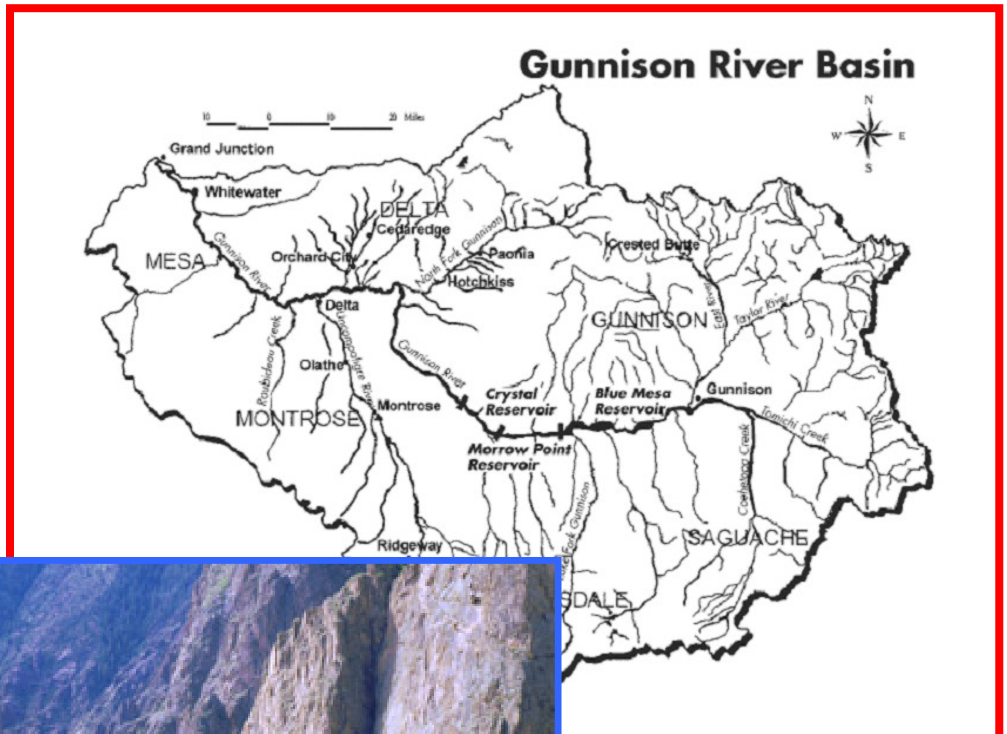
Gunnison River Basin
Water Resources Planning Model
User's Manual



July 2004

Colorado's Decision Support Systems

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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 Gunnison River Basin Water Resources Planning Model (Gunnison 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 Gunnison model “Baseline” data set, which this document describes, extends from the most currently available hydrologic year back to 1909. It simulates current demands, current infrastructure and projects, and the current administrative environment as though they had been in place throughout the modeled period.

The Gunnison 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 simulates 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 all current conditions. It is presumed that the user will compare the Baseline simulation results to results from a model to which he has added the proposed features, to determine their performance and effects.

1.2 Development of the Gunnison River Basin Water Resources Planning Model

The Gunnison model was developed in a series of phases that spanned 1998 through the present. Unlike the other basins modeled on Colorado’s Western slope, the Gunnison River Basin model was developed in two steps, Phase IIIa and Phase IIIb. The Phase IIIa model was developed to represent 100 percent of the consumptive use in the basin. Approximately 75 percent of the use was represented as individual diversions and the remaining 25 percent of use was added to the model as 41 aggregations of numerous small users. The model operated on a monthly time-step with a study period of 1975 through 1991, which also served as the model’s calibration period.

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, focusing on the period 1975 through 1996.

The State continues to refine the Gunnison model. In 2003, the study period was extended through 2002, the “variable efficiency” method was added for determining irrigation consumptive use and return flows, and a daily version was created. In addition, based on revisions to irrigated acreage, the aggregations of small users were revised and increased to 42. Calibration was reviewed after each major enhancement.

1.3 Results

The key results of the Gunnison modeling efforts are as follows:

- A water resources planning model has been developed that can make comparative analyses of historical and future water management policies in the Gunnison basin. The model includes 100% of the basin's surface water use.

- The model has been calibrated for a study period extending from calendar years 1975 to 2002.

- The calibration in the Historical scenario is considered very good, based on a comparison of historical to simulated streamflows, reservoir contents, and diversions.

- A Calculated data set has been prepared where historical irrigation demands are 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. The Calculated monthly simulation results were compared to historical streamflows, reservoir contents, and diversions. The comparison is considered good.

- A Baseline data set has been prepared which, unlike the Historical and Calculated data sets, assumes all existing water resources systems were on-line and operational for calendar years 1909 to 2002. This Baseline 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 Gunnison Model using a daily time-step has been developed. As with the monthly model, the daily model may be operated to represent the Historical, Calculated, and Baseline scenarios 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 Gunnison Model was developed to include 100 percent of the basin’s consumptive use through a combination of explicit and aggregated structures. The Gunnison 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 Gunnison model has been developed and enhanced at different stages by Boyle Engineering Corporation, Leonard Rice Engineers, and CWCB staff.

2. What's in This Document

2.1 Scope of this Manual

This reference manual describes the CDSS Gunnison 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 Gunnison River Basin development or management scenario
- Is interested in estimated conditions in the Gunnison River Basin under current development over a range of hydrologic conditions, as simulated by this model; and in understanding assumptions embedded in the modeling estimates.

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

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

2.2 Manual Contents

The manual is divided into the following sections:

Section 3 Gunnison River Basin – describes the physical setting for the model, reviews very generally water resources development and issues in the basin.

Section 4 Modeling Approach – provides an overview of methods and techniques used in the Gunnison 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 Gunnison 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 all 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 Gunnison 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 Gunnison 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 Gunnison model, written at various phases of the model's development. The body of the manual contains references to other CDSS technical memos that are more general in scope, which are available at the CDSS website.

Appendix D – discusses the comparison of historical measured data to the 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 Historical 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 all sources, pointers are included as applicable under the heading "**Where To Find More Information**," throughout the 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 Gunnison model to implement specific future operations
- introduce changes that require regenerating the baseflow 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 he needs. This list of descriptions is intended to help in selecting the most relevant data source:

Basin Information – the report "Gunnison 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.

CDSS Procedures Manual (under development) – provides an overview of the CDSS modeling environment, encompassing not only the water resources planning model, but StateCU, StateWB, and the CDSS groundwater model. The documentation describes file naming conventions and directory structures for an integrated CDSS development environment; procedures for assembling data sets; and conventions in engineering approach that have been adopted in CDSS. Following the standards presented in this documentation will promote consistency among CDSS models.

DMI user documentation – user documentation for the DMI's **makenet, watright, demandts,** and **tstool** is currently available, and covers all aspects of executing these codes against the Hydrobase database. (Creating data sets for StateMod is only one aspect of their capabilities.) The DMI's preprocess some of the StateMod input data. For example, **makenet** computes coefficients for distributing baseflow gains throughout the model, **watright** can aggregate water rights for numerous small structures, and **demandts** fills missing time series data and computes headgate demands for irrigation structures. Thus the documentation, which explains algorithms for these processes, is helpful in understanding assumptions embedded in the planning models. In addition, the documentation is essential for the user who is modifying and regenerating input files using the DMI's.

StateDMI documentation (under development) – StateDMI is a new product that will incorporate the functionality of **makenet, watright,** and **demandts.** The documentation is currently under development.

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 Gunnison model user's understanding of results. If the user is modifying input files, he should consult Section 4 Input Description to determine how to format files. To analyze model results in detail, he 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 is documented in the files themselves. Command files that directed the DMI's creation of the files are 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 for these activities are available on the CDSS website:

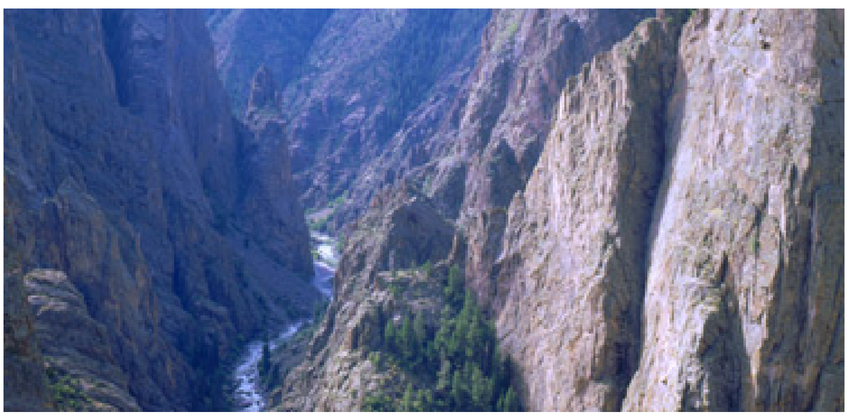
- Phase IIIb Task Memorandum 10.1 – Data Extension Feasibility
- Task Memorandum 10.2 – Evaluate Extension of Historical Data
- Task Memorandum 11.5 – Characterize Streamflow Data
- Task Memorandum 11.7 – Verify Diversion Estimates
- Task Memorandum 11.10 – Fill Missing Baseflow data (include Mixed Station 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 "Colorado River Basin Representative Irrigation Return Flow Patterns"
- Task Memorandum 1.14-23 – Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison river Basin
- Consumptive Uses and Losses Report, Comparison between StateCU CU & Losses Report and the USBR CU & Losses Report (1971-2000)

3. The Gunnison River Basin

The Gunnison River basin extends from the Continental Divide to Grand Junction, where it joins the Colorado River. The basin encompasses all of Gunnison, Delta, and Ouray counties, and parts of Montrose, Saguache, Hinsdale, and Mesa counties in Colorado. Figure 3.1 is a map of the basin. The Gunnison River and its largest tributary the Uncompahgre River flow through forested mountains and rural irrigated valleys.

3.1 Physical Geography

The Gunnison River basin is approximately 7,800 square miles in size, ranging in elevation from 14,000 feet in the headwaters to 4,550 feet at Grand Junction. Across this expanse, average annual rainfall varies from more than 40 inches in the high mountains to as little as 8 inches in the Uncompaghre Valley near the town of Delta. Temperatures generally vary inversely with elevation, and variations in the growing season follow a similar trend. The town of Gunnison has an average growing season of 144 days, while the growing season at Grand Junction has been estimated at approximately 228 days.



The Gunnison River begins at the confluence of the East and Taylor rivers, about 10 miles upstream from the city of Gunnison. The flow is increased as the river is joined by Cochetopa and Tomichi Creeks near the town of Gunnison. Just downstream, the river has carved through Precambrian rocks to form the Black Canyon of the Gunnison. Annual flow through the town of Gunnison is 547,000 acre-feet per year (United States Geological Survey [USGS] gage near Gunnison).

The Uncompahgre River is the largest tributary to the Gunnison River, entering from the south near the town of Delta. Average annual flow of the Uncompahgre near the confluence is 220,000 acre-feet (USGS gage at Delta). The average annual flow of the Gunnison River near Grand Junction is over 1.8 million acre-feet (USGS gage near Grand Junction). Approximately 60 percent of this flow is attributable to snowmelt runoff in May, June, and July.

3.2 Human and Economic Factors

The first permanent populations of white settlers came to the upper Gunnison basin in the 1800s to mine for silver. With the exception of continued mining of coal in the basin, the mineral industry is no longer a key economic sector. Farming and ranching, as well as recreation and tourism, are the primary activities in the basin today.

Figure 3.1 – Gunnison River Basin

The area remains relatively sparsely populated, with the 2001 census estimates placing the combined populations of Gunnison, Delta, and Ouray Counties at approximately 46,250. Montrose and Delta are the major population centers in the basin, with approximately 12,300 and 6,400 residents respectively. Gunnison and Delta Counties grew by just over 30 percent from 1990 to 2000, and Ouray County grew by over 60 percent in the same time period. Growth is concentrated in the lower Gunnison Valley near Grand Junction and along the Uncompahgre River near Montrose. This growth attests to the importance of recreation-based activities, as the ski area and other outdoor recreation opportunities draw people to the basin and increase tourism within the basin. Tourism serves as an important part of the basin's economy.

Much of the upper basin is predominately forest and rangeland, with irrigation becoming the principle consumptive use of water in the lower Gunnison basin. Irrigation is used for various crops including pasture, hay, fruit, corn, alfalfa, and small grains. The total irrigated acreage in the basin is estimated to be approximately 263,000 acres for the year 2000, according to the Colorado Water Conservation Board (CWCB). While diversions from many of the small irrigation ditches average one or two thousand acre-feet per year, the Gunnison Tunnel diverts approximately 320,000 acre-feet per year to supply large irrigators in the Uncompahgre River Basin.

Primary use of surface water throughout the entire basin is for hydropower generation, which has historically diverted over approximately 3 million acre-feet per year, according to the CWCB. Note that this use is non-consumptive. The Aspinall Unit of the Colorado River Storage Project encompasses the major power plants within the basin. Hydroelectric power plants are located in series at the dams of the Blue Mesa, Morrow Point, and Crystal reservoirs. The three power plants have the capability to generate up to 208,000 kilowatts of power for the basin and surrounding areas.

There are also diversions for municipal and industrial use in Delta and Montrose, as well as in a number of smaller towns. One major transbasin diversion, the Redlands Canal, exports water from the Gunnison River basin to the Colorado Mainstem basin. The diversion's senior water rights account for 750 cfs, which can be used for irrigation and power generation. There are also a number of smaller transbasin diversions from one tributary drainage basin to another.

In addition to the direct ditch diversions, there are eleven major reservoirs (greater than 4,000 acre-feet in capacity) in the Gunnison River basin. Three of the largest reservoirs, Blue Mesa, Morrow Point, and Crystal, were constructed pursuant to the Colorado River Storage Project, which was enacted in 1956. The reservoirs, with normal capacities of 940,800 acre-feet, 117,190 acre-feet, and 26,000 acre-feet respectively, were constructed to normalize and maintain the delivery of Colorado River Compact water to the lower basin in years of limited precipitation. Two reservoirs, Taylor Park and Ridgway, are predominately used to store water for supplemental irrigation water supply and release for fish flows. The remaining reservoirs include Paonia, Crawford, Silverjack, Gould, Overland, and Fruitgrowers reservoirs, which are predominantly used for irrigation.

3.3 Water Resources Development

The Gunnison River basin has seen substantial water resources developments in the form of private irrigation systems, municipal and industrial diversions, and federal projects. Table 3.1 summarizes key development and agreements within the basin over time.

Table 3.1 – Key Water Resources Developments

Date	Description	Date	Description
1908	Gunnison Tunnel and Diversion Dam	1973	Vader Right Adjudicated
1937	Taylor Park Reservoir	1975	Taylor Park Exchange Agreement
1962	Paonia and Crawford Reservoirs	1976	Crystal Reservoir
1966	Blue Mesa Reservoir	1986	Taylor Park Refill
1968	Morrow Point Reservoir	1987	Ridgway Reservoir
1971	Silverjack Reservoir		

3.4 Water Rights Administration and Operations

Historical water rights administration in the Gunnison River basin can be divided into three distinct time periods. The first time period was from 1902 through 1937 when the Gunnison Tunnel dominated administration. Prior to the construction of Taylor Park Reservoir, water rights were administrated on the basis of direct flow priorities. The senior direct flow rights of the Uncompahgre Valley Water User's Association (UVWUA) on the Uncompahgre and Gunnison Rivers regularly called out junior diverters in both basins in the summer months. Late season irrigation shortages in the Uncompahgre River basin were still relatively common even for those with senior water rights.

The second significant time period was from 1937 through 1966 when the Taylor Park Reservoir dominated administration. Prior to the Aspinall Unit, yet with the construction of Taylor Park Reservoir, junior diverters were still subjected to senior river calls by UVWUA. However, UVWUA typically had late season water that effectively eliminated the late summer shortages in the Uncompahgre River basin, except in the extreme dry year 2002.

The final significant time period is from 1966 to present time, whereby the Aspinall Unit was constructed and currently dominates flows in the Gunnison River and water rights administration in the basin. The Aspinall Unit gave the UVWUA the ability to draw its Taylor Park storage water from Blue Mesa Reservoir. This resulted in three major impacts on water rights administration. First, it eliminated the need to "Shepard" Taylor Park releases past intervening upper basin headgates to the Gunnison Tunnel. Second, subordination of the Aspinall water rights to 60,000 acre-feet of upstream junior depletions (a condition of the transfer of the project's water rights from the Colorado River Water Conservation District to the United States) meant that the Aspinall Unit could not call out water users above Blue Mesa. Lastly, Aspinall Unit releases for power generation created substantial amounts of "free water" which effectively eliminated the large senior downstream calls by the Austin and Redlands water rights.

Future administration of the Gunnison may be affected by the National Park Service (NPS) decreed reserved water right for instream flow purposes on the Gunnison River through the Black Canyon of the Gunnison. In addition to this reserved water right, the U.S. Fish and Wildlife Services have also adopted flow recommendations for the Gunnison River that could potentially affect administration.

Future administration and/or reservoir operations in the Gunnison may also be affected by activities and projects in the Recovery Program for Endangered Fish. Under the Endangered Species Act, four Colorado River native fish species are listed as endangered: Colorado pikeminnow (a.k.a. Colorado squawfish), humpback chub, bonytail chub, and razorback sucker. In 1988, the States of Colorado, Utah, and Wyoming, water users, hydropower customers, environmental organizations, and federal agencies developed a program to recover these species while allowing water use to continue and up to 50,000 acre-feet/year of new consumptive use to be developed.

As part of the recovery efforts, The Bureau of Reclamation has altered the timing and releases from the Aspinall Unit dams to help researchers refine habitat requirements of the endangered fish. The result of this research will help in preparing new biological opinions on current reservoir operations and, potentially, determine future revisions to operations.

The Colorado River Salinity Control Program is an on-going effort to decrease salinity levels from the upper Colorado River basin mainstem and tributaries. The Bureau of Reclamation and the Natural Resources Conservation Service have recommended a variety of salinity control measures in the lower Gunnison basin, including the Uncompahgre River, that could affect future irrigation methods and basin operations.

3.5 Section 3 References

1. Colorado River Decision Support System Gunnison River Basin Water Resources Planning Model, Boyle Engineering Corporation, December 1999.

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

3. USBR: Colorado River Storage Project, available at http://www.usbr.gov/dataweb/html/crsp.html

4. Black Canyon of the Gunnison National Park Reserved Water Right Facts, Colorado Water Conservation Board, 2001.

5. Colorado River Basin Salinity Control Program Lower Gunnison Basin Unit, Colorado, available at http://wwww.usbr.gov/dataweb/html/lowergun.html

4. Modeling Approach

This section describes the approach taken in modeling the Gunnison 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 Gunnison 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 5.

4.2 Model coverage and extent

4.2.1. Network Diagram

Figure 4.1 is the network diagram for the Gunnison River model. It includes almost 500 nodes, beginning with instream flow reaches near the headwaters of both East River and Taylor River and ending at the Gunnison River confluence with the Colorado River, near Grand Junction.

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 basinwide 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, a 9 cubic feet per second (cfs) cutoff value was selected for the Gunnison River basin. Key diversion structures are generally those with total absolute water rights equal to or greater than 9.0 cfs. The Gunnison model includes approximately 320 key diversion structures.

Where to find more information

- Section 3 of the CDSS document "Gunnison 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 Gunnison Basin Information Section "Division 4 Meeting".

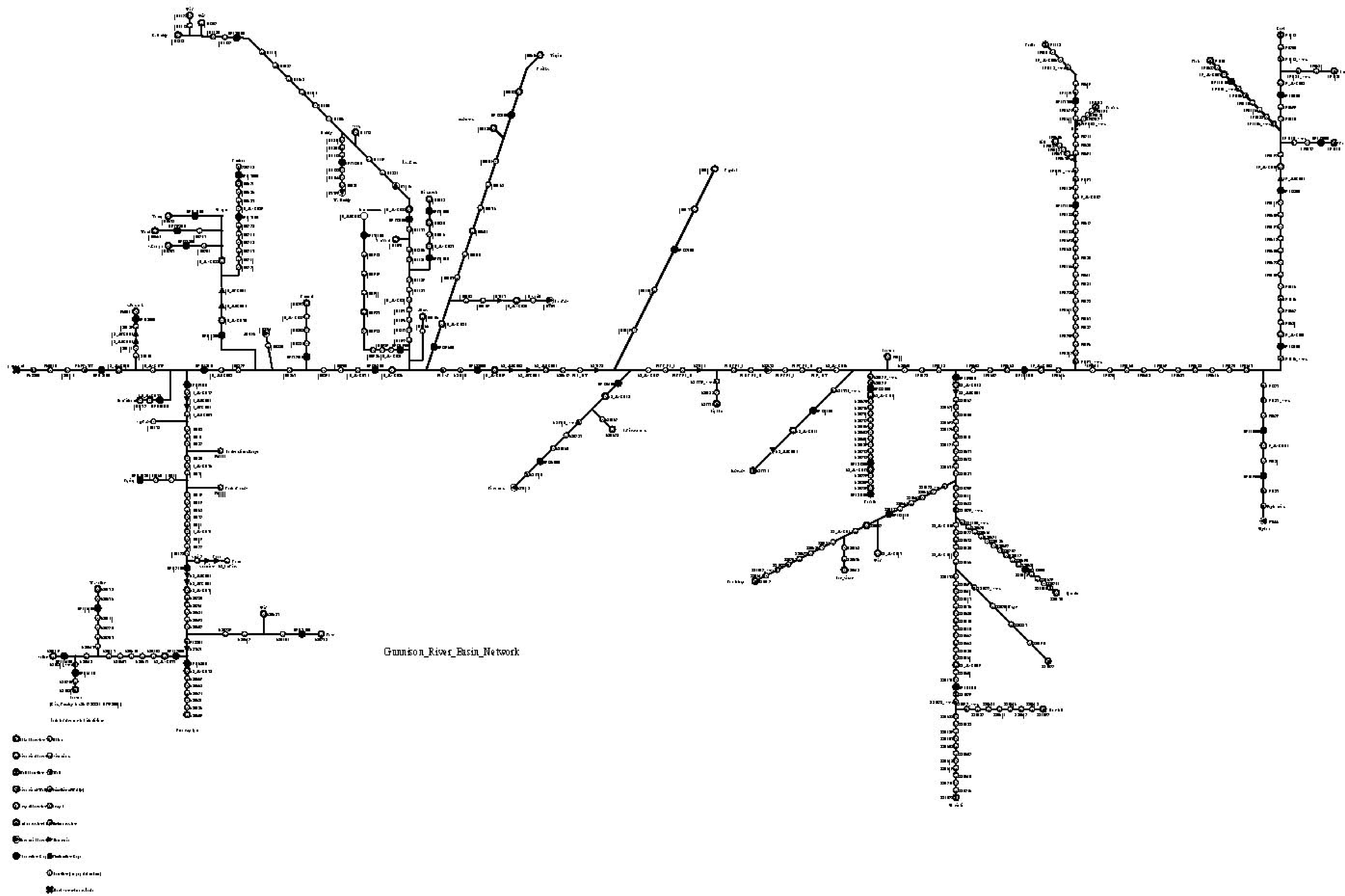


Figure 4.1 Network Diagram – Gunnison River Planning Model

4.2.2.2 Aggregation Of Irrigation Structures

In general, the use associated with irrigation diversions having total absolute rights less than 9.0 cfs 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 Gunnison model, 42 aggregated nodes were identified, representing over 61,000 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 all the water rights associated with their constituent structures. 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.

4.2.2.3 Municipal and Industrial Uses

Three nodes in the model represent the combined small diversions for municipal, industrial, and livestock use (M&I) in three water districts in the basin. Total non-irrigation consumptive use in the Gunnison basin was estimated, as documented in the task memorandum "Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison River Basin." Consumptive use of the key M&I diversions in the model was subtracted from this basinwide M&I consumption, to derive the basinwide consumptive use attributable to small M&I users. This value was distributed to Water Districts 40, 41, and 62 in accordance with a general distribution of M&I use.

The three aggregated M&I nodes in the Gunnison model represent approximately 4,600 af of consumptive use, a small percentage of the basin total use. These diversions have a priority of 1.0 (very senior) in the model, and a decreed amount that greatly exceeds their demands. In other words, these structures' diversions are not limited by their water right. The monthly demands (which are set to the consumptive use rather than diversion amount) were set in accordance with results of the BBC investigation cited above.

Project 7 Water Authority municipal diversion is represented explicitly. A component of the Dallas Creek Project, Project 7 provides treated domestic and municipal water for the Uncompahgre Valley including the towns of Montrose and Delta. Although not a basin consumptive use, M&I water "exported" from the Gunnison for power generation through the Redlands Canal and water "exported" from Kannah Creek for the City of Grand Junction are also represented.

Where to find more information

- Appendix B includes a memorandum describing the task in which municipal and industrial uses were aggregated. Appendix B also includes CRDSS Task 1.14-23 Memorandum "Non-Evapotranspiration (Other Uses) consumptive Uses and Losses in the Gunnison River Basin", May 1995.

4.2.3. Reservoirs

4.2.3.1 Key Reservoirs

Reservoirs with decreed capacities equal to or in excess of 6,000 acre-feet are considered key reservoirs, and are explicitly modeled. There are 11 key reservoirs with a combined total capacity of approximately 1,931,000 af, or 94 percent of the total absolute storage rights of the basin. In addition, two smaller reservoirs are explicitly modeled due to their importance in water administration and project deliveries.

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 were incorporated using 14 aggregated reservoir structures.

Nine structures were used to represent all the adjudicated, absolute storage rights in the database that are otherwise unaccounted for. Table 4.1 below summarizes storage capacity for the nine reservoirs. Surface area for the reservoirs was developed assuming they are straight-sided pits with a depth of 25 feet, based on available dam safety records.

Table 4.1
Aggregated Reservoirs

ID	WD	Name	Capacity (AF)	%
28_ARG001	28	AGG_RES_Tomichi	6,395	6
40_ARG001	40	AGG_RES_Surface	23,268	22
40_ARG002	40	AGG_RES_Ngunn	23,268	22
41_ARG001	41	AGG_RES_Uncomp	3,226	4
42_ARG001	42	AGG_RES_Kannah	17,876	17
59_ARG001	59	AGG_RES_East	9,826	9
62_ARG001	62	AGG_RES_Lake	6,475	6
62_ARG002	62	AGG_RES_Main	6,475	6
68_ARG001	68	AGG_RES_Upper Uncomp	8,359	8
		Total	105,168	100

The five remaining reservoirs represented stockpond use, as documented in CDSS Task 1.14-23 Memorandum "Non-Evapotranspiration (Other Uses) consumptive Uses and Losses in the Gunnison river Basin", May 1995. The total storage was divided into five aggregated stockponds, located to correspond with the major stock-use areas. The stockponds were modeled as 10-foot deep straight-sided pits.

Neither the aggregated reservoirs nor the stockponds release to the river in the models. They evaporate, however, 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.

Table 4.2
Aggregated Stockponds

ID	WD	Name	Capacity (AF)	%
40_ASG001	40	AGG_STOCK_Surface	1,727	20
41_ASG001	41	AGG_STOCK_Uncomp	1,727	20
42_ASG001	42	AGG_STOCK_Kannah	1,727	20
62_ASG001	62	AGG_STOCK_Main	1,727	20
68_ASG001	68	AGG_STOCK_UpperUncomp	1,727	20
		Total	8,635	100

> **Where to find more information**
>
> - Appendix B includes a task memo describing the original effort to aggregate small reservoir use, as well as some later simplifying changes. Appendix B also includes CRDSS Task 1.14-23 Memorandum "Non-Evapotranspiration (Other Uses) consumptive Uses and Losses in the Gunnison river Basin", May 1995.

4.2.4. Instream Flow Structures

The model includes 31 instream flow reaches representing instream flow rights held by CWCB, minimum reservoir release agreements, and filings by the U.S. Department of the Interior. These are only 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 Gunnison model data set extends from 1909 through 2002 and operates on USGS water year (October 1 through September 30). The calibration period was 1975 through 2002, 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) 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 all five West 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 *(Appendix E.1)*
>
>   -Evaluate Extension of Historical Data *(Appendix E.2)*

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 Gunnison 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 Gunnison model.

4.4.1. Historical Data Extension For Major Structures

4.4.1.1 Historical Diversions

Fourteen major diversions in the Gunnison 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, 1956 through the current year. Available records prior to 1956 were digitized from SEO records to complete historic diversions. Redlands Power Canal, which diverts from the Gunnison River for use in the Colorado River Basin, was filled using SEO and other available records then divided into irrigation diversion and power diversion. Diversion records for South Canal, which diverts from the Gunnison Tunnel, were estimated based on a percentage of historic Montrose and Delta Canal diversions.

Table 4.3
Investigated and Extended Major Structures

WDID	Name	1909-2002 Annual Diversion
420541	Redlands Power Canal	420,500
620617	Gunnison Tunnel + S Canal	298,300
410545	Montrose + Delta Canal	155,300
410534	Ironstone Canal	99,100
410559	Selig Canal	57,500
410577	West Canal	47,400
410520	East Canal	44,700
401133	Fire Mountain Canal	34,600
410537	Loutsenhizer Canal	39,600
620560	Cimmaron Canal	28,900
410527	Garnet Canal	20,800
400863	Bonafide Ditch	18,000
400900	Relief Ditch	16,100
410578	South Canal	38,000

4.4.1.2 Historical Reservoir Contents

Historical reservoir content data is limited in HydroBase. Therefore, 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 each 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 has been categorized as an Average, Wet, or Dry month based on the gage flow at long-term "indicator" gages in the Gunnison basin. A data point missing for a Wet March, for example, is then filled with the average of only the 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 three streamflow characterizations in the Gunnison basin, based on three indicator gages: Gunnison River near Grand Junction (09152500), East River at Almont (09112500), and Uncompahgre River at Colona (09147500). The characterization for the Gunnison River gage is used when filling in time series for structures in District 41 and District 42. Similarly, the East River gage characterization pertains to Districts 28, 59, 62, and 40. The Uncompahgre River gage characterization pertains to District 68.

Months with gage flows at or below the 25th percentile for that month are characterized as "Dry", while months at or above the 75th 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 1950's, 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 1950 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 (*Appendix E.1)*

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

  -Characterize Streamflow Data (*Appendix E.6)*

  -Verify Diversion Estimates (*Appendix E.7*)

  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 and demandts documentation describes how to invoke the automated data filling procedure using those DMI's

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 been occurring at the earlier time. The CDSS approach is therefore to estimate baseflows at all 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 all 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 all eligible correlations.

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 only eight gages in the Gunnison 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 29. Approximately 56 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" (*Appendix E.8*) 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 Gunnison 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 times 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 Gunnison basin, 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 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 Gunnison Basin, maximum system efficiency in the upper reaches, defined as above the Aspinall Unit, is estimated to be 40 percent. In the remaining portions of the basin, maximum system efficiency is estimated to be 50 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.

Now 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, assume the maximum system efficiency is 50 percent, therefore a maximum of 50 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 50 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 50 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 Gunnison 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 Gunnison model, irrigation water requirements have been developed for all irrigation diversions. The two basin exporters in the Gunnison model (Redlands Power Canal and the Grand Junction Pipeline from Kannah Creek) have been assigned a diversion efficiency of 1.00 in all months. During both baseflow estimation and simulation, the entire amount of the diversion is assumed to be removed from the hydrologic system. The explicitly modeled municipal system, Project 7, and the aggregated municipal demands have been modeled using historical consumptive use, not withdrawals. Therefore, they have been assigned a diversion efficiency of 1.0 in all months. Reservoir feeders and other carriers that do not irrigate lands have also been assigned a diversion efficiency of 1.00 in all months. These feeders include the following:

- Aspen Ditch
- Aspen Canal
- Fruitland Canal
- Smith Fork Feeder Canal
- Transfer Ditch
- Cimmarron Canal
- Gunnison Tunnel

Finally, every structure in the model, including irrigation structures operating by variable efficiency, has monthly efficiencies assigned to it in the model input files. For irrigation structures, these are average monthly efficiencies based on historical diversions and historical crop water requirement over the period 1975-2002, but may not exceed the assigned maximum efficiency. These are used by DMI components of CDSS to create time series of headgate demands for input to the model, as described in Section 4.9.1.

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 Time Series file (Section 5.5.2)
  - Soil moisture capacity in the Structure Parameter file (Section 5.5.1)
  - Loss to the hydrologic system in the 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 Gunnison model. One represents instantaneous (or within the same month as the diversion) returns and is applied to municipal and non-consumptive diversions. A second pattern places 100 percent of the diversion return in the fourth month following the diversion. This pattern is used for returns from artificial snowmaking.

The last two patterns are generalized irrigation return patterns, applicable to irrigated lands “close” to the stream (center of acreage is approximately 600 feet from the stream), and “further” from the stream (center of acreage is approximately 1500 feet from the stream). The two patterns were developed using the Glover analytical solution for parallel drain systems. The State’s Analytical Steam 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 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 both 600 feet from the recharge center to the stream, and 1500 feet from the recharge center to the stream.

It was assumed that the resulting pattern applies to only 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 the patterns shown reflect 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 Gunnison model are estimated to be 3 percent of unused water.

Where to find more information

- CDSS Memorandum "Colorado River Basin Representative Irrigation Return Flow Patterns", Leonard Rice Engineers, January, 2003. *(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 6 personnel. Some return flow locations were modified during calibration.

Table 4.4
Percent of Return Flow Entering Stream in Month *n* after Diversion

Month *n*	For Lands "Close" to Stream (%)	For lands "Further" from Stream (%)
1	78.6	60.4
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

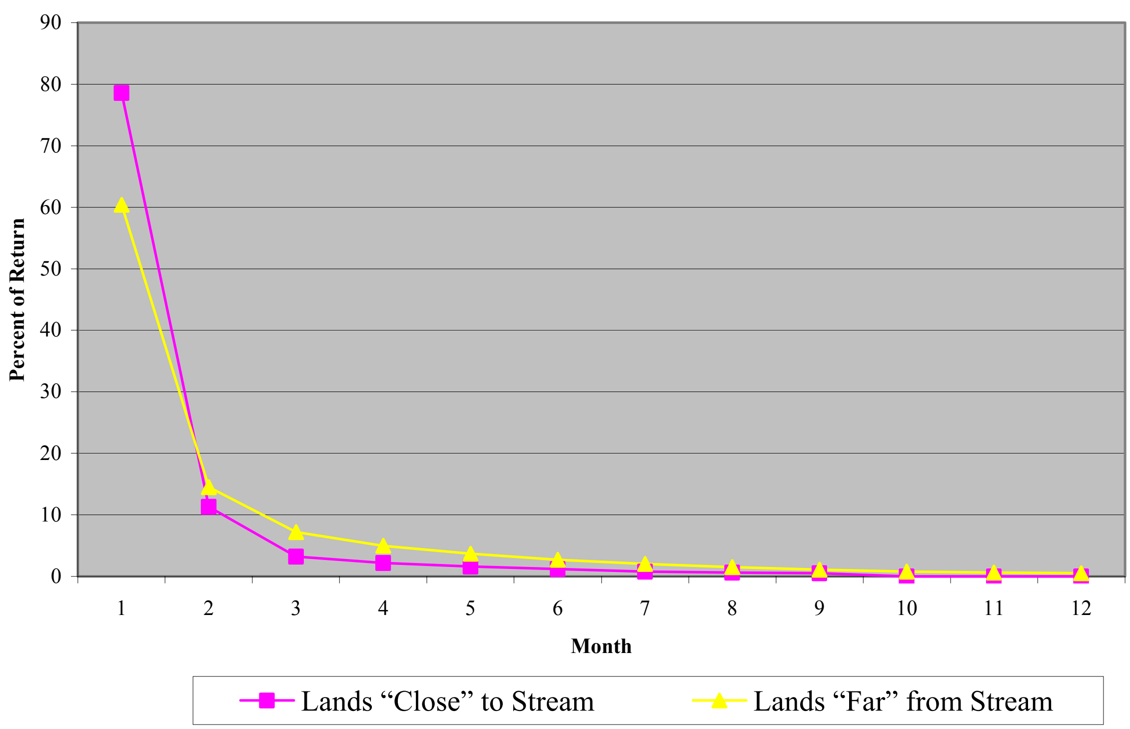


Figure 4.2 Percent of Return in Months After Division

4.7 Baseflow Estimation

In order to simulate river basin operations, the model must have at hand 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 assumption 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 any simulation, 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 all upstream depletive effects to the gaged value, and subtracting historical values of all 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 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.

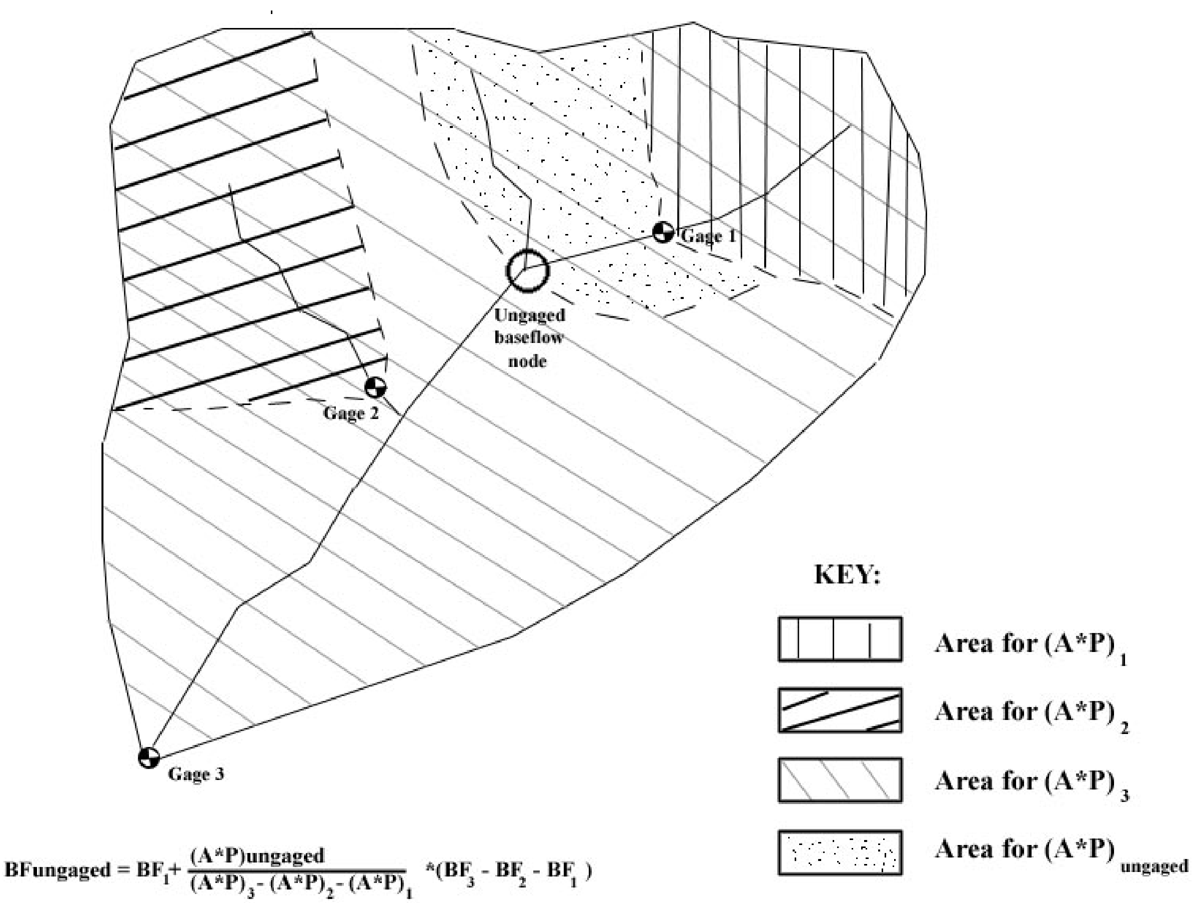


Figure 4.3 Hypothetical Basin Illustration

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 any 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 **makenet** 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 streamgages, reservoir levels, and diversions. The Gunnison 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-headgated 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 only for the period in which they were on-line historically. Reservoir storage was limited only 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 Gunnison basin, 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 gageflows, reservoir contents, and diversions with historical observations of these parameters.

Where to find more information

- Section 7 of this document describes calibration of the Gunnison model.

4.9 Baseline Data Set

The Baseline data set is intended as a generic representation of recent conditions on the Gunnison River, 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. All existing water resources systems are on line 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.

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 2002 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 (50 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 0.50) 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 Gunnison 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 were set to average monthly diversions over the period 1975-1991.

4.9.4. Reservoirs

All reservoirs are represented as being on-line throughout the study period, at their current capacities. Initial reservoir contents were set to full. During simulation, StateMod sizes reservoir releases to satisfy unmet headgate demand, assuming the reservoir is a supplemental supply to direct flow rights. (StateMod has the option of sizing releases to meet irrigation water requirement at maximum efficiency, but that style of operation is not characteristic of the Gunnison River basin reservoirs.)

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 Gunnison 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 simply 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 four 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 operating rights file, which specifies operations other than simple diversions, onstream reservoir storage, and instream flow reservations. 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 is created by hand using a text editor, and lists all the other files in the data set. StateMod reads the response file first, and then "knows" what files to open to get the rest of the input data. The list of input files is slightly different depending on whether StateMod is being run to generate baseflows or to simulate. Since the "Baseline data set" refers to a particular simulation scenario, 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 *gunnVB.rsp*, describes contents of each file, and shows the subsection of this chapter where the file is described in more detail. The file *GunnV.dum* is an empty dummy file, and is referenced in the response file for all the StateMod input file types that are not needed for this particular simulation.

File Name	Description	Reference
gunnV.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 5.2
gunnV.rin	River network file – lists every model node and specifies connectivity of network	Section 5.3.1
gunnVB.res	Reservoir station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1
gunnV.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
gunnV.ris	River station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 5.3.2
gunnV.ifs	Instream flow station file – lists instream flow reaches	Section 5.7.1
gunnVH.dum	Well station file (not used in the Gunnison model)	n/a
gunnV.ifr	Instream flow right file – gives decreed amount and administration number of instream flow rights associated with	Section 5.7.3

File Name	Description	Reference
	instream flow reaches	
gunnV.rer	Reservoir rights file – lists storage rights for all reservoirs	Section 5.6.5
gunnVC.ddr	Direct diversion rights file – lists water rights for direct diversion	Section 5.4.5
gunnVB.opr	Operational rights file – specifies many different kinds of operations that are more complex than a direct diversion or an onstream storage right. Operational rights can 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 is not downstream, or a direct diversion to fill a reservoir via a feeder	Section 5.8
gunnVH.dum	Well rights file (not used in the Gunnison model)	n/a
gunnVH.dum	Precipitation file – Annual (not used in the Gunnison model)	n/a
gunnF.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
gunnVx.xbm	Baseflow data file – time series of undepleted flows at all nodes listed in *gunnV.ris*	Section 5.3.5
gunnVB.ddm	Monthly demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
gunnVH.dum	DD demand overwrite file – Monthly (not used in the Gunnison model)	n/a
gunnVH.dum	DD demand file – Annual (not used in the Gunnison model)	n/a
gunnV.ifa	Instream flow demand file – gives the decreed monthly instream flow rates	Section 5.7.2
gunnVH.dum	Well demand file (not used in the Gunnison model)	n/a
crdss.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
gunnVB.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
gunnV.tsp	CU Time series file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
gunnV.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3
gunnV.par	Soil Parameter file – soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
gunnV.eom	Reservoir End of month contents file – Monthly time series of historical reservoir contents	Section 5.6.3

File Name	Description	Reference
gunnV.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
gunnV.rih	Historical streamflow file – Monthly time series of streamflows at modeled gages	Section 5.3.4
gunnV.ddh	Historical Diversions – Monthly time series of historical diversions	Section 5.4.3
gunnVH.dum	Historical well pumping (not used in the Gunnison model)	n/a
gunnF.gis	GIS file	n/a
gunnFB.xou	Output control file – contains a switch for each structure and operating right, indicating whether specific output reports are to be generated. A template file is created by StateMod when run in data check mode, and can be modified at the user’s discretion. See Section 5 of the StateMod documentation.	n/a

5.1.2 For Generating Baseflow

The baseflow file (*.xbm) that is part of the Baseline data set was created by StateMod and the Mixed Station Model in three steps which are described in Sections 4.7.1 through 4.7.3. In the first step, StateMod estimates baseflows at gaged locations, using the files listed in the response file gunnV.rsp. In gunnV.rsp, the dummy file name gunnV.dum occupies the position for the baseflow data file, which has not yet been created. The baseflow response file calls for different reservoir station, operational rights, and reservoir target files from the Baseline response file, in all cases to reflect strictly historical data.

The baseflow time series created in the first run are all partial series, because gage data is missing some of the time for all gages. The Mixed Station Model is used to fill the series, creating a complete series of baseflows at gages in a file named gunnV.xbf. The response file for the third step, in which StateMod distributes baseflow to ungaged points, is named gunnVx.rsp. The only difference between the first-step response file gunnV.rsp and third-step response file gunnVx.rsp is that the name gunnV.xbf replaces the historical gage file gunnV.rih.

5.2 Control File (*.ctl)

The control file is hand-created using a text editor. It contains execution parameters for the model run, including 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 is not a feature of the Gunnison model. Control file switches are all 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 is created by the DMI **makenet**, which reads in a hand-edited file (*.net) that specifies the model network.

The river network file describes the location and connectivity of each node in the model. Specifically, it is simply 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 has exactly one downstream node.

Figure 4.1 in Section 4.2.1 illustrates the network, which starts at an instream flow reach at the headwaters of East River and ends just upstream of the Gunnison River confluence with the Colorado River.

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. Other nodes are locations in the basin where information is desired, such as water quality monitoring locations. Table 5.1 shows how many nodes of each type are in the Gunnison model.

Table 5.1
River Network Elements

Type	Number
Diversion	358
Instream Flow	29
Reservoirs	27
Stream Gages [1)]	53
Total	467

1) Includes Leon Tunnel Canal import from the Colorado Basin

Where to find more information

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

5.3.2 River Station File (*.ris)

The river station file is also created by the DMI **makenet**. 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 52 gages in the model, 1 basin import, and 81 ungaged baseflow locations, for a total of 135 hydrologic inflows to the Gunnison River model. Ungaged baseflow nodes include all ungaged headwater nodes, six key reservoir nodes, 27 aggregated diversion nodes, and any other nodes where calibration revealed a need for it. In the last case, water that was simulated as entering the system further down (e.g., at the next gage) was moved up the system to the ungaged point.

5.3.3 Baseflow Parameter File (*.rib)

The baseflow parameter file has an entry for each ungaged baseflow node in the model, specifying coefficients, or "proration factors", used to calculate the baseflow gain at that point. **Makenet** computes proration factors based on the network structure and Area*Precipitation values supplied for both gages and ungaged baseflow nodes. This information is in the network file which is input to **makenet**. 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 is 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 with similar physiographic characteristics. Baseflow at the ungaged site was assumed 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 tributaries:

Tributary Name	Baseflow WDID	Neighboring Gage
Hot Springs Creek	281077	9118000
Alum Gulch	400506	9134050
Smith Fork	400586	9128500
Hubbard Creek	401190	9131200
Alfalfa Run	403365	9137050
Iron Creek	403395	9128500
North Beaver Creek	590544	9127500
Mill Creek	590606	9113300
Carbon Creek	591402	9113300
Cimarron River	620672	9124500
Big Blue Creek	621339	9124500
Cow Creek	680683	9147100

Where to find more information

- StateDMI documentation for **makenet** gives the file layout and format for the *.*net* file.
- Section 4.7.3 describes how baseflows are distributed spatially.

5.3.4 Historical Streamflow File (*.rih)

Created by **tstool**, the historical streamflow file contains historical gage records for 1909-2002, for the modeled gages. These are used for baseflow stream generation and to create comparison output that is useful during model calibration. All records are taken directly from USGS tables in the database. Missing values, when the gage was not in operation, are denoted as such, using the value “-999.”

In addition to historical gage records, the historical streamflow file also contains the single import into the Gunnison Basin from Plateau Creek, tributary to the Colorado River. Leon Tunnel Canal (720758) is included in the historical streamflow file as historic inflow into the basin. Table 5.2 lists the USGS gages used, their periods of record, and their average annual flows over the period of record.

5.3.5 Baseflow Files (*.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 are 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 13 gages that operated throughout the calibration period (1975-2002). The difference between the two represents estimated historical consumptive use over this period.

Where to find more information

- Sections 4.7.1 through 4.7.3 explain how StateMod and the Mixed Station Model are 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, *gunnV.sum* and *gunnV.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.

