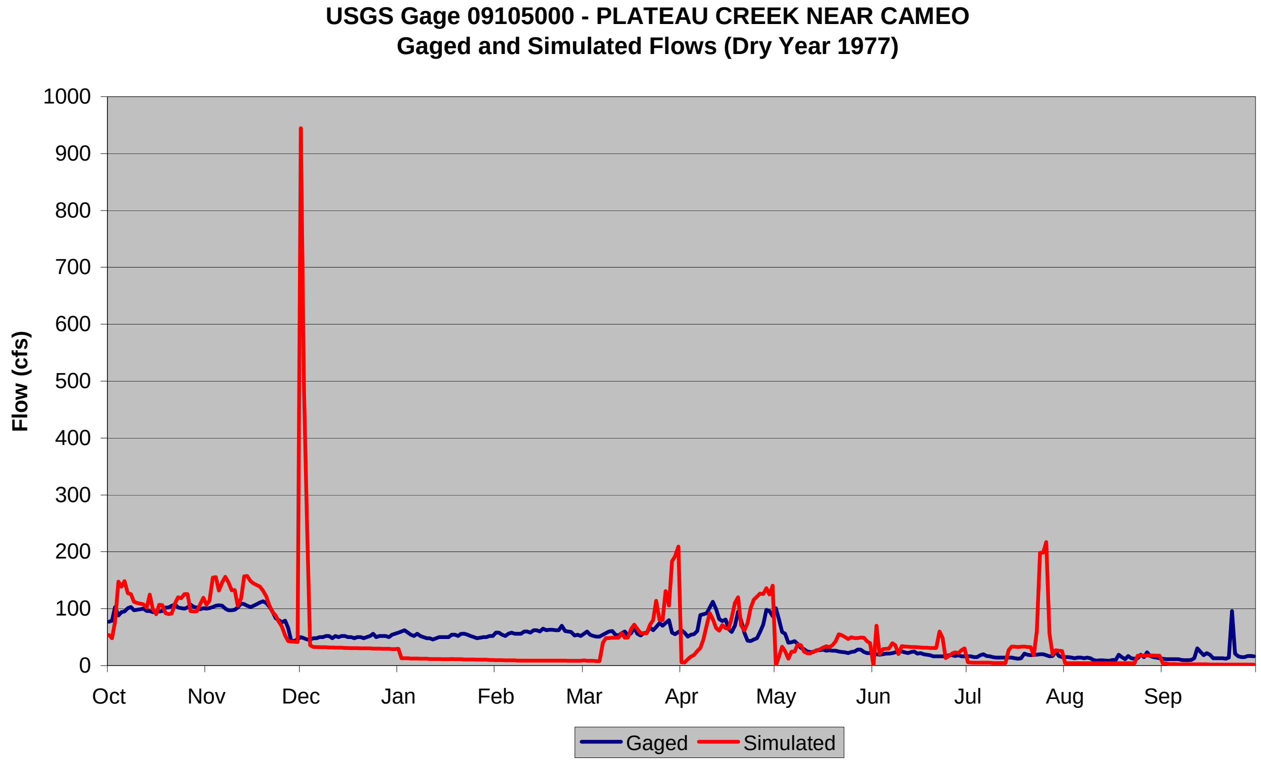


Figure E.43 Historical Daily Comparison, Dry Year – Plateau Creek near Cameo

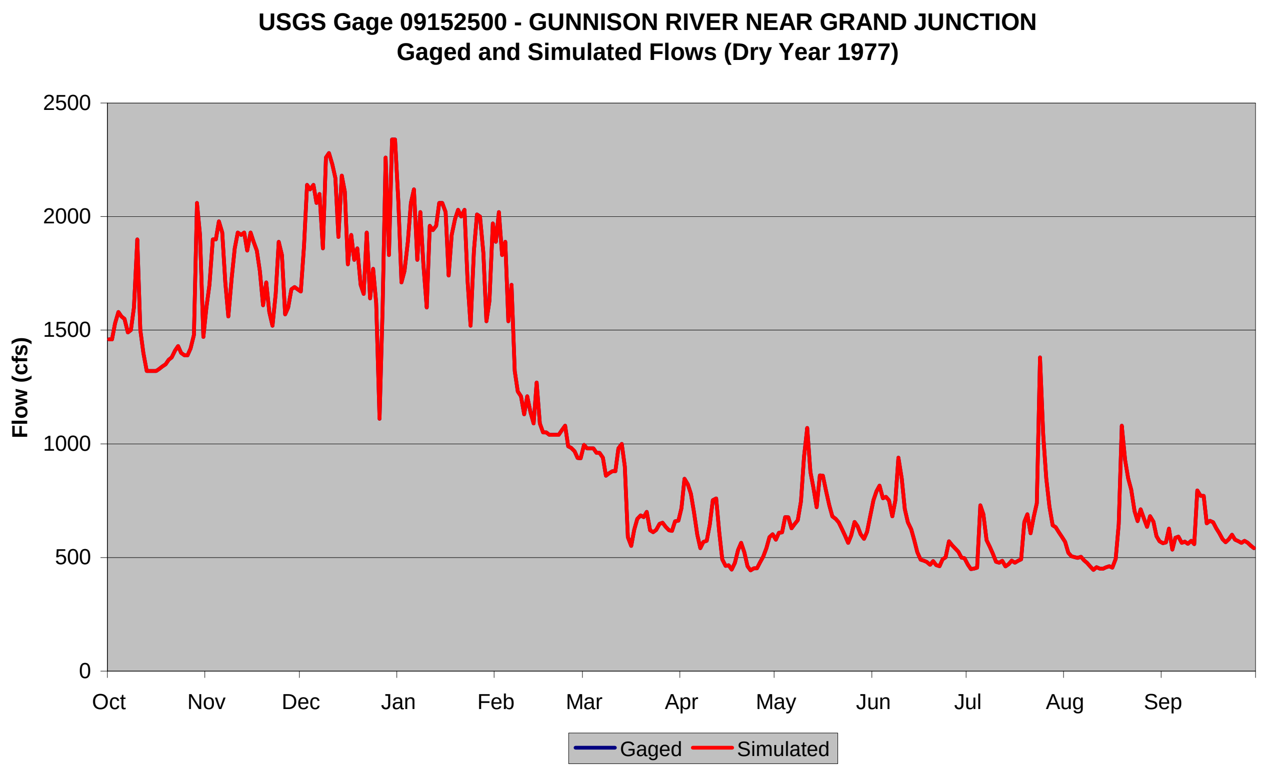


Figure E.44 Historical Daily Comparison, Dry Year – Gunnison River near Grand Junction

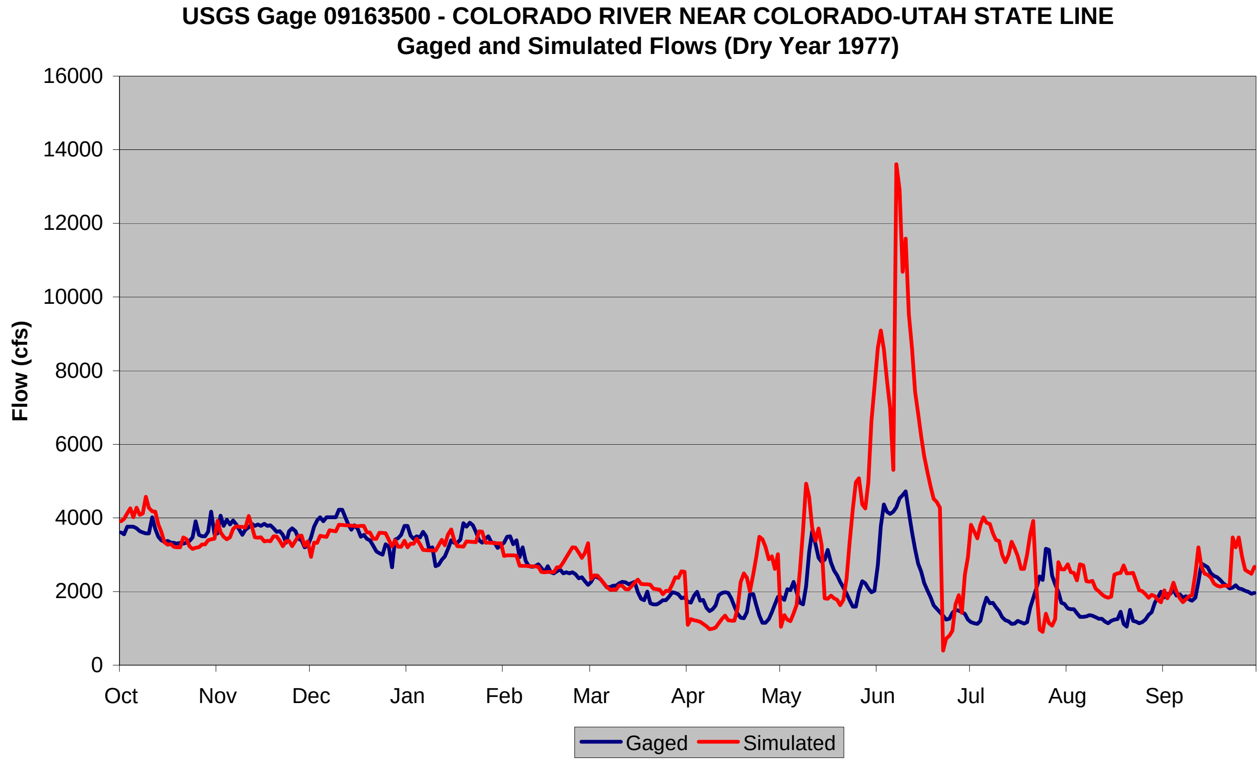


Figure E.45 Historical Daily Comparison, Dry Year – Colorado River near Colorado-Utah State Line