Table 5.2
Historical Average Annual Flows for Modeled Gunnison Stream Gages

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
9109000	Taylor River Below Taylor Park Reservoir	1938 – 2003	144,077
9110000	Taylor River at Almont	1910 – 2003	242,581
9110500	East River Near Crested Butte	1939 – 1951	96,443
9111500	Slate River Near Crested Butte	1940 – 1951 1994 - 2003	99,576
9112000	Cement Creek Near Crested Butte	1910 – 1914 1940 – 1951	26,489
9112200	East River Below Cement Creek NR Crested Butte	1964 – 1972 1980 – 1981 1994 – 2003	242,126
9112500	East River at Almont	1910 – 1922 1934 – 2003	243,763
9113300	Ohio Creek at Baldwin	1958 - 1970	33,709
9113500	Ohio Creek Near Baldwin	1940 – 1950 1959 – 1971 1980 – 1981	65,798
9114500	Gunnison River Near Gunnison	1910 – 1928 1945 – 2003	547,103
9115500	Tomichi Creek at Sargents	1916 – 1922 1938 – 1972 1993 – 2003	45,451
9118000	Quartz Creek Near Ohio City	1937 – 1950 1960 – 1970	38,941
9118450	Cochetopa Creek Below Rock Creek Near Parlin	1981 - 2003	33,098
9119000	Tomichi Creek at Gunnison	1937 - 2003	125,021
9121500	Cebolla Creek Near Lake City	1946 - 1954	10,982
9121800	Cebolla Creek Near Powderhorn	1960 - 1963	52,563
9122000	Cebolla Creek at Powderhorn	1937 - 1955	75,711
9124500	Lake Fork at Gateview	1937 - 2003	170,456
9126000	Cimarron River Near Cimarron	1954 - 2003	68,054
9126500	Cimarron River at Cimarron	1902 – 1906 1962 – 1967	79,158
9127500	Crystal Creek Near Maher	1945 – 1954 1961 – 1969	21,202
9128000	Gunnison River Below Gunnison Tunnel	1910 - 2003	942,673
9128500	Smith Fork Near Crawford	1935 - 1994	31,061
9129600	Smith Fork Near Lazear	1976 - 1987	27,243

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
9130500	East Muddy Creek Near Bardine	1934 - 1953	65,205
9131200	West Muddy Creek Near Somerset	1961 - 1973	21,596
9132500	North Fork Gunnison River Near Somerset	1933 - 2003	330,478
9134000	Minnesota Creek Near Paonia	1936 – 1947 1986 – 2003	16,100
9134050	Minnesota Creek at Paonia	1976 - 1979	6,498
9134500	Leroux Creek Near Cedaredge	1936 – 1956 1961 – 1969	34,419
9135900	Leroux Creek at Hotchkiss	1976 - 1996	21,557
9136200	Gunnison River Near Lazear	1961 - 1985	1,219,151
9137050	Currant Creek Near Read	1976 - 1987	10,495
9137800	Dirty George Creek Near Grand Mesa	1957 - 1969	4,595
9139200	Ward Creek Near Grand Mesa	1957 - 1969	8,464
9141500	Youngs Creek Near Cedaredge	1942 - 1946	1,605
9143000	Surface Creek Near Cedaredge	1939 - 2003	31,417
9143500	Surface Creek at Cedaredge	1917 - 2003	20,250
9144200	Tongue Creek at Cory	1957 – 1968 1977 – 1987	35,703
9144250	Gunnison River at Delta	1976 – 2003	1,496,382
9146200	Uncompahgre River Near Ridgway	1958 – 2003	119,080
9146400	West Fork Dallas Creek Near Ridgway	1955 – 1970	9,024
9146500	East Fork Dallas Creek Near Ridgway	1948 – 1953 1961 – 1970	17,985
9146550	Beaver Creek Near Ridgway	1960 – 1968	2,949
9147000	Dallas Creek Near Ridgway	1922 – 1927 1955 – 1971 1980 – 2003	28,304
9147100	Cow Creek Near Ridgway	1945 – 1954 1961 – 1969	44,132
9147500	Uncompahgre River at Colona	1912 – 2003	192,830
9149420	Spring Creek Near Montrose	1977 – 1981	41,468
9149500	Uncompahgre River at Delta	1938 – 2003	219,763
9150500	Roubideau Creek at Mouth, Near Delta	1938 – 1954 1976 – 1983	89,198
9152000	Kannah Creek Near Whitewater	1917 – 1982	21,834
9152500	Gunnison River Near Grand Junction	1896 – 1899 1902 – 1906 1917 – 2003	1,857,738

Table 5.3
Streamflow Comparison
1975-2002 Average (af/yr)

Gage ID	Gage Name	Baseflow	Historical	Difference
9109000	Taylor River Below Taylor Park Reservoir	150,111	147,968	2,143
9110000	Taylor River at Almont	239,854	236,375	3,479
9112500	East River at Almont	256,438	238,733	17,706
9114500	Gunnison River Near Gunnison	580,289	529,302	50,987
9119000	Tomichi Creek at Gunnison	191,703	127,952	63,751
9124500	Lake Fork at Gateview	170,033	167,999	2,034
9126000	Cimarron River Near Cimarron	71,695	70,457	1,238
9128000	Gunnison River Below Gunnison Tunnel	1,403,168	888,915	514,253
9132500	North Fork Gunnison River Near Somerset	368,424	352,863	15,561
9146200	Uncompahgre River Near Ridgway	124,599	121,827	2,772
9147500	Uncompahgre River at Colona	216,482	192,969	23,513
9149500	Uncompahgre River at Delta	308,968	236,296	72,672
9152500	Gunnison River Near Grand Junction	2,400,308	1,910,511	489,797

5.4 Diversion Files

5.4.1 Direct Diversion Station File (*.dds)

Both **watright** and **demandts** are used in succession to create the direct diversion station file.

The direct diversion station file describes the physical properties of each diversion simulated in the Gunnison Model. Table 5.4 is a summary of the Gunnison model's diversion station file contents, including each structure's diversion capacity, irrigated acreage served in 2000, and average annual system efficiency. The table also includes average annual headgate demand. This parameter is summarized from data in the diversion demand file rather than the diversion station file, but it is included here as an important characteristic of each diversion station. In addition to the tabulated parameters, the file also specifies return flow nodes and average monthly efficiencies.

Generally, the diversion station ID and name, diversion capacity, and irrigated acreage are gathered from Hydrobase by **watright**. Return flow locations are specified to **watright** in a hand-edited file gunnV.rtn. The return flow locations and distribution were based on discussions with Division 4 personnel as well as calibration efforts. **Demandts** computes monthly system efficiency from historical diversions and historical crop irrigation requirements for irrigation structures, and writes them into the initial *.dds file created by **watright**. For non-irrigation structures, monthly efficiency is specified by the user as input to **demandts**. If efficiency is constant for each month, it can also be specified in the hand-edited file gunnV.rtn.

Table 5.4
Direct Flow Diversion Summary Average
1975-2002

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
1	280500	ADAMS NO 1 DITCH	21	161	29	1,553
2	280503	AGATE NO 2 DITCH	4	46	15	500
3	280510	ARCH IRRIGATING DITCH	145	2,222	26	14,099
4	280515	BIEBEL DITCHES NOS 1&2	60	435	32	4,260
5	280520	CAIN BORSUM DITCH	28	146	24	1,891
6	280526	CHITTENDEN DITCH	24	332	30	2,716
7	280527	CLARK NO 1 DITCH	4	17	19	346
8	280528	CLARK NO 2 DITCH	10	40	22	604
9	280529	CLARK NO 3 DITCH	12	90	29	777
10	280530	CLOVIS METROZ NO 1 DITCH	15	46	16	811
11	280532	COATS BROS DITCH	20	163	26	1,830
12	280535	COLE NOS 1 2 & 3 DITCHES	11	67	27	609
13	280536	COX AND MCCONNELL DITCH	24	41	8	1,667
14	280542	CUTJO DITCH	24	147	32	1,651
15	280543	D A MCCONNELL DITCH	8	228	48	586
16	280550	DUNN AND WATTERS DITCH	45	130	19	2,651
17	280554	ELSEN VADER DITCH	18	143	33	1,473
18	280557	FIELD AND VADER DITCH	10	280	46	894
19	280564	TOMI_GILBERTSON NO 1	21	41	22	1,280
20	280566	GOODRICH DITCH	36	183	24	1,990
21	280567	GOODWIN AND WRIGHT DITCH	30	130	21	2,542
22	280568	LOS _GOVERNMENT DITC	70	1,075	44	4,491
23	280571	TOMI_GRIFFING NO 1 D	50	537	34	3,930
24	280576	GULLETT TOMICHI IRG D	41	362	30	3,025

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
25	280577	HANNAH J WINTERS NO 2D	21	200	30	1,357
26	280580	HAWES-BERGEN-GILBERTSON	16	164	23	1,179
27	280581	HAZARD DITCH	32	188	19	1,542
28	280583	HEAD AND CORTAY NO 4 D	8	119	37	876
29	280587	HOME DITCH DITCH NO 81	25	109	24	1,166
30	280588	HOME DITCH DITCH NO 182	24	46	12	915
31	280590	HOT SPRINGS NOS 1&2 D	10	117	45	361
32	280604	KANE DITCH	9	53	24	522
33	280607	KENDALL NO 3 DITCH	36	62	29	456
34	280608	KENDALL NO 4 DITCH	11	119	33	514
35	280622	LOBDELL NO 2 DITCH	4	103	50	283
36	280624	LOCKWOOD MUNDELL DITCH	57	102	21	2,846
37	280631	MCCANNE NO 1 DITCH	32	297	36	1,912
38	280632	MCCANNE 2 DITCH	46	284	31	3,464
39	280633	MCCANNE 3 DITCH	40	83	28	1,278
40	280636	MCDONOUGH DITCH	47	505	39	2,363
41	280638	TOMI_MCGOWAN IRRIGAT	48	217	33	1,898
42	280642	MEANS BROS NO 13 DITCH	15	50	26	605
43	280645	MEANS BROS NO 4 DITCH	5	28	25	333
44	280646	MEANS BROS NO 5 DITCH	8	77	30	387
45	280647	MEANS BROS NO 6 DITCH	8	14	14	448
46	280648	MEANS BROS NO 7 DITCH	5	52	24	334
47	280649	MEANS BROS NO 12 DITCH	12	19	17	604
48	280650	MEANS BROS NO 8 DITCH	21	264	34	1,147
49	280651	MESA DITCH	75	1,746	44	6,921
50	280652	MILLER DITCH	12	171	38	977
51	280654	MONSON & MCCONNELL D	27	331	29	1,668
52	280660	NORMAN DITCH	24	57	25	834
53	280662	OFALLON NO 3 DITCH	20	24	10	1,103
54	280663	OFALLON NO 4 DITCH	14	27	6	823
55	280665	OREGAN NO 1 DITCH	8	63	42	603
56	280667	OWEN NO 1 DITCH	20	61	23	1,185

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
57	280668	OWEN REDDEN DITCH	63	468	30	3,449
58	280670	PARLIN NO 2 DITCH	21	167	34	1,086
59	280671	PARLIN QUARTZ CREEK D	42	472	27	3,992
60	280673	PERRY IRRIGATING DITCH	42	617	40	3,072
61	280674	PIONEER DITCH	62	375	29	3,967
62	280679	ROGERS METROZ DITCH	27	116	22	1,624
63	280680	S DAVIDSON&CO FDR D NO 1	50	47	6	2,628
64	280681	SARGENTS NO 1 D	5	16	17	314
65	280682	SARGENTS NO 2 D	7	16	10	337
66	280686	SMITH FORD NO 2 DITCH	43	576	38	3,538
67	280690	SORRENSON IRRIGATING D	32	294	34	2,150
68	280692	SOUTH SIDE DITCH	28	136	32	1,642
69	280693	STEPHENSON DITCH	37	257	25	2,162
70	280697	SUTTON NO 3 AMENDED D	2	17	46	63
71	280703	TARBELL & ALEXANDER D	14	337	50	917
72	280707	TORNAY HIGHLINE DITCH	33	350	29	3,377
73	280709	VADER RAUSIS DITCH	14	152	40	958
74	280711	WATERMAN METROZ DITCH	12	83	27	1,055
75	280714	WICKS ROWSER DITCH	5	239	48	228
76	280715	WOOD AND GEE DITCH	32	182	25	1,611
77	280716	WOODBRIDGE DITCH	28	203	36	965
78	280823	MCDONALD BERDEL EX D	1	141	44	266
79	28_ADG009	28_ADG009_UTOMICHI	716	1,381	37	6,776
80	28_ADG010	28_ADG010_TOMICHI1	612	2,545	34	13,538
81	28_ADG011	28_ADG011_COCHETOPA	165	1,196	48	6,268
82	28_ADG012	28_ADS_012_TOMICHI2	992	2,429	30	26,830
83	28_ADG043	28_ADG043_COCHET	83	916	50	2,180
84	28_ADG044	28_ADG044_RAZOR	249	1,463	39	5,961
85	400500	CRAWFORD CLIPPER DITCH	95	3,428	35	15,732
86	400501	NEEDLE ROCK DITCH	60	1,612	37	6,428
87	400502	SADDLE MT HIGHLINE D	50	1,296	48	3,393
88	400503	GRANDVIEW CANAL	155	2,365	35	6,891

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
89	400504	CEDAR CANON IRON SPR D	53	2,301	40	7,514
90	400506	ALUM GULCH DITCH	15	208	43	1,539
91	400508 1)	ASPEN DITCH	135	0	43	6,356
92	400509 1)	ASPEN CANAL	150	0	40	1,097
93	400533	CRYSTAL VALLEY DITCH	16	489	50	1,084
94	400536	DAISY DITCH	95	281	27	2,132
95	400543	DYER FORK DITCH	14	269	45	950
96	400549 2)	FRUITLAND CANAL	300	794	0	-
97	400566	LARSON BROTHERS DITCH	6	216	28	1,450
98	400568	LONE ROCK DITCH	6	22	5	771
99	400585 2)	OVERLAND DITCH	81	9	0	6,627
100	400586	PILOT ROCK DITCH	18	546	45	1,269
101	400605 2)	SMITH FORK FEEDER CANAL	95	0	0	-
102	400616	VIRGINIA DITCH	10	299	28	1,153
103	400632	CHILDS DITCH	30	33	4	3,377
104	400661	SURFACE CR D AKA BIG D	80	2,607	43	10,438
105	400675	CEDAR MESA DITCH	50	889	37	4,027
106	400683	HORSESHOE DITCH	15	347	48	1,147
107	400686	LONE PINE DITCH	53	550	39	3,036
108	400701	CEDAR PARK DITCH	30	546	22	4,927
109	400703	DIRT_EAGLE DITCH	15	164	42	824
110	400713	GRANBY DITCH FR WARD CR	8	200	29	1,346
111	400751	ALFALFA DITCH	75	1,099	23	8,361
112	400753	SURF_BONITA DITCH	12	318	26	1,596
113	400754	BUTTES DITCH	25	217	19	2,282
114	400758	FORREST DITCH	19	491	34	2,972
115	400774	ORCHARD RANCH DITCH	20	309	32	2,415
116	400778	SETTLE DITCH	9	343	49	983
117	400797	DURKEE DITCH	20	195	28	2,214
118	400808	MORTON DITCH	8	187	33	780
119	400820	ALFA_STELL DITCH	75	1,661	30	8,826
120	400821 2)	TRANSFER DITCH	50	0	0	-

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
121	400863	BONAFIDE DITCH	76	1,541	11	22,074
122	400879	HARTLAND DITCH	59	957	11	16,642
123	400891	GUNN_NORTH DELTA CAN	103	1,873	23	19,511
124	400900	RELIEF DITCH	75	1,191	9	18,623
125	400918	COW CREEK DITCH	16	415	46	1,011
126	400919	CURRANT CREEK DITCH	15	276	17	3,025
127	400923	HIGHLINE DITCH	50	1,002	27	8,143
128	400926	LEROUX CREEK DITCH	140	684	26	6,240
129	400929	JESSIE DITCH	18	252	32	1,084
130	400932	MIDKIFF & ARNOLD D	16	253	33	1,752
131	400944	LERO_OVERLAND DITCH	150	3,690	44	10,320
132	401012	LONE CABIN DITCH	10	297	50	574
133	401020	MINNESOTA CANAL	55	1,364	41	6,076
134	401056	TURNER DITCH	10	93	17	1,890
135	401087	BLACK SAGE DITCH	4	31	16	432
136	401105	COYOTE DITCH	25	204	50	429
137	401106	COYOTE DITCH	6	241	50	421
138	401112	DEER DITCH	6	33	50	474
139	401114	DITCH NO 2 DITCH	4	31	45	311
140	401118	DRIFT CREEK DITCH	7	482	50	609
141	401119	DUGOUT DITCH	4	268	50	226
142	401120	DOWNING DITCH	10	59	34	631
143	401122	DYKE NO 2 DITCH	4	110	50	195
144	401127	ELKS BEAVER DITCH	7	53	42	317
145	401132	FILMORE DITCH	18	430	50	1,627
146	401133	FIRE MT CANAL	190	5,539	29	45,470
147	401145	GROUSE CREEK DITCH	5	43	42	432
148	401166	MUDD_LARSON NO 2 DIT	1004	111	50	134
149	401168	LEE CREEK D NO 2	10	241	48	383
150	401172	LOST CABIN DITCH	10	59	18	641
151	401183	MONITOR DITCH	15	247	23	2,285
152	401185	NORTH FORK FARMERS D	282	1,036	28	8,697

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
153	401189	PAONIA DITCH	26	326	7	6,359
154	401190	PILOT KNOB DITCH	3	77	50	107
155	401195	SHEPARD & WILMONT DITCH	14	227	17	2,836
156	401196	SHORT DITCH	21	532	26	4,994
157	401197	SMITH AND MCKNIGHT DITCH	12	351	42	1,606
158	401201	SPATAFORE DITCH NO 1	3	116	50	242
159	401206	STEWART DITCH	77	2,579	35	14,716
160	401207	STREBER DITCH	13	104	34	1,452
161	401213	VANDEFORD DITCH	15	71	9	1,815
162	401214	WADE DITCH	2	115	50	97
163	401218	WELCH MESA DITCH	18	421	44	942
164	401221	WILLIAMS CR DITCH	4	86	50	111
165	401437	ROUB_HAWKINS DITCH	42	85	36	498
166	40_ADG019	40_ADG019_GUNNTUN	17	74	50	389
167	40_ADG020	40_ADG020_IRON	42	1,311	47	4,264
168	40_ADG021	40_ADG021_SMITH	34	443	36	3,083
169	40_ADG022	40_ADG022_NFGUNN	125	1,549	43	6,952
170	40_ADG023	40_ADG023_MINN	18	440	44	1,736
171	40_ADG024	40_ADG024_NFGUNN2	738	1,498	43	7,453
172	40_ADG025	40_ADG025_LEROUX	34	819	45	3,800
173	40_ADG026	40_ADG026_GUNNL	72	1,771	36	8,940
174	40_ADG027	40_ADG027_CURRANT	64	1,603	32	7,223
175	40_ADG028	40_ADG028_UTONGUE	294	2,131	34	12,299
176	40_ADG029	40_ADG029_SURFACE	45	946	47	2,443
177	40_ADG030	40_ADG030_TONGUE	520	2,317	39	13,773
178	40_ADG031	40_ADG031_GUNND	49	576	28	5,890
179	40_ADG038	40_ADG038_ROUBIN	118	641	46	2,444
180	40_ADG039	40_ADG039_GUNNBLD	213	2,097	40	9,208
181	40_AMG002 [3)]	Lower_M&I	2	0	100	1,449
182	40_Fruitl	Fruitland	312	6,198	50	12,712
183	410508	BOLES & MANNEY D	20	236	9	3,302
184	410515	CHIPETA BEAUDRY DITCH	32	388	15	3,619

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
185	410519	EAGLE DITCH	35	976	25	6,843
186	410520	EAST CANAL	354	5,213	15	49,844
187	410527	GARNET DITCH	156	958	7	22,870
188	410534	UNCO_IRONSTONE CANAL	544	20,990	19	114,743
189	410537	LOUTSENHIZER CANAL	232	4,613	14	46,974
190	410538	LYRA DITCH	16	432	28	2,627
191	410545	MONTROSE & DELTA CANAL	604	21,620	16	181,440
192	410549	OURAY DITCH	27	690	36	4,164
193	410554	ROSS BROS DITCH	22	467	5	2,882
194	410559	SELIG CANAL	367	10,877	23	69,557
195	410560	SHAVANO VALLEY DITCH	15	38	17	1,150
196	410568	SUNRISE DITCH(HAPPY CYN)	18	83	10	1,748
197	410577	WEST CANAL	302	5,614	13	54,732
198	410578	SOUTH CANAL	1000	5,843	22	44,362
199	41_ADG035	41_ADG035_UNCOMPH3	86	976	41	6,332
200	41_ADG036	41_ADG036_UNCOMPH4	158	3,928	37	13,087
201	41_ADG037	41_ADG037_UNCOMPH5	59	760	15	7,846
202	41_AMG003 [3)]	Uncomp_M&I	2	0	100	1,272
203	420510	BROWN & CAMPION D	32	697	42	2,918
204	420529	KANNAH CREEK HIGHLINE D	89	1,489	39	5,886
205	420541 [3)]	REDLANDS POWER CANAL	795	0	0	426,860
206	420545	SMITH IRR DITCH	20	270	50	1,315
207	42_ADG040	42_ADG040_GUNNGJ	344	2,106	44	12,074
208	590501	ACME DITCH	70	716	44	3,631
209	590509	ANDERS BOTTOM D	6	18	12	358
210	590510	ANNA ROZMAN DITCH	11	42	15	1,138
211	590522	BOCKER DITCH	40	188	18	3,560
212	590524	BOURNE DITCH	12	172	45	541
213	590527	BUCKEY DITCH	26	364	50	780
214	590528	BUCKEY LEHMAN DITCH	10	121	47	313
215	590537	CEMENT CREEK DITCH	30	164	8	3,555
216	590542	CUNNINGHAM DITCH	10	502	50	616

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
217	590544	DEAN IRRIGATING DITCH	18	121	28	1,023
218	590546	DILLSWORTH DITCH	50	412	10	6,728
219	590549	EAST RIVER NO 1 DITCH	140	1,018	24	15,168
220	590550	EAST RIVER NO 2 DITCH	73	246	10	9,707
221	590556	FISHER DITCH ENLARGEMENT	50	378	17	3,856
222	590558	FRANK ADAMS NO 1 DITCH	40	300	29	3,047
223	590560	GARDEN DITCH	30	314	34	2,698
224	590563	GLEASON IRRIGATING DITCH	50	495	44	1,553
225	590566	GOOSEBERRY MESA IRG D	30	588	26	3,066
226	590569	GUNNISON & OHIO CR CANAL	100	1,037	18	13,817
227	590570	GUNNISON R OHIO CR IRG D	110	965	14	17,011
228	590572	GUNNISON TOWN DITCH	50	103	3	6,691
229	590578	HARRIS BOHM POTATO DITCH	60	621	37	4,081
230	590580	HENRY PURRIER OHIO CR D	31	174	50	190
231	590581	HENRY PURRIER OHIO CR 2D	14	62	50	260
232	590584	HIGHLAND DITCH	10	49	22	512
233	590587	HILDEBRAND NO 2 DITCH	29	145	31	1,133
234	590588	HINKLE HAMILTON DITCH	28	180	40	1,534
235	590589	HINKLE IRG DITCH	10	97	35	683
236	590591	HOPE RESICH DITCH	33	380	46	1,077
237	590593	HOWE & SHERWOOD IRR D	26	238	23	2,177
238	590596	HYZER VIDAL MILLER D	35	371	49	949
239	590597	IMOBERSTEG DITCH	32	202	18	2,756
240	590600	JAMES WATT DITCH	47	200	8	5,212
241	590602	JOHN B OUTCALT NO 2 D	35	440	46	1,974
242	590606	JUDY NORTH HIGH LINE D	25	273	39	1,335
243	590607	KELMEL OWENS NO 1 DITCH	50	519	26	5,740
244	590608	KELMEL OWENS NO 2 DITCH	40	277	31	3,269
245	590609	KUBIACK DITCH	25	168	10	2,907
246	590616	LIGHTLEY D & LINTON ENLT	30	257	23	3,081
247	590617	LONE PINE DITCH	80	791	39	3,059
248	590622	MARSHALL NO 1 DITCH	13	404	31	1,807

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
249	590623	MARSHALL NO 2 DITCH	30	182	38	2,702
250	590624	MARSTON DITCH	18	115	16	1,390
251	590625	MAY BOHM & ENLD M B H P	65	1,033	43	3,502
252	590627	MCCORMICK DITCH	8	177	50	437
253	590630	MCGLASHAN N SIDE MILL CR	6	136	50	232
254	590631	MCGLASHAN S SIDE MILL CR	15	172	50	402
255	590644	OHIO CREEK NO 2 DITCH	16	123	43	497
256	590645	OTIS MOORE DITCH	30	258	50	423
257	590646	PALISADES DITCH	10	100	30	793
258	590649	PASS CREEK DITCH	14	67	19	796
259	590651	PILONI DITCH	30	453	48	1,329
260	590653	POWER DITCH	25	222	9	4,375
261	590655	PURRIER DITCH	10	93	47	430
262	590658	RICHARD BALL DITCH	41	449	20	4,161
263	590667	SCHUPP DITCH	20	89	36	713
264	590668	SEVENTY FIVE DITCH	78	432	18	5,336
265	590671	SIMINEO DITCH	25	196	50	343
266	590672	SLIDE DITCH	47	229	18	4,297
267	590679	SPRING CR IRG DITCH	40	281	13	3,988
268	590680	SQUIRREL CREEK NO1 DITCH	10	68	33	431
269	590684	STRAND DITCH NO 1	24	119	18	2,357
270	590691	TEACHOUT DITCH	50	737	39	3,116
271	590692	TEACHOUT-FAIRCHILD DITCH	23	226	41	1,226
272	590699	VERZUH DITCH	45	137	5	5,374
273	590700	VERZUH YOUNG BIFANO D	49	201	14	5,756
274	590704	WHIPP DITCH	45	317	22	3,860
275	590707	WILLOW RUN DITCH	24	137	45	412
276	590709	WILSON DITCH	12	125	28	826
277	590711	WILSON OHIO CREEK DITCH	40	318	45	1,070
278	590720	PIONEER DITCH	9	62	43	536
279	590847	CUNNINGHAM WASTEWATER D	14	137	22	2,220
280	59_ADG001	59_ADG001_TAYLOR	78	708	36	4,764

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
281	59_ADG002	59_ADG002_EAST1	110	586	50	3,370
282	59_ADG003	59_ADS_003_SLATE	618	1,047	50	1,818
283	59_ADG004	59_ADG004_EAST2	746	1,893	43	10,119
284	59_ADG005	59_ADG005_EAST3	245	823	33	6,111
285	59_ADG006	59_ADG006_OHIO1	299	1,046	50	2,747
286	59_ADG007	59_ADG007_OHIO2	162	2,064	50	3,055
287	59_ADG008	59_ADG008_GUNN	308	1,890	26	15,362
288	620506	ANDREWS DITCH	11	62	22	711
289	620528	BIG BLUE DITCH	50	2,182	25	5,322
290	620529	BIG DITCH	45	131	22	2,999
291	620560 [2)]	CIMARRON CANAL	167	297	0	28,726
292	620567	COLLIER DITCH	13	461	50	1,521
293	620602	FOSTER DITCH NO 1	10	50	25	719
294	620604	FOSTER IRG D NO 4	4	84	43	223
295	620605	FRANK ADAMS D NO 2	50	114	21	2,180
296	620617 [2)]	GUNNISON TUNNEL&S CANAL	1141	0	0	332,759
297	620670	M B & A DITCH	28	185	31	1,867
298	620672	MCKINLEY DITCH	40	969	36	4,517
299	620732	RUDOLPH IRG DITCH	16	129	25	1,458
300	620734	SAMMONS DITCH NO 2	15	26	16	600
301	620736	CEBO_SAMMONS IRG D N	18	18	14	716
302	620737	SAMMONS IRG D NO 5	8	19	15	648
303	620738	SAMMONS IRG D NO 6	10	75	32	578
304	620779	UPPER CEBOLLA DITCH	21	199	30	1,417
305	620783	VEO DITCH	13	431	42	1,818
306	620789	WARRANT DITCH	21	66	25	905
307	620809	YOUMANS IRG D NO 1	25	34	15	1,015
308	62_ADG013	62_ADG013_CEBOLLA1	172	1,053	25	5,861
309	62_ADG014	62_ADG014_CEBOLLA2	104	1,073	29	6,988
310	62_ADG015	62_ADG015_LAKE	349	1,710	34	4,981
311	62_ADG016	62_ADG016_GUNNBM	475	1,789	14	16,176
312	62_ADG017	62_ADG017_GUNNM	19	1,779	44	1,641

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
313	62_ADG018	62_ADG018_CIM	46	853	46	2,623
314	62_AMG001 [3)]	Upper_M&I	2	0	100	1,449
315	62_IrrCim	Cimmaron_Canal	160	9,321	23	28,124
316	680501	ALKALI DITCH D NO 80	46	1,556	31	5,411
317	680502	ALKALI NO 2 DITCH	35	625	16	4,432
318	680514	BURKHART EDDY DITCH	20	796	36	1,840
319	680526	CHARLEY LOGAN DITCH	31	179	5	3,094
320	680538	CRONENBERG DITCH	7	224	41	469
321	680543	DALLAS DITCH	37	997	23	3,774
322	680559	DOC WADE DITCH	21	299	30	1,849
323	680603	HENRY TRENCHARD DITCH	14	135	13	1,106
324	680607	HOMESTRETCH DITCH	22	284	6	3,866
325	680609	HOSNER BROWNYARD DITCH	24	89	5	1,997
326	680610	HOSNER ROWELL DITCH	20	231	22	1,983
327	680613	HYDE SNEVA DITCH	20	315	24	2,261
328	680636	LEOPARD CREEK DITCH	48	433	30	2,035
329	680647	MARTIN DITCH	10	244	14	969
330	680652	MAYOL LATERAL DITCH	10	143	8	865
331	680653	MAYOL SISSON DITCH	11	213	11	807
332	680668	MOODY DITCH	25	93	10	2,048
333	680669	MOODY NO1 DITCH	25	521	21	2,393
334	680671	MORRISON DITCH	16	19	8	1,421
335	680681	OLD AGENCY DITCH	15	375	12	2,137
336	680683	OWL CREEK DITCH	13	115	15	1,294
337	680685	PARK DITCH	21	384	18	2,373
338	680692	PINION DITCH	30	623	7	3,891
339	680703	REED OVERMAN DITCH	21	176	10	1,133
340	680710	RIDGWAY DITCH	15	70	10	647
341	680720	ROSWELL HOTCHKISS DITCH	12	125	16	1,035
342	680729	SHORTLINE D COW CREEK	8	40	12	609
343	680738	SNEVA DITCH	30	945	29	3,551
344	680765	UPPER UNCOMPAHGRE DITCH	15	303	8	2,670

#	Model ID #	Name	Cap (cfs)	2000 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
345	68_ADG032	68_ADG032_UNCOMPH1	162	1,264	10	11,212
346	68_ADG033	68_ADG033_DALLAS	116	1,529	18	7,480
347	68_ADG034	68_ADG034_UNCOMPH2	160	2,261	26	8,765
348	95CSUB_I 5)	Subordinate_Crystal_Irr	999	0	0	0
349	95CSUB_M 5)	Subordinate_Crystal_M&I	999	0	20	0
350	95L_MY 5)	Lower_Market_Yield	999	0	0	0
351	95MSUB_I 5)	Subordinate_Morrow_Irr	999	0	0	0
352	95MSUB_M 5)	Subordinate_Morrow_M&I	999	0	20	0
353	95USUB_I 5)	Subordinate_Upper_Irr	999	0	0	0
354	95USUB_M 5)	Subordinate_Upper_M&I	999	0	20	0
355	95U_MY 5)	Upper_Market_Yield	999	0	100	0
355	960050	REDLANDS_POWER_CANAL-IRR	244	4,298	10	79,630
357	960051 4)	Grand_Junction_Demand	21	0	100	6,581
358	Proj_7 3)	Project_7	999	0	20	6,487

1) Secondary Structure of a Multi-structure System
2) Reservoir Feeder or Carrier Ditch
3) Municipal/Industrial Diversion
4) Basin Export
5) Node for Future Modeling of Aspinall Unit Subordination and Marketable Yield Demands

5.4.1.1 Key Structures

Key diversion structures are those that are modeled explicitly, that is, the node associated with a key structure represents that single structure only. In the Gunnison model, diversion structures with water rights totaling 9 cfs or more were generally designated key structures. They are identified by a six-digit number which is 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 Gunnison basin are for irrigation, although these exceptions divert to non-irrigation use:

WDID	Name	Diversion Type
400508	Aspen Ditch	Secondary structure in Multistructure system
400509	Aspen Canal	Secondary structure in Multistructure system
400549	Fruitland Canal	Trans-tributary carrier and reservoir feeder
400585	Overland Ditch	Trans-tributary carrier
400605	Smith Fork Feeder Canal	Trans-tributary reservoir feeder
400821	Transfer Ditch	Trans-tributary reservoir feeder
420541	Redlands Power Canal	Industrial
620560	Cimarron Canal	Trans-tributary carrier and reservoir feeder
620617	Gunnison Tunnel	Trans-tributary carrier and reservoir feeder
960051	Grand Junction Demand	Municipal
Proj_7	Project 7 Demand	Municipal

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 any give 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 and transbasin diverters, StateMod uses the efficiencies in the diversion station file directly during simulation to compute consumptive use and return flows. Diversion efficiency is set to values consistent with the type of use based on engineering judgment, or, if available, user information. For example, Proj_7 municipal use is assigned a monthly efficient of 20 percent. Reservoir feeders and other carriers are assigned an efficiency of 0 percent, meaning their diversions are delivered without loss. Exports from the basin, such as the Kannah Creek diversion to the City of Grand Junction, are assigned an efficiency of 100 percent because there are no return flows to the basin.

Diversion capacity is stored in HydroBase for most structures and is generally taken directly from the database. In preparing the direct diversion station file, however, the DMIs determine whether historical records of diversion indicate diversions greater than the database capacity. If so, the diversion capacity is modified to reflect the recorded diversion.

Return flow parameters in the diversions station file specify the nodes at which return flows will re-enter the stream, and divide 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. On of these tables gives 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_ADGxxx", where "wd" is the water District number, and "ADG" stands for Aggregated Diversions Gunnison; the "xxx" ranges from 001 to 044. Similarly, aggregated municipal and industrial structures were named "WD_AMGxxx" for Aggregated Municipal Gunnison.

For aggregated M&I diversions, efficiency was set to 100 percent because demands were modeled as depletions.

Where to find more information

- Section 4.2.2.2 describes how small irrigation structures were aggregated into larger structures

5.4.1.3 Special Structures

5.4.1.3.1 Fruitland Canal

Fruitland Mesa encompasses Fruitland Reservoir (Gould Reservoir) and a trans-tributary diversion from Crystal Creek, which provides most of the water for irrigation in the Iron Creek and Smith Fork drainages and storage water for Fruitland Reservoir. The irrigated lands, and the corresponding demand, are included in the model under the node 40_Fruitl. Fruitland Canal (400549) is modeled as a carrier to both Fruitland Reservoir and to the 40_Fruitl demand. 40_Fruitl demand can also be satisfied from releases from Fruitland Reservoir.

5.4.1.3.2 Cimarron Canal

62_IrrCim represents the irrigated acreage demand of the Bostwick Park Project. The key components of the Bostwick Park Project are Silver Jack Reservoir (623548) and the Cimarron Canal (620560). The Cimarron Canal (620560) delivers water to both supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, a small storage facility of Project 7 Water Authority, and is modeled as a carrier only.

5.4.1.3.3 Project 7

Project 7 Water Authority provides domestic and municipal treated water to its members. Project 7 owns no water rights, but a portion of the supply is delivered from the City of Montrose's ownership in the Cimarron Canal and from water purchased from storage in Cerro and Fairview Reservoirs. Proj_7 represents the municipal demand for the Project 7 Water Authority.

5.4.1.3.4 Redlands Canal

The Redlands Water and Power Company diverts water from the Gunnison River for irrigation and power generation in the Colorado River Basin. The Upper Colorado River Basin Water Resources Planning Model separates the irrigation and power use accurately model return flows to the basin. To be consistent with the Colorado model, the use types are also modeled separately in the Gunnison model. Structure 420541 represents transbasin diversion from the Gunnison to the Colorado for power generation. Structure 950050 represents transbasin diversion for irrigation.

5.4.1.3.5 Grand Junction

960051 represents water exported from Kannah Creek for the City of Grand Junction. The city has several water sources – this structure represents only their diversions from Kannah Creek.

5.4.1.3.6 Water Quality Nodes

Two nodes were added to the model to assist with estimating flows at two water quality monitoring locations in the Uncompahgre River basin. These "other" type nodes are located on Loutsenhizer Arroyo and Cedar Creek, both just upstream of their confluences with the Uncompahgre.

5.4.1.3.7 Future Use Diversion Structures

Several diversion structures in the network are "placeholders" for modeling future anticipated demands in the Gunnison 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 turned off. The diversion structures that fall into this category, and their potential configurations, are:

- 95USUB_I, 95USUB_M, 95MSUB_I, 95MSUB_M, 95CSUB_I, and 95CSUB_M. There structures are included in the model so, if desired, future analyses can represent full subordination of the Aspinall water rights, as discussed in Section 3.4 of this document.
- 95U_MY and 95L_MY are included in the model so, if desired, future analyses can investigate the use of a “marketable yield” account in Blue Mesa Reservoir.

5.4.2 Return Flow Delay Tables (*.dly)

The crdss.dly file, which is 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 all the west slope basin models. The return flow patterns also account for surface water return. Percent return flow in the first month for the Glover-derived patterns was 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 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 are estimated to be 10 percent of basin-wide crop consumptive use. However, StateMod applies 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 Gunnison Model as follows:

StateCU Total Basin Crop Consumptive Use (Ave 1950 – 2002) = 358,272 acre-feet

Incidental loss = 10% of Total Crop CU = 35,827 acre-feet

StateCU Unused Water (Ave 1950 – 2002) = 1,352,071

Incidental Loss as percent of Unused Water = 35,892 / 1,352,071 = 2.65%

Five patterns are available to the model in this file, 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 should be used for irrigation further from a live stream (>1200 feet). Pattern 3 is not used in the CRDSS models. Pattern 4 represents immediate returns, as for municipal and industrial uses. Pattern 5 is applicable to snowmaking diversions. In the Gunnison model, all irrigation use is assigned the first pattern.

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
1	75.6	57.4	53.8	100	0
2	11.3	14.5	5.6	0	0
3	3.2	7.2	3.6	0	0
4	2.2	5.0	2.9	0	0
5	1.6	3.7	2.5	0	100
6	1.2	2.7	2.2	0	0
7	0.8	2.0	2.0	0	0
8	0.6	1.5	1.8	0	0
9	0.5	1.1	1.8	0	0
10	0	0.8	1.6	0	0
11	0	0.6	1.6	0	0
12	0	0.5	etc.	0	0
Total	97	97	97	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 is created by **demandts**, which also fills missing records as described in Section 4.4.2. The file is used by StateMod for baseflow estimations at stream gage locations, and for comparison output that is useful during calibration.

The file is also referenced by **demandts** when developing average efficiency values for the diversion station file, and headgate demand time series for the diversion demand file.

5.4.3.1 Key Structures

For most explicitly modeled irrigation and M&I structures, the **demandts** utility accesses the CDSS database for historical diversion records. For certain structures, the data was assembled from other sources or developed from database data into a “replacement file” which **demandts** can be directed to read. These include the diverters in the Uncompahgre Valley who are recipients of Gunnison Tunnel water plus other larger diverters as follows:

WDID	Name
400900	Relief Ditch
400863	Bonafide Ditch
401133	Fire Mountain Canal
410520	East Canal
410527	Garnet Ditch
410534	Ironstone Canal
410537	Loutsenhizer Canal
410545	Montrose & Delta Canal
410559	Selig Canal
410577	West Canal
410578	South Canal
620617	Gunnison Tunnel

5.4.3.2 Aggregate Structures

Aggregated irrigation structures are assigned the sum of the constituent structures’ historical diversion records from the database.

Three nodes in the model represent the combined small diversion for municipal, industrial, and livestock use in three water districts in the basin. These structures are modeled as diverting only the depletive portion of their diversions, and consuming all of it. Thus estimated historic diversions are equivalent to estimated consumptive use. Total non-irrigation consumptive use in the Gunnison basin was estimated, as documented in the task memorandum “Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison river Basin.” Consumptive use of the key municipal and industrial diversion in the model was subtracted from this basin wide M&I consumption, to derive the basin wide consumptive use attributable to small M&I users. This value was distributed to Water Districts 40, 41, and 62 in accordance with a general distribution of M&I use.

The use is the same each year of the study.

5.4.3.3 Special Structures

5.4.3.3.1 Fruitland Canal Irrigation

Diversion time series for the node representing the historical irrigation demand of the Fruitland Irrigation Company (40_Fruitl) was created outside **demandts** by estimating the total irrigation demand from all sources using the average monthly efficiency of the nearby Needle Rock Ditch (400501). The Needle Rock Ditch was chosen because it has similar water rights administration numbers. As noted previously, the lands under this structure receive water from the Fruitland Canal and Fruitland Reservoir.

5.4.3.3.2 Cimarron Canal

Diversion time series for the node representing the historical irrigation demand of the Bostwick Project (62_IrrCim) was created outside **demandts** by subtracting the estimated Project 7 Water Authority demand from the historical Cimarron Canal (620560).

5.4.3.3.3 Project 7

Diversion time series for the node representing the Project 7 Water Authority M&I historical diversions (Proj_7) was created outside **demandts** from information obtained directly from the water authority.

5.4.3.3.4 Redlands Canal

Diversion time series for the two nodes that represent the historical irrigation (960050) and power (420541) demands of the Redlands Canal were created outside **demandts** from SEO records.

5.4.3.3.5 Grand Junction

Diversion time series for the node representing water exported from Kannah Creek for the City of Grand Junction (960051) was created outside **demandts** from information obtained directly from the city.

5.4.3.3.6 Future Use Diversion Structures

All future use structures have historical diversions set to zero because they did not divert historically.

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 *(Appendix E.1)*

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

5.4.4 Direct Diversion Demand File (*.ddm)

Created by **demandts**, this file contains time series of demand for each structure in the model. Demand is the amount of water the structure "wants" 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 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 1950. Prior to that, it is filled using the automatic data filling algorithm described in Section 4.4.2. Monthly efficiency is the average efficiency over the efficiency period (1950 through 2002) but capped at 0.50.

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

5.4.4.2 Aggregate Structures

Aggregated irrigation structure demand is computed as for key irrigation structures. The only difference is that the irrigated acreage, which is the basis of irrigation water requirement, is the sum of irrigated acreage for constituent structures. Similarly, diversions are summed across all constituent structures, and average efficiency is based on efficiency of the aggregation as a unit. Demand for aggregated M&I structures is the same as it is in the historical diversion file.

5.4.4.3 Future Use Diversion Structures

Demands of future depletion nodes are zeroed out, as they are not active in the Baseline data set.

5.4.5 Direct Diversion Right File (*.ddr)

The direct diversion right file contains water rights information for each diversion structure in the model. The DMI **watright** creates 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.

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 **demandts** when it is filling historical diversion time series. Based on the appropriation dates expressed in the administration number in the rights file, **demandts** determines the total amount of the water right during the time of the missing data, and constrains the diversion estimate 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 **demandts** estimated 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 study period could be simulated.

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. In addition, many structures have been assigned a "free water 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 Gunnison model, aggregated structures can include more than 40 individual structures. Therefore, aggregated irrigation structures were assigned up to 11 water rights, one for each of 11 water right (administration) classes. 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 (10x1+4x2)/(10+2)=1.5.

Aggregated M&I water rights were assigned an amount equal to their depletions and assigned an administration number of 1.00000.

5.4.5.3 Special Diversion Rights

5.4.5.3.7 Fruitland Canal Irrigation

Direct diversion water rights for the Fruitland Canal are extracted directly from Hydrobase and assigned to the feeder canal 400549. The direct diversion rights for the irrigation demand (40_Fruitl) are set to zero and water is only delivered via the feeder canal or from Fruitland Reservoir.

5.4.5.3.8 Cimarron Canal

Water is delivered through the Cimarron Canal to meet both the irrigation demand of the Bostwick Project, and to the storage and direct use demand for Project 7 Water Authority. For both Baseline simulation and historical simulation for calibration, water is delivered from the Cimarron Canal (620560) to the Bostwick area as an import to the system. The Cimarron Canal irrigation demand (60_IrrCim) is assigned a 999 cfs water right with the senior priority of 1.0000 to divert the delivered water, which is the only inflow to the subbasin. The water right remains on during the Baseline simulation, however, there is no inflow to the node and, therefore, no diversion under this direct flow water right. In the Baseline simulation, an operating rule satisfies the Cimarron Canal irrigation demand (62_IrrCim) based on the Cimarron Canal (620560) direct water right.

5.4.5.3.9 Project 7

Project 7 does not have a direct diversion water right - water is only delivered through operating rules in all simulations.

5.4.5.3.10 Redlands Canal

Redlands Canal irrigation rights are store in Hydrobase under the Redlands Power Canal (420541). They are assigned to the Redlands Canal Irrigation Structure (960050) as follows: 60 cfs with an administration number of 22283.20300 and 80 cfs with an administration number of 34419.33414.

5.4.5.3.11 Grand Junction

A senior water right for 999 cfs, with an administration number of 1.0000, was assigned to the City of Grand Junction (960051) export from Kannah Creek.

5.4.5.3.12 South and West Canals

The South and West Canals obtain their water directly from the Gunnison Tunnel and do not have water rights decreed from the Uncompahgre River. Both structures are included in the model network as diversions on the Uncompahgre River. For the historical simulation for calibration, water is delivered from the Gunnison Tunnel (620617) to the Uncompahgre River as an import to the system. To enable the modeled South and West Canals to benefit from modeled Tunnel deliveries, they are assigned 999 cfs direct flow rights with an administration number just junior to the Tunnel. These two direct flow rights are turned off in the Baseline data set, because they are supplied via operating rules that deliver Gunnison Tunnel water, either under the tunnel's direct flow rights or from storage in Blue Mesa and Taylor Park Reservoirs. Note that these operating rights were turned "off" by hand-editing the *.ddr file created directly from **watright**.

5.4.5.3.13 Other Uncompahgre Water Users Association Canals

To simulate the Uncompahgre Valley Water Users Association (UVWUA) good neighbor policy, all UVWUA rights junior to 13917.000 were turned off in the Baseline data set. This has the effect of UVWUA using Gunnison Tunnel water before exercising their Uncompahgre direct flow rights to the maximum extent. Note that these operating rights were turned "off" by hand-editing the *.ddr file created directly from **watright.**

5.4.5.3.14 Future Use Diversion Structures

Future use structures are listed in the direct diversion rights file, but the rights are turned off. This effectively disables the structures with regard to having an impact of the river.

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 diversions.

5.5.1 Structure Parameter File (*.par)

This file gives the soil moisture capacity of each irrigation structure for which efficiency varies, 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 is hand-edited.

5.5.2 CU Time Series Parameter File (*.tsp)

This file contains conveyance efficiency and maximum application efficiency by irrigation type for each irrigation structure for which efficiency varies, and each year of the study period. The file also contains acreage by irrigation type – either flood or sprinkler. In the Gunnison basin, all acreage has been assigned flood irrigation type. Maximum system efficiency in the upper reaches, defined as above the Aspinall Unit, is estimated to be 40 percent. In the remaining portions of the basin, maximum system efficiency is estimated to be 50 percent. Because overall system efficiency is considered, conveyance efficiency is set to 1.0 and maximum flood application efficiency is set to the system efficiencies outlined here. This file is hand-edited at this time.

5.5.3 Irrigation Water Requirement File (*.iwr)

Data for the irrigation water requirement file is generated by StateCU for the period 1950 through 2002, then filled and formatted in StateMod file format by **demandts**. StateCU was executed using the SCS modified Blaney-Criddle monthly evapotranspiration option with TR-21 crop parameters for structures downstream of the Aspinall Reservoirs. For structures above the Aspinall Reservoirs, StateCU was executed using the original Blaney-Criddle method with high-altitude crop coefficients, as described in the *Subordination of Wayne N. Aspinall Unit Water Rights within the Upper Gunnison Basin, 2002 Annual Report*, October 2001, Helton & Williams, P.C. The irrigation water requirement file contains the time series of monthly irrigation water requirements for structures whose efficiency varies 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 Gunnison basin. It is assembled by **watright**, using a considerable amount of information provided in the commands file. Thirteen (13) key reservoirs were modeled explicitly. Fourteen 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 Owners
1	403365	FRUIT GROWERS RES	4540	2
2	403395	FRUITLAND RESERVOIR	8100	1
3	403399	OVERLAND RES NO 1	5828	2
4	403416	PAONIA RESERVOIR	18700	4
5	403553	CRAWFORD RESERVOIR	14395	2
6	593666	TAYLOR PARK RESERVOIR	108490	3
7	623532	BLUE MESA RESERVOIR	940800	3
8	623545	MORROW POINT RESERVOIR	118764	2
9	623548	SILVERJACK RESERVOIR	13520	2
10	623578	CRYSTAL RESERVOIR	25236	1
11	683675	Ridgway	84467	6
12	28_ARG001	AGG_RES_Tomichi	6395	1
13	40_ARG001	AGG_RES_Surface	23268	1
14	40_ARG002	AGG_RES_Ngunn	23268	1
15	40_ASG001	AGG_STOCK_Surface	1727	1
16	41_ARG001	AGG_RES_Uncomp	3226	1
17	41_ASG001	AGG_STOCK_Uncomp	1727	1
18	42_ARG001	AGG_RES_Kannah	17876	1
19	42_ASG001	AGG_STOCK_Kannah	1727	1
20	59_ARG001	AGG_RES_East	9826	1
21	62_ARG001	AGG_RES_Lake	6475	1
22	62_ARG002	AGG_RES_Main	6475	1
23	62_ASG001	AGG_STOCK_Main	1727	1
24	68_ARG001	AGG_RES_UpperUncomp	8359	1
25	68_ASG001	AGG_STOCK_UpperUncomp	1727	1
26	Cerro	Cerro	650	1
27	Fairview	Fairview	350	1

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 are set to average September end-of-month contents over the period 1975 through 1996. After filling dead pools, initial contents are 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 interview with the Division Engineer, local water commissioners, and in most cases, the owner/operator of the individual reservoirs.