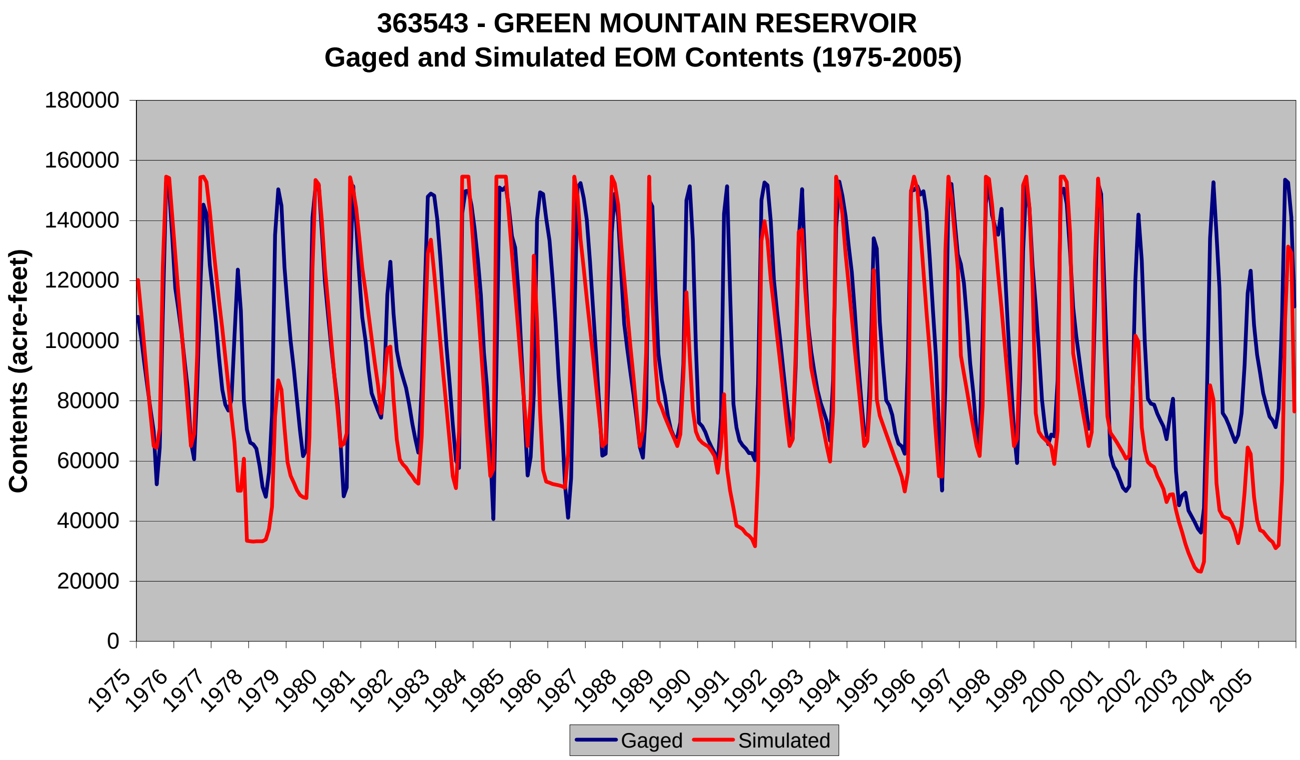


Figure E.46 Historical Daily Reservoir Simulation – Green Mountain Reservoir

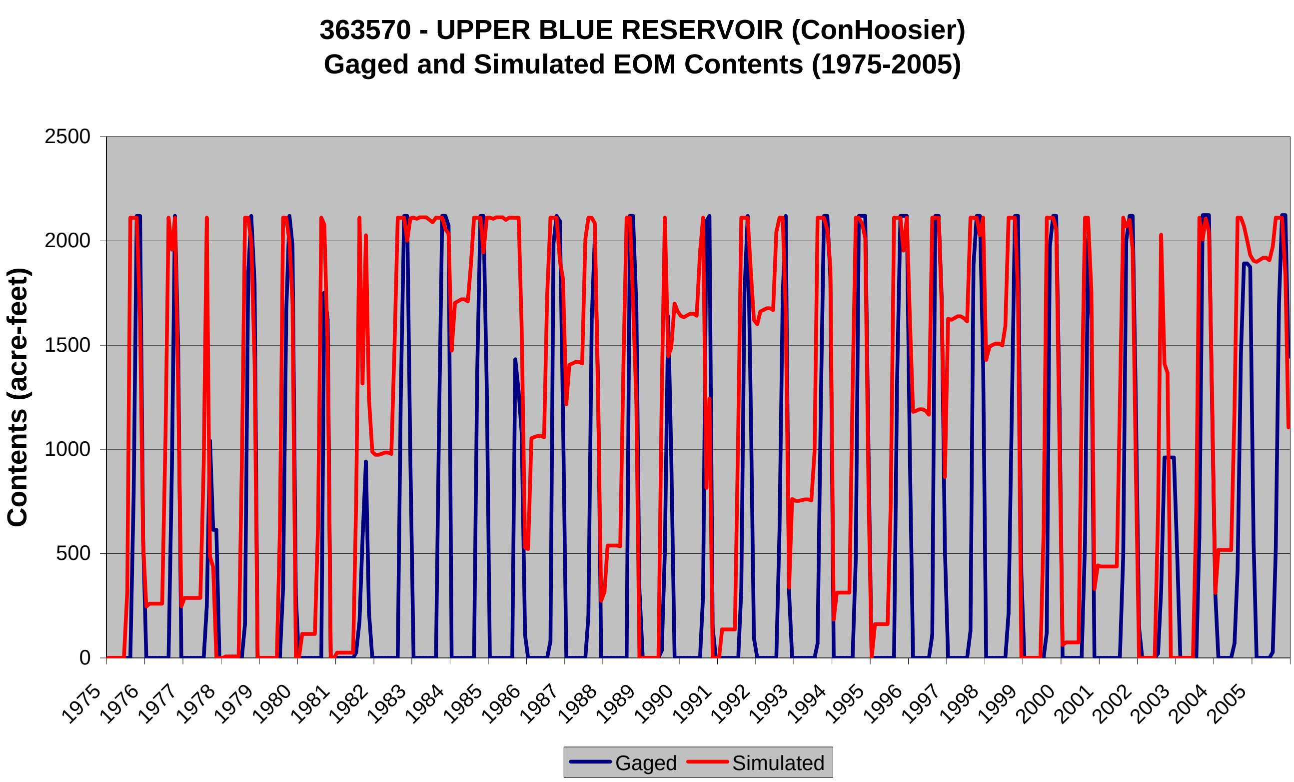


Figure E.47 Historical Daily Reservoir Simulation – Upper Blue Reservoir (ConHoosier)

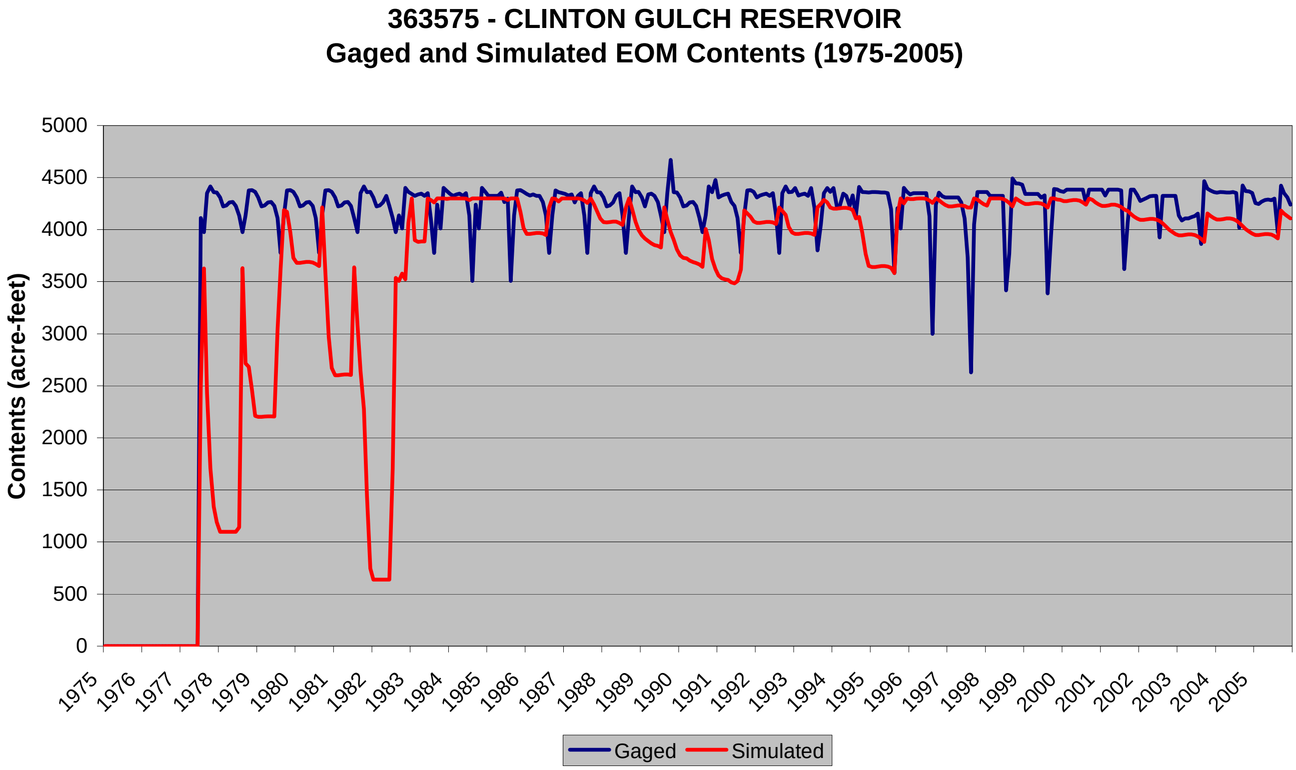


Figure E.48 Historical Daily Reservoir Simulation – Clinton Gulch Reservoir

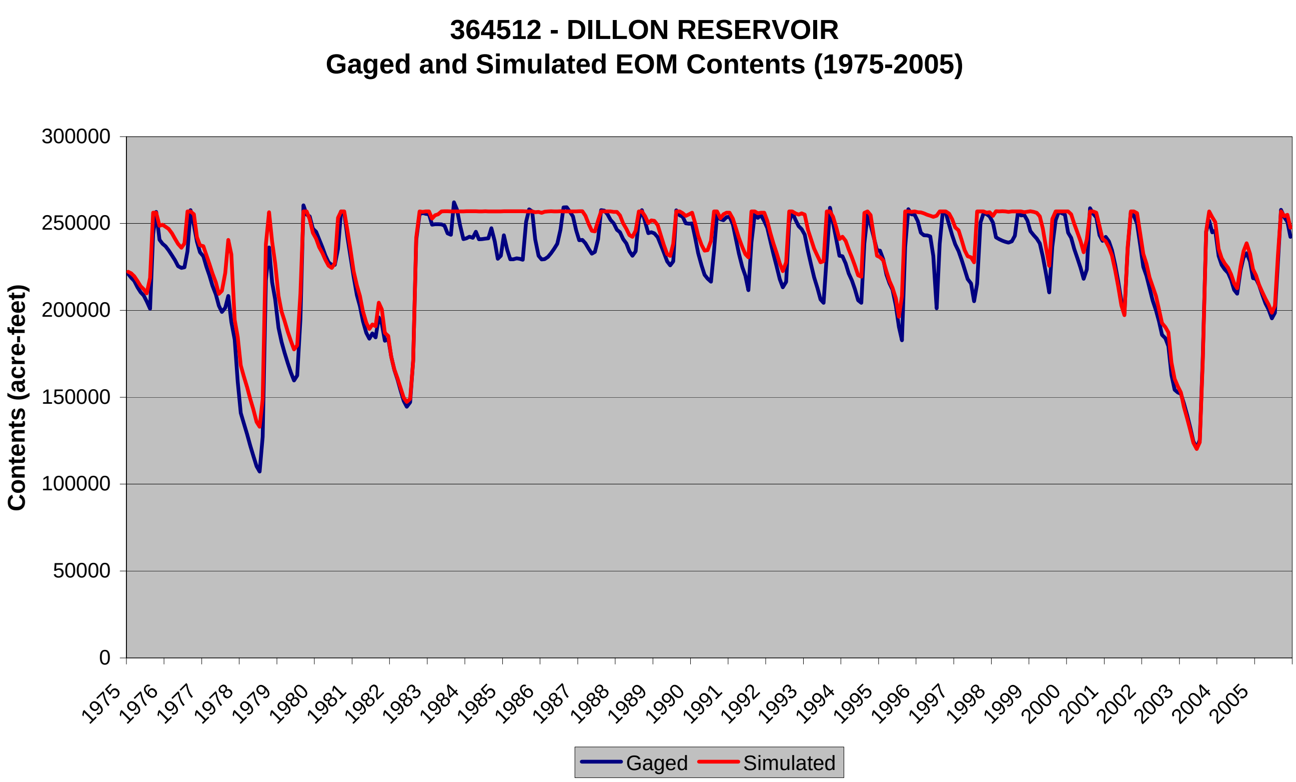


Figure E.49 Historical Daily Reservoir Simulation – Dillon Reservoir

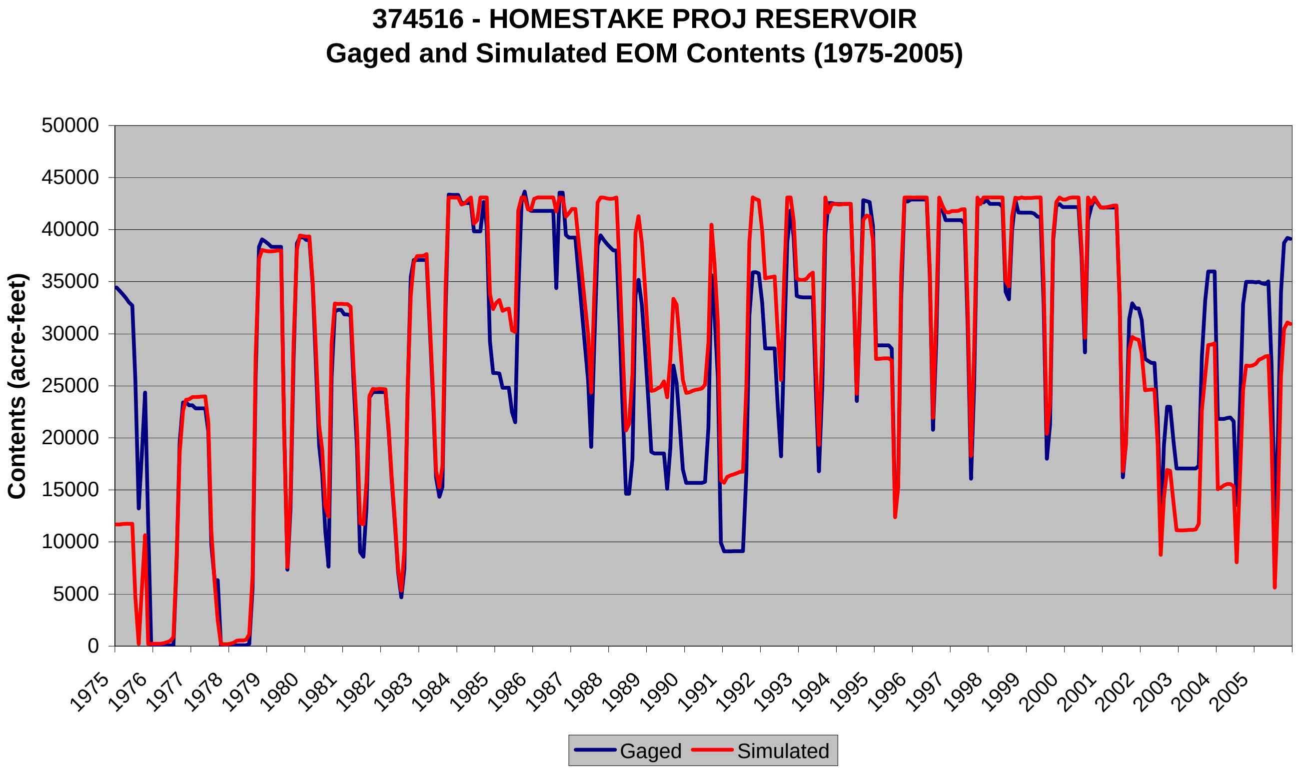