5.6.1.2 Aggregate Reservoirs

The amount of storage for aggregate reservoirs and stockponds is based on storage decrees and the CDSS Task 1.14-23 Memorandum “Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison river Basin.” (see Appendix B). Surface area for the 14 aggregate reservoirs was developed assuming they are straight-sided pits with a depth of 25 feet for aggregate reservoirs and a depth of 10 feet for aggregate stockponds, based on available dam safety records. Initial contents were set to full.

5.6.1.3 Reservoir Accounts

5.6.1.3.15 Fruit Growers Reservoir

Fruit Growers Reservoir (403365) furnishes a dependable irrigation water supply in the Tongue Creek and Alfalfa Run area. Inflow to the reservoir, which is in the Alfalfa Run drainage, originates from Tongue and Surface Creeks. Water releases are delivered to project lands through a privately owned system of canals and laterals. Although the decreed capacity is 7,360 acre-feet, the estimated actual capacity is 4,540 acre-feet including an 80 acre-feet dead pool. An irrigation account with a capacity of 4,460 acre-feet for Stell Ditch, and a dead pool account of 80 acre-feet, are modeled for Fruit Growers Reservoir.

5.6.1.3.16 Fruitland Reservoir

Fruitland Mesa encompasses Fruitland Reservoir (aka Gould Reservoir, aka Onion Valley Reservoir, 403395) and a transbasin diversion from Crystal Creek, which irrigate lands in the Iron Creek and Smith Fork drainages. These systems obtain the majority of their water from Crystal Creek. Fruitland Canal (400549) is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir. The model node 40_Fruitl was included to simulate the water diverted directly for irrigation by Fruitland Canal.

Although the decreed capacity is over 10,100 acre-feet, the estimated actual capacity is 8,100 acre-feet. A single irrigation account, with a capacity of 8,100 acre-feet, is modeled for supplemental water to 40_Fruitl.

5.6.1.3.17 Overland Reservoir

Overland Reservoir #1 (403399) is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch (400585) to Leroux Creek, and then picked up by the Lower Overland Ditch

(400944) or by Vanderford Ditch (401213). A single irrigation account with a capacity of 5,776 and a dead pool account of 52 acre-feet are modeled for Overland Reservoir.

5.6.1.3.18 Paonia Reservoir

The Paonia Project provides fill and supplemental irrigation water to land near Paonia and Hotchkiss. The Paonia Project consists of Paonia Reservoir (403416) and Fire Mountain Canal (401133), which diverts from the North Fork of the Gunnison River downstream of the reservoir.

In accordance with the Ragged Mountain Exchange Agreement, the Paonia Project provides supplemental irrigation water, by exchange, for up to 2,400 acres of land upstream of Paonia Reservoir, along East and West Muddy Creeks. As a result of this agreement, the storage in Paonia Reservoir is allocated as follows:

Structure (Account)	**Structure ID**	**Storage (ac-ft)**
Fire Mountain Canal	401133	12,650
Ragged Mountain Exchange Account	401120, 401121, 401119, 401106, 401105, 401145, 401168, 401112, 401201, 401214, 401166, 401122, 401087, 401114, 401127	2,000
Endangered Fish		1,500
Inactive Pool		2,550
TOTAL		18,700

5.6.1.3.19 Crawford Reservoir

Crawford Reservoir (403553) is the key component of the Smith Fork Project. The Smith Fork Project, located east of Delta, provides a full irrigation water supply to lands not previously irrigated, and a supplemental irrigation water supply to already existing irrigated lands in the Iron Creek and Smith Fork river basins. Crawford Reservoir is filled in part by natural inflows from Iron Creek, although the majority of inflow originates from Smith Fork by way of the Smith Fork Feeder Canal (400605).

Numerous irrigation diversion structures use Crawford Reservoir water directly or by exchange, including 400500, 400501, 400502, 400503, 400509, 400536, and 400616. An irrigation account with a capacity of 10,350 acre-feet and a recreation account with a capacity of 4,045 acre-feet are modeled for Crawford Reservoir.

5.6.1.3.20 Taylor Park Reservoir

The U.S. Bureau of Reclamation constructed Taylor Park Reservoir (593666) as part of the Uncompahgre Project to store and deliver supplemental irrigation water to irrigable lands in the Uncompahgre Valley. Located in the upper Gunnison Basin on the Taylor River, the reservoir was decreed in 1941, with a priority date of August 3, 1904, for irrigation and other purposes. The Upper Gunnison River Water Conservancy District (UGRWCD) obtained a decree in Case No. 86CW203 for the right to refill Taylor Park Reservoir, for a total amount of 106,230 acre-feet, with an appropriation date of August 28, 1975.

The reservoir is owned by the United States and is operated by the Uncompahgre Valley Water Users Association (UVWUA). Historically, releases were made from Taylor Park Reservoir to provide a supplemental water supply for the Gunnison Tunnel. Decree 86CW203 requires continued releases for fishery, and has provided significant fishery and recreation benefits.

Taylor Park Reservoir is modeded with a first-fill irrigation account for UVWUA and a refill account for the UGRWCD. Both accounts have a capacity of 106,200 acre-feet. Note that the UGRWCD account occupies the same space as the original decree. In addition, an inactive pool is modeled with a capacity of 2,290 acre-feet.

5.6.1.3.21 Aspinall Unit - Blue Mesa, Morrow Point, and Crystal Reservoirs

The Aspinall Unit was constructed as part of the Colorado River Storage Project. The unit is located along the main stem of the Gunnison River between the Black Canyon of the Gunnison National Monument and the City of Gunnison. Three reservoirs form the Aspinall Unit: Blue Mesa (623532), Morrow Point (623545), and Crystal (623578).

The flows of the Gunnison River are largely controlled by the operation of Blue Mesa Reservoir. Water releases through Blue Mesa power plants receive short-term re-regulation by Morrow Point and Crystal Reservoirs. Water releases from Morrow Point are primarily for peaking power, while releases from Crystal power plant are more uniform to satisfy downstream water rights.

As part of the 1975 Taylor Park Reservoir Operations and Storage Exchange Agreement, UVWUA stores and releases their water from Blue Mesa Reservoir with the goal of stabilizing the Taylor and Gunnison river flows throughout the year, to provide flood control and irrigation uses, and to minimize abrupt changes that would adversely affect fisheries and recreation uses.

Blue Mesa is modeled with a 748,520 acre-feet capacity “USA” account for power releases and a 106,200 acre-feet capacity account that provides water to the UVWUA. Blue Mesa also has a 192,270 acre-feet dead-pool account.

Morrow Point Reservoir is modeled with a re-regulation account of 42,120 and a dead-pool account of 76,644. Crystal Reservoir has a single re-regulation account with capacity of 25,236 acre-feet.

5.6.1.3.22 SilverJack Reservoir

Bostwick Park Water Conservancy District was formed in 1962 to supplement irrigation water in the Bostwick Park area. The Bostwick Park Project was authorized as a participating project of the Colorado River Storage Project. The key components of the project are Silverjack Reservoir (623548) and the Cimarron Canal (620560). Cimarron Canal diverts water to supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, a small storage facility of Project 7 Water Authority. Model node 62_IrrCim represents the irrigation demands only. Note that Project 7 does not own any storage in Silverjack Reservoir.

An irrigation account with a capacity of 12,837 acre-feet is modeled to supplement 62_IrrCim demands. There is also a dead-pool account with a capacity of 683 acre-feet.

5.6.1.3.23 Ridgway Reservoir

Dallas Creek Project, and its principal component Ridgway Reservoir (683675), provide supplemental water supplies for municipal, industrial, and irrigation uses in the Uncompahgre Valley. Project 7 Water Authority, though not a component of the Dallas Creek Project, is a main provider of water to domestic and municipal members using Ridgway Reservoir and has been grouped with the Dallas Creek Project in the application.

In addition to irrigation and municipal accounts, Ridgway is modeled with an exchange account that receives book-over water from Blue Mesa Reservoir as part of the 1991 Ridgway Reservoir Exchange Agreement, and a recreation account as follows:

Structure (Account)	**Structure ID**	**Storage (ac-ft)**
Project 7	Proj_7	28,200
UVWUA	410520, 410527, 410534, 410537, 410545, 410559, 410577, 410578	10,300
Recreation		20,000
Inactive Pool		25,067
Unallocated		900
Exchange		15,000
TOTAL		99,467

5.6.1.3.24 Cerro and Fairview Reservoirs

Cerro and Fairview Reservoirs are essentially flow-through reservoirs that were added to model Project 7 water use. They are each modeled with a single account for Project 7 use – 650 acre-feet capacity for Cerro Reservoir and 350 acre-feet capacity for Fairview Reservoir.

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 were used in the calculation of annual net evaporation in the Gunnison River basin:

1. Shadow Mountain Reservoir Station (10009) was used to calculate evaporation for the following reservoirs: Fruitgrowers, Fruitland, Crawford, 40_ARG001, and 40_ARG002.
2. Taylor Park Reservoir Station (10010) was used to calculate evaporation for the following reservoirs: Overland, Taylor Park, and 28ARG001.

3. Blue Mesa Reservoir Station (10011) was used to calculate evaporation for the following reservoirs: Paonia, Blue Mesa, Morrow Point, 62_ARG001, 62_ARG002, 68_ARG001, and 68_ARG002.
4. Ridgway Reservoir Station (10012) was used to calculate evaporation for the following reservoirs: Silverjack, Cerro, Fairview, 68_ARG001, 41_ARG001, 42_ARG001, 59_ARG001, and all aggregated stock ponds.

The resulting net monthly free water surface evaporation estimates used in the Gunnison model are as follows:

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
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
10010	0.08	0.01	-0.02	-0.01	0.01	0.04	0.12	0.18	0.24	0.21	0.18	0.16	1.20
10011	0.14	0.07	0.02	0.03	0.05	0.13	0.24	0.33	0.40	0.35	0.31	0.29	2.36
10012	0.08	-0.02	0.05	0.04	0.06	0.02	0.19	0.31	0.44	0.33	0.28	0.18	1.96

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

The end-of-month content file contains historical end-of-month storage contents for all 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 is created by **tstool**, which reads data from Hydrobase and can fill it under a variety of user-specified algorithms.

5.6.3.1 Key Reservoirs

Data for the Gunnison model key reservoirs was either provided by Division 4, reservoir owners, the USBR, or generated by converting sporadic daily observations stored in Hydrobase to month-end data. Missing end-of-month contents were filled with the average of available values for months with the same hydrologic condition. 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 are 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
403365	Fruitgrowers	1959	USBR
403395	Fruitland	1962	Hydrobase Daily
403399	Overland No. 1	1962	USBR
403416	Paonia	1962	USBR
403553	Crawford	1963	USBR
593666	Taylor Park	1937	USBR
623532	Blue Mesa	1965	USBR
623545	Morrow Point	1970	USBR
623548	Silverjack	1971	USBR
623578	Crystal	1977	USBR
683675	Ridgway	1987	USBR
Cerro	Cerro	1932	Capacity Used
Fairview	Fairview	1968	Capacity Used

5.6.3.2 Aggregate Reservoirs

Aggregated reservoirs were assigned contents equal to their capacity, because there is no actual data. Aggregated reservoirs were modeled as through 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 all 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 for all reservoirs, and the maximum targets were set to capacity for all reservoirs that operate primarily for agricultural and municipal diversion storage. Maximum targets were set to capacity for regulating reservoirs (Morrow Point and Crystal reservoirs.) Maximum targets were set to operational targets according to rule curves provided by USBR for reservoirs that operate for flood control or power generation (Paonia, Taylor Park, and Blue Mesa reservoirs.) When the model was originally developed, Ridgway Reservoir had just recently been completed, and operators were still determining “normal” operating targets. Therefore, historic end-of-month contents were used as targets for Ridgway Reservoir. Targets allow maximum control of reservoir levels by storage rights and releases to meet demands.

5.6.5 Reservoir Right File (*.rer)

The reservoir right file contains the 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 accures, and whether the right is used as a first or second fill.

5.6.5.1 Key Reservoirs

In general, water rights for explicitly modeled reservoirs were taken from the CDSS database and correspond to the State Engineer's official water rights tabulation. In addition, the 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

5.6.5.3.25 Ridgway Reservoir

Ridgway Reservoir (683675) has a decreed absolute storage right for 84,594. It also has an absolute decreed storage right for 14.9 acre-feet that is assigned in HydroBase to structure ID 683679. This right has been re-assigned for modeling purposes to structure 683675.

5.6.5.3.26 Cerro and Fairview Reservoirs

Cerro and Fairview Reservoirs are essentially flow-through reservoirs that were added to model Project 7 water use. They were both assigned a senior water right for their modeled capacity (650 acre-feet for Cerro and 350 acre-feet for Fairview) with an administration number of 1.0000.

5.7 Instream Flow Files

5.7.1 Instream Station File (*.ifs)

Twenty-nine instream flow reaches are defined in this file, which is created by **watright**. 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 Gunnison Model along with their location and average annual 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 modeled instream flow stations were not obtained from Hydrobase as follows:

- An instream flow node was added to reflect minimum bypass requirements at Taylor Park Reservoir (Taylormin).
- An instream flow node was added to reflect the National Park Service Black Canyon filing (95NPS) for future modeling efforts. It is disabled in the Baseline data set and has no impact on the river.
- An instream flow node was added to reflect the U.S. Fish and Wildlife Service filing (96USFS) for future modeling efforts. It is disabled in the Baseline data set and has no impact on the river.
- The Tri-County Water Conservancy District and the USBR have coordinated a "no spill" policy for the reservoir in order to prevent a fishery loss over the spillway of Ridgway. Operations of Ridgway are handled in the Baseline data set through reservoir release targets, however, a "no spill" node was added below the reservoir to represent the condition for future modeling efforts (NoSpill). It is disabled in the Baseline data set and has no impact of the river.

5.7.2 Instream Demand File (*.ifa)

Instream flow demands were developed from decreed amounts and comments in the State Engineer's water rights tabulation. Twelve monthly instream flow demands were used for each year of the simulation. The file contains monthly demands for each instream flow structure included in the Gunnison model.

5.7.3 Instream Right File (*.ifr)

Water rights for each instream flow reach modeled in the Gunnison model are contained in the instream flow right file, and shown in Table 5.8. These data were obtained from the CWCB instream flow database with the exception of instream flow reaches listed under the following section.

Table 5.8
Instream Flow Summary

#	ID	Name	Location	Demand
1	281057	Cochetopa Creek	Headwaters to Nutras Creek	2896
2	281072	Tomichi Creek	Triano Creek to Marshall Creek	6516
3	281077	Hot Springs Creek	Headwater to Tomichi Creek	1086
4	281078	Cochetopa Creek	Pauline Creek to Tomichi Creek	6154
5	281079	Tomichi Creek	Marshall Creek to Quartz Creek	13032
6	281097	Marshall Creek	Tank 7 Creek to Indian Creek	4110
7	281100	Quartz Creek	Gold Creek to Tomichi Creek	3620
8	591402	Carbon Creek	Headwaters to Ohio Creek	2172
9	591412	East River	Copper Creek to Brush Creek	13894
10	591485	Brush Creek	West Brush Creek to Jarvis Ditch Headgate	6585
11	591493	Ohio Creek Seg 3	Mill Creek to Gunnison River	8688
12	591495	Ohio Creek Seg 2	Castle Creek to Mill Creek	7240
13	591505	Slate River Loc C	Oh-Be-Joyful Creek to Coal Creek	12080
14	591506	Slate River Loc D	Coal Creek to East River	14011
15	591516	East River	Alkali Creek to Taylor River	27896
16	591550	Cement Creek	Headwaters to East River	7240
17	591552	Castle Creek	Confluence N. and S. Castle Creek to Acme Ditch Headgate	5068
18	591583	Taylor River	Spring Creek to East River	101476
19	620579	Cebolla Creek	Confluence E.Fork and W.Fork Cebolla Creek to Brush Creek	13777
20	621331	Lake Fork Gunnison	Henson Creek to Blue Mesa Reservoir	24169
21	621339	Blue Creek	Little Blue Creek to Morrow Point Reservoir	5068
22	621340	Cimarron River	Fox Creek to Little Cimarron River	13894
23	681084	Beaver Creek	Headwaters to Dallas Creek	1086
24	Taylormin	Taylormin	Minimum Release from Taylor Park Reservoir	108200
25	591273	Taylor_River_Vader	Confluence with East River	322170
26	621540	Black_Canyon	Black Canyon of the Gunnison	217193
27	95NPS	NPS_Request	Black Canyon of the Gunnison	0
28	952201	NoSpill	Downstream Ridgway Reservoir	129870
29	96USFWS	USFWS_Request	Upstream Redland Power Canal Headgate	0

5.7.3.1 Special Instream Flow rights

Several modeled instream flow water rights were not obtained from Hydrobase as follows:

- The Taylor River instream flow right (591273) above the confluence with East Creek is stored in Hydrobase with a use type of “RECFISSTK”. Only use types of “MIN” are extracted when the –rightsi option is used with **watright**. Therefore, the 445 cfs instream flow right with an administration number of 49673.45896 was defined using the setisfr command.
- The CWCB Black Canyon instream flow right (621540) is stored in Hydrobase with a use type of “OTH”. Therefore, the 300 cfs instream flow right with an administration number of 42347.00000 was defined using the setisfr command.
- The instream flow right used to represent the Taylor minimum bypass requirements at Taylor Park Reservoir (Taylormin) was set to reflect the 400 cfs bypass with an administration number of 30667.19939.

5.8 Operating Rights File (*.opr)

The operating rights file specifies all operations that are more complicated than a direct diversion or 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 on reservoir to a second reservoir, or a diversion to an off-stream reservoir. The file is created by hand, and the user is required to assign each operating right an administration number consistent with the structures' other rights and operations.

In the Gunnison model, seven different types of operating rights are used:

- **Type 1 –** a release from storage to the stream to satisfy an instream flow demand. In the Gunnison model, this rule is used to satisfy minimum reservoir release requirements at Taylor Park Reservoir.
- **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 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.
- **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.
- **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 legally available water occurs in the exchange reach. Typically, the storage water is supplemental, and is give an administration number junior to direct flow rights at the diverting structure.
- **Type 6 –** a reservoir to reservoir transfer (bookover). It is commonly used to transfer water from one reservoir storage account to another in a particular month. It can be used to transfer water from one storage account to another based on the amount of water diverted by another operating rule. For example, in the Gunnison model, water is transferred from the Blue Mesa Reservoir USA account to the UVWUA account whenever releases are made from Taylor Park Reservoir's UVWUA account.
- **Type 9 –** a release from storage to the river to meet a reservoir target. This operation is used in the Gunnison Baseline data set for the reservoirs that operate for flood control or power generation (Paonia, Taylor Park, and Blue Mesa reservoirs.) Targets allow maximum control of reservoir levels by storage rights and releases to meet demands.
- **Type 11 –** a direct flow diversion to another diversion or reservoir through an intervening carrier. It 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 Gunnison model, the Type 11 operating right 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 through the Gunnison Tunnel to Garnet Canal on the Uncompahgre; the demand is the Garnet Canal demand. This rule type is also used to deliver water to Crawford Reservoir through the Smith Fork Feeder Canal; the demand is Crawford Reservoir's capacity.

For all type 2, 3, 4, and 11 operating rules where water is released from a reservoir or diverted by a carrier to irrigation, the variable iopsou(4,1) in the operating file has been set to "1". This directs StateMod to release water only when an irrigation water requirement exists. When an irrigation water requirement exists, the operating rule will attempt to release the full amount required to satisfy the headgate demand defined in the *.ddm file. The variable efficiency algorithm will then determine the actual efficiency of the released water.

The presentation of operating rights for the Gunnison model is generally organized according to the projects involved:

Section	Description
5.8.1	Taylor Park Reservoir
5.8.2	Overland Reservoir and Ditch
5.8.3	Paonia Project
5.8.4	Aspinall Unit
5.8.5	Uncompahgre Project
5.8.6	Dallas Creek Project
5.8.7	Smith Fork Project
5.8.8	Fruitland Mesa
5.8.9	Bostwick Park Project
5.8.10	Project 7 Water Authority
5.8.11	Fruitgrowers Dam Project
5.8.12	Other Operating Rules

Where to find more information

- StateMod documentation describes the different types of operating rights that can be specified in this file, and describes the required format for the file.
- The section "Gunnison River Projects and Special Operations" in the document "Gunnison Basin Information" describes each reservoir's typical operations.

5.8.1 Taylor Park Reservoir

Taylor Park Reservoir (593666) is part of the Uncompahgre Project, and delivers supplemental water for irrigation in the Uncompahgre Valley via the Gunnison Tunnel from the Uncompahgre Valley Water Users Association (UVWUA) account. The Upper Gunnison River Water Conservancy District (UGRWCD) has a junior right to refill Taylor Park Reservoir. Note that the refill storage occupies the same space as the UVWUA storage.

Account	Owner	Capacity (acre-feet)
1	UVWUA	106,200
2	UGRWCD	106,200
3	Inactive Pool	2,290

Thirteen operating rights are used to specify Taylor Park Reservoir operations:

Right #	Destination	Resvr Account	Admin #	Right Type	Description
1	Gunnison Tunnel	1	20393.18781	2	Release to direct diversion
2	Taylor Park Min Release	1	49348.22950	1	Release to instream flow demand
3	Taylor Park Min Release	2	49348.22950	1	Release to instream flow demand
4	Opr Taylor Park Target	1 and 2	99999.99999	9	Release to river by target
5	South Canal	1	49348.22951	2	Release to river to carrier
6	West Canal	1	49348.22951	2	Release to river to carrier
7	Montrose and Delta Canal	1	49348.22951	2	Release to river to carrier
8	Loutsenhizer Canal	1	49348.22951	2	Release to river to carrier
9	Selig Canal	1	49348.22951	2	Release to river to carrier
10	Ironstone Canal	1	49348.22951	2	Release to river to carrier
11	East Canal	1	49348.22951	2	Release to river to carrier
12	Garnet Canal	1	49348.22951	2	Release to river to carrier
13	Opr Taylor Park Bookover	2 to 1	99999.99999	6	Reservoir account bookover

Operating rule 1 provides water to the Gunnison Tunnel (620617) from the UVWUA account. The senior administration number, which is junior to the Tunnel's direct flow decree, insures this rule is operated and water is released to the Gunnison Tunnel prior to any other Taylor Park Reservoir releases. This operating rule is only turned on for the historical simulation; during the Baseline simulations water is delivered through the Gunnison Tunnel based on the destination canal demands.

Operating rules 2 and 3 release water from the UVWUA and UGRWCD accounts, respectively, to meet the minimum release (Taylormin) demand located downstream of the reservoir. Taylormin demands reflect releases outlined in the 1975 exchange agreement. This operating rule was given an administration date senior to Taylor Park Reservoir second fill decree to replicate required releases for fisheries.

Operating rule 4 releases water from the UVWUA and UGRWCD accounts proportionally to operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

Operating rules 5 through 12 provide supplemental water to eight Uncompahgre Valley diversion structures. The water is released and the Gunnison Tunnel is used as the carrier. The rules are given an administration number just junior to the minimum release right, per the 1975 exchange agreement. The amount of water released is restricted by the amount currently available in the account, and the unsatisfied demand at the individual canals.

Operating rule 13 implements the Taylor Park "bookover", part of the 1975 Exchange agreement. This operating right moves water from the UGRWCD account to UVWUA's account on October 31 of each year. It has a very junior administration number.

5.8.2 Overland Reservoir and Ditch

Overland Reservoir (403399) is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch (400585) to Leroux Creek, then picked up by the Lower Overland Ditch (400944). Overland Reservoir is operated with two accounts.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	5776
2	Dead Pool	52

Six operating rules are used to simulate Overland Ditch and Reservoir operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Lower Overland Ditch	1	35997.00001	3	Release to carrier
2	Vanderford Ditch	1	35997.00001	3	Release to carrier
3	Overland Ditch	1	35997.00001	3	Release to carrier
4	Opr Overland to Target	1	99999.99999	9	Release to river by target
5	Lower Overland Ditch	Overland Ditch	21263.15919	11	Carrier to diversion
6	Lower Overland Ditch	Overland Ditch	21263.15919	11	Carrier to diversion

Operating rules 1 and 2 allow Lower Overland Ditch (400944) and Vanderford Ditch (401213) to get reservoir releases by using Overland Ditch (400585) as a carrier. The amount of water released to the carrier is restricted by the amount currently available in the account, and the unsatisfied demand at the destination ditches.

Operating rule 3 releases water to Overland Ditch, which is a carrier structure. This operating rule is turned on only in the historical simulation – it is disabled for the Baseline data set.

Operating rule 4 releases water to meet storage target values. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Overland Reservoir are set to capacity, so releases to target are never made.

Operating rule 5 allows Lower Overland Ditch (400944) river water to be carried by the Overland Ditch (400585) senior water right. The amount diverted at the Overland Ditch headgate is restricted by the amount of water physically and legally available based on Overland Ditch's senior water right, and unsatisfied demand at Lower Overland Ditch. As noted previously, Type 11 Operating rule 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.

Operating rule 6 allows Lower Overland Ditch (400944) water to be carried by the Upper Overland Ditch (400585) junior water right.   The amount diverted at the Overland Ditch headgate is restricted by the amount of water physically and legally available based on Overland Ditch's junior water right, and unsatisfied demand at Lower Overland Ditch. As noted previously, Type 11 Operating rule 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.

5.8.3 Paonia Project

The Paonia Project provides full and supplemental irrigation water to land near Paonia and Hotchkiss, Colorado. The Paonia Project consists of the Paonia Reservoir (403416) and the Fire Mountain Canal (401133), which diverts from the North Fork of the Gunnison River downstream of the reservoir. In accordance with the Ragged Mountain Exchange Agreement, the Paonia Project provides supplemental irrigation water, by exchange, for up to 2,400 acres of land upstream of Paonia Reservoir, along East and West Muddy Creeks. Paonia Reservoir is operated with four accounts, which are listed below and described in more detail in Section 5.6.1.3.4.

Acct	Owner	Capacity (acre-feet)
1	Fire_Mtn	12,650
2	Ragged_Mtn	2,000
3	Endangered_F	1,500
4	Inactive Pool	2,550

Seventeen operating rules are used to simulate Paonia Project operations:

Right #	Destination	Acct #	Admin #	Right Type	Description
1	Fire Mountain Canal	1	43829.43799	2	Release to direct diversion
2	Downing Ditch	2	43829.43799	4	Exchange to direct diversion
3	Williams Creek Ditch	2	43829.43799	4	Exchange to direct diversion
4	Dugout Ditch	2	43829.43799	4	Exchange to direct diversion
5	Coyote Ditch (401105)	2	43829.43799	4	Exchange to direct diversion
6	Coyote Ditch (401106)	2	43829.43799	4	Exchange to direct diversion
7	Grouse Creek Ditch	2	43829.43799	4	Exchange to direct diversion
8	Lee Creek D No 2	2	43829.43799	4	Exchange to direct diversion
9	Deer Ditch	2	43829.43799	4	Exchange to direct diversion
10	Spatafora Ditch No 1	2	43829.43799	4	Exchange to direct diversion
11	Wade Ditch	2	43829.43799	4	Exchange to direct diversion
12	Larson No 2 Ditch	2	43829.43799	4	Exchange to direct diversion
13	Dyke No 2 Ditch	2	43829.43799	4	Exchange to direct diversion
14	Black Sage Ditch	2	43829.43799	4	Exchange to direct diversion
15	Ditch No 2 Ditch	2	43829.43799	4	Exchange to direct diversion
16	Elks Beaver Ditch	2	43829.43799	4	Exchange to direct diversion
17	Opr Paonia to Target	1 and 2	99999.99999	9	Release to river by target

Operating rule 1 releases Paonia Reservoir water directly to Fire Mountain Canal (401133). The administration number reflects project administration, and has been set just senior to Paonia Reservoir's storage right. The amount of water released is restricted by the amount currently available in the Fire Mountain account, and the unsatisfied demand at Fire Mountain Canal headgate.

Operating rules 2 through 16 release water from Paonia Reservoir to the various Ragged Mountain water users by exchange, up to 2,000 acre-feet per year, their account limit. The administration number reflects project administration, and has been set just senior to Paonia Reservoir's storage right. The amount of water released to each direct diversion is restricted by the amount currently available in the account, unsatisfied demand at each ditch, and available water in Muddy Creek from the ditch to below Paonia Reservoir.

Operating rule 17 releases water to meet operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

5.8.4 Aspinall Unit

The Aspinall Unit was constructed as part of the Colorado River Storage Project. The unit is located along the main stem of the Gunnison River between the Black Canyon of the Gunnison National Monument and the City of Gunnison. Three reservoirs form the Aspinall Unit, Blue Mesa (623532), Morrow Point (623545), and Crystal (623578).

The flows of the Gunnison River are largely controlled by the operation of Blue Mesa Reservoir. Water released through Blue Mesa power plants receives short-term re-regulation by Morrow Point and Crystal Reservoirs. Water releases from Morrow Point are primarily for peaking power, while releases from Crystal power plant are more uniform to satisfy downstream water rights. The three reservoirs are operated by the model with a USA active account. In addition, the model represents the Uncompahgre Valley Water Users Association (UVWUA) account in Blue Mesa, as described in more detail in section 5.6.1.3.7:

Reservoir	Acct	Owner	Capacity (acre-feet)
Blue Mesa	1	USA	748,530
Blue Mesa	2	UVWUA	106,200
Blue Mesa	3	Inactive Pool	192,270
Morrow Point	1	USA	42,120
Morrow Point	2	Inactive Pool	76,644
Crystal	1	USA	25,236

Seventeen operating rules are used to simulate Aspinall Unit operations:

Right #	Destination	Acct #	Admin #	Right Type	Description
1	Opr Blue Mesa Bookover	1 to 2	1.00000	6	Reservoir account bookover
2	Opr Blue Mesa Bookover	1 to 2	1.00000	6	Reservoir account bookover
3	Opr Blue Mesa to Target	1 and 2	99999.99999	9	Release to river by target
4	Gunnison Tunnel	2	20393.18780	2	Release to direct diversion
5	Fairview Reservoir	2	20393.18780	2	Release to river to carrier
6	Black Canyon Instream Flow	1	56156.00000	1	Release to instream flow demand
7	South Canal	2	20393.18780	2	Release to river to carrier
8	West Canal	2	20393.18780	2	Release to river to carrier
9	Montrose and Delta Canal	2	20393.18780	2	Release to river to carrier
10	Loutsenhizer Canal	2	20393.18780	2	Release to river to carrier
11	Selig Canal	2	20393.18780	2	Release to river to carrier
12	Ironstone Canal	2	20393.18780	2	Release to river to carrier
13	East Canal	2	20393.18780	2	Release to river to carrier
14	Garnet Canal	2	20393.18780	2	Release to river to carrier
15	NPS Black Canyon Instream Flow	1	30376.00000	1	Release to instream flow demand
16	Opr Morrow Point Target	1	99999.99999	9	Release to river by target
17	Opr Crystal to Target	1	99999.99999	9	Release to river by target

Operating rules 1 and 2 allow the booking over of water, part of the 1975 Exchange Agreement. These operating rules move water from the USA account in Blue Mesa Reservoir to the UVWUA's account whenever releases are made from either Taylor Park Reservoir UVWUA's account (rule 1), or from the UGRWCD’s refill account (rule 2).

Operating rule 3 releases water to meet operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

Operating rule 4 allows the Gunnison Tunnel to use Blue Mesa storage water for UVWUA needs. This operating rule is only turned on during the historical simulation when the demand for UVWUA water is placed at the tunnel, not at the individual ditch headgates. The administration number assigned to this operating rule is just junior to the Gunnison Tunnel direct diversion right. This operating rule is used for historical calibration only, and is disabled for the Baseline data set.

Operating rule 5 provides Blue Mesa Reservoir storage water to Project 7, by way of Fairview Reservoir. The administration number assigned to this operating rule is just junior to the Gunnison Tunnel direct diversion right. The amount of water released is restricted by the amount of water currently available in the UVWUA account, and by the available capacity for storage in Fairview Reservoir.

Operating rule 6 provides Blue Mesa Reservoir storage water to the CWCB Black Canyon instream flow water right. The administration number has been set to reflect the date for spring flows requested in the settlement with the National Park Service. The amount of water released is restricted by the amount of water currently available in the USA account and the current flow through the instream flow reach. Note that in the historical data set, the administration date is just junior to the instream flow right, to reflect historic operations.

Operating rules 7 through 14 provide supplemental water to the eight Uncompahgre Valley canal recipients. The water is carried through the Gunnison Tunnel. The administration number assigned to these operating rules is just junior to the Gunnison Tunnel direct diversion right. The amount of water released is limited by the amount currently in the UVWUA account, and unsatisfied demand at the individual ditch headgates. These operating rules are turned off during the historical simulation.

Operating rule 15 provides Blue Mesa Reservoir storage water from the USA account to a NPS Black Canyon instream flow node. This operating rule is included for future modeling efforts, and is disabled for the Baseline, and other, simulations.

Operating rule 16 releases water to meet the storage target values for Morrow Point Reservoir. The junior administration number insures this is the last operating rule to fire. Because Morrow Point Reservoir essentially operates as a re-regulation reservoir, end-of-month targets are set to historic contents in the Baseline data set.

Operating rule 17 releases water to meet the storage target values for Crystal Reservoir. The junior administration number insures this is the last operating rule to fire. Because Crystal Reservoir essentially operates as a re-regulation reservoir, end-of-month targets are set to historic contents in the Baseline data set.
Uncompahgre Project

5.8.5 Uncompahgre Project

The Uncompahgre Project was one of the first major irrigation projects constructed by the USBR under the Reclamation Act of 1902. The project was developed to provide supplemental irrigation water supplies for lands in the Uncompahgre River basin between Montrose and Delta, Colorado. The irrigation supplies are obtained from direct flow rights from the Uncompahgre River, direct flow rights from the Gunnison River via the Gunnison Tunnel (620617), storage in Taylor Park, Blue Mesa and Ridgway reservoirs.

The operating rules associated with the storage for the Uncompahgre Project are detailed in sections 5.8.1, 5.8.4, and 5.8.6. Water diversions under the Gunnison Tunnel direct diversion right on the Gunnison are discussed in this section:

Right #	Destination	Carrier	Admin #	Right Type	Description
1	South Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
2	West Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
3	Montrose and Delta Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
4	Loutsenhizer Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
5	Selig Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
6	Ironstone Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
7	East Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
8	Garnet Canal	Gunnison Tunnel	20393.18779	11	Carrier to diversion
9	Fairview Reservoir	Gunnison Tunnel	20393.18779	11	Carrier to diversion

Operating rules 1 through 8 provide supplemental water to eight Uncompahgre diversion structures. The water is diverted directly from the Gunnison River using the Gunnison Tunnel administration number. The water diverted is limited by the amount physically and legally available at the Gunnison Tunnel headgate (based on the Gunnison Tunnel priority), and the unsatisfied demand at the recipient canal headgates. Note that these operating rules are turned off during the historical simulation.

Operating rule 9 delivers Project 7 water through the Gunnison Tunnel to Fairview Reservoir. The water diverted is limited by the amount physically and legally available at the Gunnison Tunnel headgate (based on the Gunnison Tunnel priority), and the available capacity of Fairview Reservoir. Note that this operating rule is turned off during the historical simulation.

5.8.6 Dallas Creek Project

The Dallas Creek Project and its principal component, Ridgway Reservoir (683675), provide supplemental water supplies for municipal, industrial and irrigation uses in the Uncompahgre valley. Project 7 Authority, though not a component of the Dallas Creek Project, is a main provider of water to domestic and municipal member using Ridgway Reservoir and has been grouped with the Dallas Creek Project in the application. It has a modeled account in Ridgway Reservoir to represent actual operations. Ridgway Reservoir is modeled with six accounts, which are listed below and described in more detail in Section 5.6.1.3.9.

Acct	Owner	Capacity (acre-feet)
1	Project 7	28,200
2	UVWUA	10,300
3	Recreation	20,000
4	Inactive Pool	25,067
5	Unallocated	900
6	Exchange	15,000

Seventeen operating rules are used to simulate Ridgway operations:

Right #	Destination	Acct #	Admin #	Right Type	Description
1	Opr Ridgway Bookover	1 to 6	1.00000	6	Reservoir account bookover
2	Opr Ridgway Bookover	1 to 6	1.00000	6	Reservoir account bookover
3	Montrose and Delta Canal	6	20393.18782	2	Release to direct diversion
4	Loutsenhizer Canal	6	20393.18782	2	Release to direct diversion
5	Selig Canal	6	20393.18782	2	Release to direct diversion
6	Ironstone Canal	6	20393.18782	2	Release to direct diversion
7	East Canal	6	20393.18782	2	Release to direct diversion
8	Garnet Canal	6	20393.18782	2	Release to direct diversion
9	West Canal	6	20393.18782	2	Release to direct diversion
10	Montrose and Delta Canal	2	20393.18783	2	Release to direct diversion
11	Loutsenhizer Canal	2	20393.18783	2	Release to direct diversion
12	Selig Canal	2	20393.18783	2	Release to direct diversion
13	Ironstone Canal	2	20393.18783	2	Release to direct diversion
14	East Canal	2	20393.18783	2	Release to direct diversion
15	Garnet Canal	2	20393.18783	2	Release to direct diversion
16	West Canal	2	20393.18783	2	Release to direct diversion
17	Opr Ridgway to Target	1 to 6	99999.99999	9	Release to river by target

Operating rule 1 allows Project 7 to move water (bookover) from account 1 to the exchange account (6) whenever UVWUA account releases are made from Blue Mesa Reservoir to Fairview Reservoir under Blue Mesa operating rule 5. Water stored in this exchange account (6) can then be used directly by the UVWUA canals, per operating rules 3 through 9.

Operating rule 2 allows Project 7 to move water (bookover) from account 1 to the exchange account (6) whenever UVWUA diverts water through the Gunnison Tunnel to Fairview Reservoir under Gunnison Tunnel operating rule 9. Water stored in this exchange account (6) can then be used directly by the UVWUA canals, per operating rules 3 through 9.

Operating rules 3 through 9 allow releases to meet the supplemental needs of the Uncompahgre Project from the exchange account. The administration number assigned to these operating rules is just junior to the Gunnison Tunnel priority, but senior to releases from the UVWUA account (operating rules 10 through 16). The amount of water released is limited by the amount currently in the exchange account and the unsatisfied demand at the individual ditch headgates. Note that although the South Canal receives project water from the Gunnison Tunnel, Taylor Park Reservoir, and Blue Mesa Reservoir, Ridgway cannot physically deliver water to the canal, as there is no headgate on the Uncompahgre River. The headgate is directly off the Gunnison Tunnel.

Operating rules 10 through 16 allow releases to meet the supplemental needs of the Uncompahgre Project from the UVWUA account. The administration number assigned to these operating rules is junior to releases from the exchange account (operating rules 3 through 9), allowing exchange water to be used before water from the UVWUA account. The amount of water released is limited by the amount currently in the UVWUA account and the unsatisfied demand at the individual ditch headgates.

Operating rule 17 releases water to meet storage target values for Ridgway Reservoir. The junior administration number insures this is the last operating rule to fire. For the Baseline data set, end-of-month targets for Ridgway Reservoir are set to historical storage values.

5.8.7 Smith Fork Project

The Smith Fork Project, located east of Delta, Co., provides a full irrigation water supply to lands not previously irrigated and a supplemental irrigation water supply to already existing irrigated lands in the Iron Creek and Smith Fork river basins. The key component of the Smith Fork Project is Crawford Reservoir (403553). This reservoir is filled in part by natural inflows from Iron Creek, although the majority of inflow originates from Smith Fork by way of the Smith Fork Feeder Ditch. Numerous diversion structures use Crawford Reservoir water directly or by exchange and are reflected in the operating rules. Crawford Reservoir is modeled with two accounts, which are listed below and described in more detail in Section 5.6.1.3.5.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	10,350
2	Recreation	4,045

Fifteen operating rules are used to simulate Crawford Reservoir and Smith Fork Project operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Clipper Ditch	1	31924.12152	3	Release to carrier
2	Aspen Canal	1	31924.18486	2	Release to direct diversion
3	Grandview Ditch	1	31924.18488	3	Release to carrier
4	Needle Rock Ditch	1	31924.29261	4	Exchange to direct diversion
5	Saddle Mountain Ditch	1	31924.29276	4	Exchange to direct diversion
6	Daisy Ditch	1	31924.13697	4	Exchange to direct diversion
7	Virginia Ditch	1	31924.13868	4	Exchange to direct diversion
8	Needle Rock Ditch	1	38064.35308	2	Release to direct diversion
9	Opr Crawford to Target	1 and 2	99999.99999	9	Release to river by target
10	Grandview Ditch	Aspen Ditch	21263.18487	11	Carrier to diversion
11	Grandview Ditch	Aspen Ditch	25807.23557	11	Carrier to diversion
12	Grandview Ditch	Aspen Ditch	31924.18487	11	Carrier to diversion
13	Needle Rock Ditch	Aspen Canal	38064.35309	11	Carrier to diversion
14	Crawford Reservoir	Smith Fork Feeder	38064.35309	11	Carrier to reservoir
15	Crawford Reservoir	Smith Fork Feeder	47847.47095	11	Carrier to reservoir

Operating rule 1 provides Crawford Reservoir storage water from the irrigation account to the Clipper Ditch (400500) by a carrier structure that diverts from the reservoir directly. The administration number for this operating right is just junior to the direct flow rights for Clipper Ditch. The amount of water released is limited by the amount currently in the irrigation account and the unsatisfied demand at the ditch.

Operating rule 2 provides Crawford Reservoir storage water from the irrigation account to the Aspen Canal (400509) by a direct release from the reservoir. The administration number for this operating right is just junior to the direct flow rights for Aspen Ditch. The amount of water released is limited by the amount currently in the irrigation account and the unsatisfied demand at the ditch. Aspen Canal is a secondary structure in the Baseline data set – this direct reservoir release is not active during the Baseline simulation

Operating rule 3 provides Crawford Reservoir storage water from the irrigation account to the Grandview Canal (400503) by a carrier structure that diverts from the reservoir directly. The administration number for this operating right is just junior to the direct flow rights for the Grandview Canal. The amount of water released is limited by the amount currently in the irrigation account and the unsatisfied demand at the ditch.

Operating rules 4 through 7 provide Crawford Reservoir storage water from the irrigation account to the Needle Rock Ditch (400501), Saddle Mountain Ditch (400502), Daisy Ditch (400536) and Virginia Ditch (400616) by exchange. The administration numbers for these operating rules are just junior to the direct flow rights for the ditches. The amount of water released is limited by the amount currently in the irrigation account, the unsatisfied demand at each ditch, and available water in Smith Fork from each ditch to the confluence with Iron Creek, below Crawford Reservoir.

Operating rule 8 provides Crawford Reservoir storage water to Needle Rock Ditch via Aspen Canal. The administration number for this operating right is just senior to Aspen Canal's most junior water right. The amount of water released is limited by the amount currently in the irrigation account, and the unsatisfied demand at the ditch. Note that this is not active during the historic simulation.

Operating rule 9 releases water to meet storage target values for Crawford Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Crawford Reservoir are set to capacity, so releases to target are never made.

Operating rules 10 through 12 deliver water carried through Aspen Ditch (400508) to Grandview Ditch (400503). The administration number for these operating rules correspond to the three direct diversion rights for the Aspen Ditch. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Aspen Ditch) rights, and unsatisfied demand at each ditch. Note that these rules are not active during the historic simulation.

Operating rule 13 delivers water carried through Aspen Canal (400509) to Needle Rock Ditch (400501). The administration number for this operating rule corresponds to the direct diversion right for Aspen Canal. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Aspen Canal) right, and unsatisfied demand at the ditch. Note that this rule is not active during the historic simulation.

Operating rules 14 and 15 deliver Smith Fork Feeder (400605) water to Crawford Reservoir (403553). The administration number for these operating rules correspond to the two direct diversion rights for the Smith Fork Feeder. The amount of water delivered is limited to water physically and legally available under the Smith Fork Feeder rights, and storage capacity in Crawford Reservoir.

5.8.8 Fruitland Mesa

Fruitland Mesa encompasses Fruitland Reservoir (Gould Reservoir, 403395) and a transbasin diversion from Crystal Creek, which irrigate lands in the Iron Creek and Smith Fork drainages. All of these systems obtain the majority of their water from Crystal Creek. The Fruitland Canal (400549) is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir. The model node 40_Fruitl was included in the model network to simulate the water diverted directly for irrigation by the Fruitland Canal (400549).

Fruitland Reservoir is modeled with a single irrigation account, with capacity of 8,100 acre-feet. Fifteen operating rules are used to simulate Fruitland Reservoir and Fruitland Canal operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	40_Fruitl	Fruitland Canal	21263.18764	11	Carrier to diversion
2	Fruitland Reservoir	Fruitland Canal	21263.18764	11	Carrier to reservoir
3	40_Fruitl	Fruitland Canal	25807.18764	11	Carrier to diversion
4	Fruitland Reservoir	Fruitland Canal	25807.18764	11	Carrier to reservoir
5	40_Fruitl	Fruitland Canal	25807.23557	11	Carrier to diversion
6	Fruitland Reservoir	Fruitland Canal	25807.23557	11	Carrier to reservoir
7	40_Fruitl	Fruitland Canal	31924.18764	11	Carrier to diversion
8	Fruitland Reservoir	Fruitland Canal	31924.18764	11	Carrier to reservoir
9	40_Fruitl	1	31924.18766	2	Release to direct diversion
10	Opr Fruitland to Target	1	99999.99999	9	Release to river by target

Operating rules 1 through 8 divert water from Crystal Creek to 40_Fruitl and Fruitland Reservoir by way of Fruitland Canal (400549). The administration numbers for these operating rules correspond to the four direct diversion rights for Fruitland Canal. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Fruitland Canal) rights, and either unsatisfied demand at 40_Fruitl or storage capacity in Fruitland Reservoir.

Operating rule 9 releases water from Fruitland Reservoir to 40_Fruitl to provide supplemental water for irrigation. The administration number for this operating right is junior to Fruitland Canal's direct water rights. The amount of water released is limited by the amount currently in the irrigation account, and the unsatisfied demand at 40_Fruitl.

Operating rule 10 releases water to meet storage target values for Fruitland Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Fruitland Reservoir are set to capacity, so releases to target are never made.

5.8.9 Bostwick Park Project

Bostwick Park Water Conservancy District was formed in 1962 to supplement irrigation water in the Bostwick Park area. The project was authorized as a participating project of CRSP.

The key components of the Bostwick Park Project are Silverjack Reservoir (623548) and the Cimarron Canal (620560). Cimarron Canal diverts water to supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, a small storage facility of Project 7 Water Authority. Modeling node 62_IrrCim represents the irrigation demand only.

Operating rules allow Cimarron Canal to divert under 3 direct flow decrees for 62_IrrCim and Cerro Reservoir. Additional operating rules allow releases from Silverjack Reservoir via the Cimarron Canal for 62_IrrCim. Project 7 does not own any storage in Silverjack Reservoir.

Silverjack Reservoir is modeled with two accounts, which are listed below.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	12,837
2	Dead Pool	683

Eight operating rules are used to simulate Silverjack Reservoir and Bostwick Park Project operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	62_IrrCim	1	38532.00001	2	Reservoir to river to carrier
2	Opr Silverjack to Target	1	99999.99999	9	Release to river by target
3	62_IrrCim	Cimarron Canal	19810.19448	11	Carrier to diversion
4	Cerro Reservoir	Cimarron Canal	19810.19448	11	Carrier to reservoir
5	62_IrrCim	Cimarron Canal	20393.20175	11	Carrier to diversion
6	Cerro Reservoir	Cimarron Canal	20393.20175	11	Carrier to reservoir
7	62_IrrCim	Cimarron Canal	27585.27545	11	Carrier to diversion
8	Cerro Reservoir	Cimarron Canal	27585.27545	11	Carrier to reservoir

Operating rule 1 releases water from Silverjack Reservoir to the irrigation component (62_IrrCim) of the Bostwick Park Project via the Cimarron Canal. The administration number for this operating rule is just junior to Silverjack Reservoir's storage right. The amount of water released is limited by the amount currently in the irrigation account, and the unsatisfied demand at the ditch.

Operating rule 2 releases water to meet storage target values for Silverjack Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Silverjack Reservoir are set to capacity, so releases to target are never made.

Operating rules 3 and 8 allow both the irrigation (62_IrrCim) and municipal demands (Cerro Reservoir) to be served by the Cimarron Canal's three water rights. The administration numbers for these operating rules correspond to the three Cimarron Canal direct diversion rights. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Cimarron Canal) rights, and either unsatisfied demand at 62_IrrCim or storage capacity in Cerro Reservoir.

Cerro Reservoir is operated to meet demands of Project 7 water users and has very little holding capacity. There is no modeled inflow to Cerro Reservoir – all water is delivered through the Cimarron Canal.

5.8.10 Project 7 Water Authority

Project 7 (Proj_7) provides domestic and municipal water treatment and is responsible for supplying a raw water supply to its members. Project 7 has no direct diversion or storage rights. Demand in the Gunnison model is satisfied from releases from Cerro and Fairview reservoirs. A portion of Project 7 supply is delivered from the City of Montrose's ownership in the Cimarron Canal to Cerro Reservoir. Montrose does not have any entitlement to Silverjack Reservoir storage water. Project 7 is also provided water, by agreement, from UVWUA sources via the Gunnison tunnel to Fairview Reservoir, in exchange for storage in Ridgway Reservoir.

Both Cerro Reservoir and Fairview Reservoir are modeled with one Project 7 account for 650 and 350 acre-feet respectively. Two operating rules are used to simulate Cerro and Fairview Reservoir releases to meet Project 7 demands:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Project 7	Cerro Reservoir	27585.27547	2	Release to direct diversion
2	Project 7	Fairview Reservoir	27585.27547	2	Release to direct diversion

Operating rule 1 releases water from Cerro Reservoir to Project 7 demand. The administration number for this operating rule is just junior to the Cimarron Canal rights. The amount of water released is limited by the available capacity in Cerro Reservoir, and the unsatisfied Project 7 demand.

Operating rule 2 releases water from Fairview Reservoir to Project 7 demand. The administration number for this operating rule is just junior to the Cimarron Canal rights. The amount of water released is limited by the available capacity in Fairview Reservoir, and the unsatisfied Project 7 demand.

5.8.11 Fruitgrowers Dam Project

The Fruitgrowers Dam Project furnishes a dependable irrigation water supply in the Tongue Creek and Alfalfa Run area. Inflow to the reservoir originates from Alfalfa Run from Tongue and Surface Creeks. Water releases are delivered to project lands through a privately owned system of canals and laterals.

Fruitgrowers Reservoir is modeled with two accounts, which are listed.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	4,460
2	Dead Pool	80

Four operating rules are used to simulate Fruitgrowers operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Fruitgrowers Reservoir	Transfer Ditch	27528.00000	11	Carrier to reservoir
2	Fruitgrowers Reservoir	Transfer Ditch	29261.00000	11	Carrier to reservoir
3	Stell Enlargement Ditch	1	38064.31951	2	Release to direct diversion
4	Opr Fruitgrowers to Target	1	99999.99999	9	Release to river by target

Operating rules 1 and 2 allow Fruitgrowers Reservoir to fill through the Transfer Ditch (400821). The administration numbers for these two operating rules correspond to the two Transfer Ditch direct diversion rights. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Transfer Ditch) rights, and storage capacity in Fruitgrowers Reservoir.

Operating rule 3 allows releases from Fruitgrowers Reservoir irrigation account to meet the supplemental needs of Stell Enlargement Ditch (aka Fogg Ditch 400820). The administration number is just junior to Fruitgrowers first two storage rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demand.

Operating rule 4 releases water to meet storage target values for Fruitgrowers Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Fruitgrowers Reservoir are set to capacity, so releases to target are never made.

5.8.12 Other Operating Rules

A type 22 operating rule is also used in the Baseline data set. This 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 will be 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 can be withdrawn from the soil reservoir to meet unsatisfied demands. The depth of the soil zone is defined in the control file (*.ctl). For the Gunnison 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, is defined for each irrigating structure in the structure parameter file (*.par).

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 Gunnison model characterizes it, under these assumptions.

6.1 Baseline Streamflows

Table 6.1 shows, for each gage, the average annual flow from the Baseline simulation, based on the entire simulation period (1909 – 2002). 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 Gunnison 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 6.11 for selected gages. Each figure shows two graphs: overlain hydrographs of historical gage flow, simulated gage flow, and simulated available flow for 1975 through 2002; and an average annual hydrograph based on the entire modeling 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 2002.

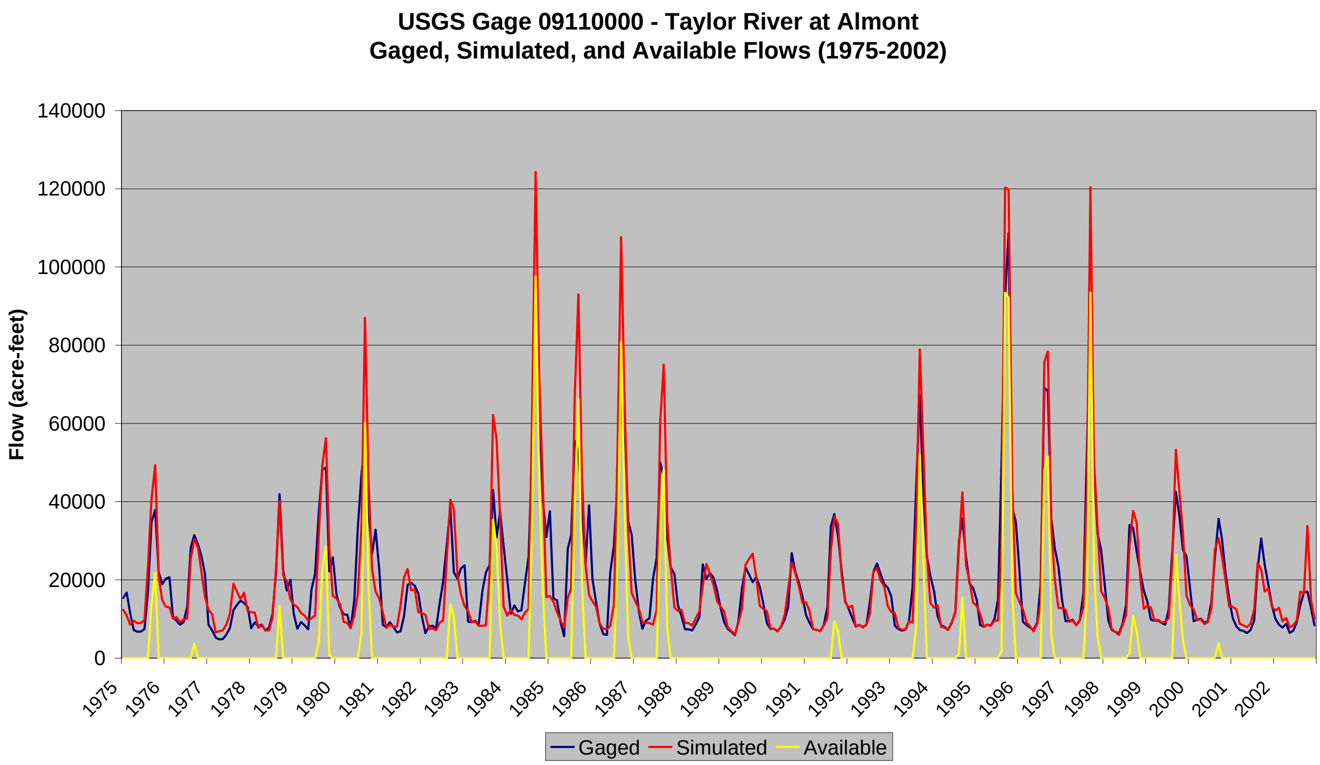
Baseline flows are generally higher than historical flows during the irrigation season on tributaries with significant storage and on the mainstem. This is, in part, due to increased reservoir releases required to meet the higher Baseline demands. In addition, all of the reservoirs included in the Gunnison model came on-line during the simulation period, and most of them came on-line since the 1960s. Their ability to re-regulate natural flow and provide supplemental water during the late irrigation season is not represented in the historical record for much of the study period, therefore not fully represented in the 1909 through 2002 graphs.

On the Gunnison River below Blue Mesa Reservoir, average monthly available flows exceed historical gaged flows during the irrigation season. This flow represents return flows as a result of increased use of storage water to meet Baseline demands. These increased return flows are available for downstream use.

Table 6.1
Simulated and Available Baseline Average Annual Flows for Gunnison Model Gages (1909-2002)

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
9109000	Taylor River Below Taylor Park Reservoir	150,890	45,504
9110000	Taylor River at Almont	242,587	53,629
9110500	East River Near Crested Butte	105,745	75,092
9111500	Slate River Near Crested Butte	99,256	70,564
9112000	Cement Creek Near Crested Butte	26,002	13,897
9112200	East River Below Cement Creek NR Crested Butte	234,582	165,686
9112500	East River at Almont	239,016	176,297
9113300	Ohio Creek at Baldwin	42,448	26,337
9113500	Ohio Creek Near Baldwin	60,293	39,187
9114500	Gunnison River Near Gunnison	524,557	371,684
9115500	Tomichi Creek at Sargents	45,703	17,800
9118000	Quartz Creek Near Ohio City	40,852	22,463
9118450	Cochetopa Creek Below Rock Creek Near Parlin	26,751	13,254
9119000	Tomichi Creek at Gunnison	129,840	99,473
9121500	Cebolla Creek Near Lake City	11,379	8,610
9121800	Cebolla Creek Near Powderhorn	49,836	29,608
9122000	Cebolla Creek at Powderhorn	70,865	46,140
9124500	Lake Fork at Gateview	174,916	127,238
9126000	Cimarron River Near Cimarron	70,024	30,125
9126500	Cimarron River at Cimarron	84,006	68,655
9127500	Crystal Creek Near Maher	24,252	3,529
9128000	Gunnison River Below Gunnison Tunnel	860,662	640,589
9128500	Smith Fork Near Crawford	32,862	11,837
9129600	Smith Fork Near Lazear	21,244	21,111
9130500	East Muddy Creek Near Bardine	63,807	58,555
9131200	West Muddy Creek Near Somerset	19,553	18,328
9132500	North Fork Gunnison River Near Somerset	337,940	276,034
9134000	Minnesota Creek Near Paonia	17,255	6,387
9134050	Minnesota Creek at Paonia	8,269	7,774
9134500	Leroux Creek Near Cedaredge	37,222	13,386

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
9135900	Leroux Creek at Hotchkiss	19,551	19,455
9136200	Gunnison River Near Lazear	1,242,578	1,139,331
9137050	Currant Creek Near Read	8,656	8,618
9137800	Dirty George Creek Near Grand Mesa	5,544	1,059
9139200	Ward Creek Near Grand Mesa	8,892	5,045
9141500	Youngs Creek Near Cedaredge	2,314	1,610
9143000	Surface Creek Near Cedaredge	31,619	4,737
9143500	Surface Creek at Cedaredge	22,160	4,743
9144200	Tongue Creek at Cory	35,645	35,302
9144250	Gunnison River at Delta	1,414,524	1,260,567
9146200	East Fork Dallas Creek Near Ridgway	123,239	72,972
9146400	Dallas Creek Near Ridgway	9,962	4,675
9146500	Beaver Creek Near Ridgway	19,106	8,400
9146550	West Fork Dallas Creek Near Ridgway	2,933	1,319
9147000	Uncompahgre River Near Ridgway	28,110	18,648
9147100	Cow Creek Near Ridgway	47,547	34,715
9147500	Uncompahgre River at Colona	193,374	88,053
9149420	Spring Creek Near Montrose	41,462	32,689
9149500	Uncompahgre River at Delta	211,078	207,178
9150500	Roubideau Creek at Mouth, Near Delta	94,256	93,399
9152000	Kannah Creek Near Whitewater	21,846	11,527
9152500	Gunnison River Near Grand Junction	1,854,782	1,382,776



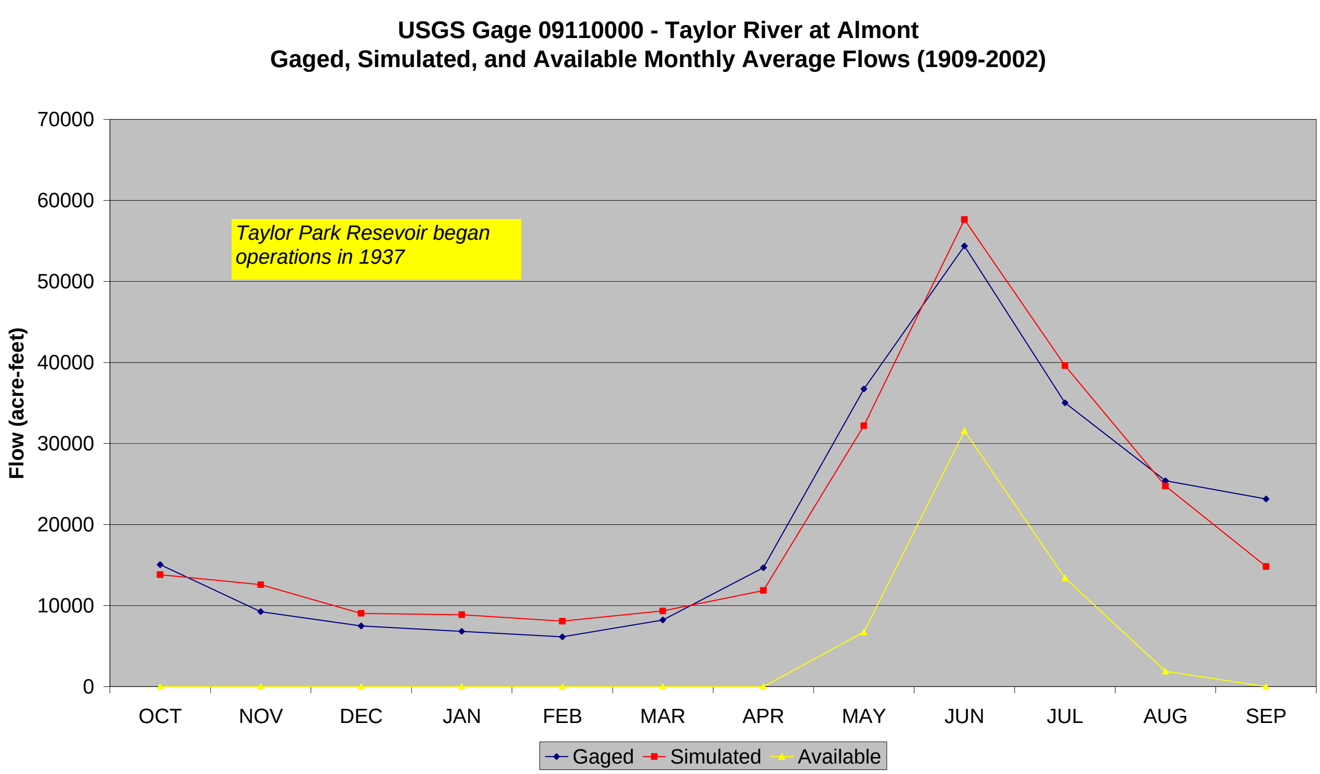
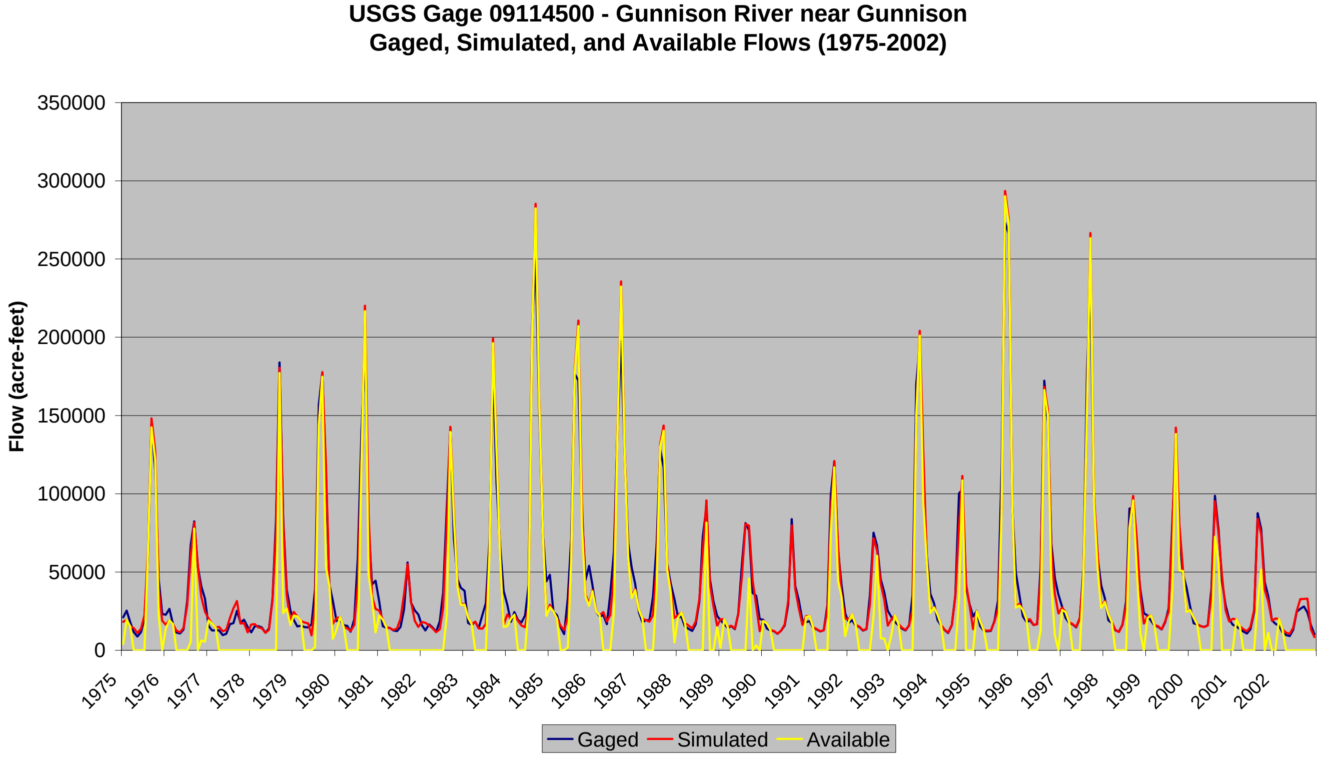


Figure 6.1 Baseline Results – Taylor River at Almont



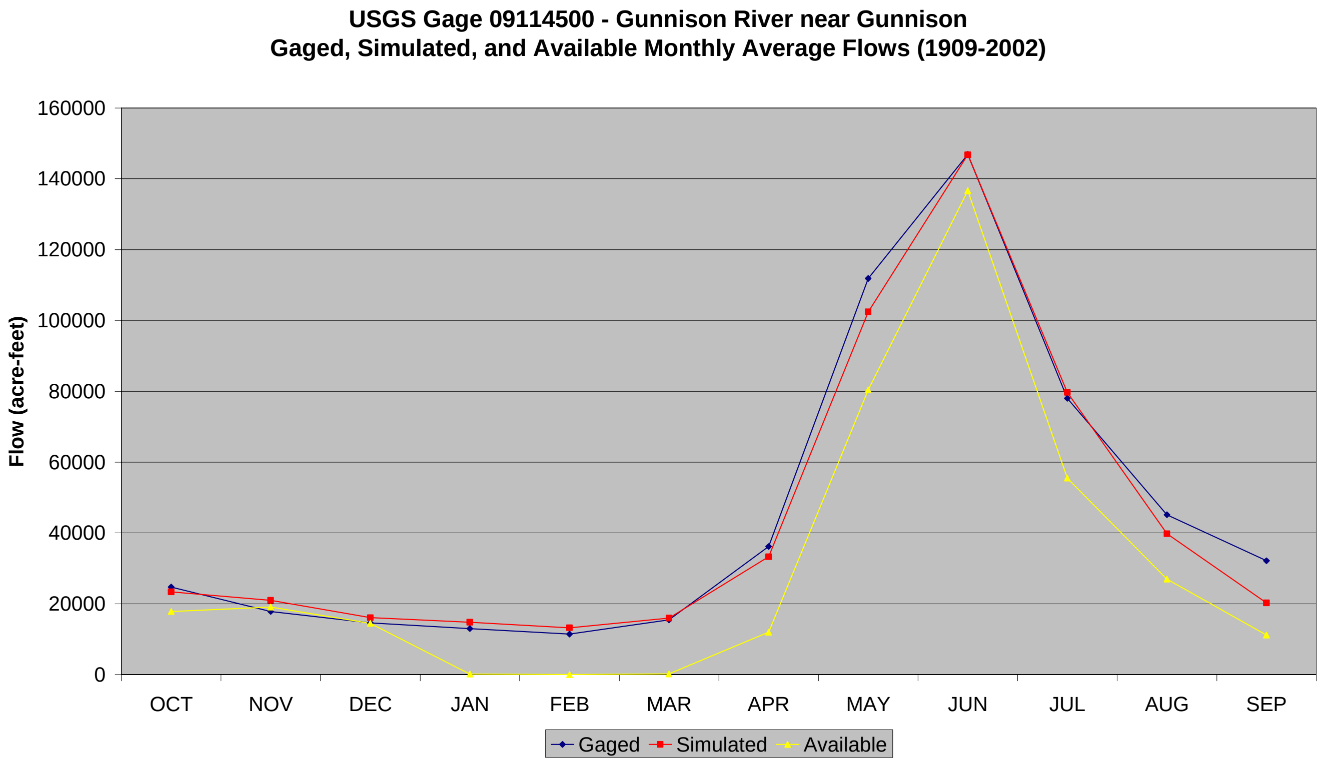
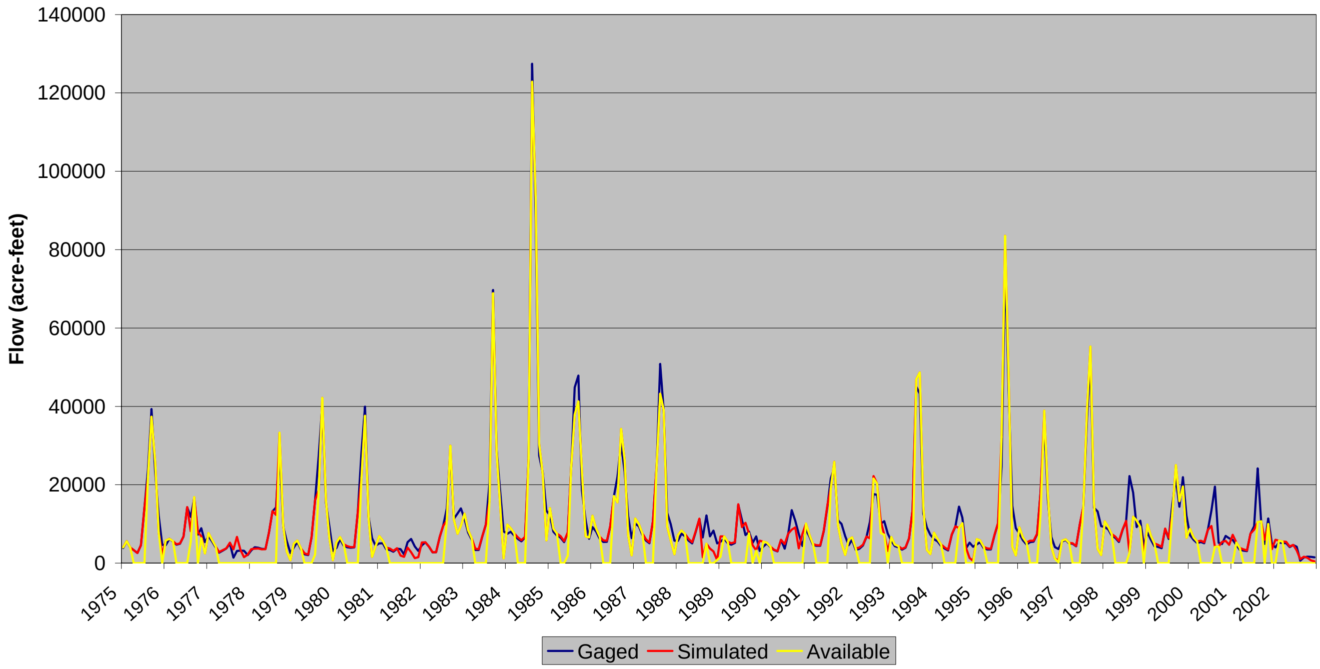


Figure 6.2 Baseline Results – Gunnison River near Gunnison

USGS Gage 09119000 - Tomichi Creek at Gunnison
Gaged, Simulated, and Available Flows (1975-2002)



USGS Gage 09119000 - Tomichi Creek at Gunnison
Gaged, Simulated, and Available Monthly Average Flows (1909-2002)

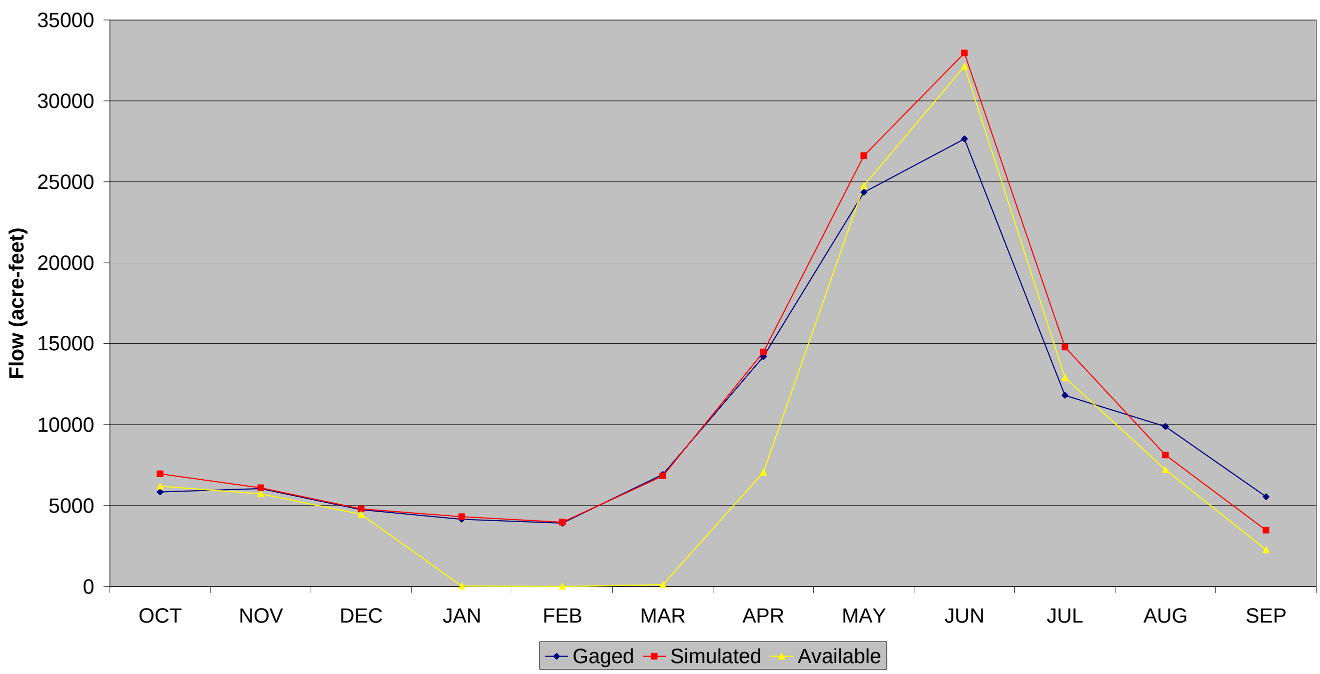
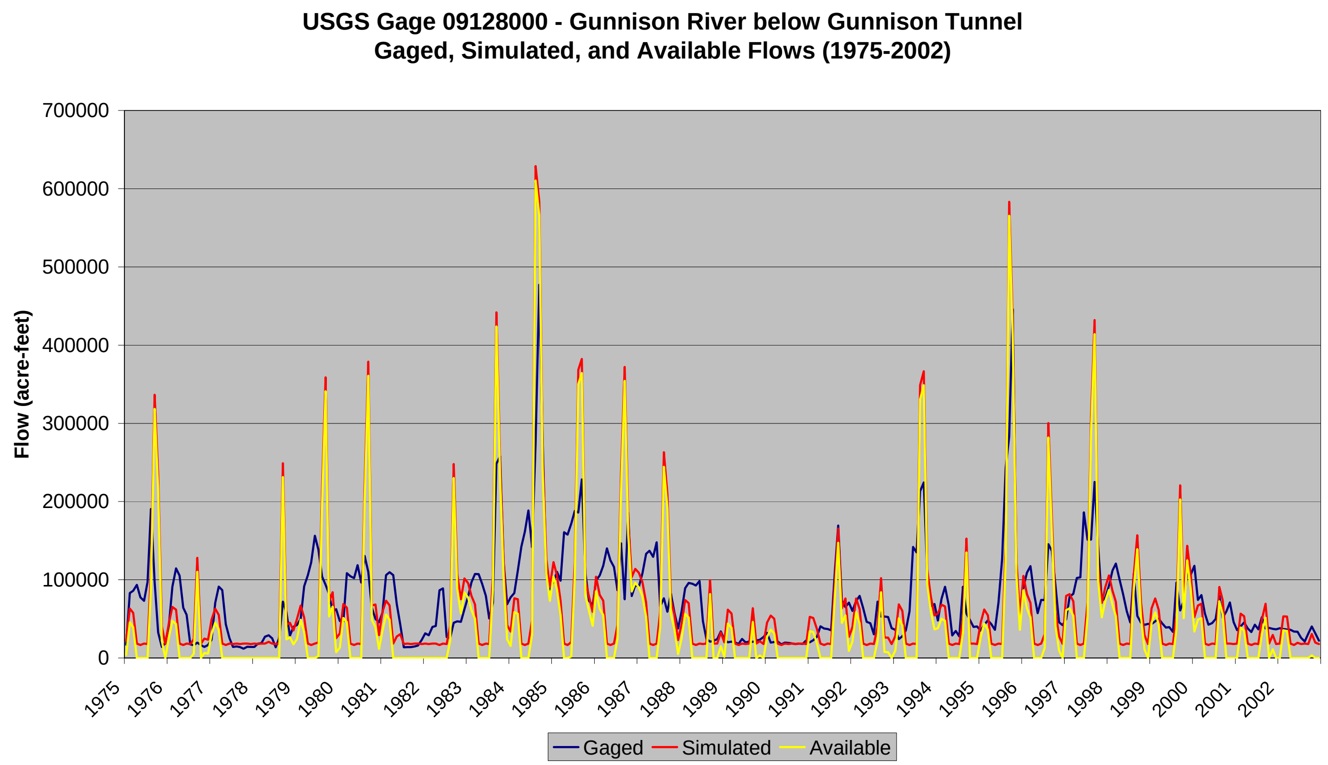


Figure 6.3 Baseline Results – Tomichi Creek at Gunnison



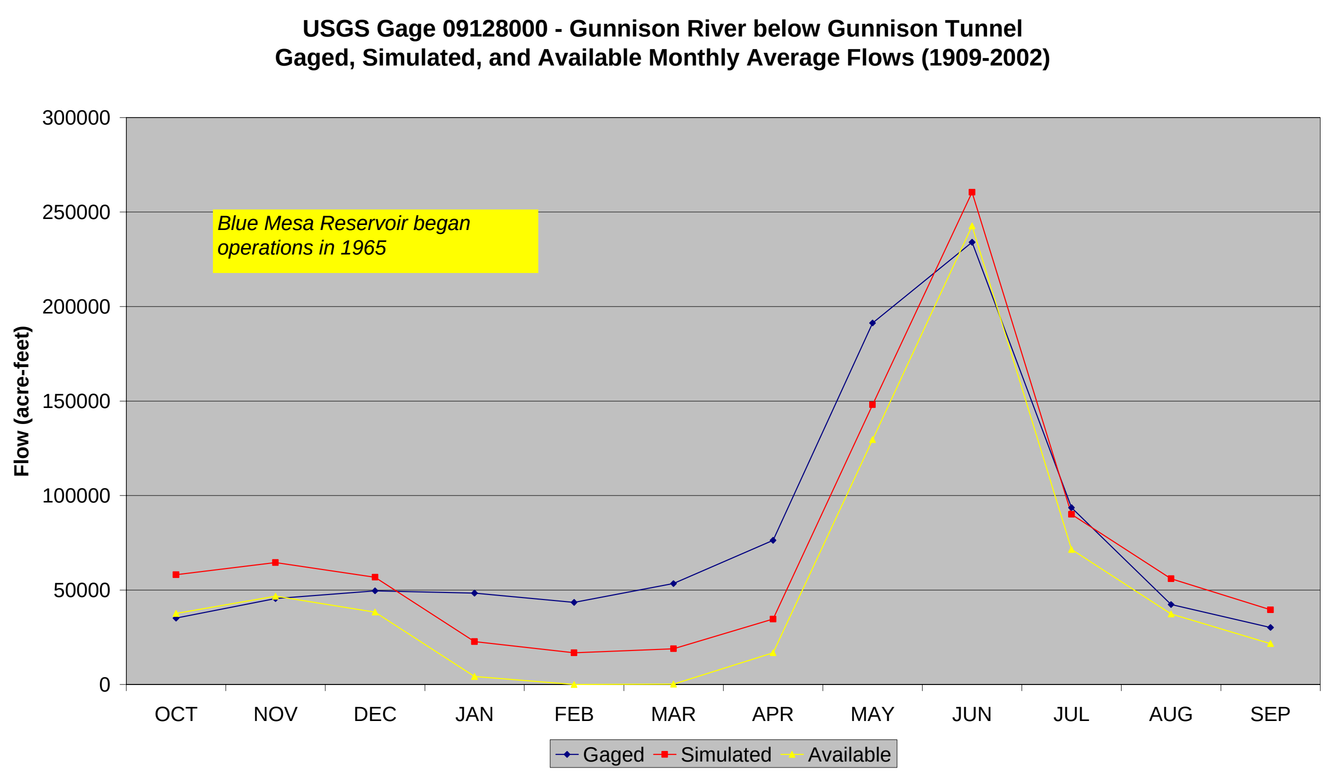
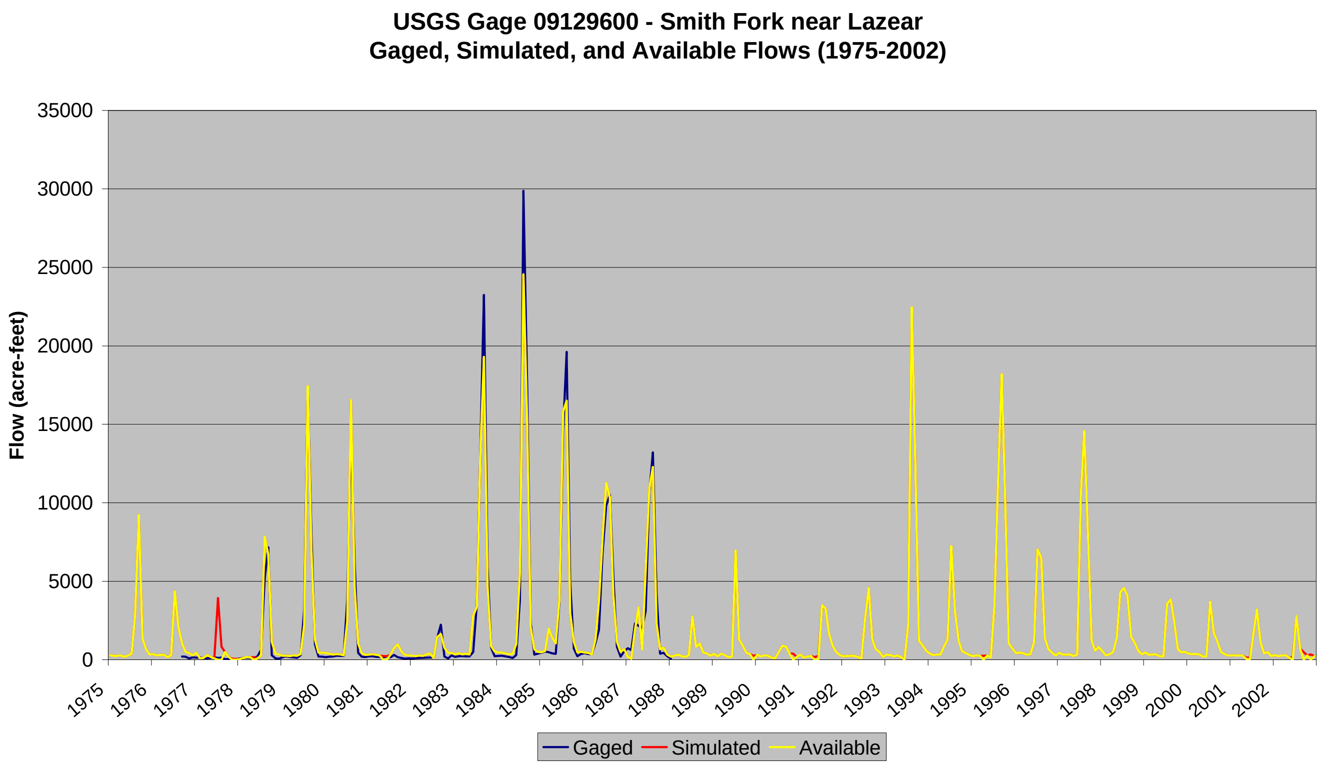


Figure 6.4 Baseline Results – Gunnison River below Gunnison Tunnel



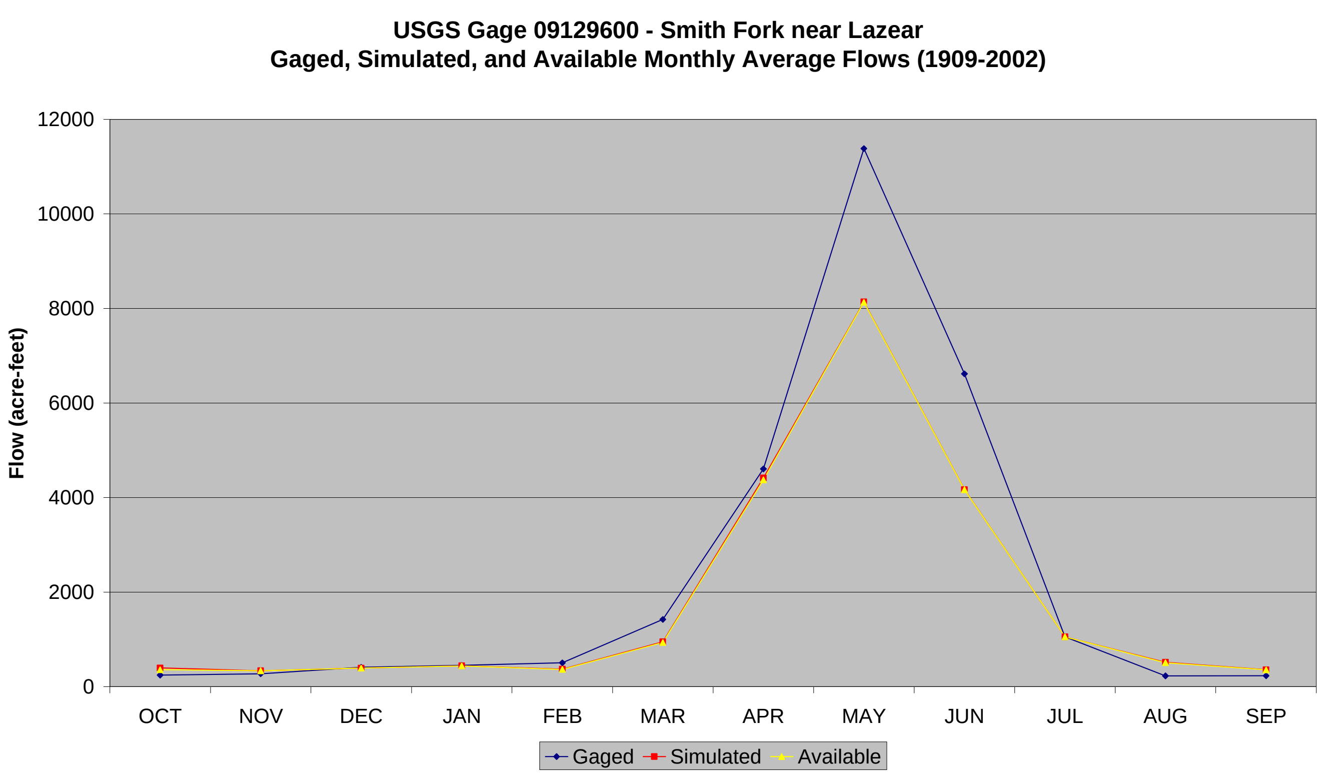
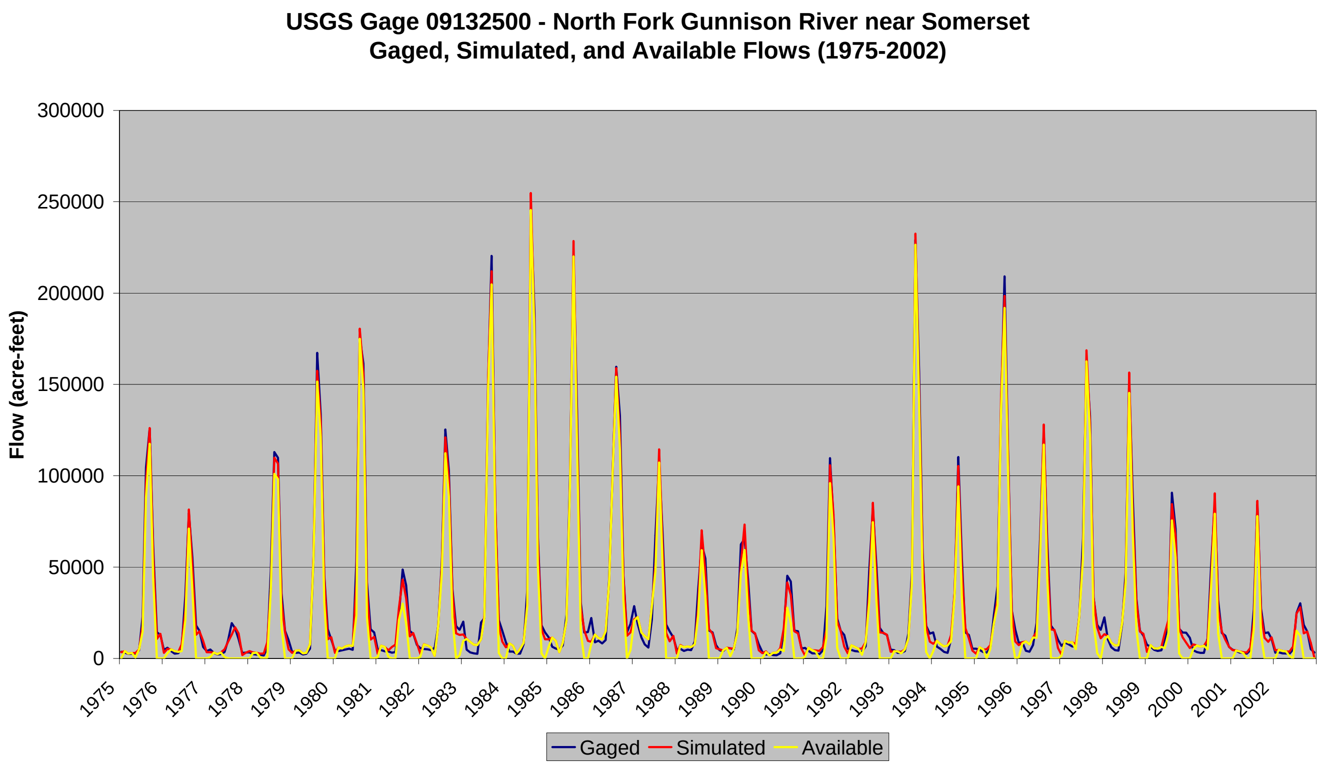


Figure 6.5 Baseline Results – Smith Fork near Lazear



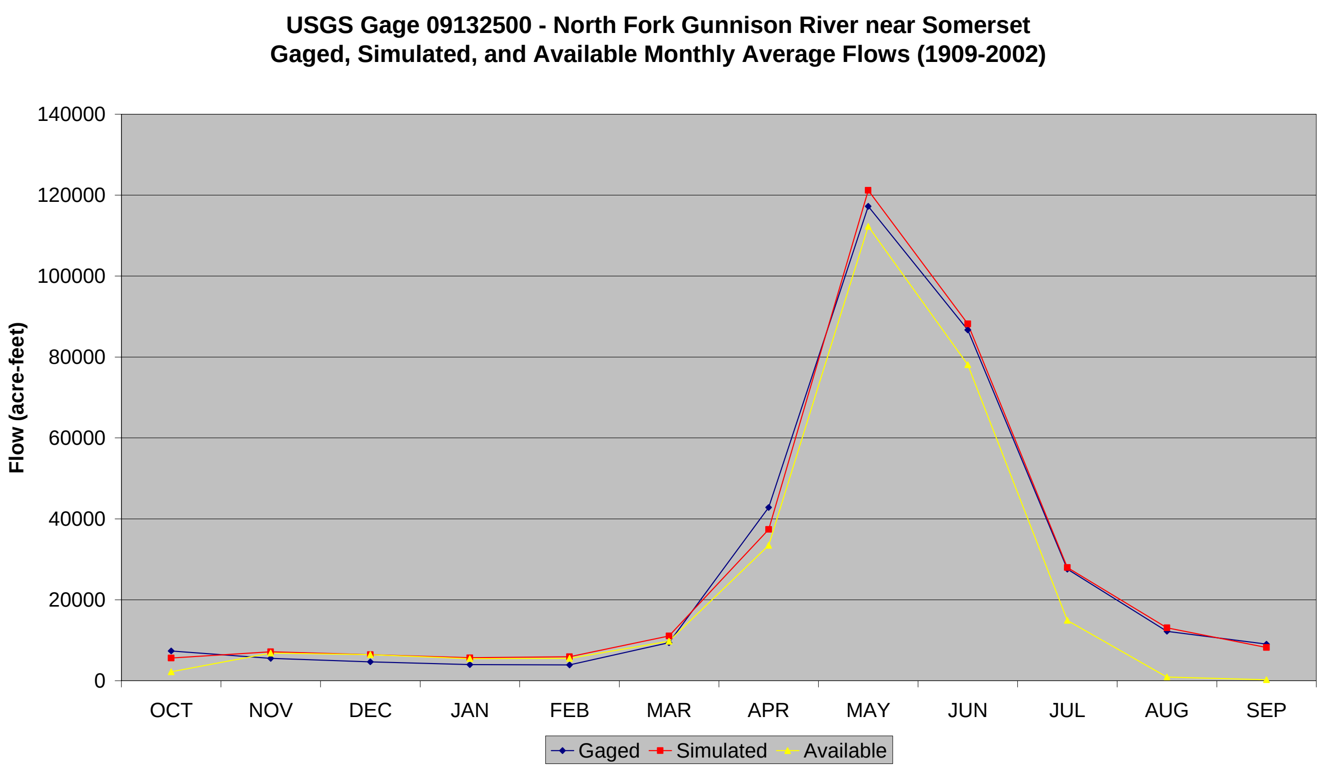
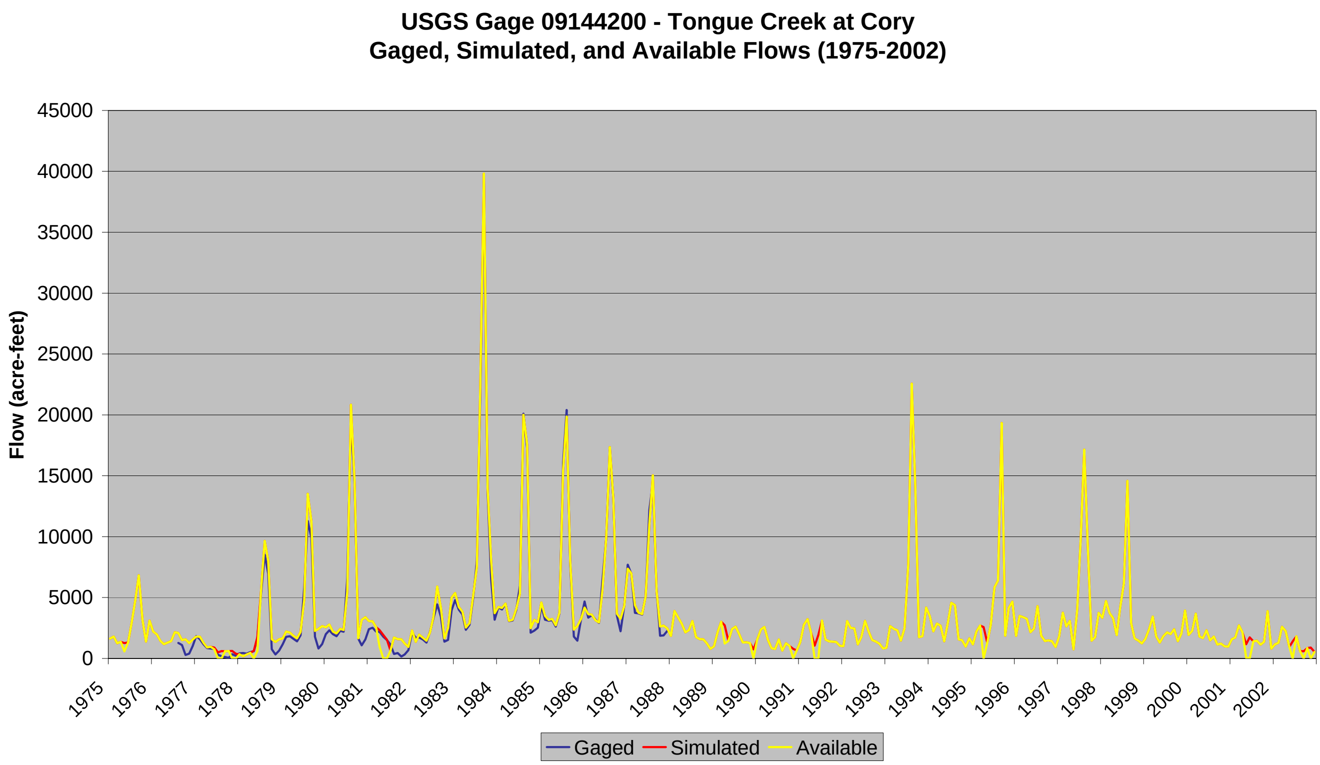