Figure E.50 Historical Daily Reservoir Simulation – Homestake Proj Reservoir

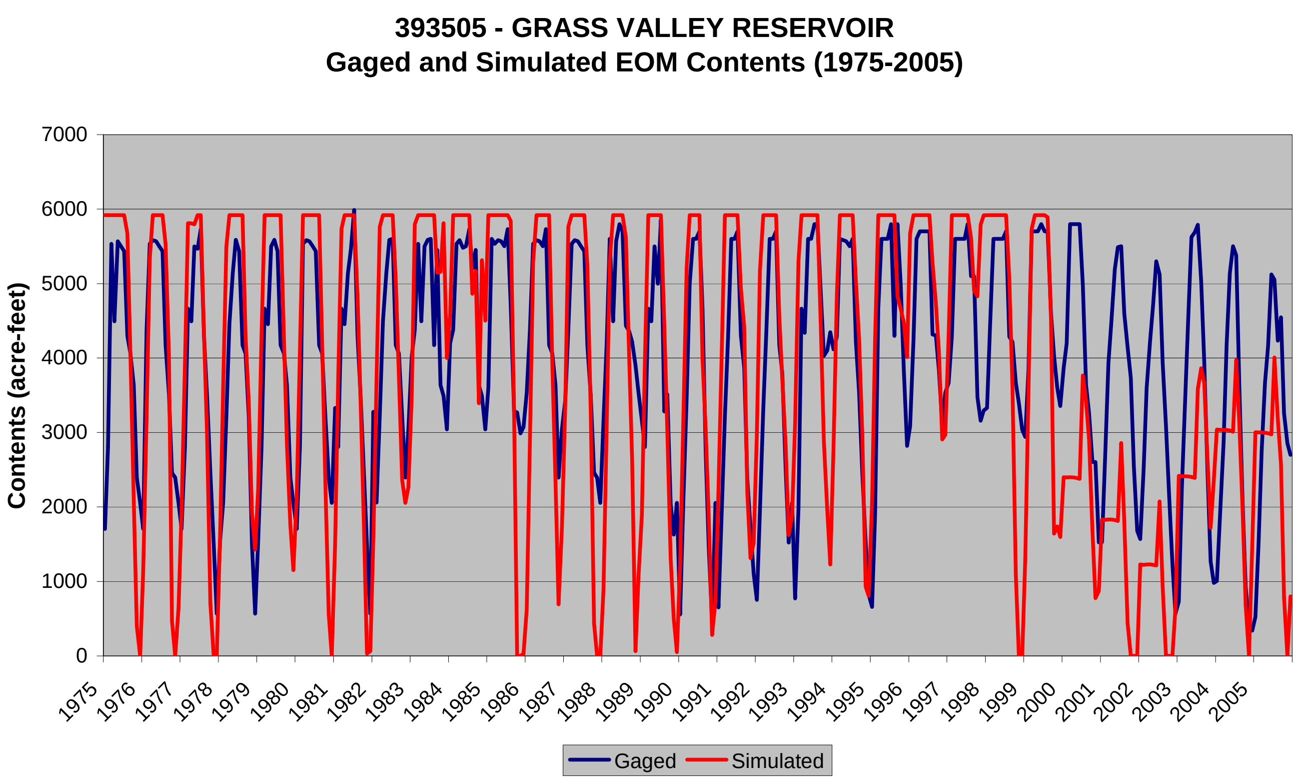


Figure E.51 Historical Daily Reservoir Simulation – Grass Valley Reservoir

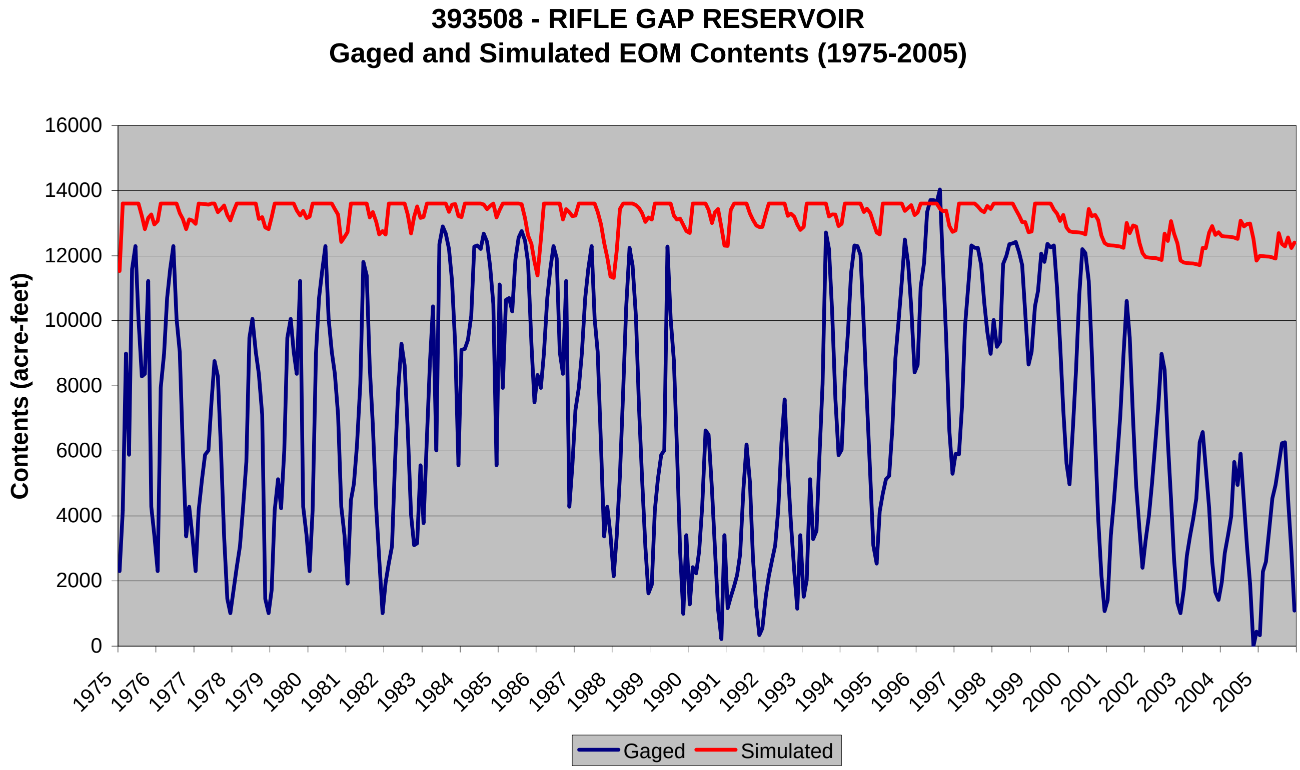


Figure E.52 Historical Daily Reservoir Simulation – Rifle Gap Reservoir

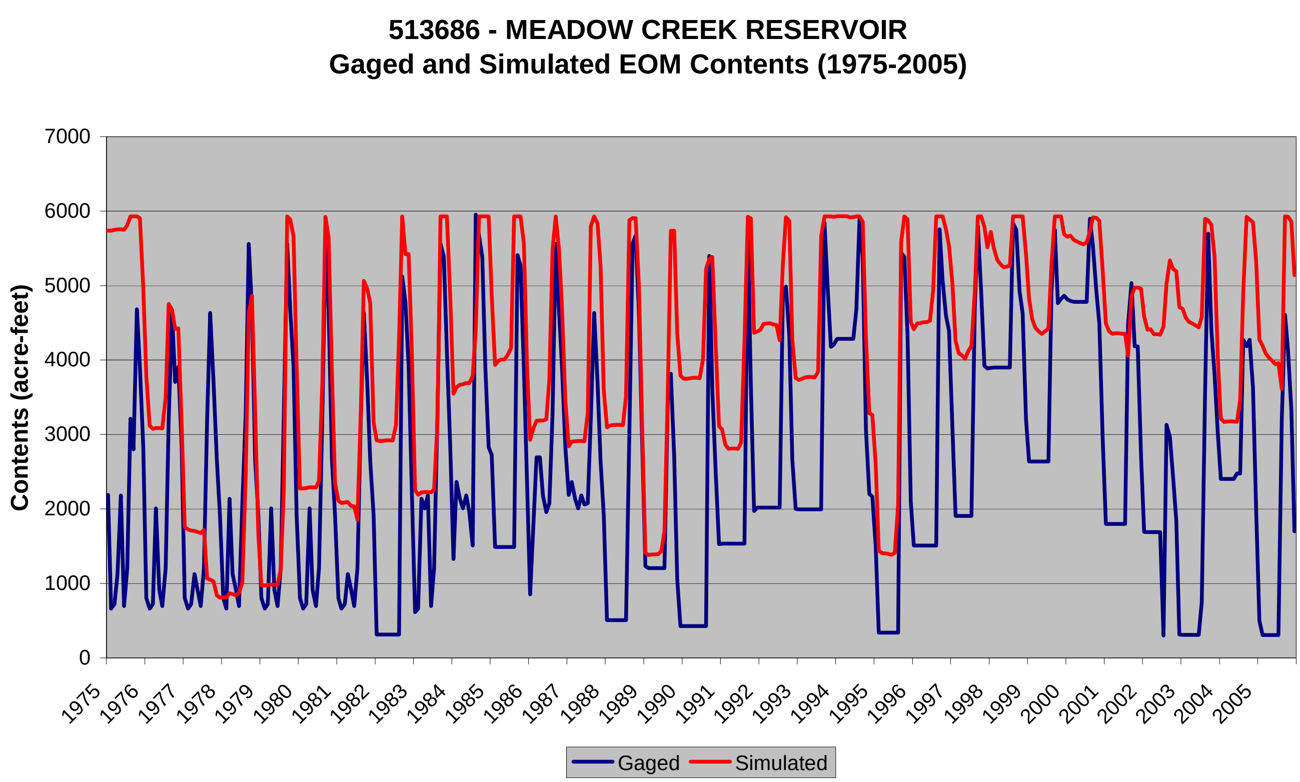


Figure E.53 Historical Daily Reservoir Simulation – Meadow Creek Reservoir

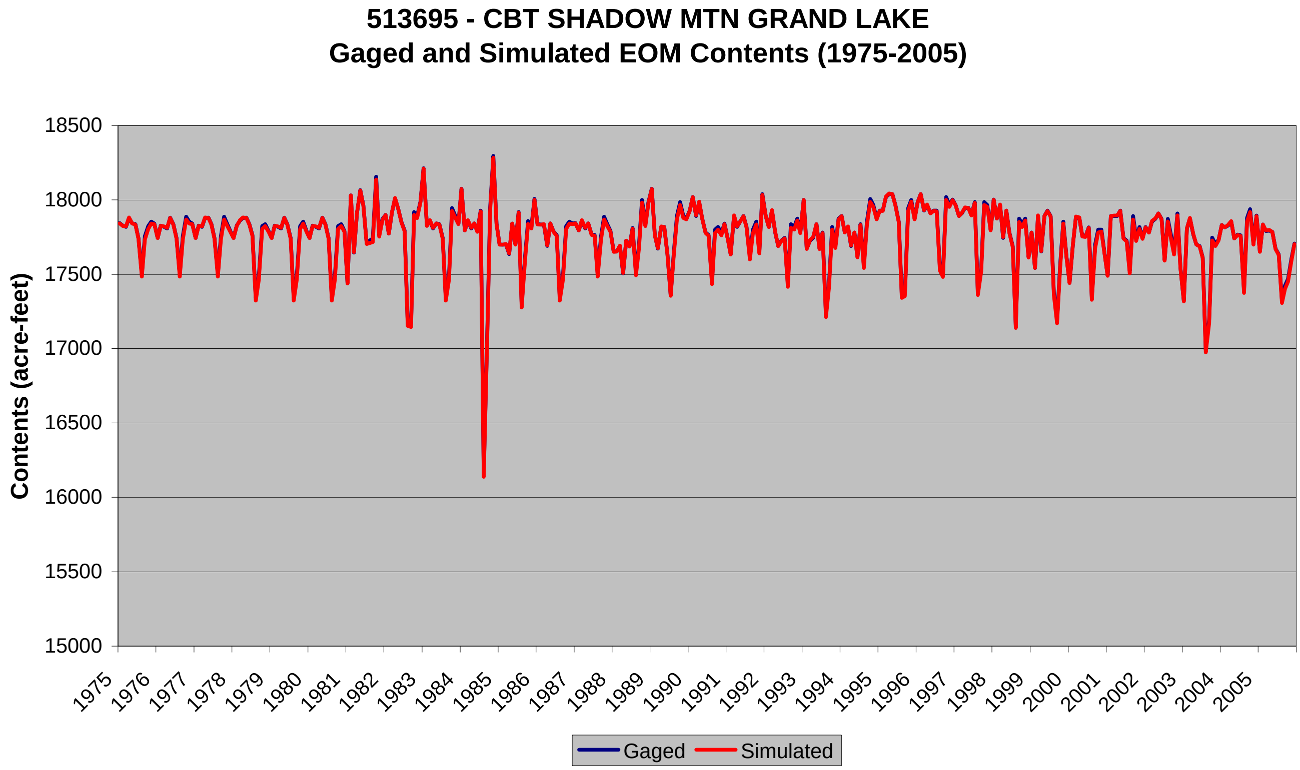


Figure E.54 Historical Daily Reservoir Simulation – CBT Shadow Mtn Grand Lake

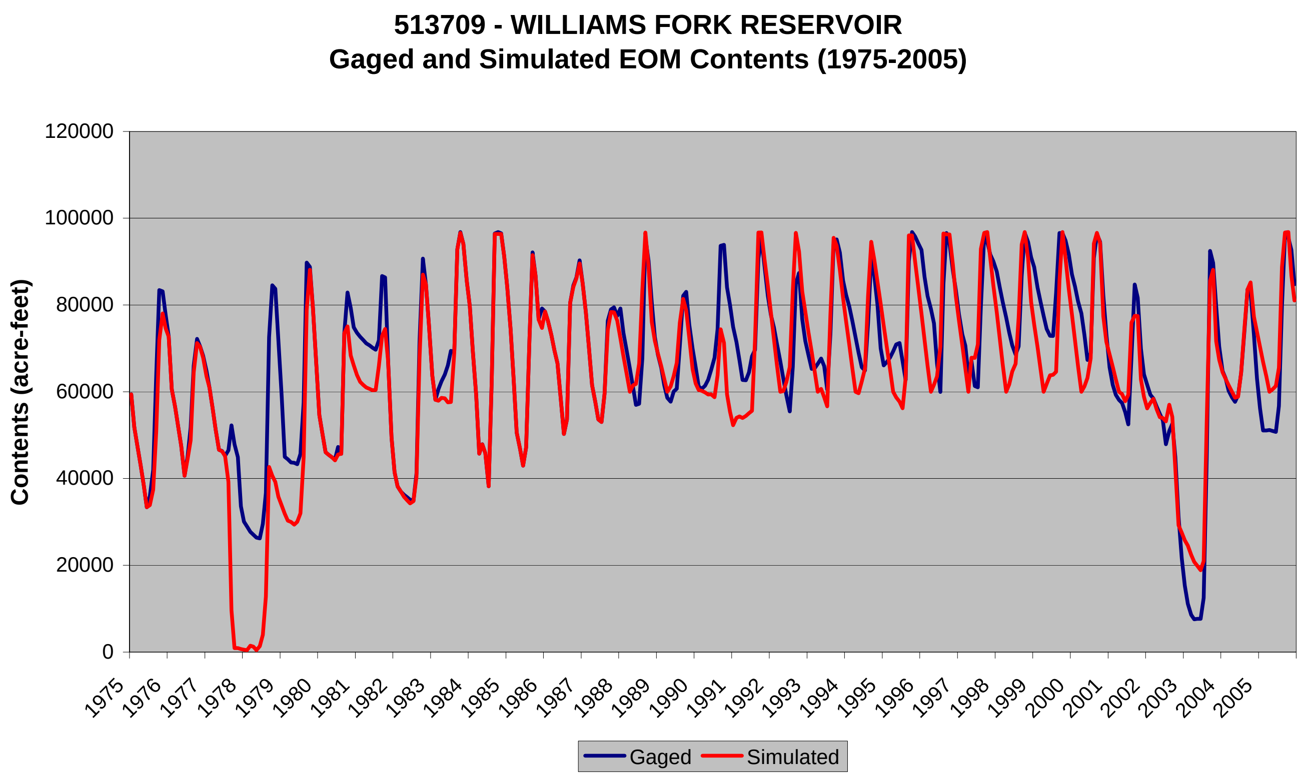


Figure E.55 Historical Daily Reservoir Simulation – Williams Fork Reservoir