Figure 6.6 Baseline Results – North Fork Gunnison River near Somerset



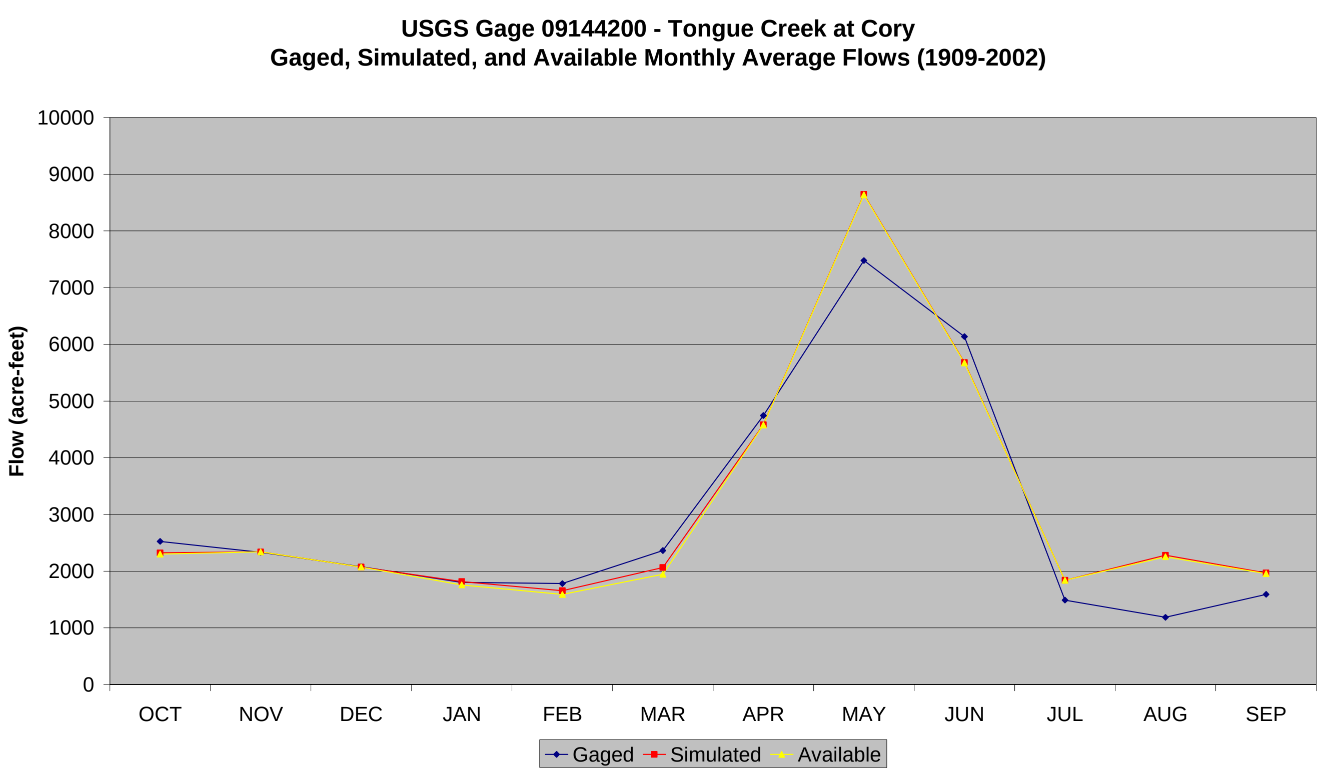
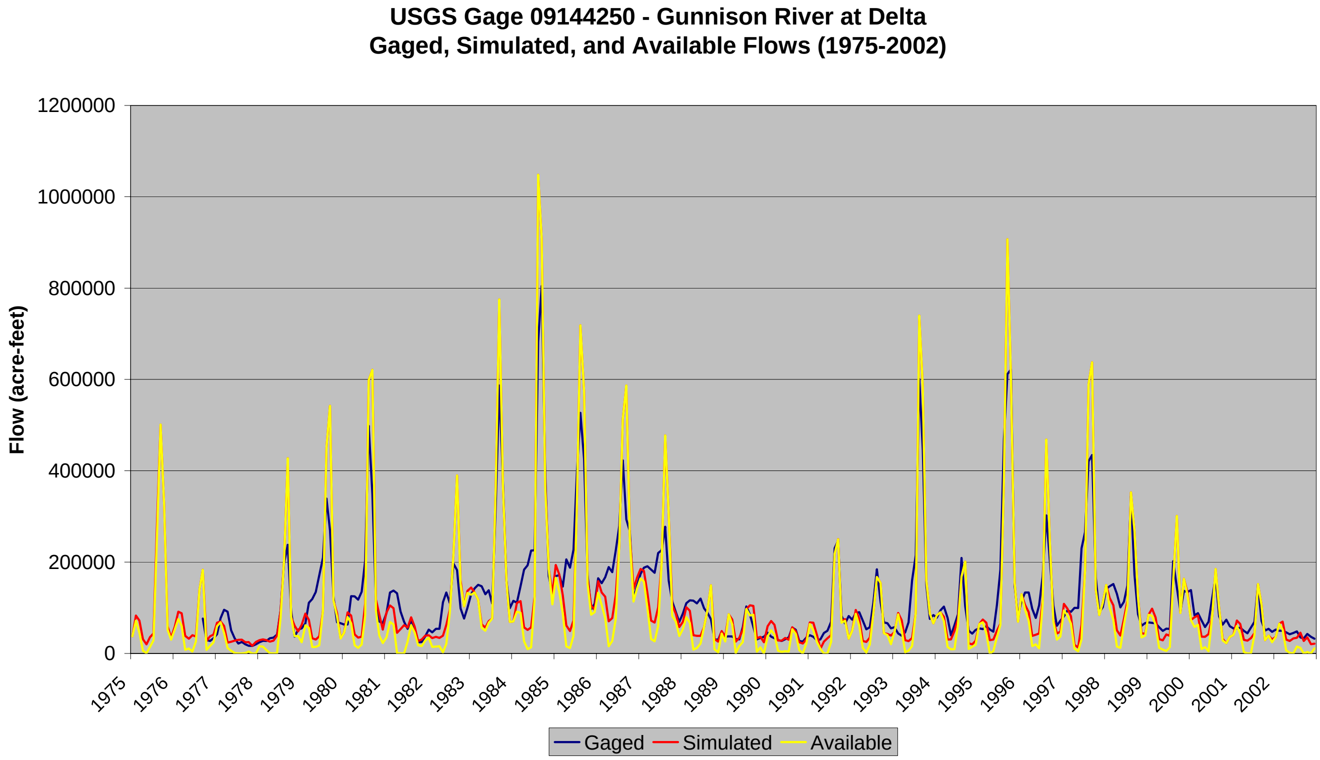


Figure 6.7 Baseline Results – Tongue Creek at Cory



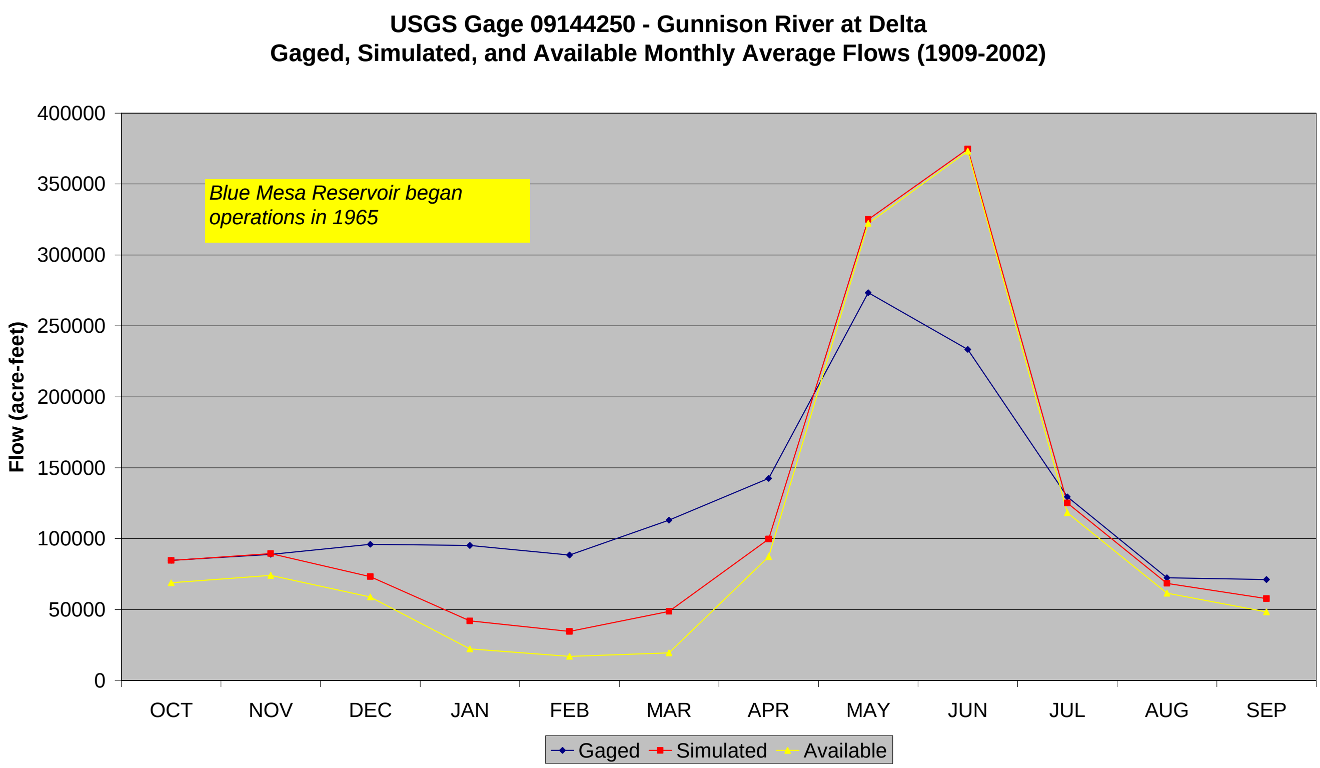
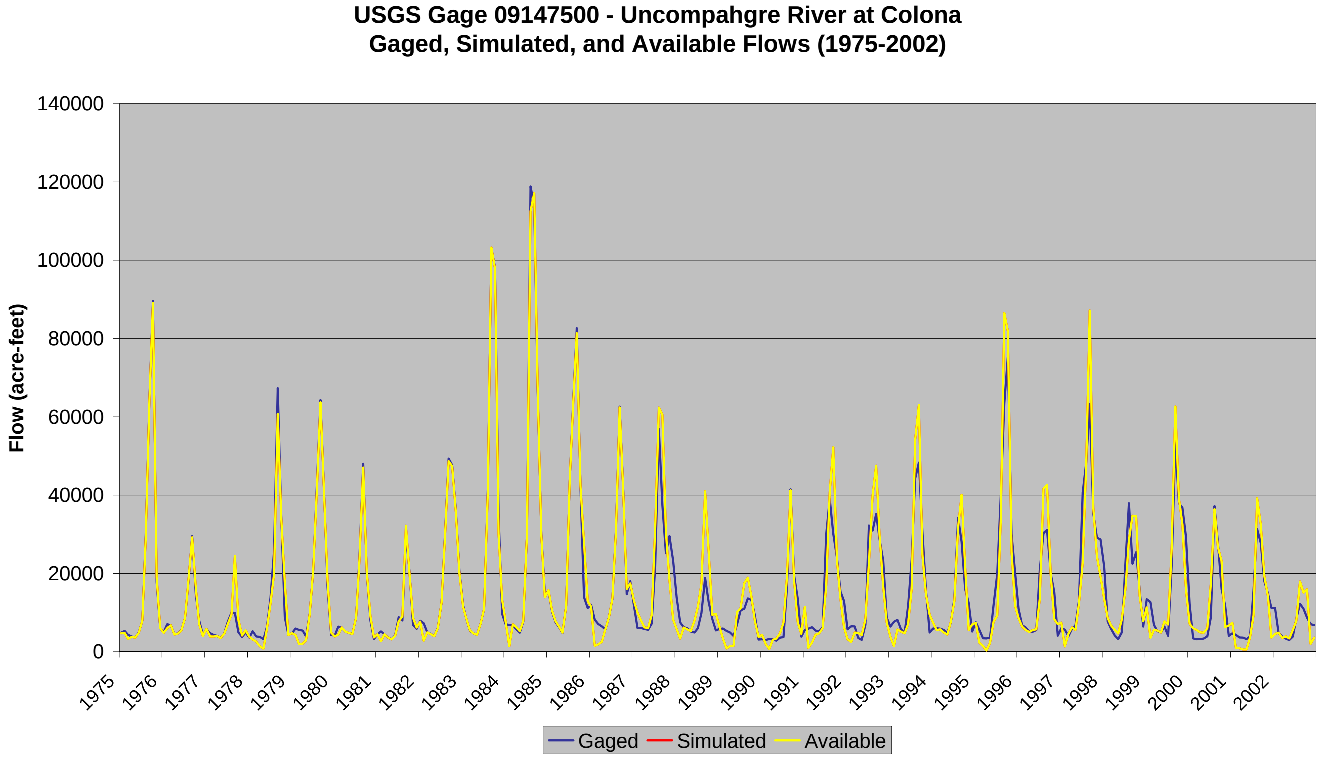


Figure 6.8 Baseline Results – Gunnison River at Delta



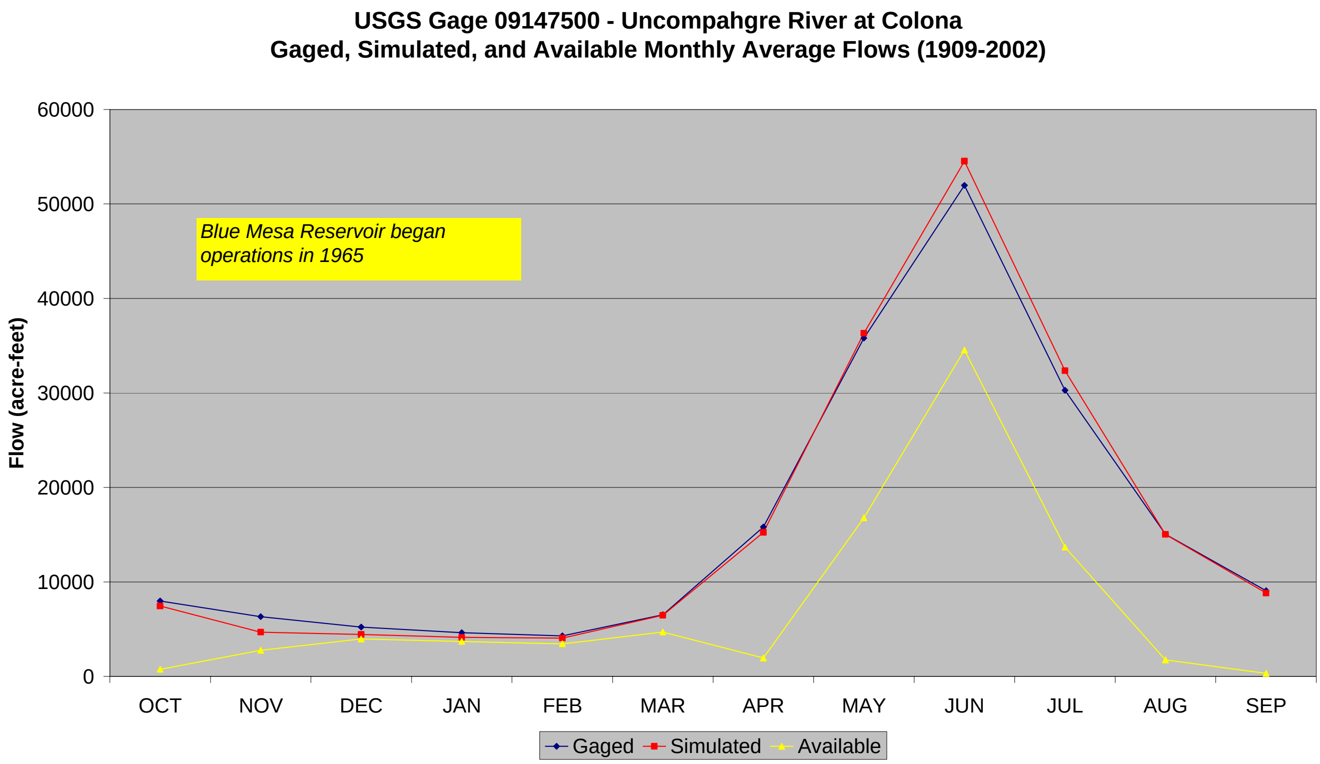
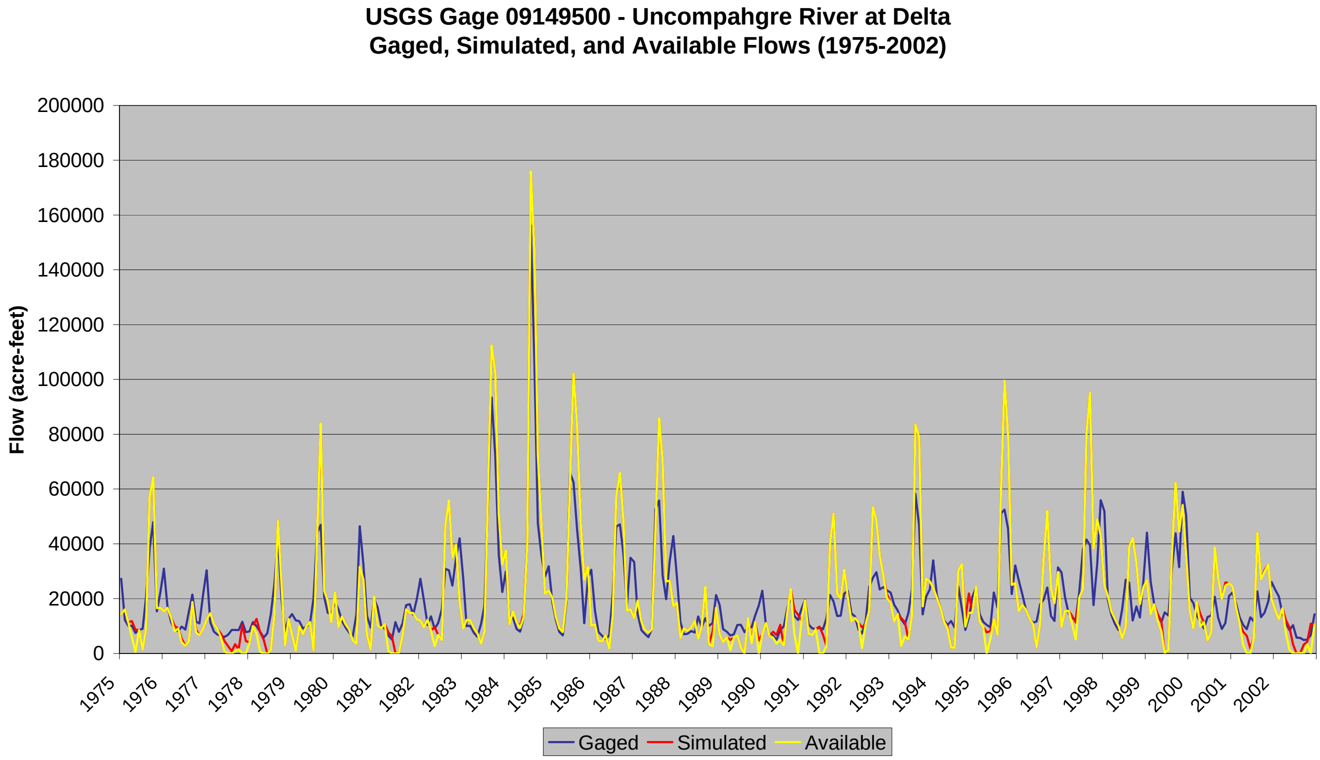


Figure 6.9 Baseline Results – Uncompahgre River at Colona



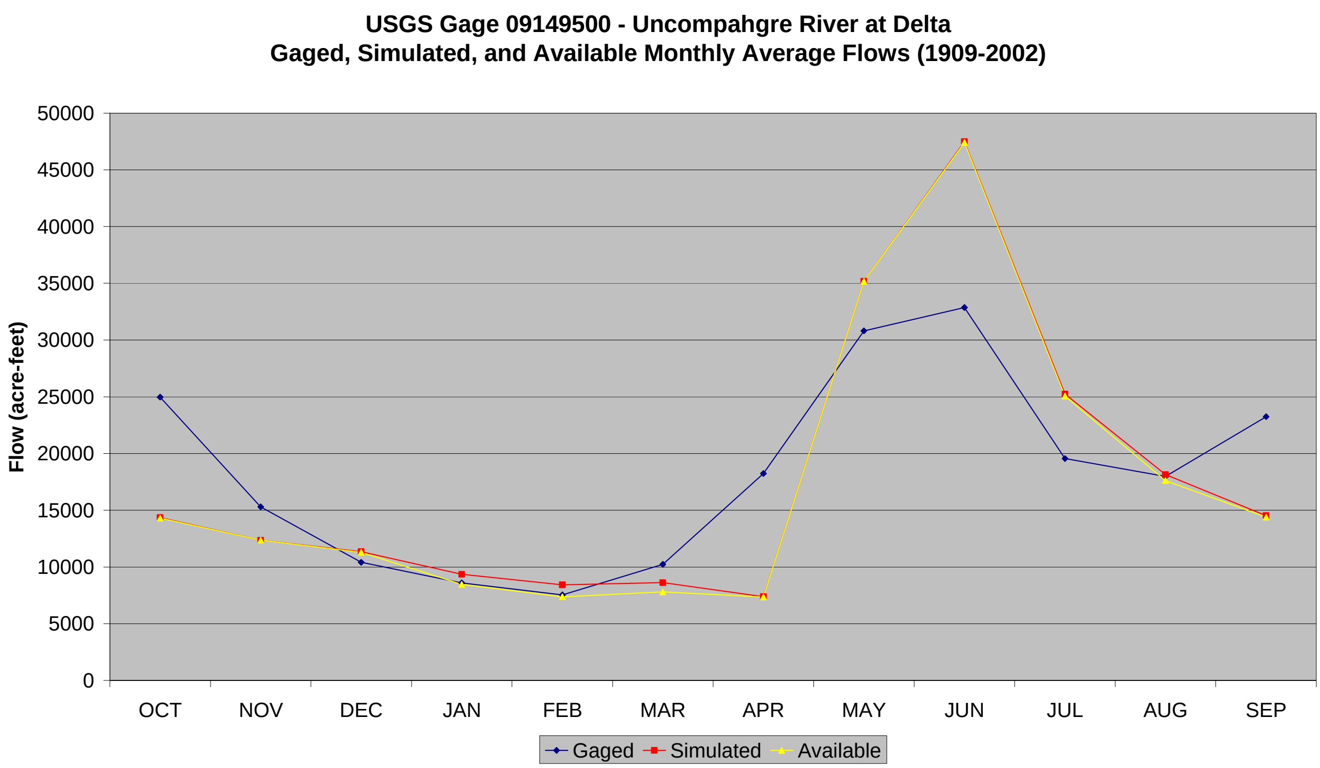
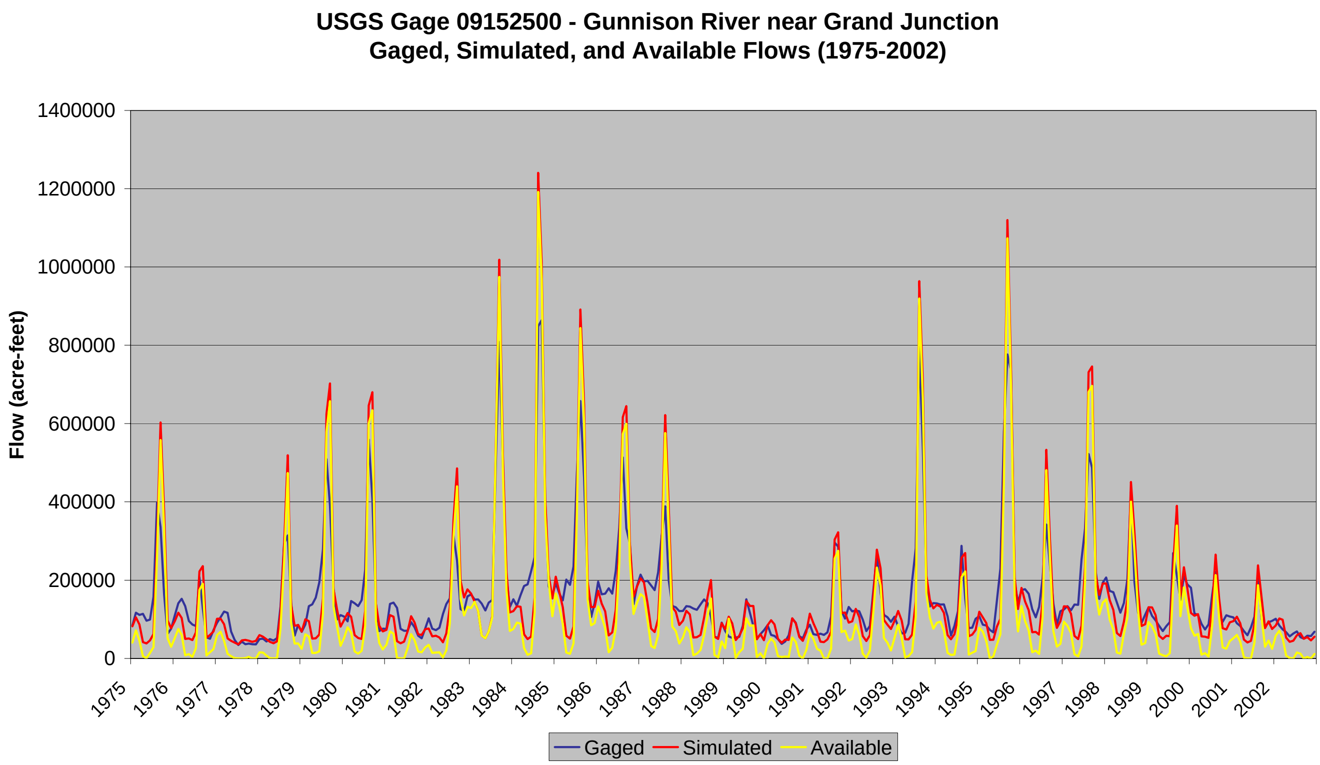


Figure 6.10 Baseline Results – Uncompahgre River at Delta



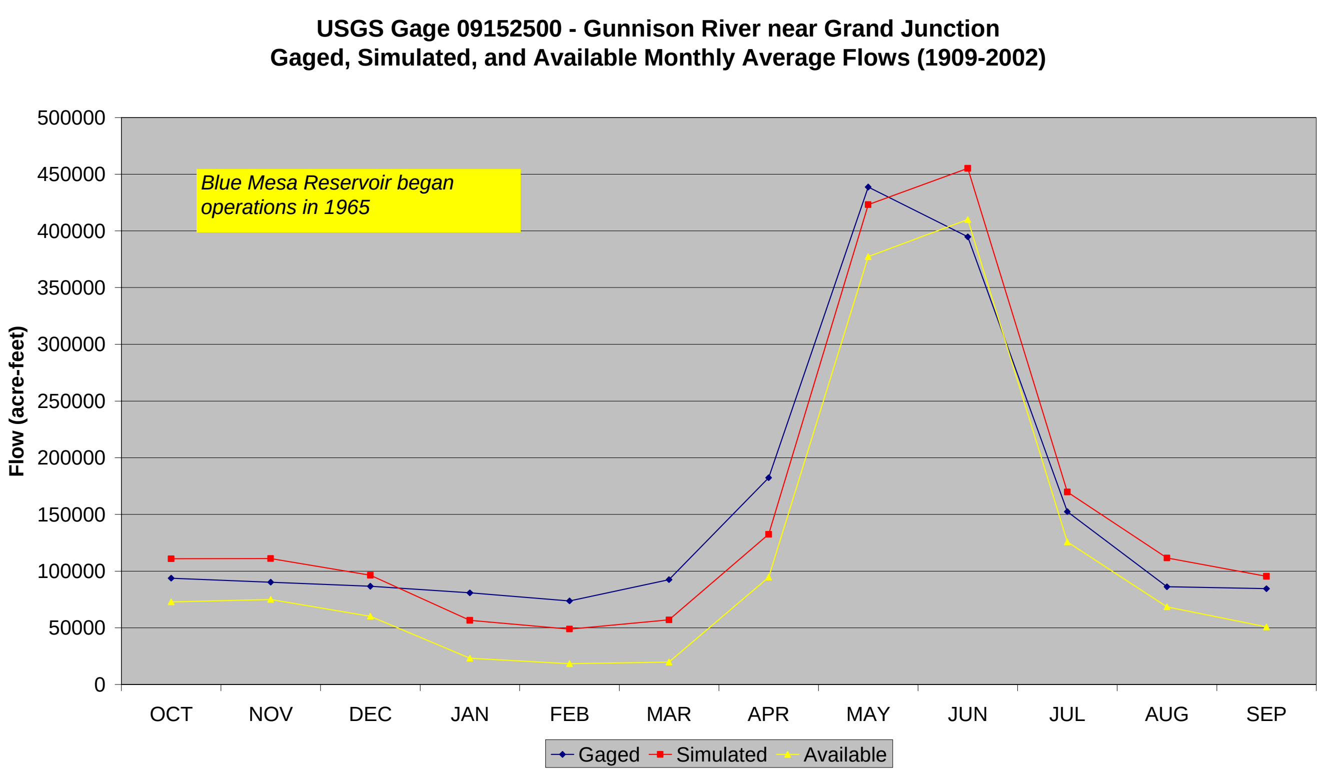


Figure 6.11 Baseline Results – Gunnison River near Grand Junction

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 Gunnison model. It describes specific areas of the basin that were worked on, and it presents summaries comparing modeled results for 1975 through 2002 with historical values for the period.

7.1 Calibration Process

The Gunnison model was calibrated in a two-step process, based on the period 1975 through 2002. 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 in general, 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 occured. For example, a shortage might occur because a user's water right is 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 occur in the system until the next downstream gage, bypassing the shorted structures. Because the historical diversion and consumption do not occur in the model, the model then overestimates flow at the downstream gage. Baseflow distribution parameters must be adjusted such that more water enters the system within the tributary, and typically, incremental inflow below the tributary is 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, operations were generalized. Reservoirs responded to demands, and were permitted to seek the level required to meet the demands. Model results were again scrutinized, this time focusing on the operations. For example, operating criteria in the form of monthly targets might be added for reservoirs that operate for unmodeled 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.

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 the historical record. This data set is referred to as the "Historical data set", and it is helpful to understand how it differs from the Baseline data set described in Section 5.

7.2.1. 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 multi-structures and carrier structure diversions were placed at the point of diversion. These include the Gunnison Tunnel (620617), the Cimarron Canal (620560), the multi-structure system of Aspen Canal (400509), and Needle Rock Ditch (400501), and the multi-structure system of Aspen Ditch (400508) and Grandview Canal (400503). In the Baseline data set, these demands were placed at the destination node, and operating rules drove the diversion from the individual headgates.

7.2.2. Direct Diversion Right File

The South and West Canals obtain their water directly from the Gunnison Tunnel and do not have water rights decreed from the Uncompahgre River. Both structures are included in the model network as diversions on the Uncompahgre River. For the historical simulation for calibration, water is delivered from the Gunnison Tunnel (620617) to the Uncompahgre River as an import to the system. To enable the modeled South and West Canals to benefit from modeled Tunnel deliveries, they are assigned 999 cfs direct flow rights with an administration number just junior to the Tunnel. These two direct flow rights are turned off in the Baseline data set, because they are supplied via operating rules that deliver Gunnison Tunnel water, either under the Tunnel's direct flow rights or from storage in Blue Mesa and Taylor Park Reservoirs. In the Historical calibration, these rights are turned on.

As noted above, for the historical simulation for calibration, water is delivered from the Gunnison Tunnel (620617) to the Uncompahgre River as an import to the system. Therefore, the UVWUA's good neighbor policy is represented by historical diversions through the tunnel. All water rights assigned to the UVWUA ditches are active in the Historical data set.

7.2.3. Reservoir Station File and Reservoir Target File

In the Historical data set, reservoirs are inactive prior to onset of their historical operations. Initial contents in the reservoir file (*.res) are set to zero (as they were historically in 1909), and storage targets (*.tar file) are set to zero until the reservoir actually began to fill. In the first calibration step, storage targets assume the value of the historical end-of-month contents, but in the second calibration step, storage targets are set to the reservoir's capacity as soon as the reservoir comes on-line. Exceptions were made for reservoirs known to operate by power or flood control curves, and regulating reservoirs. In these cases, which include Taylor Park, Blue Mesa, and Paonia reservoirs, targets were developed to express the operations. Targets were set to historical end-of-month contents for Morrow Point and Crystal Reservoirs; both operate essentially as regulating reservoirs for Aspinall Unit power generation. In addition, as discussed below in Section 7.3.5, Ridgway Reservoir targets were also set to historical end-of-month. If capacity of a reservoir changed midway through the study period, the Historical model takes the enlargement into account (not applicable in the Gunnison model.)

7.2.4. Operational Rights File

The reservoir storage targets and the operating rules (the *.opr file) work together to constrain reservoir operations in the first calibration step. The operational rights include rules to release water that remains in the reservoir above historical levels (specified in the target file), after all 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 are set to capacity. The exceptions are noted above in Section 7.2.2. In the initial calibration run, when water is released to a downstream 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 have been satisfied. In the second step calibration, enough water is relased to meet the historical diverted amount only if there is deficit crop irrigation water requirement. Section 5.8 describes each operating rule used in the Baseline and Historical calibration simulations.

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

Table 7.1
Comparison of Baseline and Historical (Calibration) Files

Input File	Baseline Data Set	Historical Data Set
Demand (*.ddm)	▪ Irrigation structures – “Calculated” demand for full supply, based on historical efficiency ▪ Non-irrigation structures – estimated current demand ▪ Demands placed on primary structures of multi-structure systems and demands placed at carrier structure headgates	▪ Historical diversions ▪ Historical diversions for multi-structures and carrier structures are set to historical diversions
Direct Rights (*.ddr)	▪ Uncompahgre Valley Water Users Association Junior Rights are turned off	▪ Uncompahgre Valley Water Users Association Junior Rights are turned on and direct diversion water rights are set for South and West Canals
Reservoir station (*.res)	▪ Initial content = average September end-of month content	▪ Initial content = 0.
Reservoir target (*.tar)	▪ Current maximum capacity except reservoirs that release for flood control or power generation	▪ First step – historical eom contents, 0 prior to historical operation ▪ Second step – historical maximum capacity, 0 prior to historical operation except Taylor Park, Blue Mesa, Paonia, and Ridgway as discussed above
Operational right (*.opr)	▪ Operating rules drive diversions to demand destination through multi-structure and carrier structures ▪ Reservoir releases are made to irrigation structures to satisfy headgate demands only if crop irrigation water requirements have not been met by other sources.	▪ Release-to-target operations allow reservoirs to release to target contents ▪ Step 1 calibration, reservoir releases are made to irrigation structures to satisfy headgate demands regardless if crop irrigation water requirements have been met.

7.3 Calibration Issues

This section describes areas of the model that have been investigated in the various calibrations of the Gunnison model.

7.3.1. Aggregated Structures

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 revised by Division 4 after the initial modeling efforts were completed. The revisions concentrated on correcting assignments of irrigated lands to the supplying ditch on the mainstem Gunnison and tributaries above the Aspinall Reservoirs. As a result of these revisions, new key structures were added to the model, and the aggregate structures were revised to represent the corrected acreage to supply associations. These efforts greatly helped to reduce shortages to aggregate structures in the upper basin.

7.3.2. Uncompahgre River Return Flows

In the first execution of the model in baseflow mode, the baseflow reach of the Uncompahgre River between the Delta gage and the Colona gage appeared to lose close to 100,000 af on an average annual basis. This value represented approximately 35 percent of the baseflow at the Delta gage. Furthermore, there were many negative baseflow estimates, which the model sets to zero. In the historical calibration simulation, the Uncompahgre River at Delta gage was high because when negative baseflows are set to zero, the total amount of water in the system is not conserved.

USGS topo quad maps were reviewed and return flow locations for the Uncompahgre Project ditches were re-examined. The maps indicated that a greater proportion of the ditches' returns might reach Roubideau Creek or the Gunnison River directly, rather than re-enter the Uncompahgre River. Modeled return flow locations were modified accordingly. In addition, discrepancies were found in the 1993 Irrigated Acreage Coverage, used in the modeling efforts to determine acreage, crop type, and corresponding crop irrigation water requirements. Approximately 10,000 acres of land in the Uncompahgre Valley were identified as irrigated, but had not been assigned to an irrigation structure. Based on review of the GIS coverage and conversations with Division 4, most of these lands were assigned to the Ironstone Canal.

Simulation of the Uncompahgre River at Delta gage, and both the gage and diversions on Roubideau Creek were greatly improved by these modifications. Historical simulation results in the Uncompahgre River at Delta gage are within 4 percent on average of historical gaged flows.

7.3.3. Tomichi Creek Basin

Many of the diversions on upper Tomichi Creek and its tributary, Cochetopa Creek, were shorted by more than 15 percent of their demand in the historical data simulation. The basin-wide shortage for diversions on Tomichi Creek and its tributaries was 9 percent of demand.

Original work to aggregate irrigation structures placed an aggregate of 1,084 acres (28_ADG009) on Upper Tomichi Creek, and one of 1,855 acres (28_ADG011) on Cochetopa Creek. Flows were estimated for USGS gage 09117000 Tomichi Creek at Parlin, because there were no historical records available during the study period. The section above this gage was particularly water short. Thirteen structures originally aggregated in 28_ADG009, and seven structures originally aggregated in 28_ADG011, were removed from their respective aggregations and modeled explicitly. The simulation improved because (formerly aggregated) explicit structures were able to benefit from return flows from other (formerly aggregated) explicit structures. The filled USGS gage 09117000 was simply removed from the model. Node 28_ADG009 was made a baseflow node, and given the area and precipitation values originally assigned to gage 09117000.

The diversions on Hot Springs continued to be shorted more than on other Tomichi Creek tributaries. The method for determining baseflow to Hot Springs was revised from the "gain" approach to the "neighboring gage" approach.

Shortages on Tomichi Creek were greatly reduced. Although many diverters in this sub-basin are still shorted in the Historical simulation, shortages are small in magnitude. The basin-wide shortage has been reduced from 9 percent of demand to 3 percent of demand

7.3.4. Surface and Currant Creeks

Surface and Currant Creeks are related because many of the Surface Creek diversions return to Currant Creek. In addition, Fruitgrowers Reservoir, an offstream reservoir, is filled from Alfalfa Ditch on Surface Creek, and the Transfer Ditch on Current Creek. The model did not simulate historical conditions well on either tributary in the preliminary runs. Many structures were shorted, and the tributary gages were overestimated.

Several different kinds of adjustments were made in these basins. The standard approach of making aggregate nodes above a gage into baseflow nodes was invoked. Return flows from Surface Creek to Currant Creek (as well as Alfalfa Run) were adjusted many times, always considering topography per USGS quad maps. The aggregated node 40_ADG031 on the mainstem was moved upstream, from below Tongue Creek to above Currant Creek. This step was taken because 40_ADG031 was calling out diverters on Tongue Creek, Surface Creek, and Current Creek. The aggregation area terminates above gage 09144250 Gunnison River at Delta, and the standard approach is to place the aggregated node at the downstream end of the aggregation area. In this case, however, nearly all the land lies above Currant Creek, and 40_ADG031 was calling out structures in the model that its component structures cannot actually call out.

Surface Creek and Currant Creek are better represented in the model, but both still experience basin-wide shortages of 7 and 8 percent respectively. Because they are relatively small tributaries in the basin, additional calibration efforts were not warranted. Remaining shortages may be attributable to several factors as follows:

- diverters in the Tongue and Surface Creek basins are known to use small reservoirs on the south end of the Grand Mesa, and enjoy a neighborly trade-and-share approach to water management; facilities apparently exist to move water around, and diversion records may not reflect actual operations.

- data for the gage at the bottom of Tongue Creek and the gage at the bottom of Currant Creek had to be estimated from 1988 through 2002. Simulation is worse in these years than in the years when the gages were operating.

7.3.5. Calibration Reservoir Targets

In step 1 of calibration, EOM targets for all reservoirs were set to historical contents. In step 2, the standard approach for reservoirs that are supplemental irrigation or municipal supply is to set their targets to reservoir capacity. Reservoirs falling into this category are:

- Fruitgrowers Reservoir
- Fruitland Reservoir
- Overland Reservoir
- Crawford Reservoir
- Silverjack Reservoir
- Cerro Reservoir
- Fairview Reservoir

Reservoirs that operate to provide flood control (storage capacity for spring runoff), or for hydropower generation, are operated using StateMod's forecast feature, based on rules provided by the USBR. These reservoirs include Paonia and Blue Mesa. Although Taylor Park Reservoir provides an irrigation supply, the USBR also operates the reservoir on a pre-set schedule; therefore, the forecasting feature is used based on operating curves provided.

The following concerns were noted during initial calibration efforts:

- The Blue Mesa target worked well from 1975 through 1988, but did not seem to reflect historical practices after that year. Furthermore, when modeled Blue Mesa releases are not realistic, the impact to the downstream gages is very evident, because of the size of Blue Mesa.

- Morrow Point and Crystal Reservoirs help to regulate Blue Mesa releases. As evidenced by the historical record of end-of-month contents, their contents fluctuate greatly around a point well below capacity. Neither capacity targets nor forecasting was appropriate for these reservoirs.

- Ridgway Reservoir provides supplemental supply for irrigation and municipal use, and under the standard approach, should have targets set to capacity in the calculated data set. However, the reservoir came on line in 1986 and required several annual cycles to fill. The period of "normal" operations was too small to deduce a pattern that reflects current operations. Ridgway's impact to the downstream gages was great enough to have an effect on the overall simulation of the Uncompahgre River.

A meeting was held with USBR to find out more about operations since 1988. As a result, Blue Mesa has one set of targets for 1975-1988 and a different set for 1989-2002. Note that the recent targets are used in the Baseline data set. Morrow Point and Crystal Reservoir targets were set to historical end-of-month content in the calculated data set. This approach is reasonable for regulating reservoirs. Ridgway Reservoir targets were set to historical end-of-month contents throughout the study period. In the future, as more history with this reservoir has developed, the targets can be changed.

The forecasting enhancements and use of historical contents for reservoir targets, when justified, resulted in good simulation of reservoir operations throughout the Gunnison model.

7.4 Calibration Results

Calibration of the Gunnison River model is considered very good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. More than half the diversion structures' shortages are at or below 1 percent on an annual basis, and the basinwide shortage is less than 2 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 Gunnison River model, for the calibration period (1975-2002). Following are observations based on the summary table:

- Stream water inflow to the basin averages 2.40 million acre-feet per year, and stream water outflow averages 1.91 million acre-feet per year.
- Annual diversions amount to approximately 2.57 million acre-feet on average, indicating that there is extensive re-diversion of return flows in the basin.
- Approximately 453,000 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 Gunnison River Model 1975-2002(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	90,413	172,972	644	264,028	175,605	1,906	128,941	-43,068	3,819	-3,174	264,028	0	12,088
NOV	67,182	73,422	131	140,735	49,386	720	132,723	-42,226	809	-678	140,735	0	1,791
DEC	61,706	64,259	0	125,964	51,410	276	115,777	-41,498	632	-632	125,964	0	1,163
JAN	59,552	58,433	0	117,985	49,167	360	82,958	-14,501	477	-477	117,985	0	1,206
FEB	56,427	51,827	0	108,254	46,081	701	79,816	-18,344	369	-369	108,254	0	1,453
MAR	87,816	56,349	669	144,834	53,924	1,465	101,097	-12,320	343	326	144,834	0	3,439
APR	214,684	139,155	2,506	356,345	167,954	3,258	134,394	48,232	1,490	1,016	356,345	0	16,906
MAY	612,543	273,287	3,939	889,768	380,319	5,421	381,012	119,078	4,980	-1,041	889,768	0	61,287
JUN	625,364	365,490	5,759	996,613	518,940	7,223	327,203	137,487	5,864	-105	996,613	0	108,494
JUL	291,394	352,052	12,412	655,858	470,761	6,212	177,561	-11,088	3,955	8,457	655,858	0	113,272
AUG	133,796	281,798	10,977	426,571	347,869	5,169	129,855	-67,299	2,224	8,753	426,571	0	84,631
SEP	99,433	227,866	4,791	332,090	260,878	4,112	117,692	-55,383	1,501	3,291	332,090	0	46,990
AVG	2,400,308	2,116,909	41,828	4,559,046	2,572,294	36,823	1,909,029	-928	26,462	15,365	4,559,046	0	452,721

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 2002, 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 7.11 (at the end of this section) graphically present monthly streamflow estimated by the model compared to historical observations at key streamgages 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 is generally very good in terms of both annual volume and monthly pattern. Exceptions include Smith Fork, Surface Creek, and Currant Creek drainages. Several structures are shorted in the basin and Smith Fork Feeder ditch is diverting less than historical to fill Crawford Reservoir. Streamflows at both Surface Creek and Currant Creek gages are overestimated. As noted above, interactions between the two tributaries and Fruitgrowers Reservoir are not completely understood. These exceptions do not affect mainstem or major tributary calibration. Future enhancements could include additional efforts to understand water use on these tributaries.

Simulation of streamflow on the mainstem of the Gunnison River below Blue Mesa Reservoir accurately models annual volume, but the monthly patterns vary from gaged. Blue Mesa is modeled using a forecasting curve provided by the USBR that is intended to mimic hydropower operations. It is clear that the rule curve is used only as a guideline by the USBR, and decisions based on other factors drive actual operations. Because of the large volume of water stored and released from the reservoir, relatively small deviations from historic reservoir operations result in large deviations in downstream flow. Step 1 calibration results, when Blue Mesa was "releasing to targets" of historical end-of-month contents, are also shown on Figure 7.4, Gunnison River below Gunnison Tunnel, further reinforcing the conclusion regarding streamgages below Blue Mesa.

Table 7.3
Historical and Simulated Average Annual Streamflow Volumes (1975-2002)
Calibration Run (acre-feet/year)

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9109000	147,968	148,444	-476	0	Taylor River Below Taylor Park Reservoir
9110000	236,375	236,719	-344	0	Taylor River at Almont
9110500	*No gage during calibration period*			0	East River Near Crested Butte
9111500	98,931	98,942	-12	0	Slate River Near Crested Butte
9112000	*No gage during calibration period*			0	Cement Creek Near Crested Butte
9112200	231,532	231,989	-457	0	East River Below Cement Creek NR Crested Butte
9112500	238,733	238,850	-117	0	East River at Almont
9113300	*No gage during calibration period*			0	Ohio Creek at Baldwin
9113500	56,954	56,954	-1	0	Ohio Creek Near Baldwin

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9114500	529,302	529,762	-461	0	Gunnison River Near Gunnison
9115500	45,797	45,881	-84	0	Tomichi Creek at Sargents
9118000	*No gage during calibration period*			0	Quartz Creek Near Ohio City
9118450	33,105	33,341	-236	-1	Cochetopa Creek Below Rock Creek Near Parlin
9119000	127,952	128,831	-879	-1	Tomichi Creek at Gunnison
9121500	*No gage during calibration period*			0	Cebolla Creek Near Lake City
9121800	*No gage during calibration period*			0	Cebolla Creek Near Powderhorn
9122000	*No gage during calibration period*			0	Cebolla Creek at Powderhorn
9124500	167,999	168,003	-4	0	Lake Fork at Gateview
9126000	70,457	71,290	-834	-1	Cimarron River Near Cimarron
9126500	*No gage during calibration period*			0	Cimarron River at Cimarron
9127500	*No gage during calibration period*			0	Crystal Creek Near Maher
9128000	888,915	891,127	-2,212	0	Gunnison River Below Gunnison Tunnel
9128500	33,416	34,748	-1,332	-4	Smith Fork Near Crawford
9129600	28,116	30,157	-2,040	-7	Smith Fork Near Lazear
9130500	*No gage during calibration period*			0	East Muddy Creek Near Bardine
9131200	*No gage during calibration period*			0	West Muddy Creek Near Somerset
9132500	352,863	353,514	-651	0	North Fork Gunnison River Near Somerset
9134000	15,138	15,410	-272	-2	Minnesota Creek Near Paonia
9134050	10,181	10,251	-69	-1	Minnesota Creek at Paonia
9134500	*No gage during calibration period*			0	Leroux Creek Near Cedaredge
9135900	20,892	21,046	-154	-1	Leroux Creek at Hotchkiss
9136200	1,446,348	1,461,677	-15,329	-1	Gunnison River Near Lazear
9137050	10,560	12,714	-2,154	-20	Currant Creek Near Read
9137800	*No gage during calibration period*			0	Dirty George Creek Near Grand Mesa
9139200	*No gage during calibration period*			0	Ward Creek Near Grand Mesa
9141500	*No gage during calibration period*			0	Youngs Creek Near Cedaredge
9143000	32,964	32,964	-1	0	Surface Creek Near Cedaredge
9143500	22,602	23,918	-1,315	-6	Surface Creek at Cedaredge
9144200	52,622	54,836	-2,215	-4	Tongue Creek at Cory
9144250	1,501,545	1,498,091	3,454	0	Gunnison River at Delta
9146200	121,827	121,827	0	0	Uncompahgre River Near Ridgway
9146400	*No gage during calibration period*			0	West Fork Dallas Creek nr Ridgway
9146500	*No gage during calibration period*			0	East Fork Dallas Creek nr Ridgway
9146550	*No gage during calibration period*			0	Beaver Creek nr Ridgway
9147000	29,636	29,890	-254	-1	Dallas Creek nr Ridgway
9147100	*No gage during calibration period*			0	Cow Creek Near Ridgway
9147500	192,969	193,024	-55	0	Uncompahgre River at Colona
9149420	39,882	39,882	0	0	Spring Creek Near Montrose
9149500	236,296	245,597	-9,300	-4	Uncompahgre River at Delta
9150500	88,628	88,665	-37	0	Roubideau Creek at Mouth, Near Delta
9152000	17,377	17,491	-113	-1	Kannah Creek Near Whitewater
9152500	1,910,511	1,917,023	-6,512	0	Gunnison River Near Grand Junction

7.4.3. Diversion Calibration Results

Table 7.4 summarizes the average annual shortage for water years 1975 through 2002, by tributary or sub-basin. Table 7.6 (at the end of this section) shows the average annual shortages for water years 1975 through 2002 by structure. On a basin-wide basis, average annual diversions differ from historical diversions by less than 2 percent in the calibration run.

Table 7.4
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2002)
Calibration Run (acre-feet/year)

Tributary or Sub-basin	Historical	Simulated	Historical minus Simulated	
			Volume	Percent
Taylor River	9,264	9,210	54	1%
East River	103,025	99,523	3,502	3%
Ohio Creek	47,065	46,389	676	1%
Tomichi Creek	198,034	191,965	6,069	3%
Cebolla Creek, Lake Fork, and Cimarron River	70,891	69,106	1,785	3%
Crystal River	19,688	18,068	1,620	8%
Smith Fork	69,108	68,738	370	1%
N.F. Gunnison River	168,663	164,776	3,887	2%
Currant Creek	31,186	28,720	2,466	8%
Surface Creek	77,987	72,715	5,272	7%
Uncompahgre River	751,121	732,821	18,300	2%
Roubideau Creek	2,942	2,922	20	1%
Kannah Creek	16,700	16,096	604	4%
Gunnison River Mainstem	1,074,732	1,073,312	1,420	0%
Basin Total	2,640,406	2,594,361	46,045	1.74%

Estimated diversions are within a few percentages of recorded diversions except in a couple areas:

- The Crystal River drainage irrigation demands are generally met, with the exception of Fruitland Canal. Fruitland Canal is shorted, on average, 1,000 acre-feet per year. Diversions through the canal are simulated using an operationg rule where demand is driven by both storage levels in Fruitland Reservoir, and irrigation demand on Fruitland Mesa. The project also receives water from Smith Fork tributaries, and the order in which they use their various sources may not be completely understood. The irrigation demand is generally satisfied, therefore additional calibration efforts were not conducted as part of this modeling phase.

- Shortages on Currant Creek and Surface Creek are fairly uniform throughout. As discussed above, the shortages were greatly reduced through calibration efforts. Many of the diversions on Surface Creek return to Currant Creek, and it is likely that interactions between the two tributaries, irrigated lands in the Alfalfa Run drainage, and the filling of Fruitgrowers Reservoir are not completely understood; therefore, not as accurately modeled as other areas in the basin. Additional calibration efforts were not conducted as part of this modeling phase.

7.4.4. Reservoir Calibration Results

Figures 7.12 through 7.20 (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:

- Fruitgrowers Reservoir is underused in the calibration run. The irrigation structures receiving supplemental water from Fruitgrowers Reservoir are completely satisfied. However, other diverters on Surface and Currant Creek are shorted. As noted above, operations on these tributaries are not completely understood and future investigation may indicate more demand on the reservoir than is currently modeled.

- In general, Fruitland Reservoir simulation matches historical patterns. During the period 1988 through 1990, water was not stored so structural repairs could take place. The calibration simulation models normal operations during this period.

- Overland Reservoir is greatly underused in the calibration run. This could be, in part, because Overland Reservoir contents were estimated by the USBR for use in their modeling efforts, and may not reflect actual operations. Most structures are shorted on West Muddy Creek, indicating that future investigation may indicate more demand on the reservoir than currently modeled.

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 scenario. This file 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, the StateMod structure summary file (*.xss) results were “filtered” to only include the structures in the StateCU analysis.

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 near 2 percent difference is consistent with the overall basin diversion shortages simulated by the model.

Table 7.5
Average Annual Crop Consumptive Use Comparison (1975-2002)

Comparison	StateCU Results (af/yr)	Calibration Run Results (af/yr)	% Difference
Explicit Structures	318,883	310,764	2.55
Aggregate Structures	92,167	90,603	1.70
Basin Total	411,050	401,367	2.36

Table 7.6
Historical and Simulated Average Annual Diversions (1975-2002)
Calibration Run (acre-feet/year)

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
280500	1,553	1,547	6	0	ADAMS NO 1 DITCH
280503	500	323	177	35	AGATE NO 2 DITCH
280510	14,099	13,975	123	1	ARCH IRRIGATING DITCH
280515	4,260	4,259	1	0	BIEBEL DITCHES NOS 1&2
280520	1,891	1,874	18	1	CAIN BORSUM DITCH
280526	2,716	2,694	22	1	CHITTENDEN DITCH
280527	346	328	18	5	CLARK NO 1 DITCH
280528	604	556	48	8	CLARK NO 2 DITCH
280529	777	745	32	4	CLARK NO 3 DITCH
280530	811	787	24	3	CLOVIS METROZ NO 1 DITCH
280532	1,830	1,764	65	4	COATS BROS DITCH
280535	609	423	187	31	COLE NOS 1 2 & 3 DITCHES
280536	1,667	1,606	61	4	COX AND MCCONNELL DITCH
280542	1,651	1,645	6	0	CUTJO DITCH
280543	586	555	31	5	D A MCCONNELL DITCH
280550	2,651	2,538	113	4	DUNN AND WATTERS DITCH
280554	1,473	1,473	0	0	ELSEN VADER DITCH
280557	894	834	61	7	FIELD AND VADER DITCH
280564	1,280	1,210	70	5	TOMI_GILBERTSON NO 1
280566	1,990	1,939	50	3	GOODRICH DITCH
280567	2,542	2,416	126	5	GOODWIN AND WRIGHT DITCH
280568	4,491	4,173	317	7	LOS _GOVERNMENT DITC
280571	3,930	3,910	20	1	TOMI_GRIFFING NO 1 D
280576	3,025	3,025	0	0	GULLETT TOMICHI IRG D
280577	1,357	1,249	109	8	HANNAH J WINTERS NO 2D
280580	1,179	1,120	59	5	HAWES-BERGEN-GILBERTSON
280581	1,542	1,496	46	3	HAZARD DITCH
280583	876	873	3	0	HEAD AND CORTAY NO 4 D
280587	1,166	1,123	43	4	HOME DITCH DITCH NO 81
280588	915	904	11	1	HOME DITCH DITCH NO 182
280590	361	359	2	1	HOT SPRINGS NOS 1&2 D
280604	522	428	94	18	KANE DITCH
280607	456	359	97	21	KENDALL NO 3 DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
280608	514	398	116	23	KENDALL NO 4 DITCH
280622	283	280	3	1	LOBDELL NO 2 DITCH
280624	2,846	2,846	0	0	LOCKWOOD MUNDELL DITCH
280631	1,912	1,912	0	0	MCCANNE NO 1 DITCH
280632	3,464	3,419	45	1	MCCANNE 2 DITCH
280633	1,278	1,276	2	0	MCCANNE 3 DITCH
280636	2,363	2,046	317	13	MCDONOUGH DITCH
280638	1,898	1,671	227	12	TOMI_MCGOWAN IRRIGAT
280642	605	501	104	17	MEANS BROS NO 13 DITCH
280645	333	301	32	10	MEANS BROS NO 4 DITCH
280646	387	372	14	4	MEANS BROS NO 5 DITCH
280647	448	326	121	27	MEANS BROS NO 6 DITCH
280648	334	273	61	18	MEANS BROS NO 7 DITCH
280649	604	528	75	12	MEANS BROS NO 12 DITCH
280650	1,147	1,109	38	3	MEANS BROS NO 8 DITCH
280651	6,921	6,332	589	9	MESA DITCH
280652	977	942	35	4	MILLER DITCH
280654	1,668	1,648	20	1	MONSON & MCCONNELL D
280660	834	813	20	2	NORMAN DITCH
280662	1,103	1,084	18	2	OFALLON NO 3 DITCH
280663	823	783	40	5	OFALLON NO 4 DITCH
280665	603	602	1	0	O'REGAN NO 1 DITCH
280667	1,185	1,154	30	3	OWEN NO 1 DITCH
280668	3,449	3,448	1	0	OWEN REDDEN DITCH
280670	1,086	1,086	0	0	PARLIN NO 2 DITCH
280671	3,992	3,978	14	0	PARLIN QUARTZ CREEK D
280673	3,072	2,806	266	9	PERRY IRRIGATING DITCH
280674	3,967	3,967	0	0	PIONEER DITCH
280679	1,624	1,556	68	4	ROGERS METROZ DITCH
280680	2,628	2,003	624	24	S DAVIDSON&CO FDR D NO 1
280681	314	220	94	30	SARGENTS NO 1 D
280682	337	293	44	13	SARGENTS NO 2 D
280686	3,538	3,459	79	2	SMITH FORD NO 2 DITCH
280690	2,150	2,133	16	1	SORRENSON IRRIGATING D
280692	1,642	1,638	4	0	SOUTH SIDE DITCH
280693	2,162	2,149	13	1	STEPHENSON DITCH
280697	63	63	0	0	SUTTON NO 3 AMENDED D
280703	917	809	108	12	TARBELL & ALEXANDER D
280707	3,377	3,232	145	4	TORNAY HIGHLINE DITCH
280709	958	958	0	0	VADER RAUSIS DITCH
280711	1,055	1,037	18	2	WATERMAN METROZ DITCH
280714	228	227	0	0	WICKS ROWSER DITCH
280715	1,611	1,594	17	1	WOOD AND GEE DITCH
280716	965	918	47	5	WOODBRIDGE DITCH
280823	266	260	6	2	MCDONALD BERDEL EX D
400500	15,732	18,031	-2,299	-15	CRAWFORD CLIPPER DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
400501	6,428	4,905	1,523	24	NEEDLE ROCK DITCH
400502	3,393	2,283	1,110	33	SADDLE MT HIGHLINE D
400503	6,891	8,650	-1,760	-26	GRANDVIEW CANAL
400504	7,514	7,260	254	3	CEDAR CANON IRON SPR D
400506	1,539	1,530	10	1	ALUM GULCH DITCH
400508	6,356	4,765	1,591	25	ASPEN DITCH
400509	1,097	1,097	0	0	ASPEN CANAL
400533	1,084	1,025	60	5	CRYSTAL VALLEY DITCH
400536	2,132	1,941	191	9	DAISY DITCH
400543	950	861	89	9	DYER FORK DITCH
400549	10,140	8,922	1,218	12	FRUITLAND CANAL
400566	1,450	1,444	6	0	LARSON BROTHERS DITCH
400568	771	723	48	6	LONE ROCK DITCH
400585	6,627	8,920	-2,293	-35	OVERLAND DITCH
400586	1,269	1,243	25	2	PILOT ROCK DITCH
400605	3,827	4,905	-1,078	-28	SMITH FORK FEEDER CANAL
400616	1,153	852	301	26	VIRGINIA DITCH
400632	3,377	2,972	405	12	CHILDS DITCH
400661	10,438	10,226	212	2	SURFACE CR D AKA BIG D
400675	4,027	3,351	676	17	CEDAR MESA DITCH
400683	1,147	1,098	49	4	HORSESHOE DITCH
400686	3,036	2,513	523	17	LONE PINE DITCH
400701	4,927	3,959	967	20	CEDAR PARK DITCH
400703	824	572	252	31	DIRT_EAGLE DITCH
400713	1,346	1,093	252	19	GRANBY DITCH FR WARD CR
400751	8,361	7,670	691	8	ALFALFA DITCH
400753	1,596	1,534	63	4	SURF_BONITA DITCH
400754	2,282	2,191	91	4	BUTTES DITCH
400758	2,972	2,468	504	17	FORREST DITCH
400774	2,415	2,379	36	1	ORCHARD RANCH DITCH
400778	983	973	10	1	SETTLE DITCH
400797	2,214	913	1,302	59	DURKEE DITCH
400808	780	695	85	11	MORTON DITCH
400820	8,826	8,215	611	7	ALFA_STELL DITCH
400821	1,583	1,620	-37	-2	TRANSFER DITCH
400863	22,074	22,074	1	0	BONAFIDE DITCH
400879	16,642	16,642	0	0	HARTLAND DITCH
400891	19,511	19,502	9	0	GUNN_NORTH DELTA CAN
400900	18,623	18,607	17	0	RELIEF DITCH
400918	1,011	1,004	7	1	COW CREEK DITCH
400919	3,025	2,992	33	1	CURRANT CREEK DITCH
400923	8,143	7,887	256	3	HIGHLINE DITCH
400926	6,240	6,229	10	0	LEROUX CREEK DITCH
400929	1,084	1,068	17	2	JESSIE DITCH
400932	1,752	1,588	164	9	MIDKIFF & ARNOLD D
400944	10,320	9,884	435	4	LERO_OVERLAND DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
401012	574	362	211	37	LONE CABIN DITCH
401020	6,076	5,698	378	6	MINNESOTA CANAL
401056	1,890	1,663	227	12	TURNER DITCH
401087	432	432	0	0	BLACK SAGE DITCH
401105	429	429	0	0	COYOTE DITCH
401106	421	421	1	0	COYOTE DITCH
401112	474	352	122	26	DEER DITCH
401114	311	311	0	0	DITCH NO 2 DITCH
401118	609	576	34	6	DRIFT CREEK DITCH
401119	226	226	0	0	DUGOUT DITCH
401120	631	629	1	0	DOWNING DITCH
401122	195	137	58	30	DYKE NO 2 DITCH
401127	317	317	0	0	ELKS BEAVER DITCH
401132	1,627	1,343	285	17	FILMORE DITCH
401133	45,470	42,887	2,583	6	FIRE MT CANAL
401145	432	432	0	0	GROUSE CREEK DITCH
401166	134	95	40	29	MUDD_LARSON NO 2 DIT
401168	383	382	1	0	LEE CREEK D NO 2
401172	641	608	33	5	LOST CABIN DITCH
401183	2,285	2,266	19	1	MONITOR DITCH
401185	8,697	8,592	105	1	NORTH FORK FARMERS D
401189	6,359	6,081	278	4	PAONIA DITCH
401190	107	103	4	4	PILOT KNOB DITCH
401195	2,836	2,833	2	0	SHEPARD & WILMONT DITCH
401196	4,994	4,994	0	0	SHORT DITCH
401197	1,606	1,606	0	0	SMITH AND MCKNIGHT DITCH
401201	242	196	45	19	SPATAFORE DITCH NO 1
401206	14,716	14,495	221	2	STEWART DITCH
401207	1,452	1,093	359	25	STREBER DITCH
401213	1,815	1,815	0	0	VANDEFORD DITCH
401214	97	85	12	13	WADE DITCH
401218	942	906	36	4	WELCH MESA DITCH
401221	111	109	2	2	WILLIAMS CR DITCH
401437	498	496	2	0	ROUB_HAWKINS DITCH
410508	3,302	3,291	12	0	BOLES & MANNEY D
410515	3,619	3,619	0	0	CHIPETA BEAUDRY DITCH
410519	6,843	6,843	0	0	EAGLE DITCH
410520	49,844	48,260	1,584	3	EAST CANAL
410527	22,870	22,870	0	0	GARNET DITCH
410534	114,743	111,237	3,506	3	UNCO_IRONSTONE CANAL
410537	46,974	44,569	2,405	5	LOUTSENHIZER CANAL
410538	2,627	2,620	6	0	LYRA DITCH
410545	181,440	181,440	0	0	MONTROSE & DELTA CANAL
410549	4,164	4,157	7	0	OURAY DITCH
410554	2,882	2,882	0	0	ROSS BROS DITCH
410559	69,557	64,841	4,716	7	SELIG CANAL

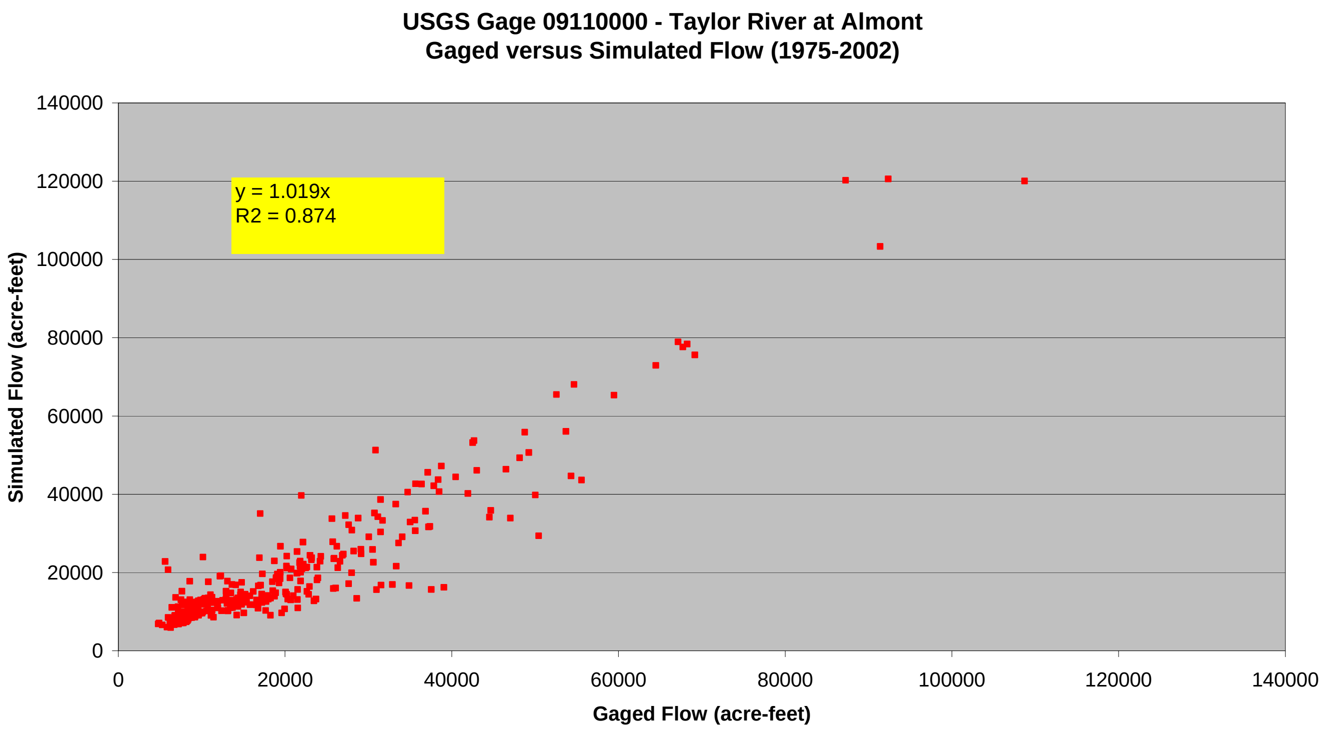
WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
410560	1,150	1,150	0	0	SHAVANO VALLEY DITCH
410568	1,748	1,748	0	0	SUNRISE DITCH(HAPPY CYN)
410577	54,732	54,547	185	0	WEST CANAL
410578	44,362	44,224	138	0	SOUTH CANAL
420510	2,918	2,897	21	1	BROWN & CAMPION D
420529	5,886	5,405	482	8	KANNAH CREEK HIGHLINE D
420541	426,860	426,435	424	0	REDLANDS POWER CANAL
420545	1,315	1,275	41	3	SMITH IRR DITCH
590501	3,631	3,462	170	5	ACME DITCH
590509	358	314	44	12	ANDERS BOTTOM D
590510	1,138	1,022	115	10	ANNA ROZMAN DITCH
590522	3,560	3,517	44	1	BOCKER DITCH
590524	541	536	4	1	BOURNE DITCH
590527	780	769	10	1	BUCKEY DITCH
590528	313	313	0	0	BUCKEY LEHMAN DITCH
590537	3,555	3,448	107	3	CEMENT CREEK DITCH
590542	616	609	7	1	CUNNINGHAM DITCH
590544	1,023	1,020	3	0	DEAN IRRIGATING DITCH
590546	6,728	6,286	442	7	DILLSWORTH DITCH
590549	15,168	15,094	75	0	EAST RIVER NO 1 DITCH
590550	9,707	9,343	364	4	EAST RIVER NO 2 DITCH
590556	3,856	3,834	22	1	FISHER DITCH ENLARGEMENT
590558	3,047	3,040	7	0	FRANK ADAMS NO 1 DITCH
590560	2,698	2,622	76	3	GARDEN DITCH
590563	1,553	1,530	23	1	GLEASON IRRIGATING DITCH
590566	3,066	3,040	25	1	GOOSEBERRY MESA IRG D
590569	13,817	13,817	0	0	GUNNISON & OHIO CR CANAL
590570	17,011	16,736	275	2	GUNNISON R OHIO CR IRG D
590572	6,691	6,691	0	0	GUNNISON TOWN DITCH
590578	4,081	4,065	16	0	HARRIS BOHM POTATO DITCH
590580	190	190	0	0	HENRY PURRIER OHIO CR D
590581	260	260	0	0	HENRY PURRIER OHIO CR 2D
590584	512	508	4	1	HIGHLAND DITCH
590587	1,133	1,066	67	6	HILDEBRAND NO 2 DITCH
590588	1,534	1,529	5	0	HINKLE HAMILTON DITCH
590589	683	683	0	0	HINKLE IRG DITCH
590591	1,077	1,077	0	0	HOPE RESICH DITCH
590593	2,177	2,132	45	2	HOWE & SHERWOOD IRR D
590596	949	949	0	0	HYZER VIDAL MILLER D
590597	2,756	2,353	403	15	IMOBERSTEG DITCH
590600	5,212	5,087	125	2	JAMES WATT DITCH
590602	1,974	1,974	0	0	JOHN B OUTCALT NO 2 D
590606	1,335	1,317	18	1	JUDY NORTH HIGH LINE D
590607	5,740	5,692	48	1	KELMEL OWENS NO 1 DITCH
590608	3,269	3,264	5	0	KELMEL OWENS NO 2 DITCH
590609	2,907	2,751	156	5	KUBIACK DITCH

WDID	Historical	Simulated	Historical minus Simulated Volume	Historical minus Simulated Percent	Structure Name
590616	3,081	3,071	9	0	LIGHTLEY D & LINTON ENLT
590617	3,059	3,059	0	0	LONE PINE DITCH
590622	1,807	1,803	4	0	MARSHALL NO 1 DITCH
590623	2,702	2,698	4	0	MARSHALL NO 2 DITCH
590624	1,390	1,366	24	2	MARSTON DITCH
590625	3,502	3,502	0	0	MAY BOHM & ENLD M B H P
590627	437	425	12	3	MCCORMICK DITCH
590630	232	230	2	1	MCGLASHAN N SIDE MILL CR
590631	402	368	35	9	MCGLASHAN S SIDE MILL CR
590644	497	497	0	0	OHIO CREEK NO 2 DITCH
590645	423	423	0	0	OTIS MOORE DITCH
590646	793	773	19	2	PALISADES DITCH
590649	796	755	42	5	PASS CREEK DITCH
590651	1,329	1,329	0	0	PILONI DITCH
590653	4,375	4,271	105	2	POWER DITCH
590655	430	430	0	0	PURRIER DITCH
590658	4,161	3,958	203	5	RICHARD BALL DITCH
590667	713	690	23	3	SCHUPP DITCH
590668	5,336	5,205	132	2	SEVENTY FIVE DITCH
590671	343	343	0	0	SIMINEO DITCH
590672	4,297	3,949	348	8	SLIDE DITCH
590679	3,988	3,951	37	1	SPRING CR IRG DITCH
590680	431	410	21	5	SQUIRREL CREEK NO1 DITCH
590684	2,357	2,138	219	9	STRAND DITCH NO 1
590691	3,116	3,096	20	1	TEACHOUT DITCH
590692	1,226	1,214	13	1	TEACHOUT-FAIRCHILD DITCH
590699	5,374	5,247	127	2	VERZUH DITCH
590700	5,756	5,154	603	10	VERZUH YOUNG BIFANO D
590704	3,860	3,768	93	2	WHIPP DITCH
590707	412	412	0	0	WILLOW RUN DITCH
590709	826	824	3	0	WILSON DITCH
590711	1,070	1,052	18	2	WILSON OHIO CREEK DITCH
590720	536	536	0	0	PIONEER DITCH
590847	2,220	2,102	118	5	CUNNINGHAM WASTEWATER D
620506	711	602	109	15	ANDREWS DITCH
620528	5,322	5,290	32	1	BIG BLUE DITCH
620529	2,999	2,816	182	6	BIG DITCH
620560	28,726	28,131	594	2	CIMARRON CANAL
620567	1,521	1,477	43	3	COLLIER DITCH
620602	719	683	36	5	FOSTER DITCH NO 1
620604	223	195	28	13	FOSTER IRG D NO 4
620605	2,180	2,179	1	0	FRANK ADAMS D NO 2
620617	332,759	332,759	0	0	GUNNISON TUNNEL&S CANAL
620670	1,867	1,813	54	3	M B & A DITCH
620672	4,517	4,390	127	3	MCKINLEY DITCH
620732	1,458	1,435	23	2	RUDOLPH IRG DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
620734	600	568	32	5	SAMMONS DITCH NO 2
620736	716	692	25	3	CEBO_SAMMONS IRG D N
620737	648	629	18	3	SAMMONS IRG D NO 5
620738	578	530	49	8	SAMMONS IRG D NO 6
620779	1,417	1,359	58	4	UPPER CEBOLLA DITCH
620783	1,818	1,705	113	6	VEO DITCH
620789	905	814	91	10	WARRANT DITCH
620809	1,015	887	128	13	YOUMANS IRG D NO 1
680501	5,411	5,404	7	0	ALKALI DITCH D NO 80
680502	4,432	4,253	178	4	ALKALI NO 2 DITCH
680514	1,840	1,802	38	2	BURKHART EDDY DITCH
680526	3,094	3,085	9	0	CHARLEY LOGAN DITCH
680538	469	431	38	8	CRONENBERG DITCH
680543	3,774	3,652	122	3	DALLAS DITCH
680559	1,849	1,781	67	4	DOC WADE DITCH
680603	1,106	1,046	60	5	HENRY TRENCHARD DITCH
680607	3,866	3,861	5	0	HOMESTRETCH DITCH
680609	1,997	1,992	4	0	HOSNER BROWNYARD DITCH
680610	1,983	1,962	22	1	HOSNER ROWELL DITCH
680613	2,261	2,226	35	2	HYDE SNEVA DITCH
680636	2,035	2,034	1	0	LEOPARD CREEK DITCH
680647	969	967	2	0	MARTIN DITCH
680652	865	861	4	0	MAYOL LATERAL DITCH
680653	807	780	28	3	MAYOL SISSON DITCH
680668	2,048	2,048	0	0	MOODY DITCH
680669	2,393	2,393	0	0	MOODY NO1 DITCH
680671	1,421	1,414	7	0	MORRISON DITCH
680681	2,137	2,136	1	0	OLD AGENCY DITCH
680683	1,294	1,285	9	1	OWL CREEK DITCH
680685	2,373	2,373	0	0	PARK DITCH
680692	3,891	3,891	0	0	PINION DITCH
680703	1,133	1,132	0	0	REED OVERMAN DITCH
680710	647	599	48	7	RIDGWAY DITCH
680720	1,035	1,035	0	0	ROSWELL HOTCHKISS DITCH
680729	609	609	0	0	SHORTLINE D COW CREEK
680738	3,551	3,551	0	0	SNEVA DITCH
680765	2,670	2,669	0	0	UPPER UNCOMPAHGRE DITCH
960050	79,630	79,474	156	0	REDLANDS_POWER_CANAL-IRR
960051	6,581	6,519	63	1	Grand_Junction_Demand
28_ADG009	6,776	6,743	33	0	28_ADG009_UTOMICHI
28_ADG010	13,538	13,467	71	1	28_ADG010_TOMICHI1
28_ADG011	6,268	6,265	3	0	28_ADG011_COCHETOPA
28_ADG012	26,830	26,830	0	0	28_ADS_012_TOMICHI2
28_ADG043	2,180	1,739	441	20	28_ADG043_COCHET
28_ADG044	5,961	5,961	0	0	28_ADG044_RAZOR
40_ADG019	389	389	0	0	40_ADG019_GUNNTUN

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
40_ADG020	4,264	3,834	431	10	40_ADG020_IRON
40_ADG021	3,083	3,066	18	1	40_ADG021_SMITH
40_ADG022	6,952	6,931	21	0	40_ADG022_NFGUNN
40_ADG023	1,736	1,595	141	8	40_ADG023_MINN
40_ADG024	7,453	7,453	0	0	40_ADG024_NFGUNN2
40_ADG025	3,800	3,777	23	1	40_ADG025_LEROUX
40_ADG026	8,940	8,940	0	0	40_ADG026_GUNNL
40_ADG027	7,223	5,305	1,918	27	40_ADG027_CURRANT
40_ADG028	12,299	12,032	267	2	40_ADG028_UTONGUE
40_ADG029	2,443	2,236	207	8	40_ADG029_SURFACE
40_ADG030	13,773	13,707	66	0	40_ADG030_TONGUE
40_ADG031	5,890	5,890	0	0	40_ADG031_GUNND
40_ADG038	2,444	2,426	18	1	40_ADG038_ROUBIN
40_ADG039	9,208	9,208	0	0	40_ADG039_GUNNBLD
40_AMG002	1,449	1,448	1	0	Lower_M&I
40_Fruitl	12,712	12,443	269	2	Fruitland
41_ADG035	6,332	6,332	0	0	41_ADG035_UNCOMPH3
41_ADG036	13,087	13,087	0	0	41_ADG036_UNCOMPH4
41_ADG037	7,846	7,846	0	0	41_ADG037_UNCOMPH5
41_AMG003	1,272	1,272	0	0	Uncomp_M&I
42_ADG040	12,074	12,074	0	0	42_ADG040_GUNNGJ
59_ADG001	4,764	4,751	13	0	59_ADG001_TAYLOR
59_ADG002	3,370	3,370	0	0	59_ADG002_EAST1
59_ADG003	1,818	1,815	4	0	59_ADS_003_SLATE
59_ADG004	10,119	10,119	0	0	59_ADG004_EAST2
59_ADG005	6,111	6,111	0	0	59_ADG005_EAST3
59_ADG006	2,747	2,686	61	2	59_ADG006_OHIO1
59_ADG007	3,055	3,055	0	0	59_ADG007_OHIO2
59_ADG008	15,362	15,362	0	0	59_ADG008_GUNN
62_ADG013	5,861	5,788	73	1	62_ADG013_CEBOLLA1
62_ADG014	6,988	6,988	0	0	62_ADG014_CEBOLLA2
62_ADG015	4,981	4,981	0	0	62_ADG015_LAKE
62_ADG016	16,176	16,176	0	0	62_ADG016_GUNNBM
62_ADG017	1,641	1,641	0	0	62_ADG017_GUNNM
62_ADG018	2,623	2,623	0	0	62_ADG018_CIM
62_AMG001	1,449	1,448	1	0	Upper_M&I
62_IrrCim	28,124	27,045	1,079	4	Cimmaron_Canal
68_ADG032	11,212	11,212	0	0	68_ADG032_UNCOMPH1
68_ADG033	7,480	7,474	6	0	68_ADG033_DALLAS
68_ADG034	8,765	8,765	0	0	68_ADG034_UNCOMPH2
95CSUB_I	0	0	0	0	Default information
95CSUB_M	0	0	0	0	Subordinate_Crystal_M&I
95L_MY	0	0	0	0	Default information
95MSUB_I	0	0	0	0	Default information
95MSUB_M	0	0	0	0	Subordinate_Morrow_M&I
95U_MY	0	0	0	0	Upper_Market_Yield

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
95USUB_I	0	0	0	0	Default information
95USUB_M	0	0	0	0	Subordinate_Upper_M&I
Proj_7	6,487	3,931	2,556	39	Project_7
Basin Total	2,640,406	2,594,361	46,042	1.74	



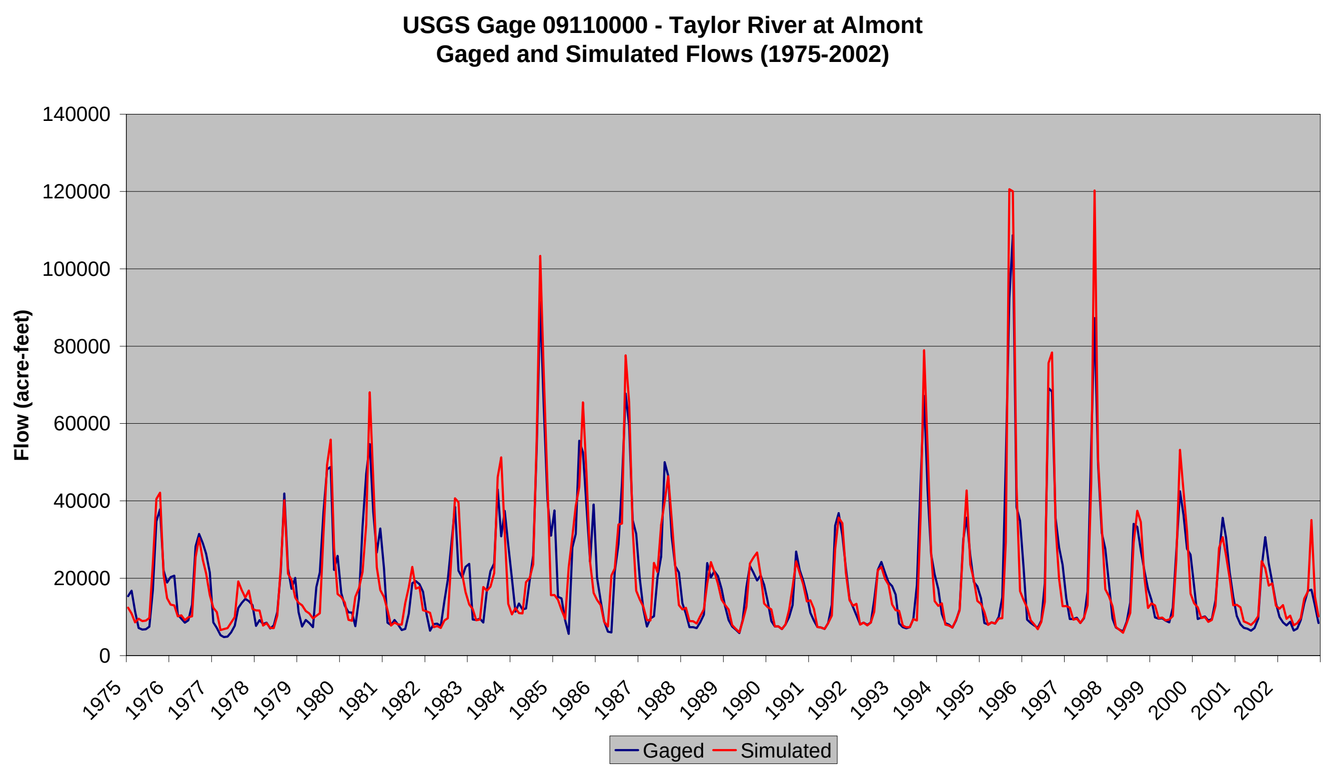
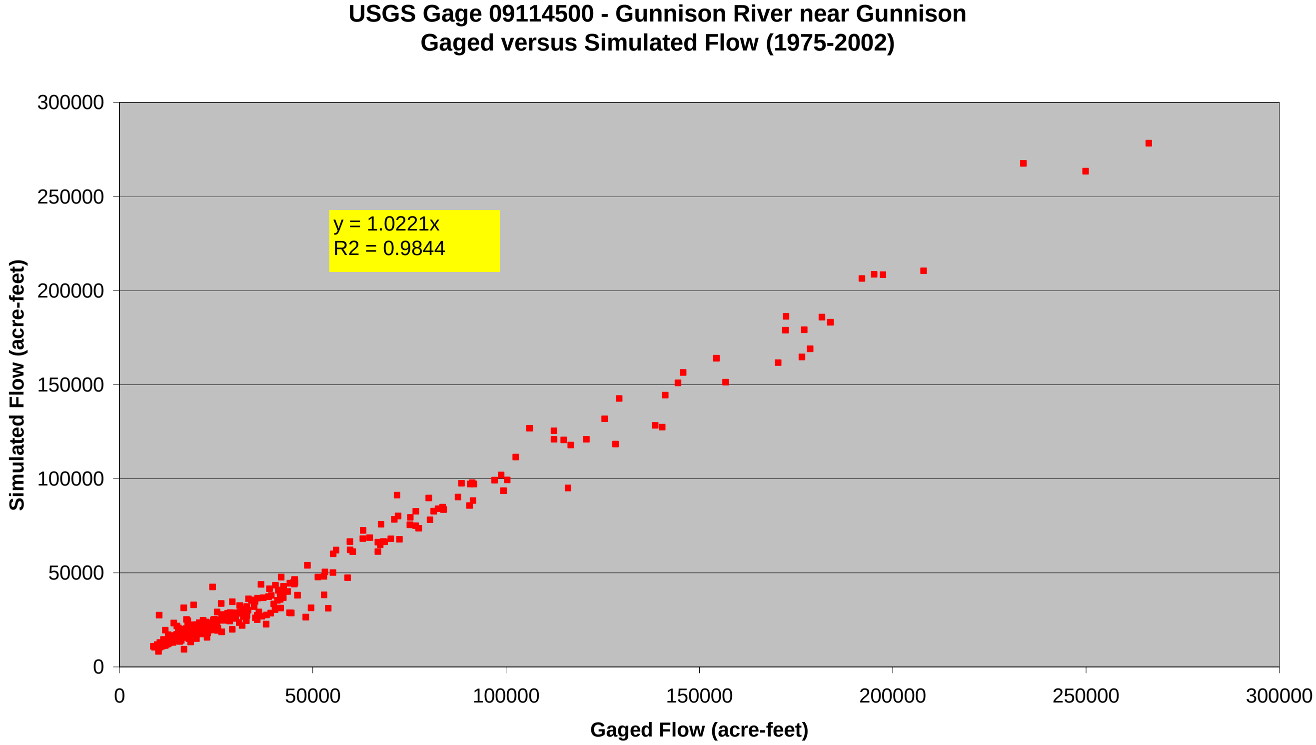


Figure 7.1 Streamflow Calibration – Taylor River at Almont



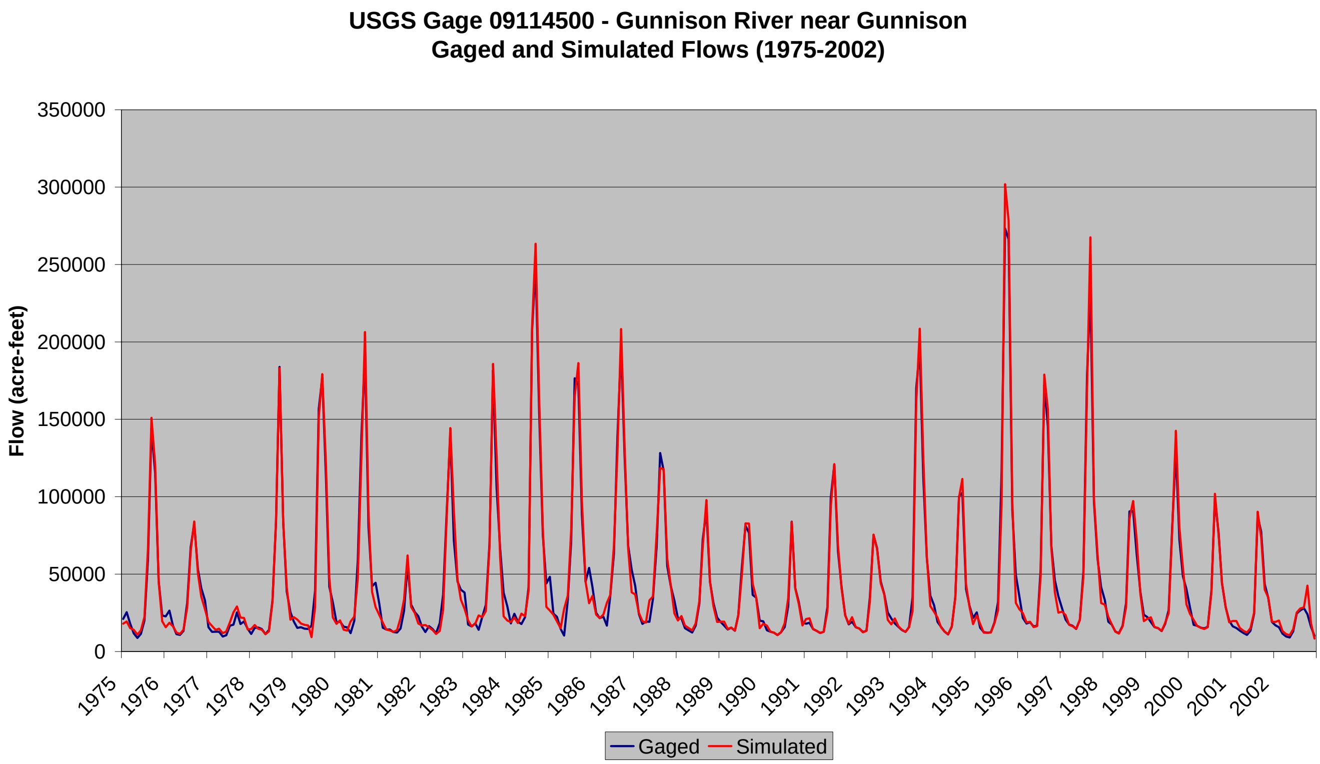
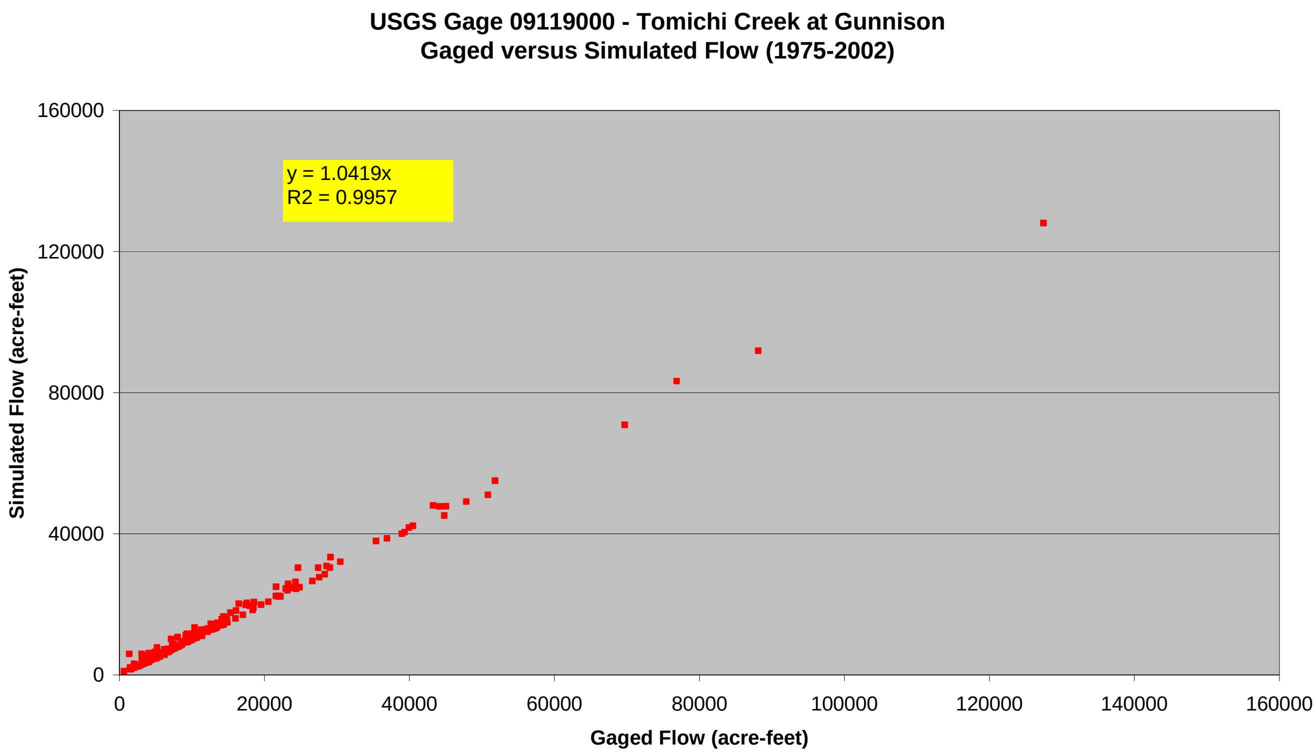