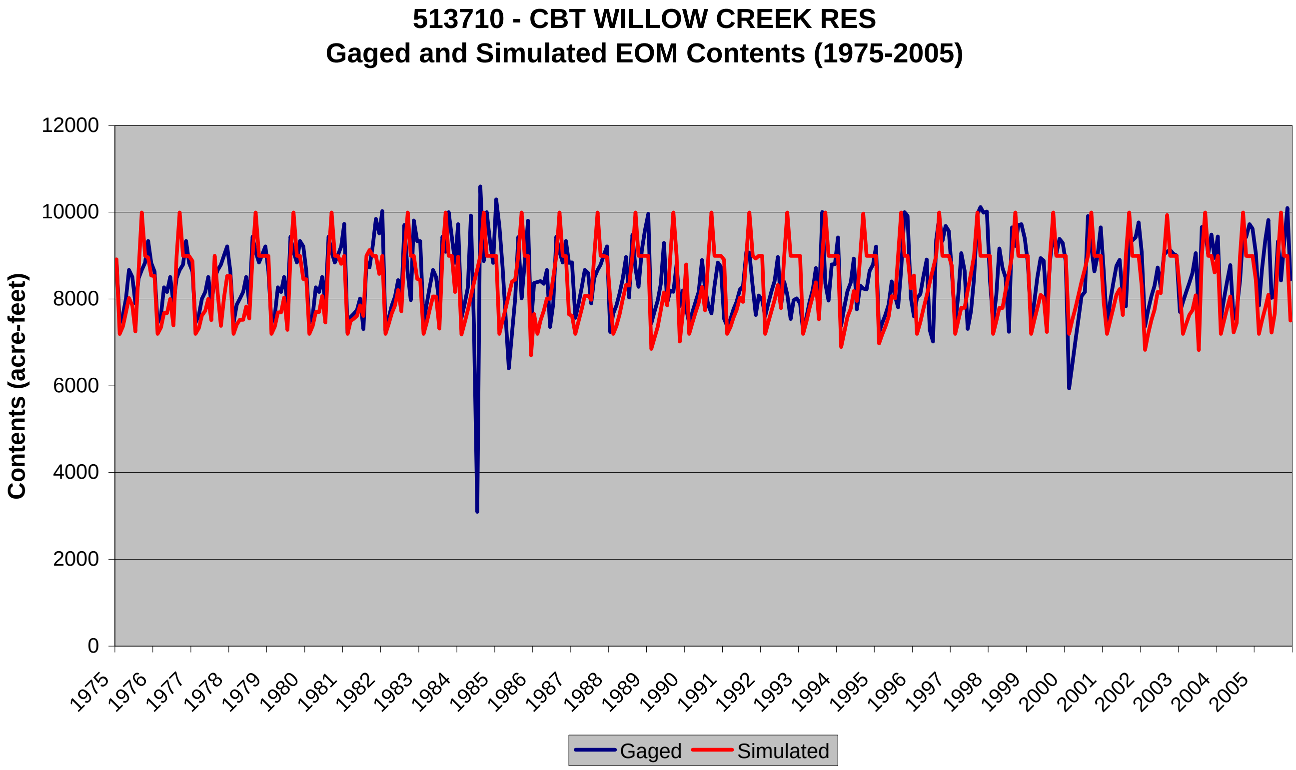


Figure E.56 Historical Daily Reservoir Simulation – CBT Willow Creek Res

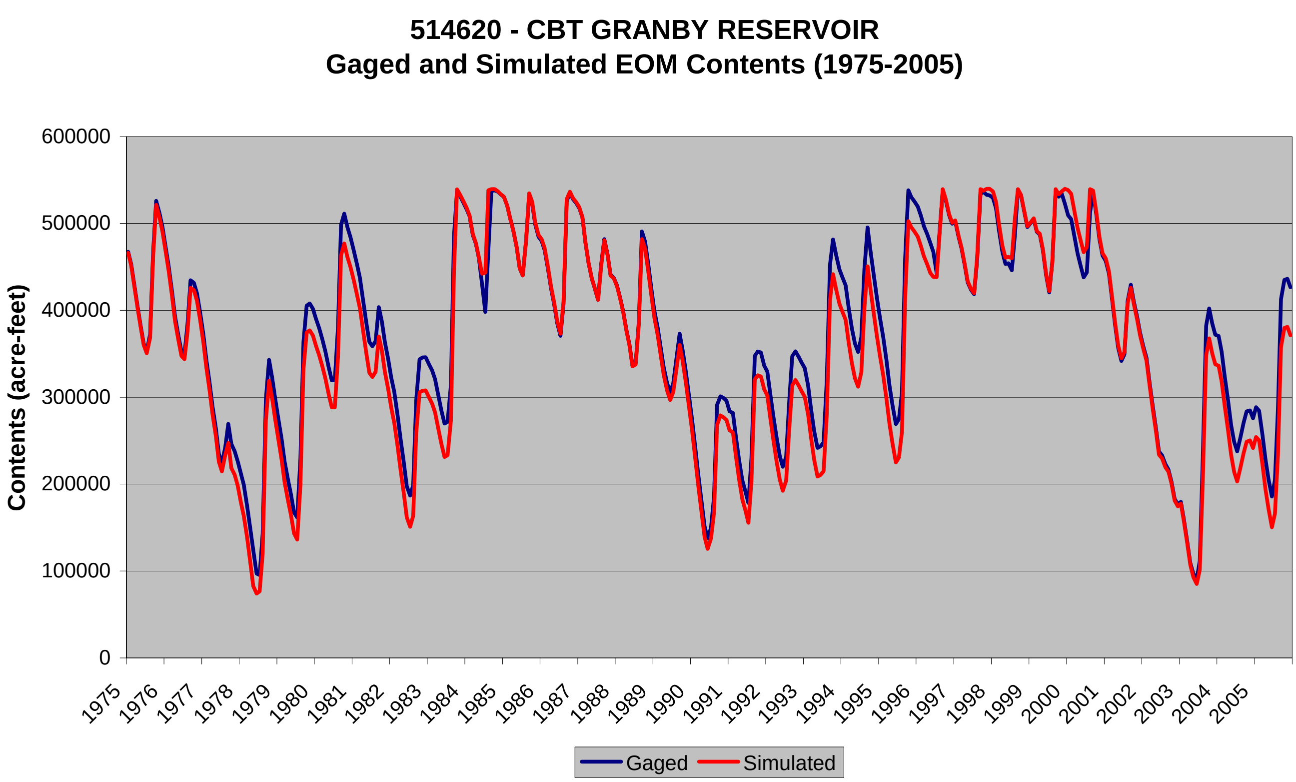


Figure E.57 Historical Daily Reservoir Simulation – CBT Granby Reservoir

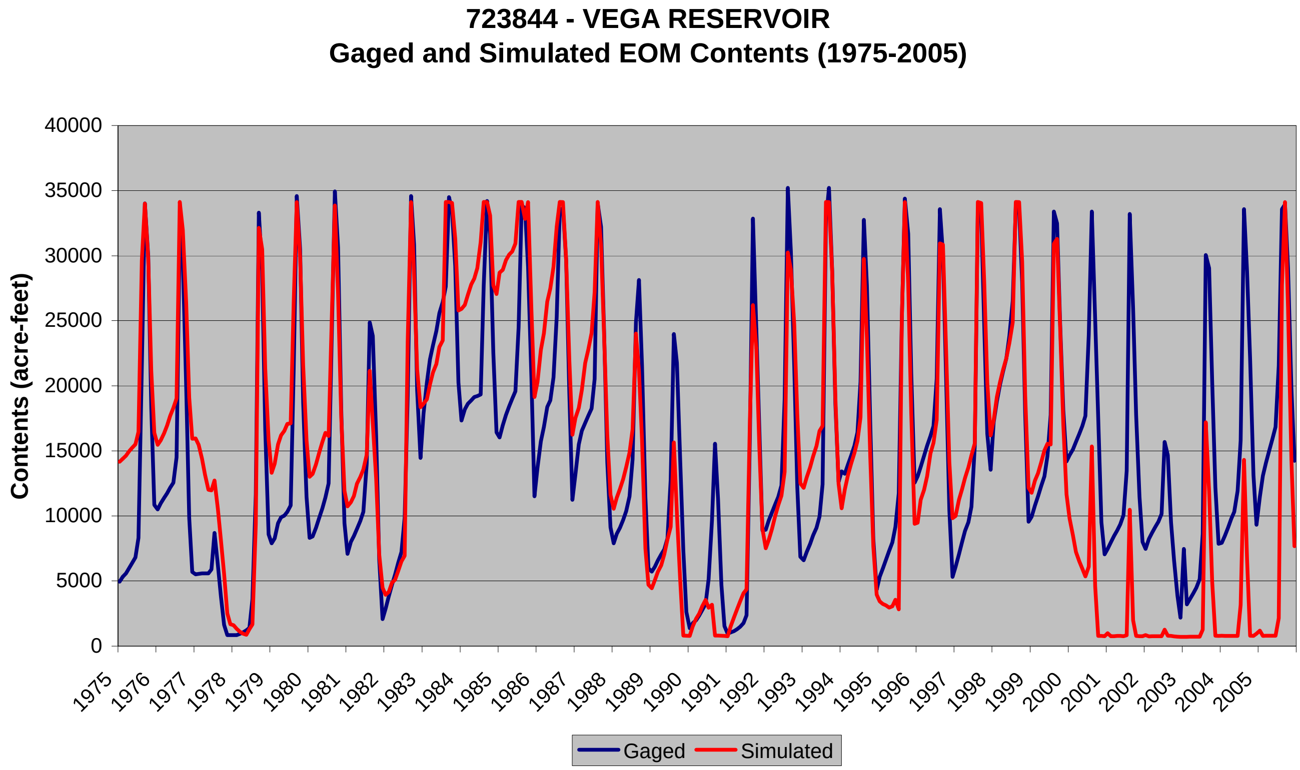


Figure E.58 Historical Daily Reservoir Simulation – Vega Reservoir

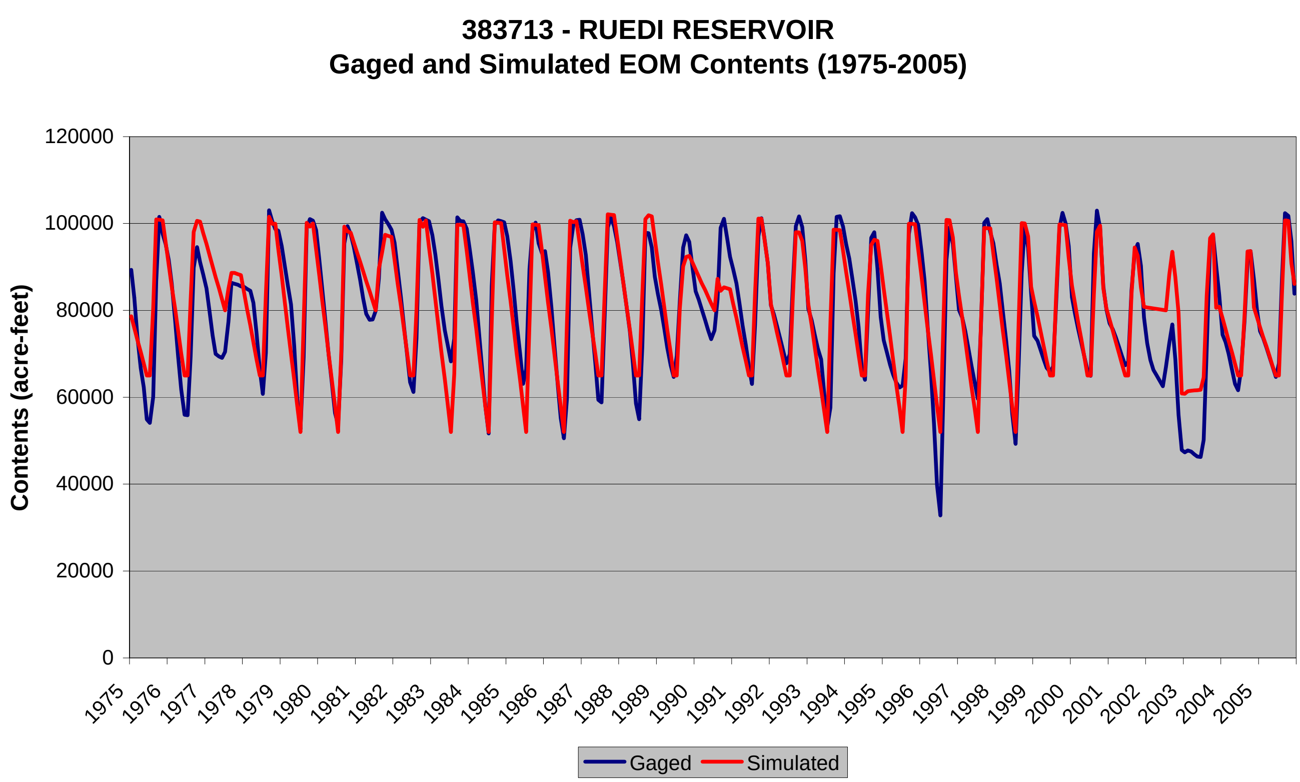


Figure E.59 Historical Daily Reservoir Simulation – Ruedi Reservoir

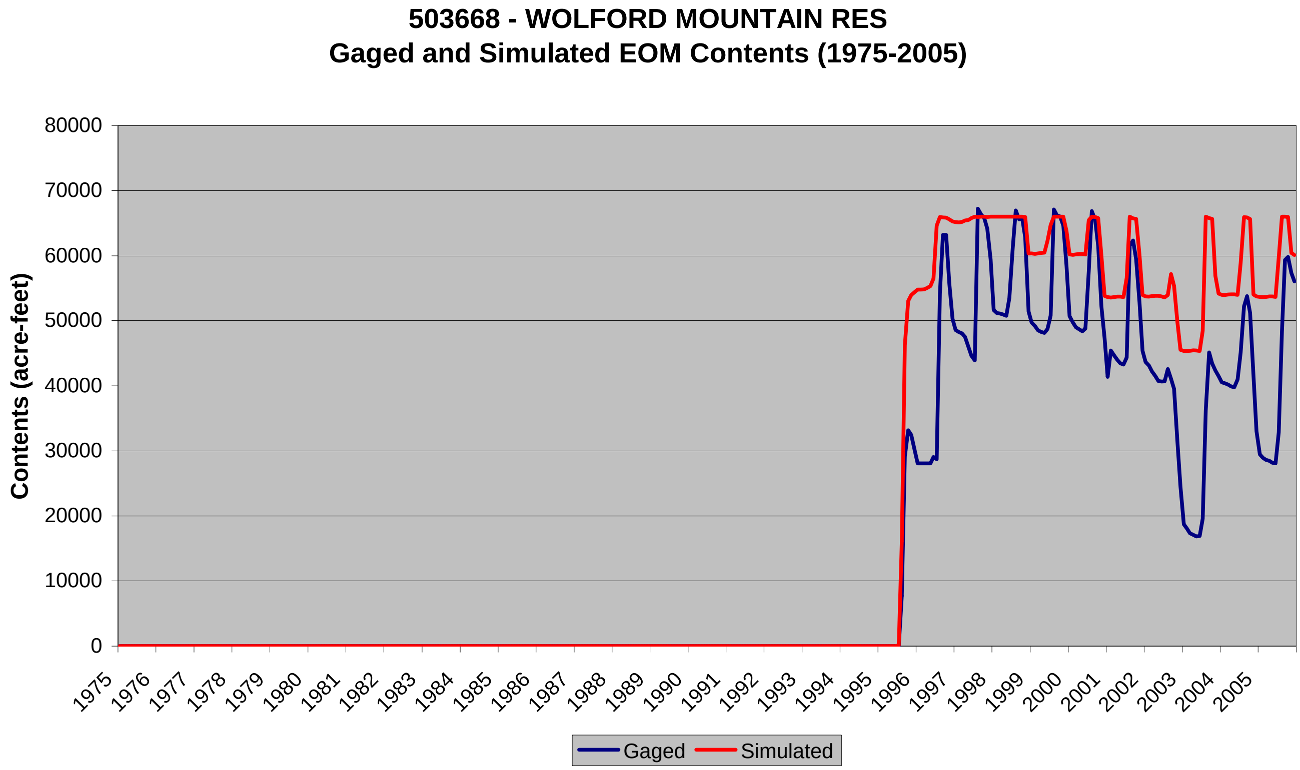


Figure E.60 Historical Daily Reservoir Simulation – Wolford Mountain Reservior