Figure 7.2 Streamflow Calibration – Gunnison River near Gunnison



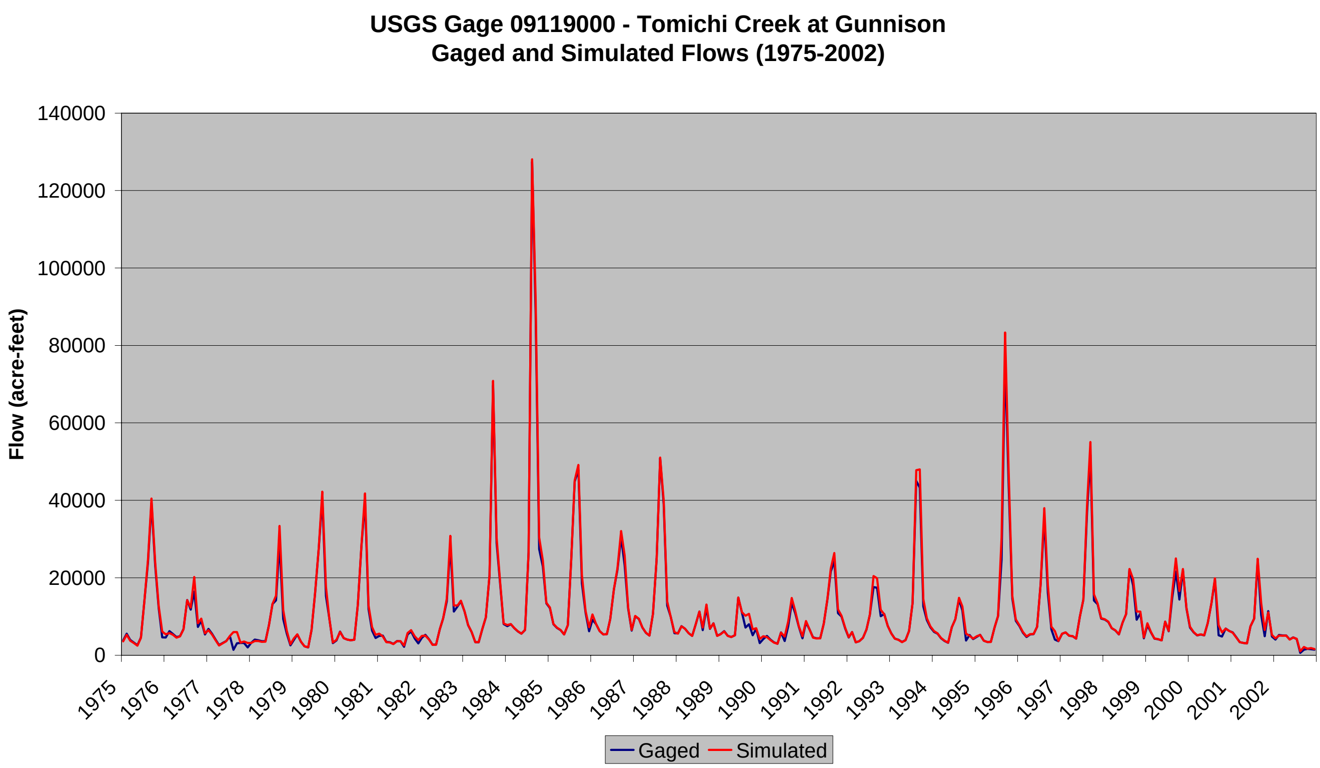
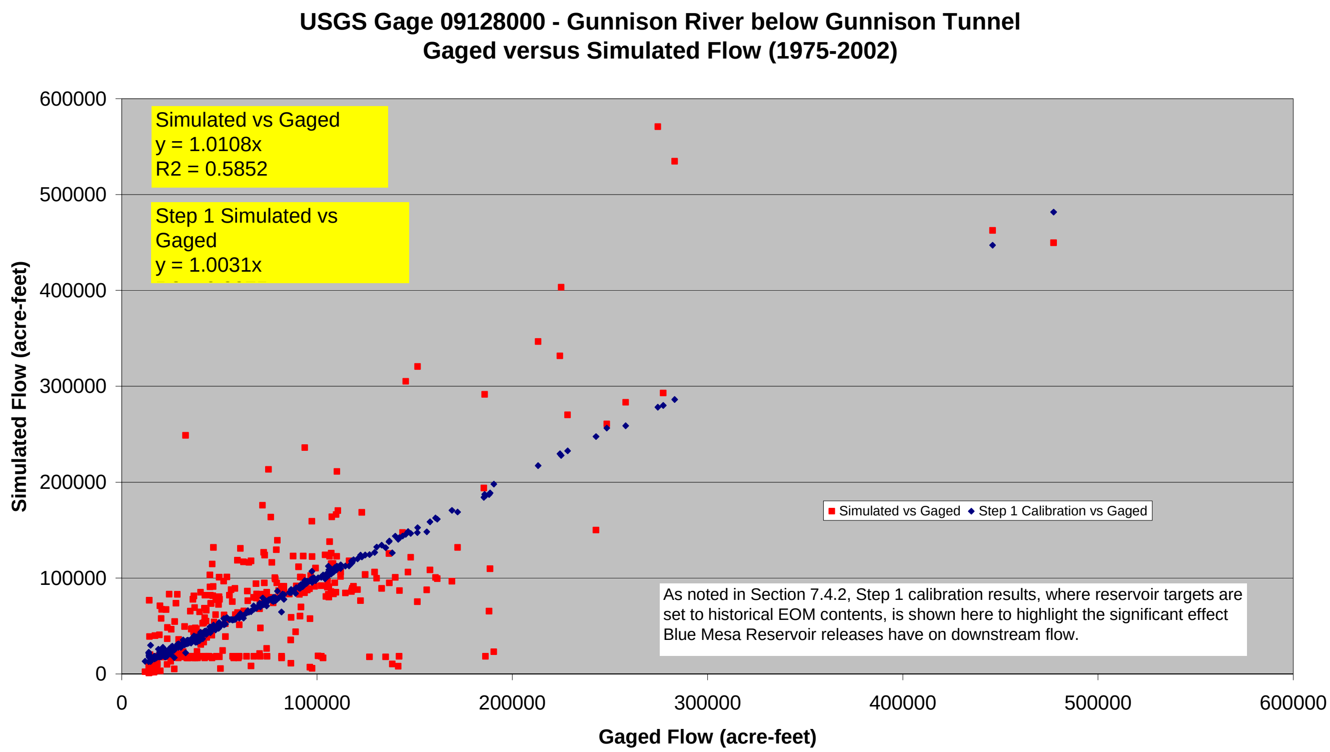


Figure 7.3 Streamflow Calibration – Tomichi Creek at Gunnison



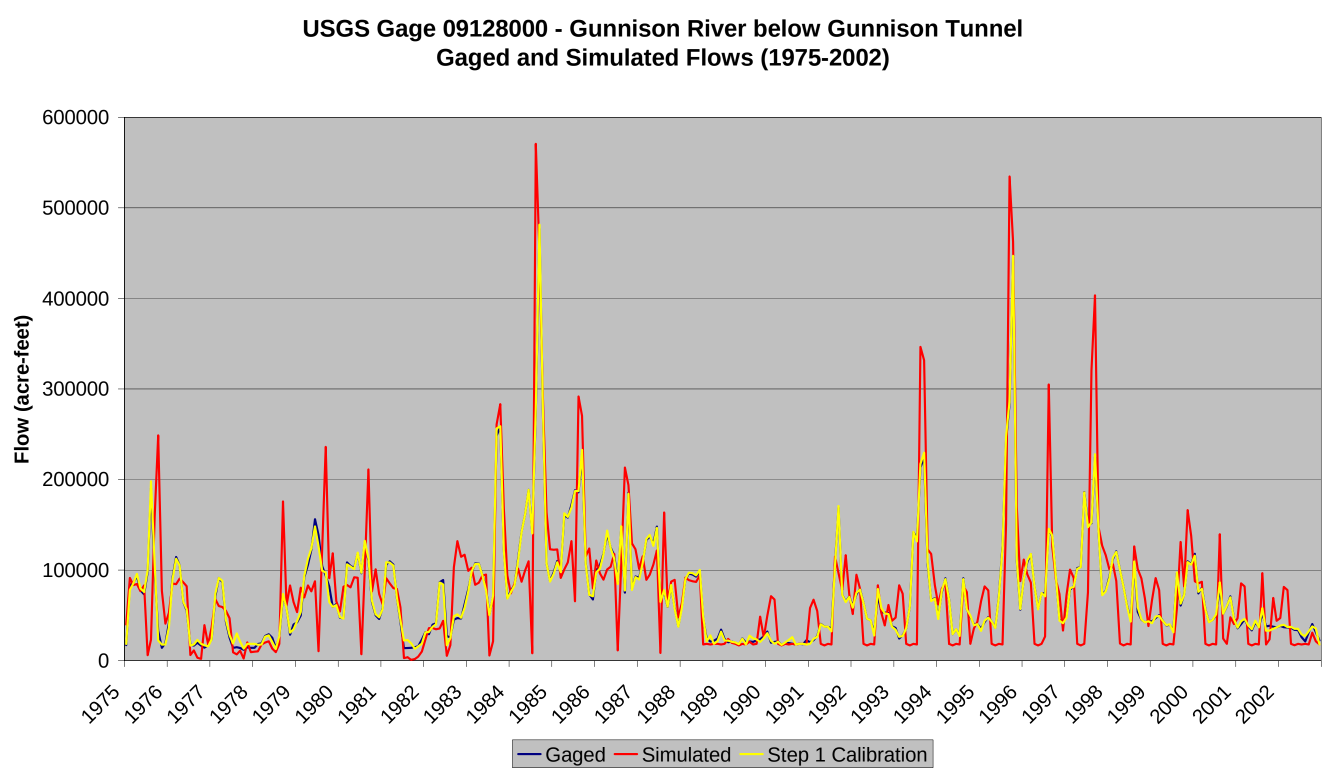
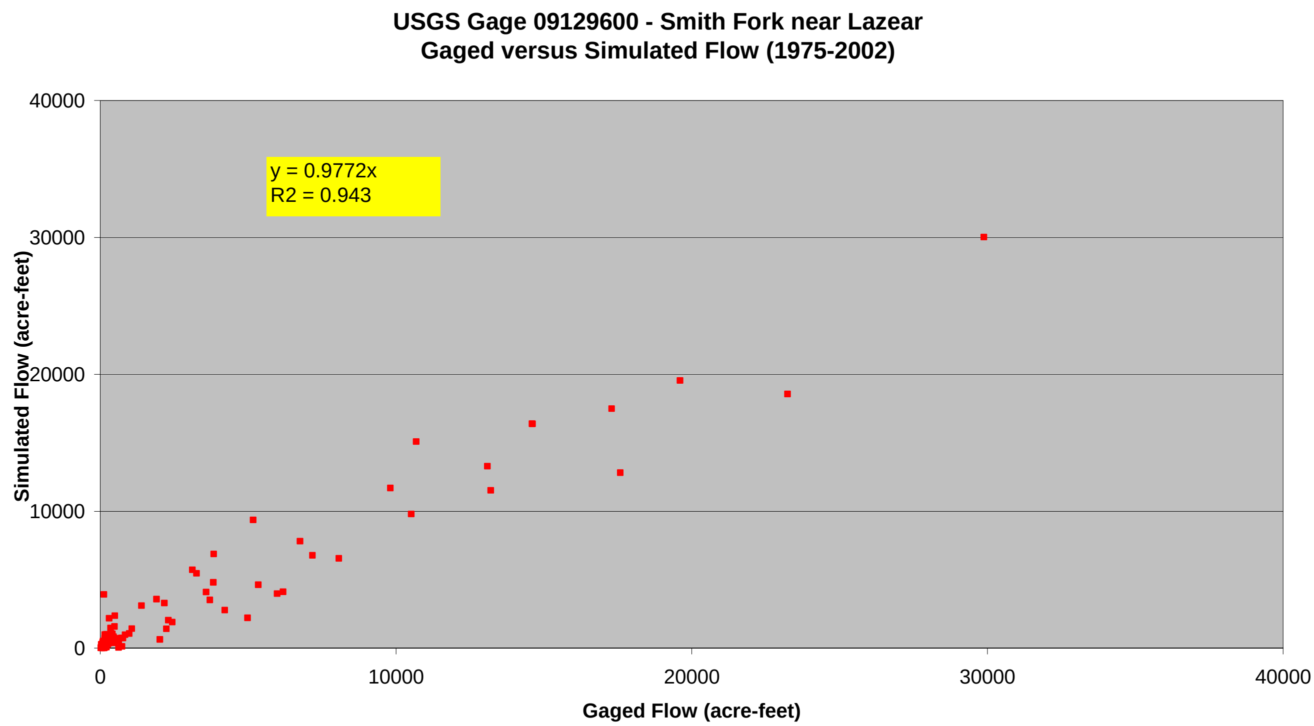


Figure 7.4 Streamflow Calibration – Gunnison River below Gunnison Tunnel



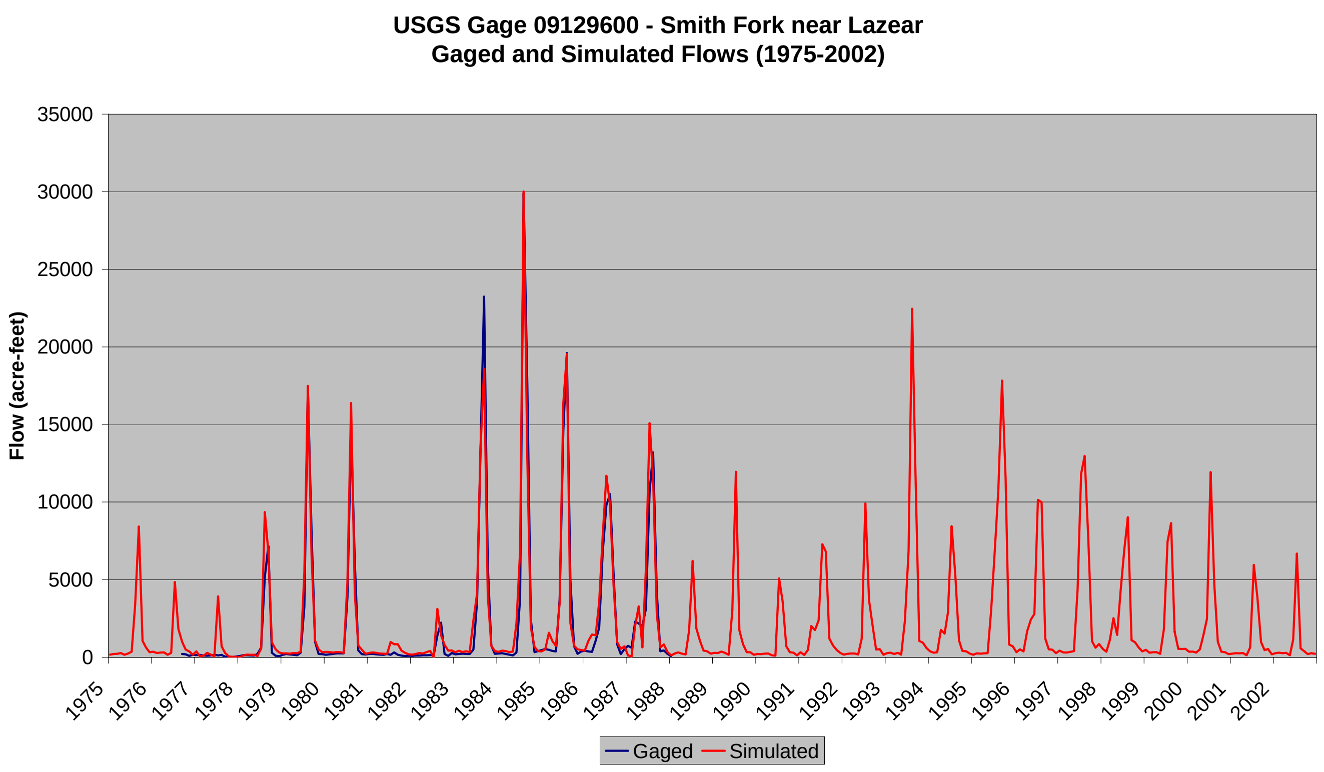
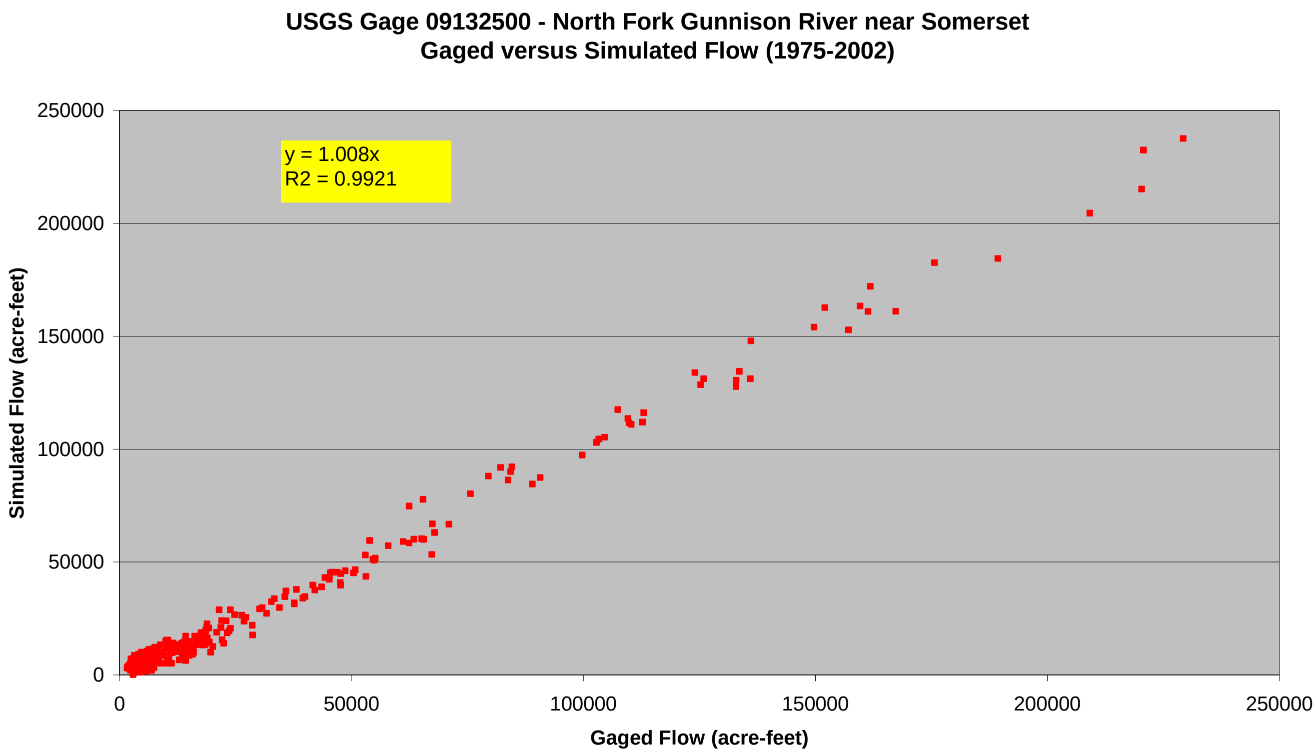


Figure 7.5 Streamflow Calibration – Smith Fork near Lazear



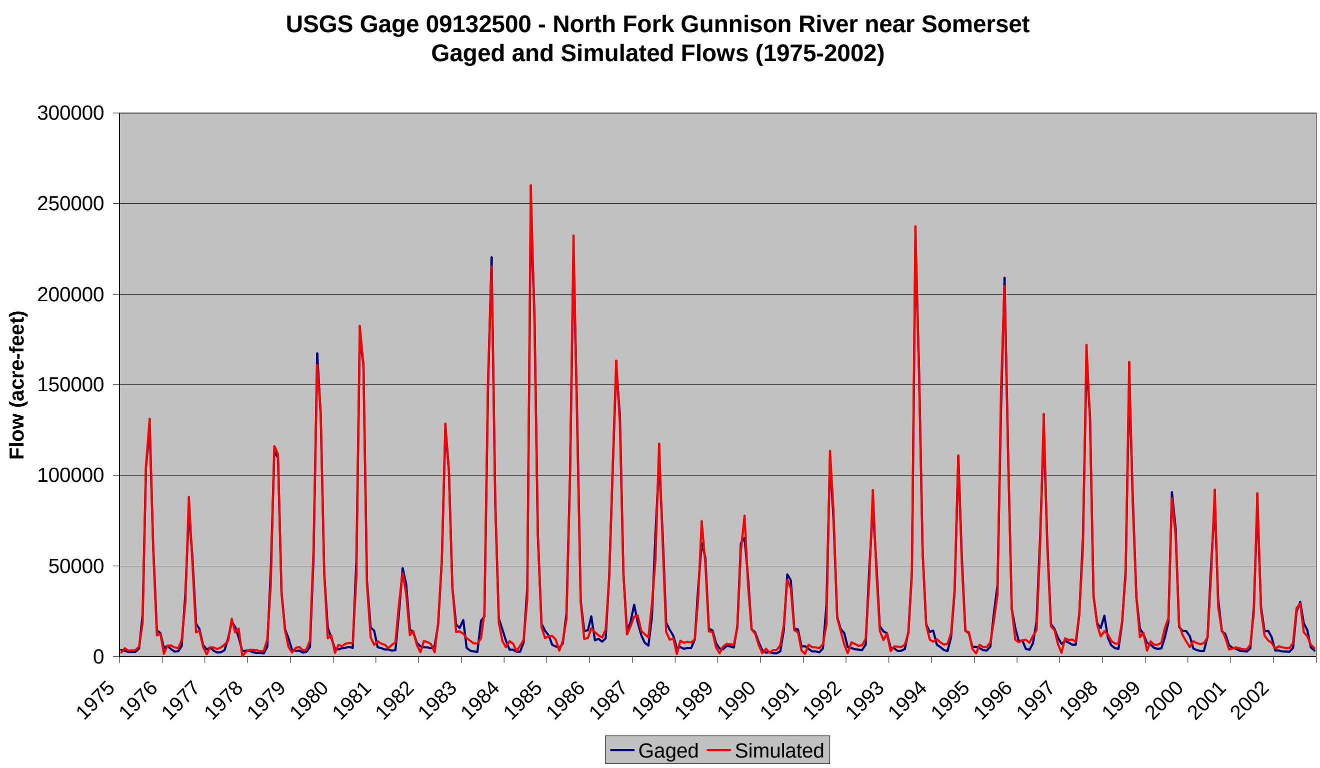
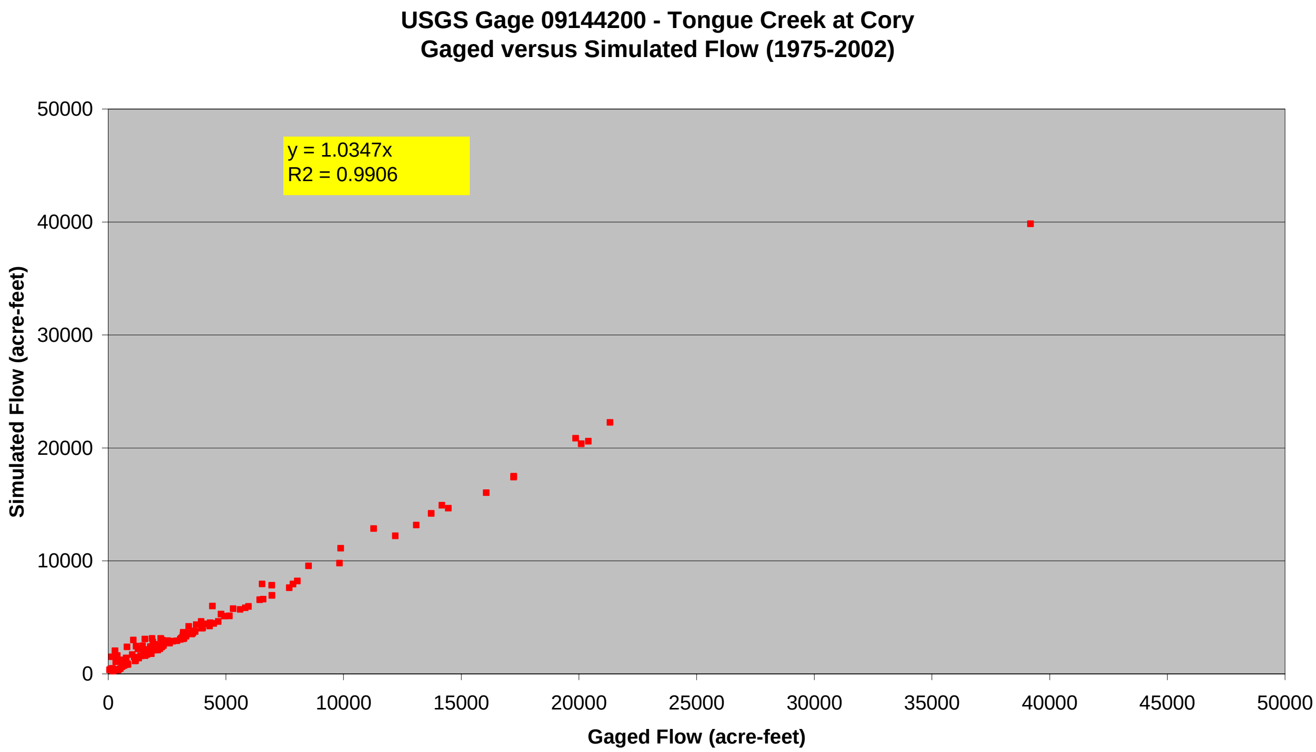


Figure 7.6 Streamflow Calibration – North Fork Gunnison River near Somerset



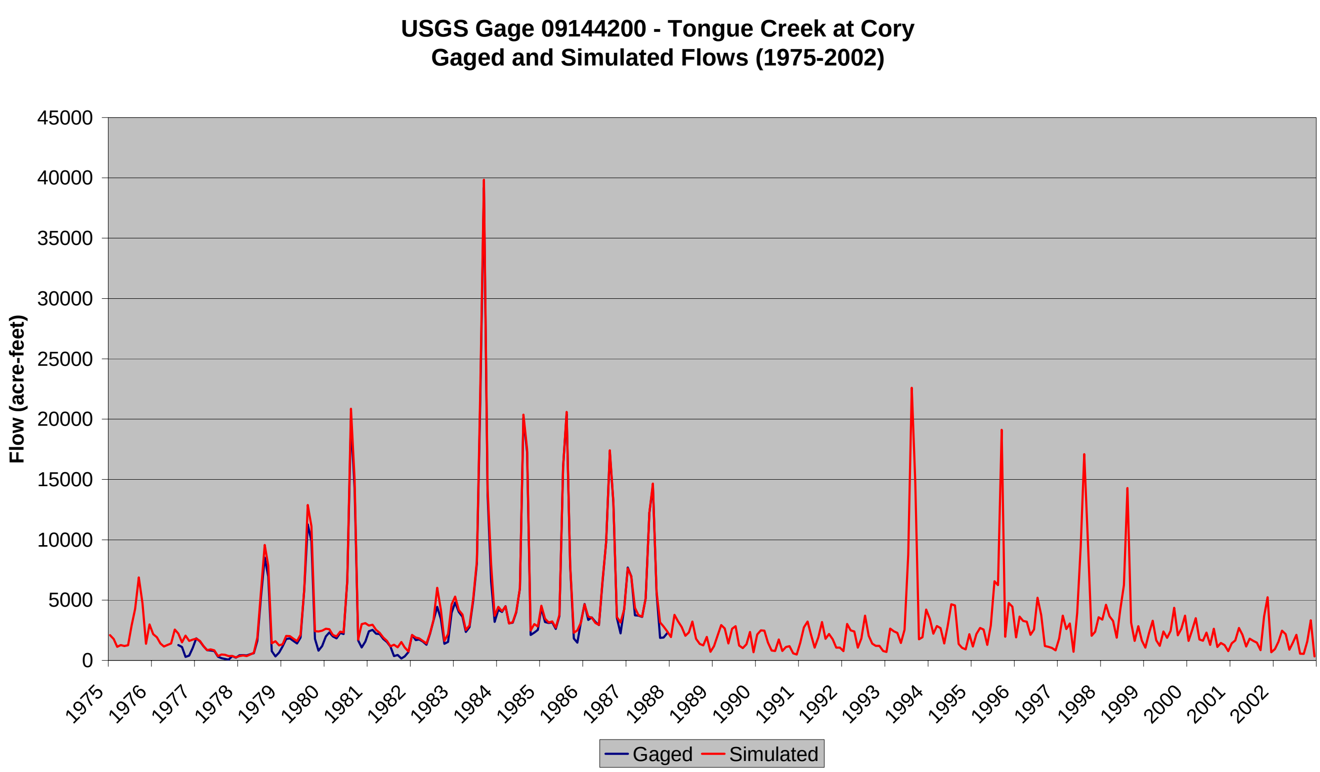
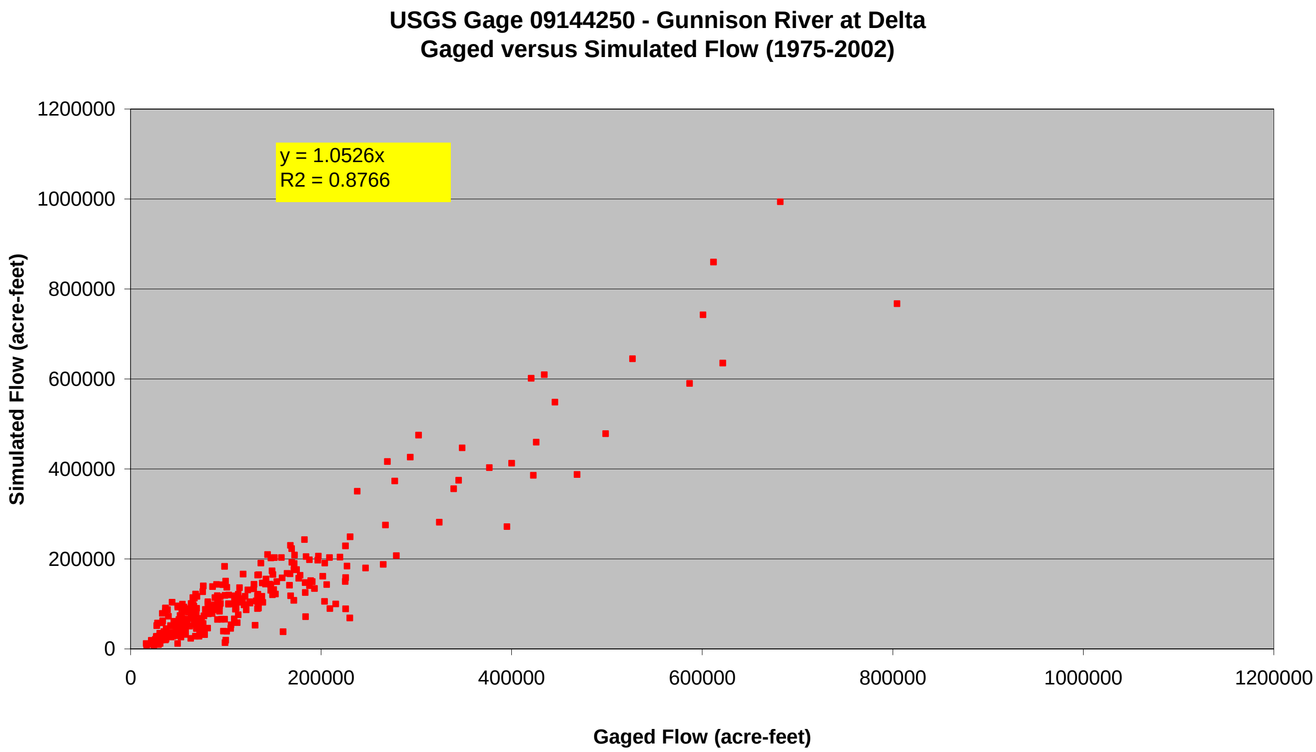


Figure 7.7 Streamflow Calibration – Tongue Creek at Cory



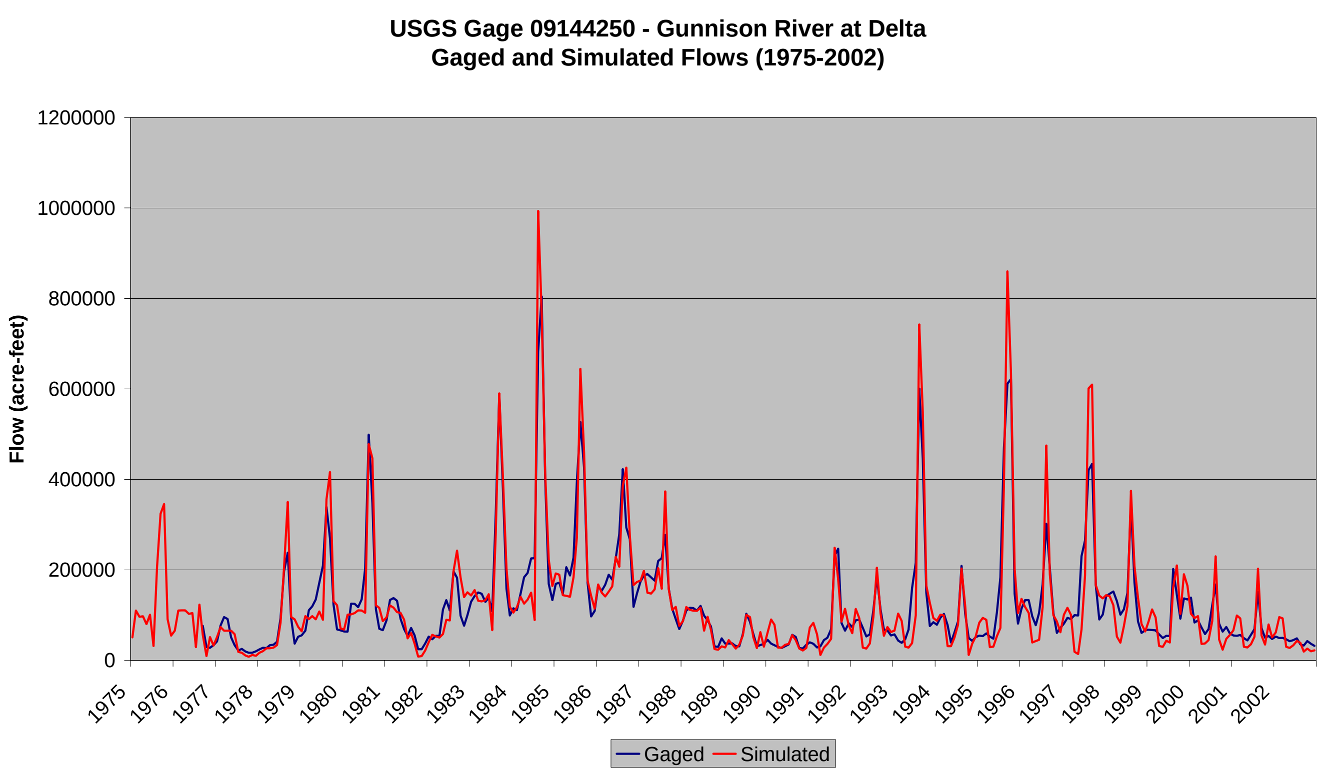
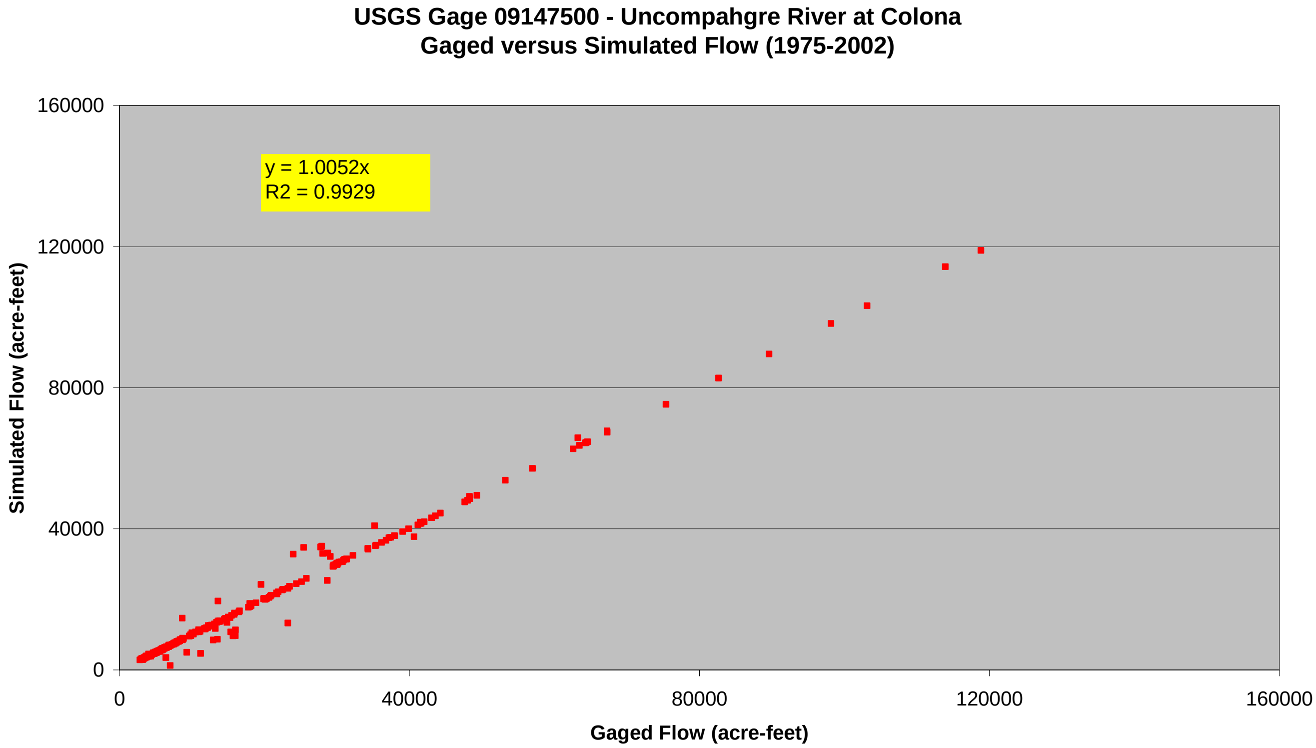


Figure 7.8 Streamflow Calibration – Gunnison River at Delta



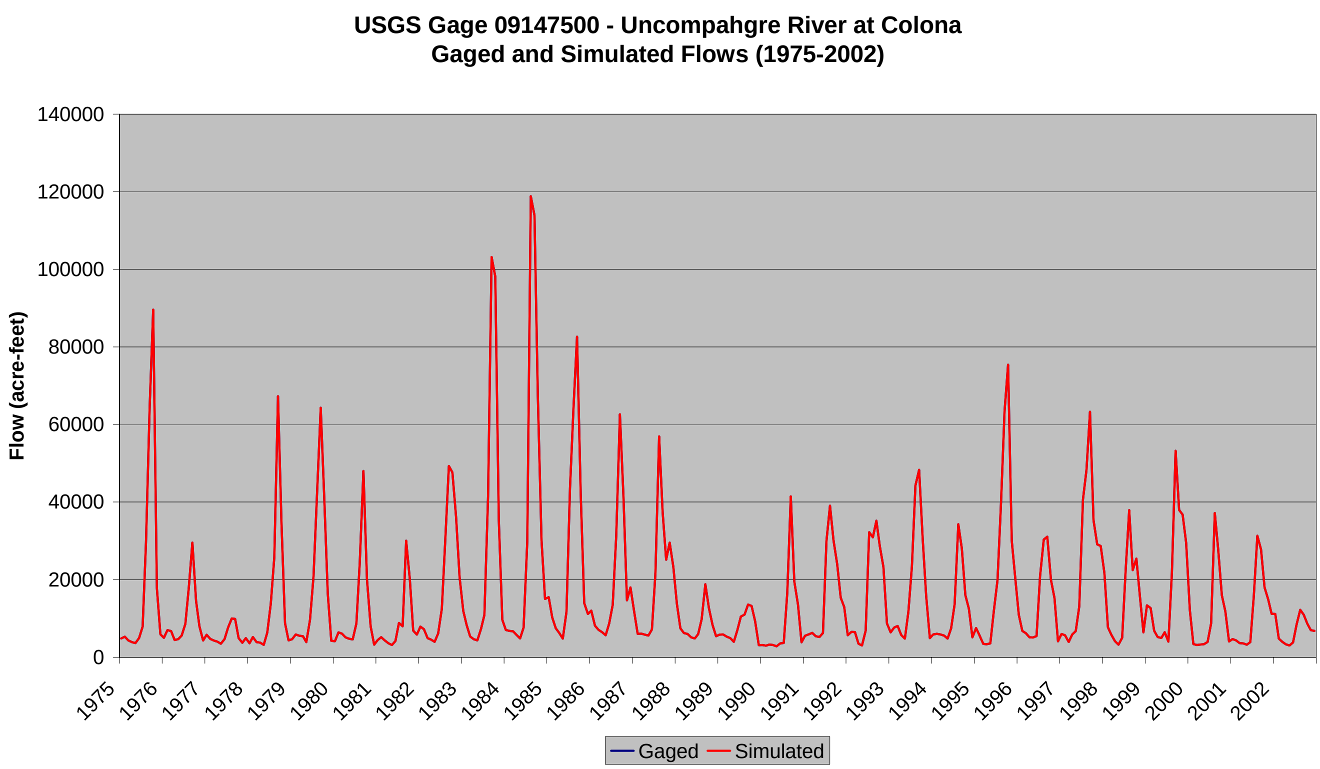
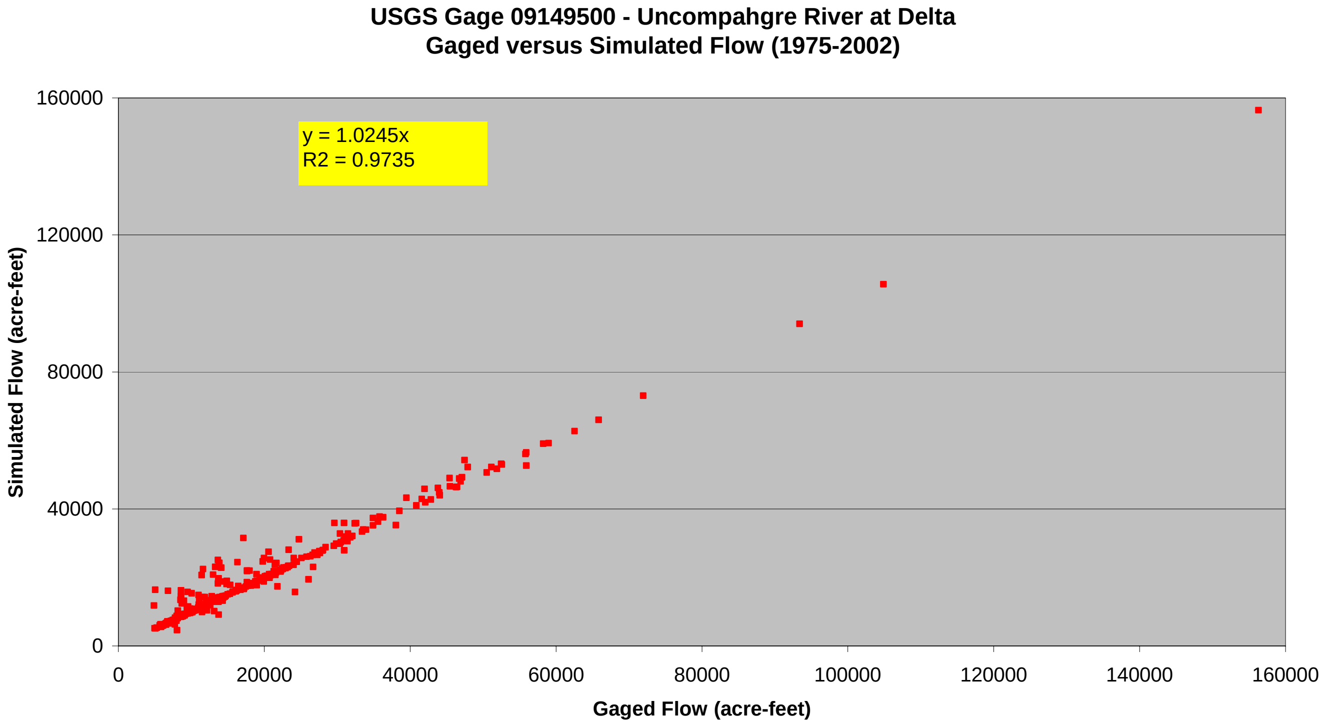


Figure 7.9 Streamflow Calibration – Uncompahgre River at Colona



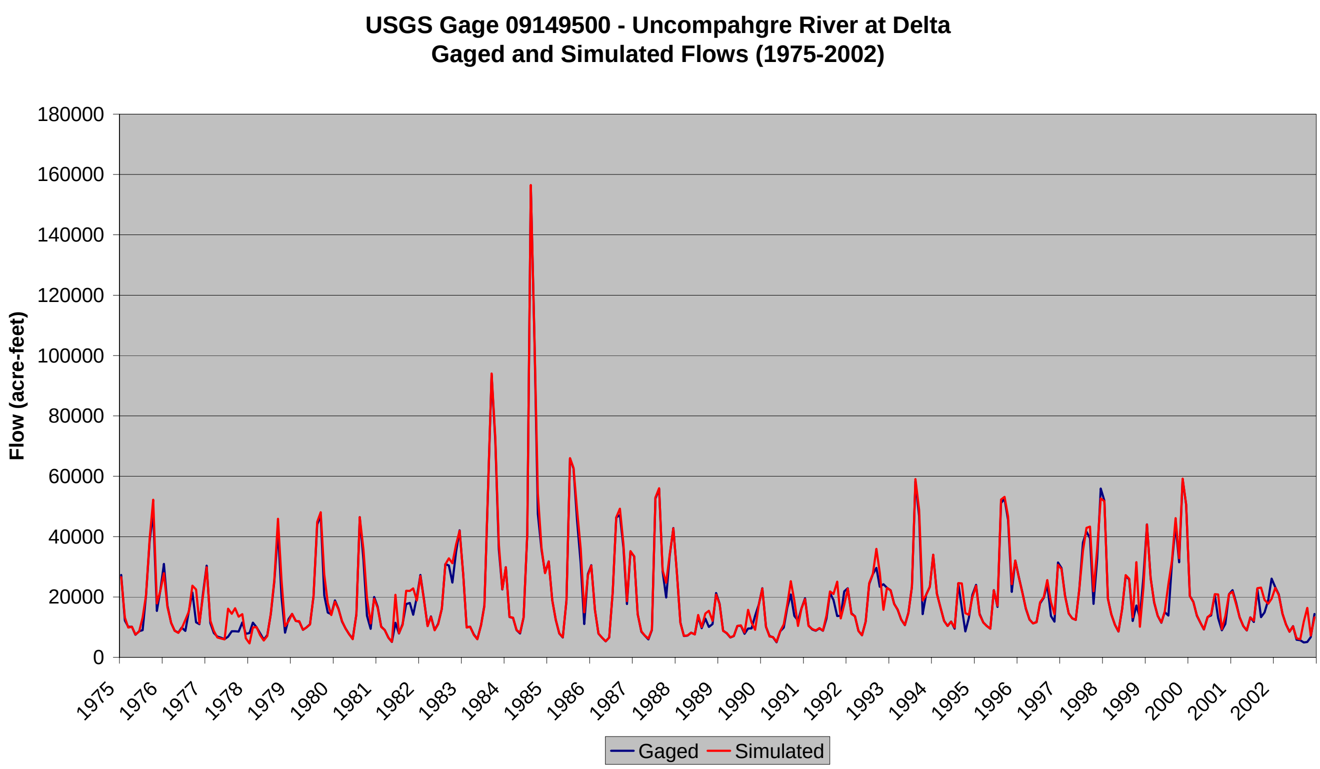
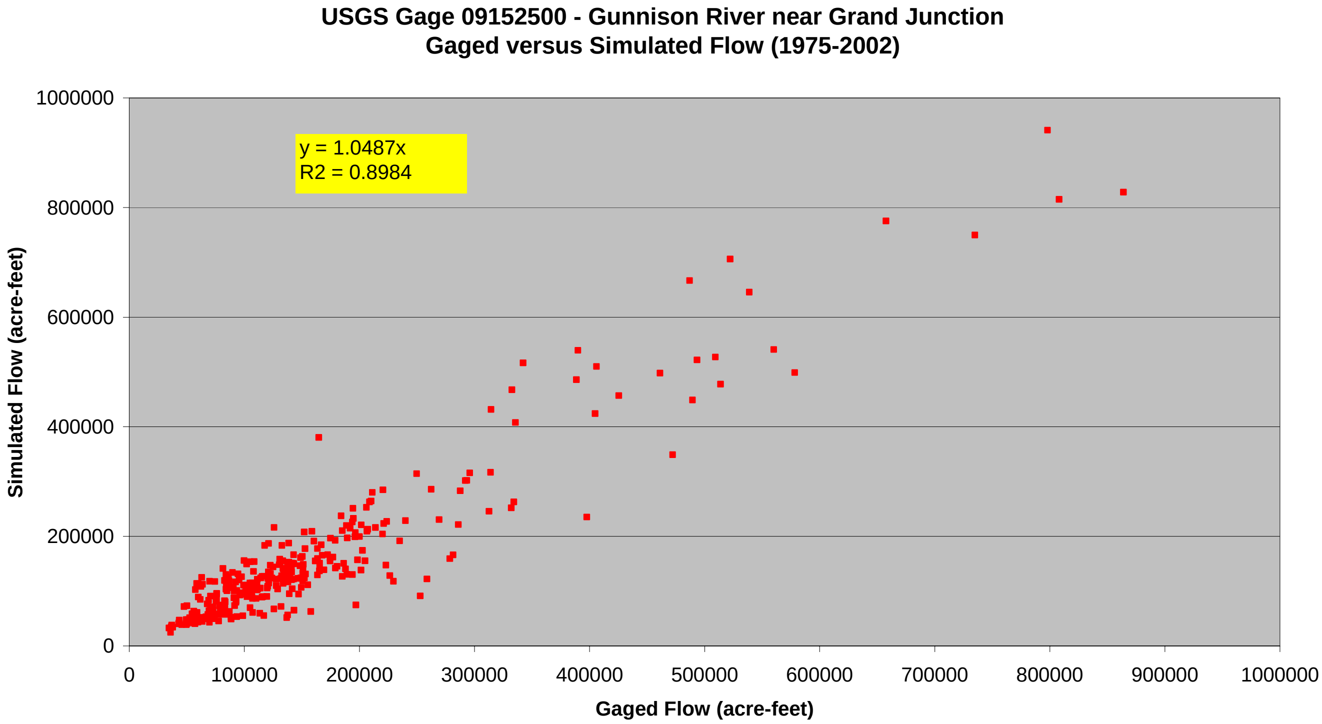


Figure 7.10 Streamflow Calibration – Uncompahgre River at Delta



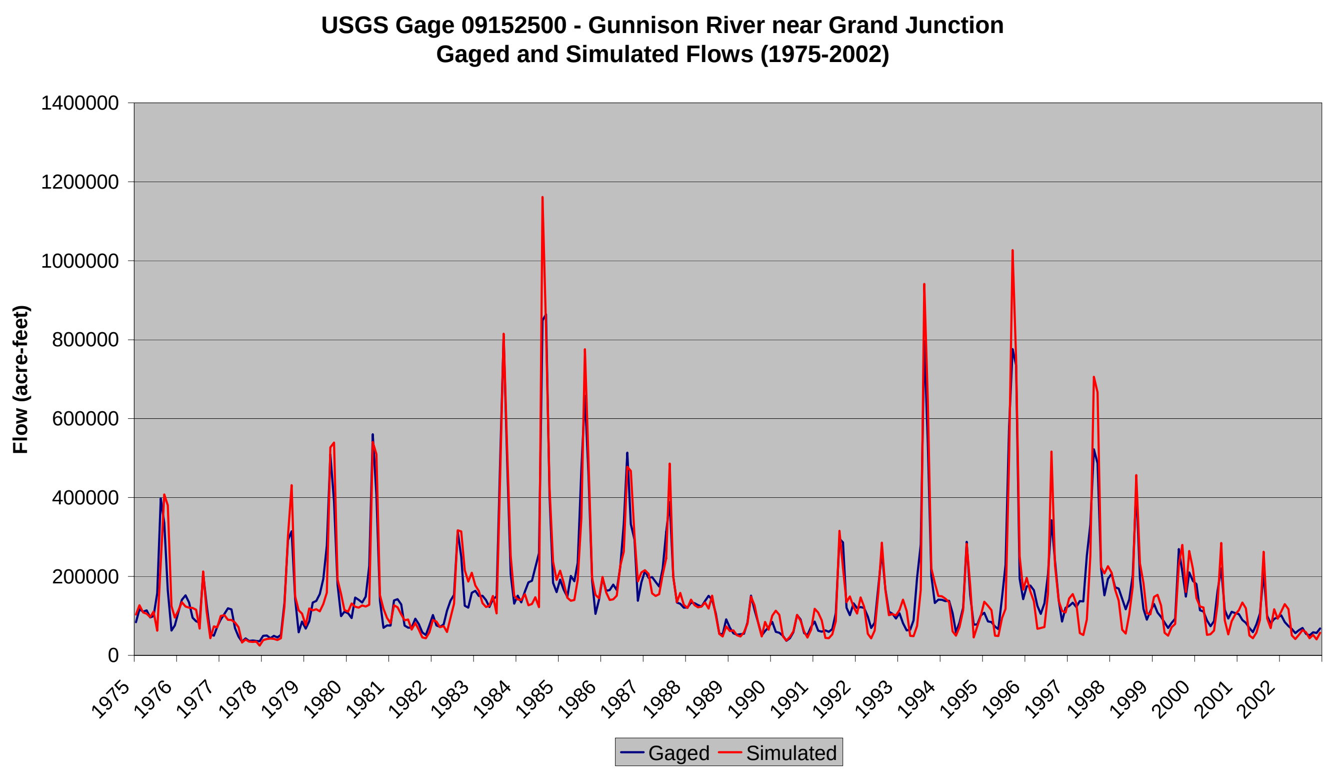


Figure 7.11 Streamflow Calibration – Gunnison River near Grand Junction

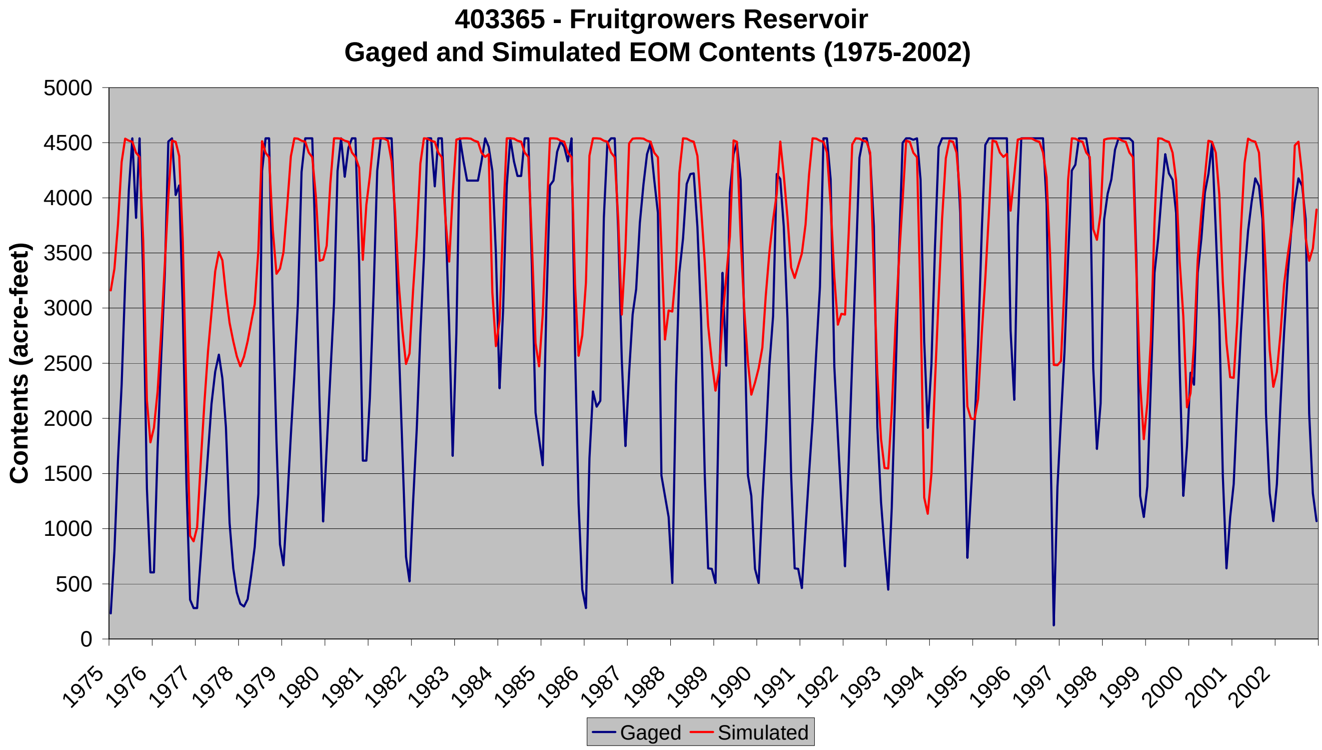


Figure 7.12 Reservoir Calibration – Fruitgrowers Reservoir

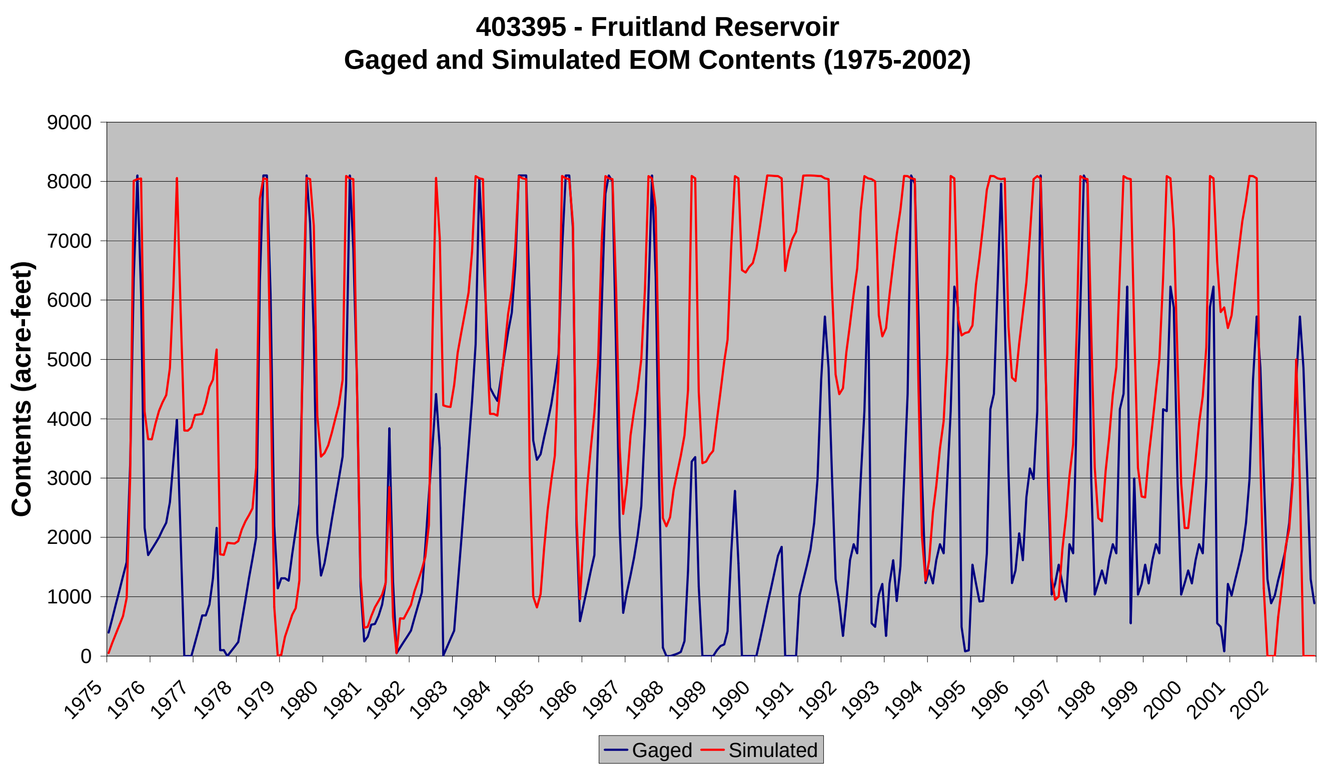


Figure 7.13 Reservoir Calibration – Fruitland Reservoir

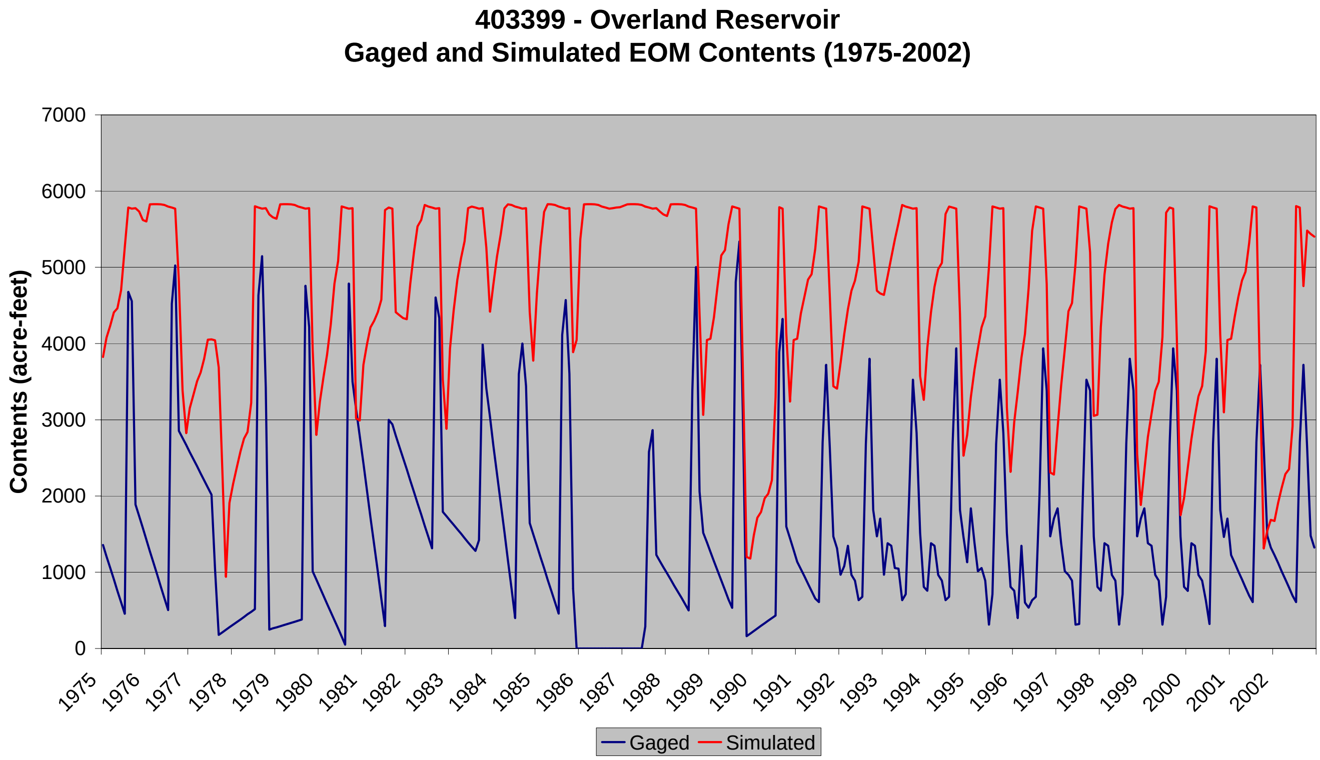


Figure 7.14 Reservoir Calibration – Overland Reservoir

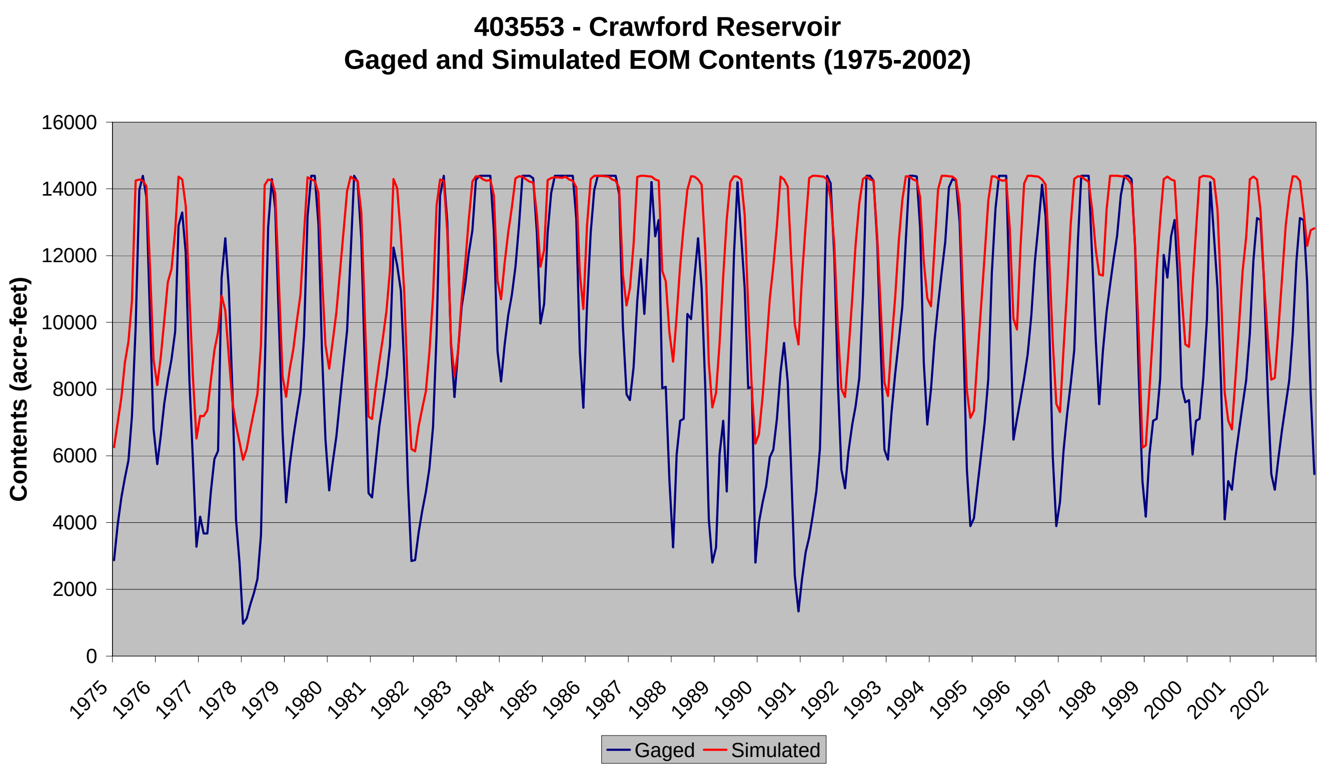


Figure 7.15 Reservoir Calibration – Crawford Reservoir

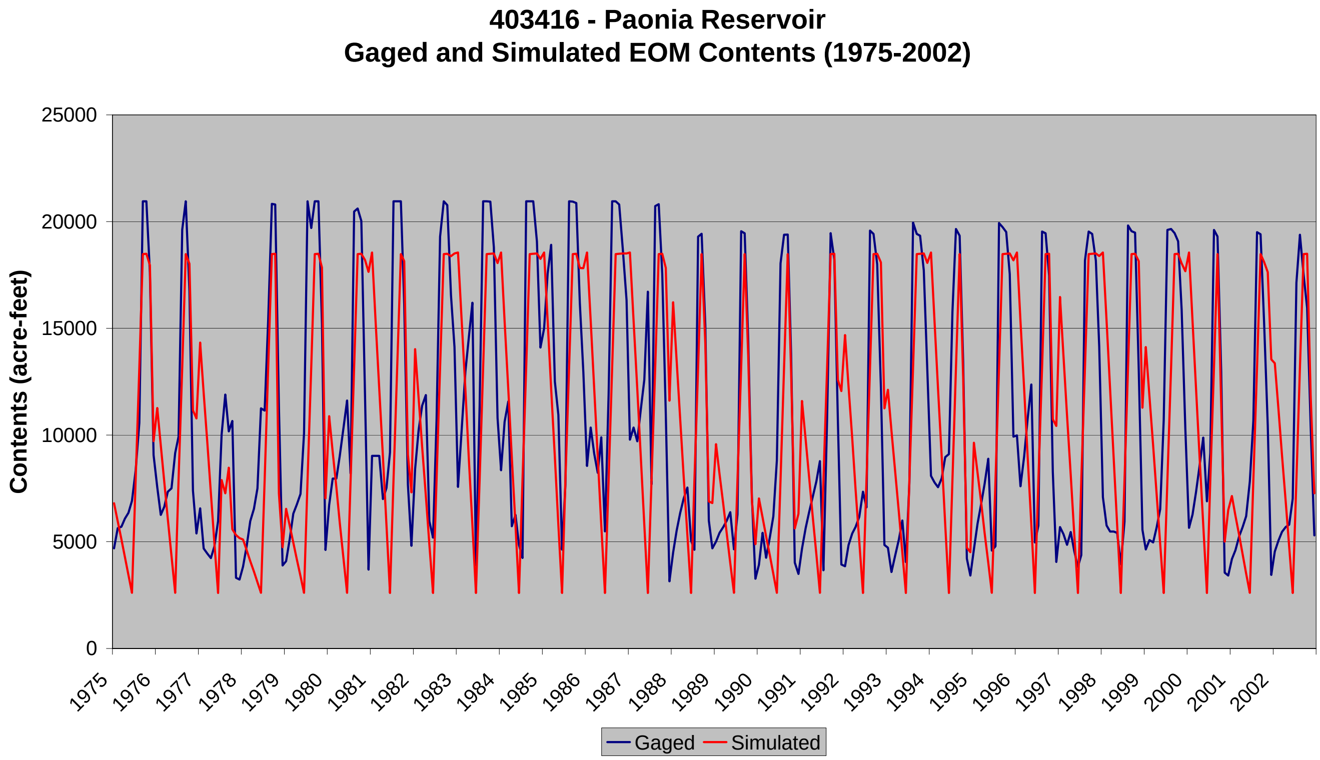


Figure 7.16 Reservoir Calibration – Paonia Reservoir

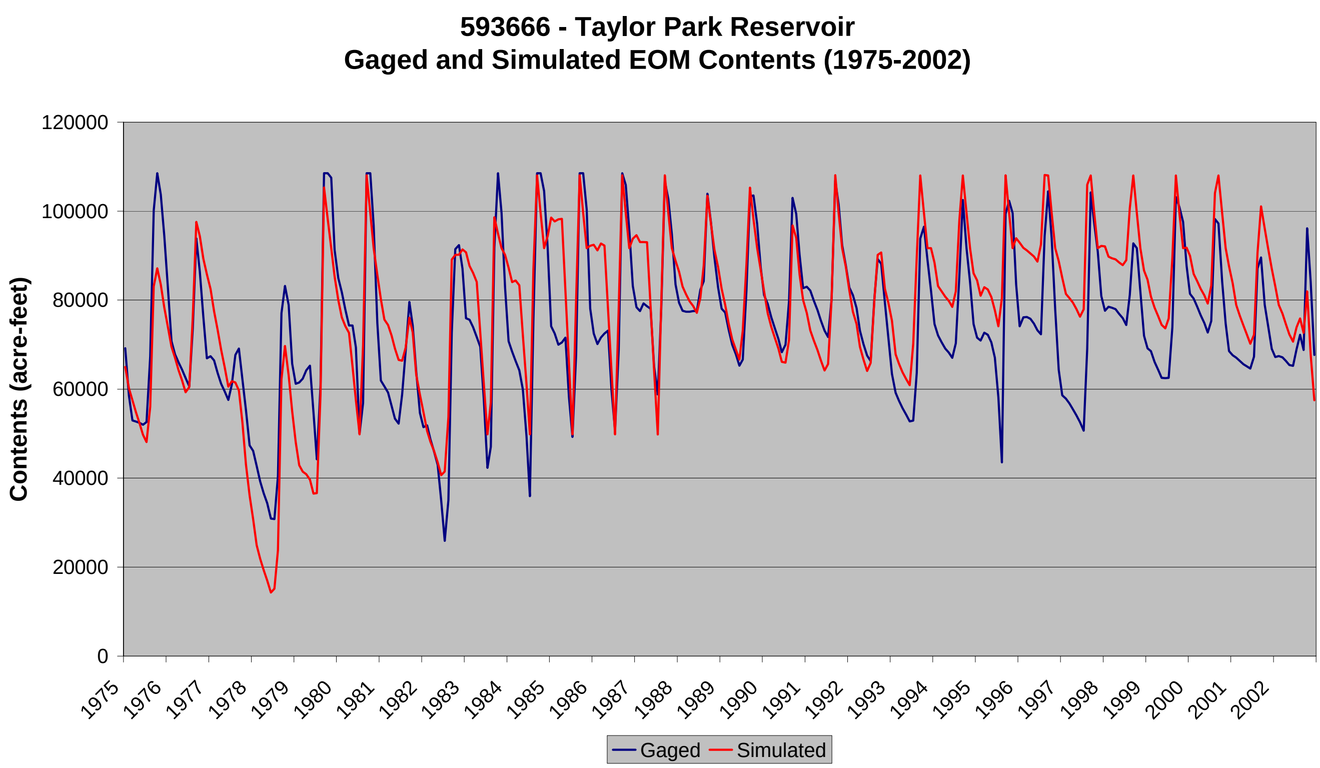


Figure 7.17 Reservoir Calibration – Taylor Park Reservoir

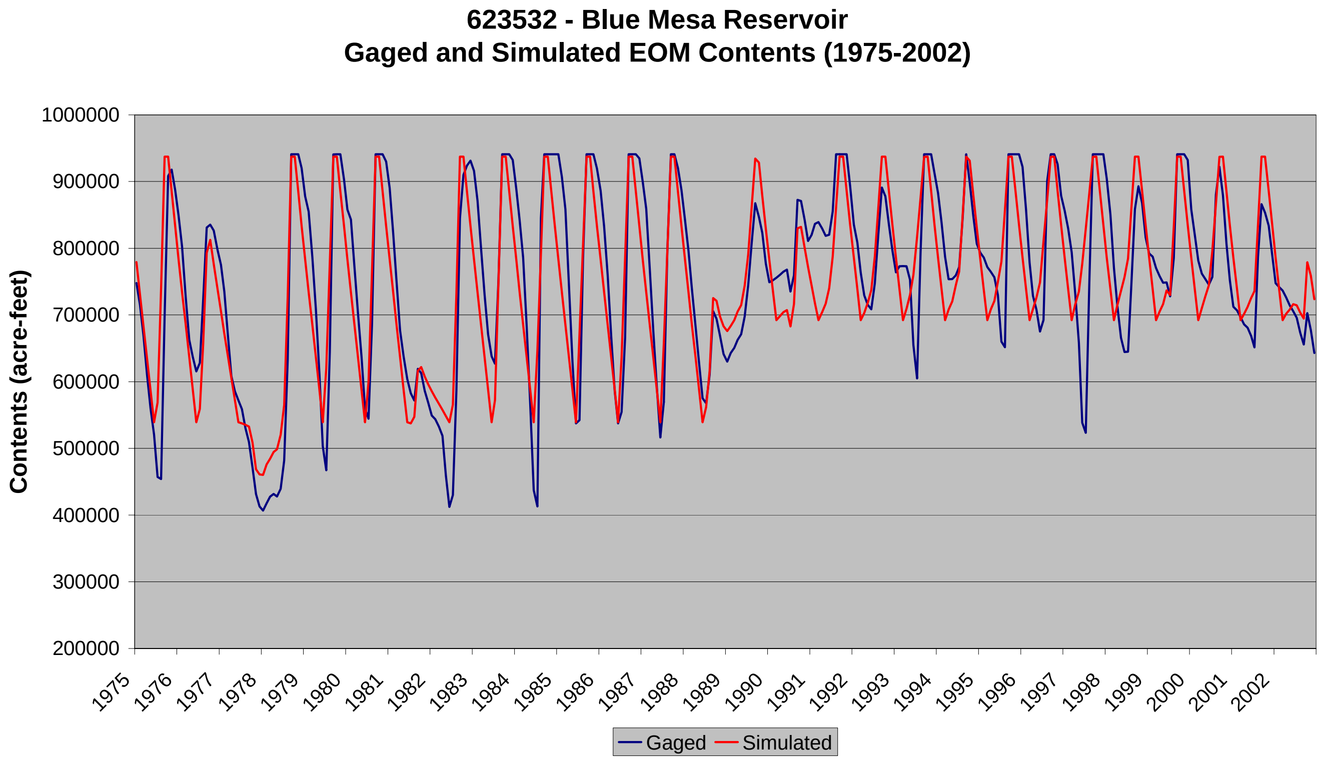


Figure 7.18 Reservoir Calibration – Blue Mesa Reservoir

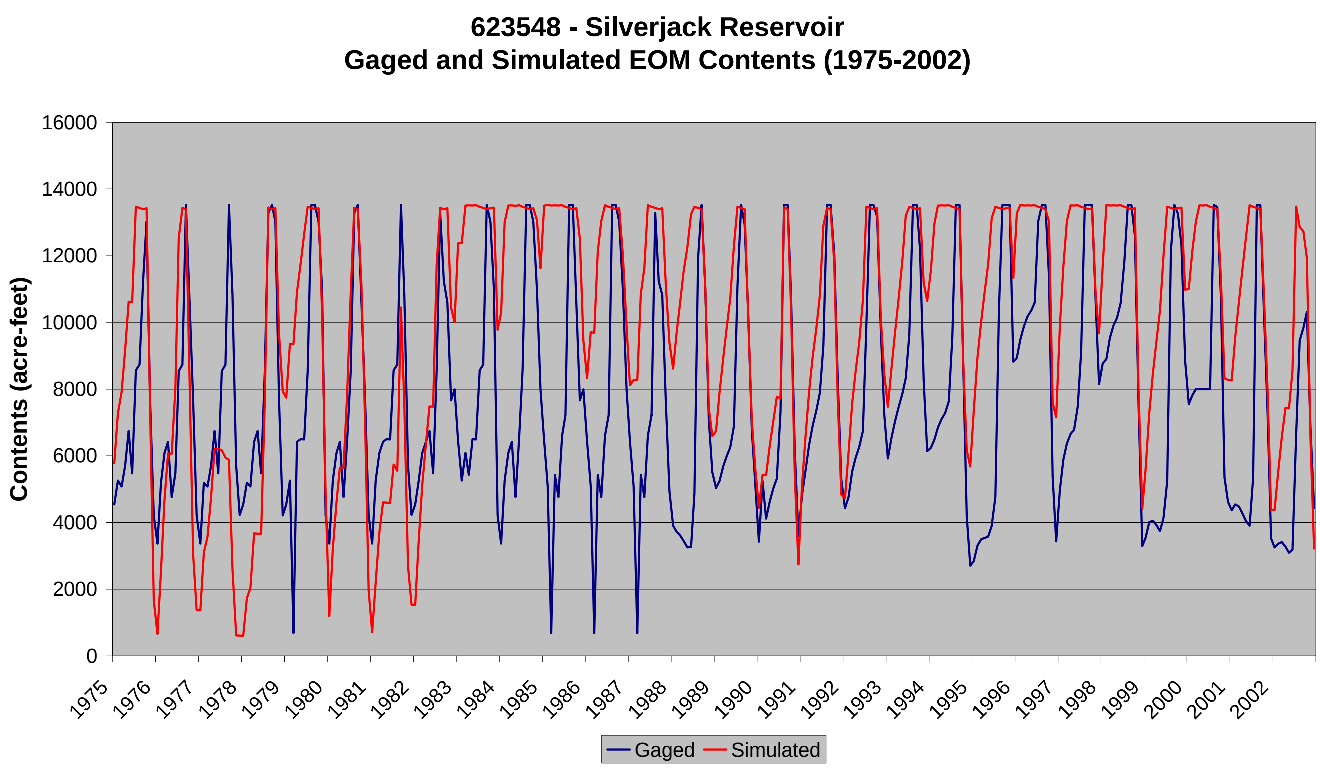


Figure 7.19 Reservoir Calibration – Silverjack Reservoir

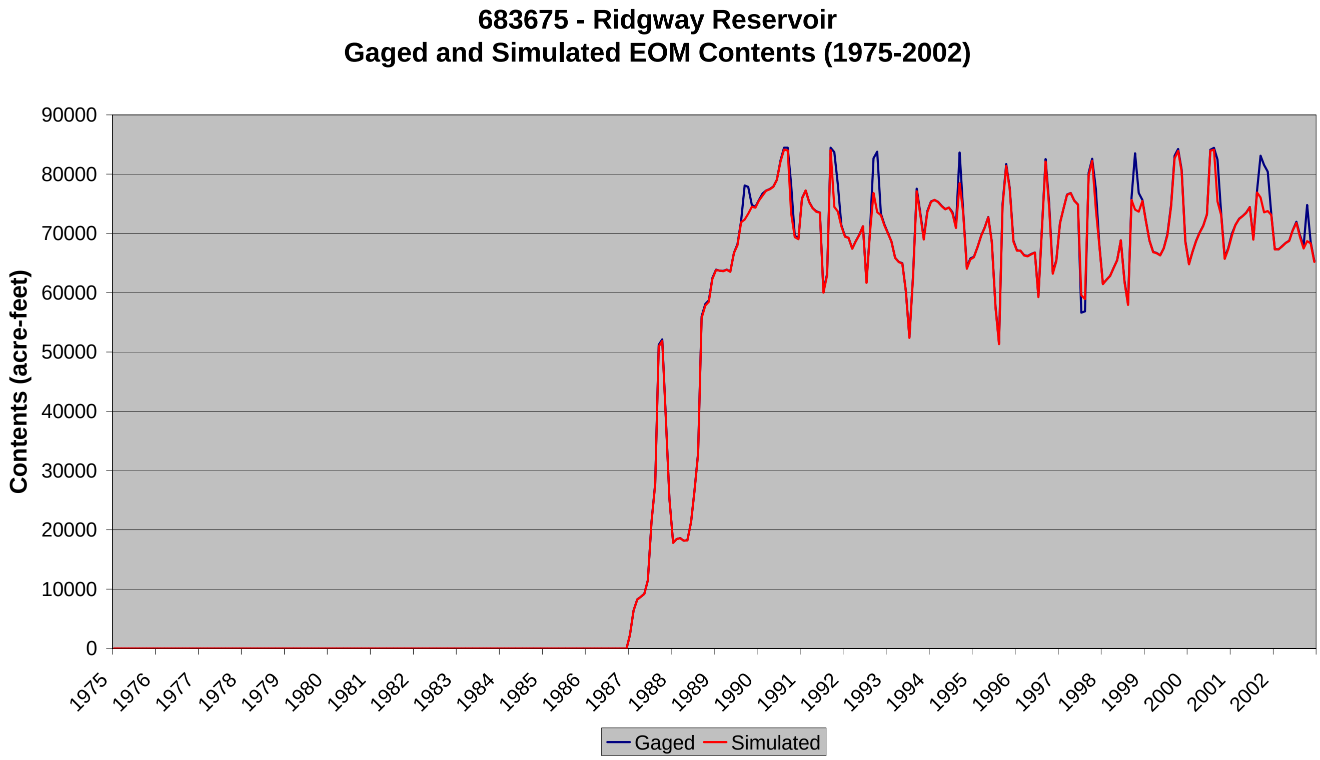


Figure 7.20 Reservoir Calibration – Ridgway Reservoir

8. Daily Baseline Results

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 2002. 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 subbasins throughout the Gunnison 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 Gunnison River water resources planning 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 Gunnison 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 (gunndlyB.rps) 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. The file *GunnV.dum* is an empty dummy file, and is referenced in the response file for all the StateMod input file types that are not needed for this particular simulation.

File Name	Description	Reference
gunndlyB.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 8.1.2
gunnV.rin	River network file – lists every model node and specifies connectivity of network	Section 5.3.1
gunnVB.res	Reservoir station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1 & Section 8.1.4
gunnV.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
gunndly.ris	River station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 8.1.3
gunnV.ifs	Instream flow station file – lists instream flow reaches	Section 5.7.1
gunnVH.dum	Well station file (not used in the Gunnison model)	N/a
gunnV.ifr	Instream flow right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches	Section 5.7.3
gunnV.rer	Reservoir rights file – lists storage rights for all reservoirs	Section 5.6.5
gunnVC.ddr	Direct diversion rights file – lists water rights for direct diversion	Section 5.4.5
gunnVB.opr	Operational rights file – specifies many different kinds of operations that are more complex than a direct diversion or an onstream storage right. Operational rights can 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 is not downstream, or a direct diversion to fill a reservoir via a feeder	Section 5.8
gunnVH.dum	Well rights file (not used in the Gunnison model)	N/a
gunnVH.dum	Precipitation file – Annual (not used in the Gunnison model)	N/a
gunnF.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
gunnVx.xbm	Baseflow data file – time series of undepleted flows at all nodes listed in *gunnV.ris*	Section 5.3.5
gunnVB.ddm	Monthly demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
gunnVH.dum	DD demand overwrite file – Monthly (not used in the Gunnison model)	N/a
gunnVH.dum	DD demand file – Annual (not used in the Gunnison model)	N/a
gunnV.ifa	Instream flow demand file – gives the decreed monthly instream flow rates	Section 5.7.2

File Name	Description	Reference
gunnVH.dum	Well demand file (not used in the Gunnison model)	N/a
crdss.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
gunnVB.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
gunnV.tsp	CU Time series file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
gunnV.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3
gunnV.par	Soil Parameter file – soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
gunnV.eom	Reservoir End of month contents file – Monthly time series of historical reservoir contents	Section 5.6.3
gunnV.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
gunnV.rih	Historical streamflow file – Monthly time series of streamflows at modeled gages	Section 5.3.4
gunnV.ddh	Historical Diversions – Monthly time series of historical diversions	Section 5.4.3
gunnVH.dum	Historical well pumping (not used in the Gunnison model)	N/a
gunnF.gis	GIS file	N/a
gunndly.xou	Output control file	N/a
gunndly.rid	Daily historical streamflow file	Section 8.1.3
gunnVH.dum	Daily direct flow demand file (not used in the Gunnison model)	N/a
gunnVH.dum	Daily instream flow demand file (not used in the Gunnison model)	N/a
gunnVH.dum	Daily well demand file (not used in the Gunnison model)	N/a
gunnVH.dum	Daily reservoir target file (not used in the Gunnison model)	N/a
crdss.dld	Daily return flow delay pattern file	Section 8.1.5
gunndly.rid	Daily historical streamflow file	Section 8.1.3
gunnvH.dum	Daily historical diversion file (not used in the Gunnison model)	N/a
gunnVH.dum	Historical reservoir end-of-day content file (not used in the Gunnison model)	N/a

8.1.2. Control File

The control file, which is created and maintained by editing manually, contains information that controls the model simulation. Only one change was made to the monhly Baseline control file. 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 simulations; the river station file (gunndly.ris) and the daily streamflow file (gunndly.rid). The river station file assigns each baseflow node to a representative historical streamflow gage with daily flow records in the daily streamflow file. Representative streamflow gages were identified based on the following criteria:

- Completeness of Daily Records. The streamflow gages within the Gunnison Model were reviewed for completeness of daily records over the 1975 through 2002 study period. Note that although the recommended daily modeling period for the CRDSS basins is 1975 through 2002, many streamflow gages in the Gunnison 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 Gunnison 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 streamflow file (*.rid) contains daily streamflows extracted from HydroBase for these gages. 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 Gunnison River Sub-basins

Recommended Pattern Gage	Gage Period of Record	Basin Subdivision Assignment
09112500 - East River at Almont	1910 to 1922 1935 to current	East, Taylor, Slate, Cement, Ohio, and Castle Creeks (District 59), and the mainstem Gunnison
09119000 - Tomichi Creek at Gunnison	1938 to current	Tomichi Creek (District 28)
09124500 - Lake Fork at Gateway	1938 to current	Lake Fork, Cimarron, and Cebolla Creeks (District 62)
09132500 - North Fork Gunnison River near Somerset	1934 to current	E. Muddy, W. Muddy, North Fork, Smith Fork, Iron, Alum, Virginia, and Crystal Creeks (Portion of District 40)
09143500 - Surface Creek at Cedaredge	1918 to current	Surface, Currant, Kannah, and Lereaux Creeks, along with the Fruit Growers Area (Portion of District 40)
09146200 - Uncompahgre River near Ridgeway	1959 to current	Uncompahgre River (Districts 41 & 68)

Where to find more information

- Documentation for **makenet** 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 Gunnison modeling efforts.

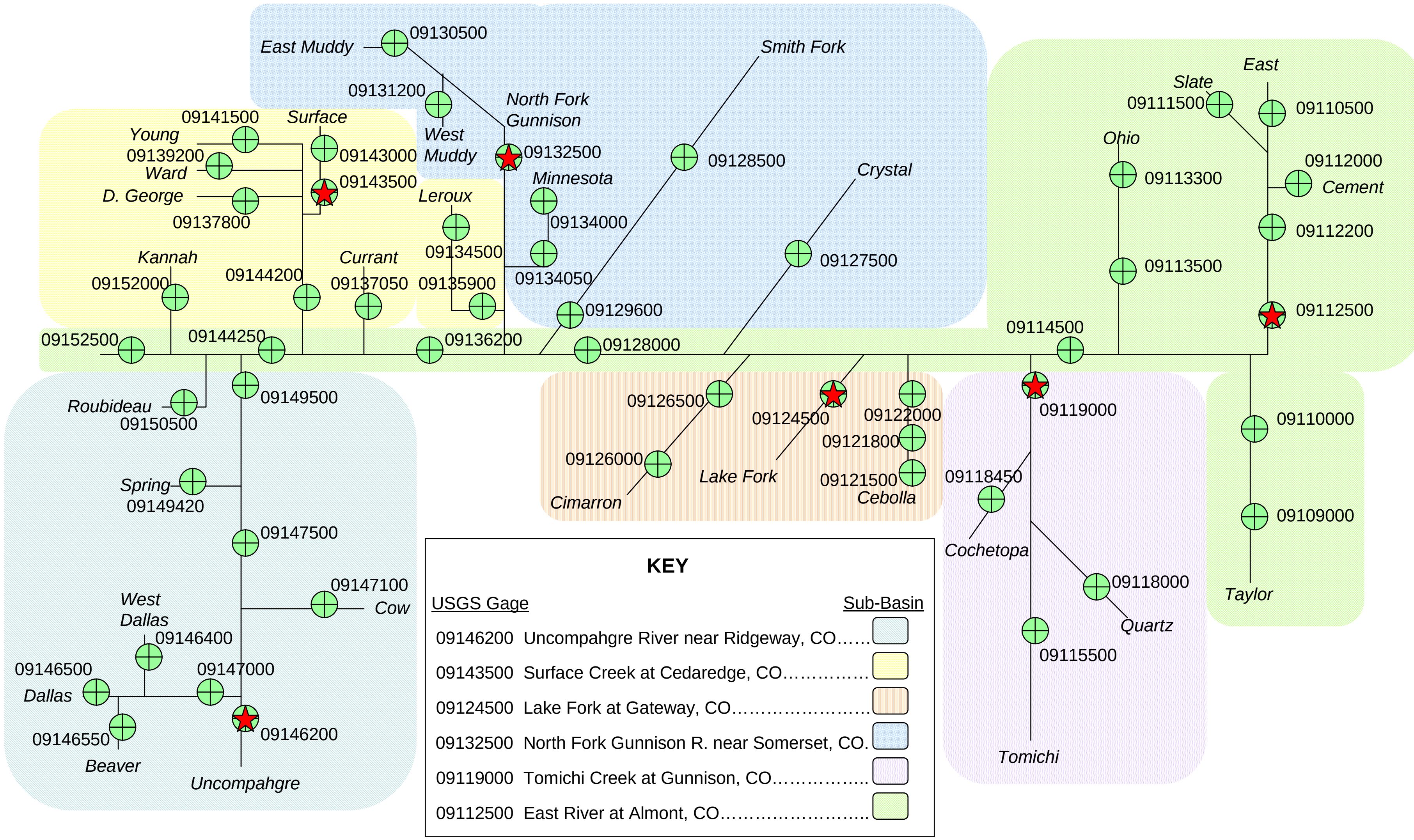


Figure 8.1 – Recommended Application of Daily Pattern Gages

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 (gunnV.dds). This flag instructs StateMod, while in daily simulation mode, to disaggregate the monthly diversion demands found in the diversion demand file (gunnVB.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 (gunnVB.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 (gunnVB.tar).

The daily flag variable (*cifrdy*) was set equal to "0" for all instream flow nodes in the instream flow station file (gunnV.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 (gunnV.ifa) 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 crdss.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, 2003. *(Technical Papers)*

8.2 Daily Baseline Streamflows

Table 8.1 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 2002). 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. In general, available flow is greater for the Daily Baseline simulation than the Monthly Baseline simulation. Daily simulation better represents large flow events that occur within a monthly time step, and 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 8.1 through 8.27 for three selected years for each of the daily pattern gages and for three downstream gages; Gunnison River below Gunnison Tunnel, Uncompahgre River at Delta, and Gunnison River near Grand Junction. The selected years represent wet (1995), average (1982) and dry (1977) years in the Gunnison 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, however, annual basin-wide Baseline demands are about 5 percent lower than historic demands. Simulated flows at the pattern gages, which are not affected by storage, are similar to gaged flows with slight monthly variations. However, simulated flows at gages below the major Aspinall unit reservoirs and below UVWUA canals vary significantly from gaged flows during the spring and summer months. As discussed in the daily Baseline comparison (Appendix E), these gages are affected by the reservoir forecasting curve provided by the USBR to mimic general operations. It is clear that the rule curve is used only as a guideline by the USBR, and operations change during extreme hydrologic years.

In the daily modeling efforts, the release to target rule used to mimic hydropower operations uses a monthly storage target. At this time, there appears to be a discrepancy between the releases to this monthly target on the first day of each simulated year (October 1) compared to the releases to this monthly target for the remaining months in the year. This is particularly noticeable downstream of Blue Mesa Reservoir, due to the relatively large amount of monthly target releases. Therefore, as shown on Figures 8.7, 8.9, 8.25, and 8.27, in some years large flows are seen at the downstream gages on October 1. It is important to note that this “spike” flow does not affect overall results or usefulness of the model. It is expected that future StateMod code enhancements will correct this discrepancy.

During the representative dry year, annual basin-wide Baseline demands are about 20 percent higher than historic demands. Simulated flows at the pattern gages, which are not affected by storage, are greater than gaged flows, as water is called through the tributaries for senior diverters downstream. However, simulated flows at gages below the major Aspinall unit reservoirs and below UVWUA canals are lower during much of the irrigation season, as less reservoir water is available to meet the higher demands. Again, these gages are affected by the forecasting curves used to mimic USBR operations, which likely change during extreme hydrologic years.

Table 8.2
Baseline Average Annual Flows for Gunnison model Gages (1975-2002)
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)	% Different
9109000	Taylor River Below Taylor Park Reservoir	44,970	43,417	1,553	3%
9110000	Taylor River at Almont	54,522	52,928	1,594	3%
9110500	East River Near Crested Butte	80,043	71,205	8,838	11%
9111500	Slate River Near Crested Butte	75,541	68,384	7,157	9%
9112000	Cement Creek Near Crested Butte	14,694	13,394	1,300	9%
9112200	East River Below Cement Creek NR Crested Butte	167,521	158,510	9,011	5%
9112500	East River at Almont	176,646	167,806	8,840	5%
9113300	Ohio Creek at Baldwin	28,910	25,908	3,002	10%
9113500	Ohio Creek Near Baldwin	41,126	36,712	4,414	11%
9114500	Gunnison River Near Gunnison	358,489	350,736	7,753	2%
9115500	Tomichi Creek at Sargents	17,635	14,869	2,766	16%
9118000	Quartz Creek Near Ohio City	23,795	20,142	3,653	15%
9118450	Cochetopa Creek Below Rock Creek Near Parlin	16,312	13,882	2,430	15%
9119000	Tomichi Creek at Gunnison	94,073	84,885	9,188	10%
9121500	Cebolla Creek Near Lake City	9,845	8,148	1,697	17%
9121800	Cebolla Creek Near Powderhorn	31,482	26,837	4,645	15%
9122000	Cebolla Creek at Powderhorn	45,573	39,443	6,130	13%
9124500	Lake Fork at Gateview	127,555	118,502	9,053	7%
9126000	Cimarron River Near Cimarron	31,875	30,026	1,849	6%
9126500	Cimarron River at Cimarron	70,871	64,106	6,765	10%
9127500	Crystal Creek Near Maher	9,215	5,775	3,440	37%
9128000	Gunnison River Below Gunnison Tunnel	585,850	591,024	-5,174	-1%
9128500	Smith Fork Near Crawford	12,442	12,023	419	3%

Gage ID	Gage Name	Daily Simulated Available Flow (af)	Monthly Simulated Available Flow (af)	Difference Daily less Monthly (af)	% Different
9129600	Smith Fork Near Lazear	22,308	21,489	819	4%
9130500	East Muddy Creek Near Bardine	59,984	59,576	408	1%
9131200	West Muddy Creek Near Somerset	18,395	18,096	299	2%
9132500	North Fork Gunnison River Near Somerset	277,018	274,290	2,728	1%
9134000	Minnesota Creek Near Paonia	7,347	7,014	333	5%
9134050	Minnesota Creek at Paonia	8,966	8,568	398	4%
9134500	Leroux Creek Near Cedaredge	14,511	13,614	897	6%
9135900	Leroux Creek at Hotchkiss	19,590	18,921	669	3%
9136200	Gunnison River Near Lazear	1,068,386	1,081,492	-13,106	-1%
9137050	Currant Creek Near Read	8,117	9,071	-954	-12%
9137800	Dirty George Creek Near Grand Mesa	1,456	1,031	425	29%
9139200	Ward Creek Near Grand Mesa	5,528	4,342	1,186	21%
9141500	Youngs Creek Near Cedaredge	2,166	1,666	500	23%
9143000	Surface Creek Near Cedaredge	6,789	5,431	1,358	20%
9143500	Surface Creek at Cedaredge	6,796	5,439	1,357	20%
9144200	Tongue Creek at Cory	39,176	38,698	478	1%
9144250	Gunnison River at Delta	1,210,914	1,228,366	-17,452	-1%
9146200	East Fork Dallas Creek Near Ridgway	73,004	71,521	1,483	2%
9146400	Dallas Creek Near Ridgway	4,998	4,430	568	11%
9146500	Beaver Creek Near Ridgway	9,438	8,482	956	10%
9146550	West Fork Dallas Creek Near Ridgway	1,578	1,249	329	21%
9147000	Uncompahgre River Near Ridgway	20,960	19,433	1,527	7%
9147100	Cow Creek Near Ridgway	36,569	34,693	1,876	5%
9147500	Uncompahgre River at Colona	91,041	89,754	1,287	1%
9149420	Spring Creek Near Montrose	34,728	32,450	2,278	7%

Gage ID	Gage Name	Daily Simulated Available Flow (af)	Monthly Simulated Available Flow (af)	Difference Daily less Monthly (af)	% Different
9149500	Uncompahgre River at Delta	235,864	236,195	-331	0%
9150500	Roubideau Creek at Mouth, Near Delta	95,384	95,040	344	0%
9152000	Kannah Creek Near Whitewater	8,948	8,432	516	6%
9152500	Gunnison River Near Grand Junction	1,328,742	1,348,642	-19,900	-1%

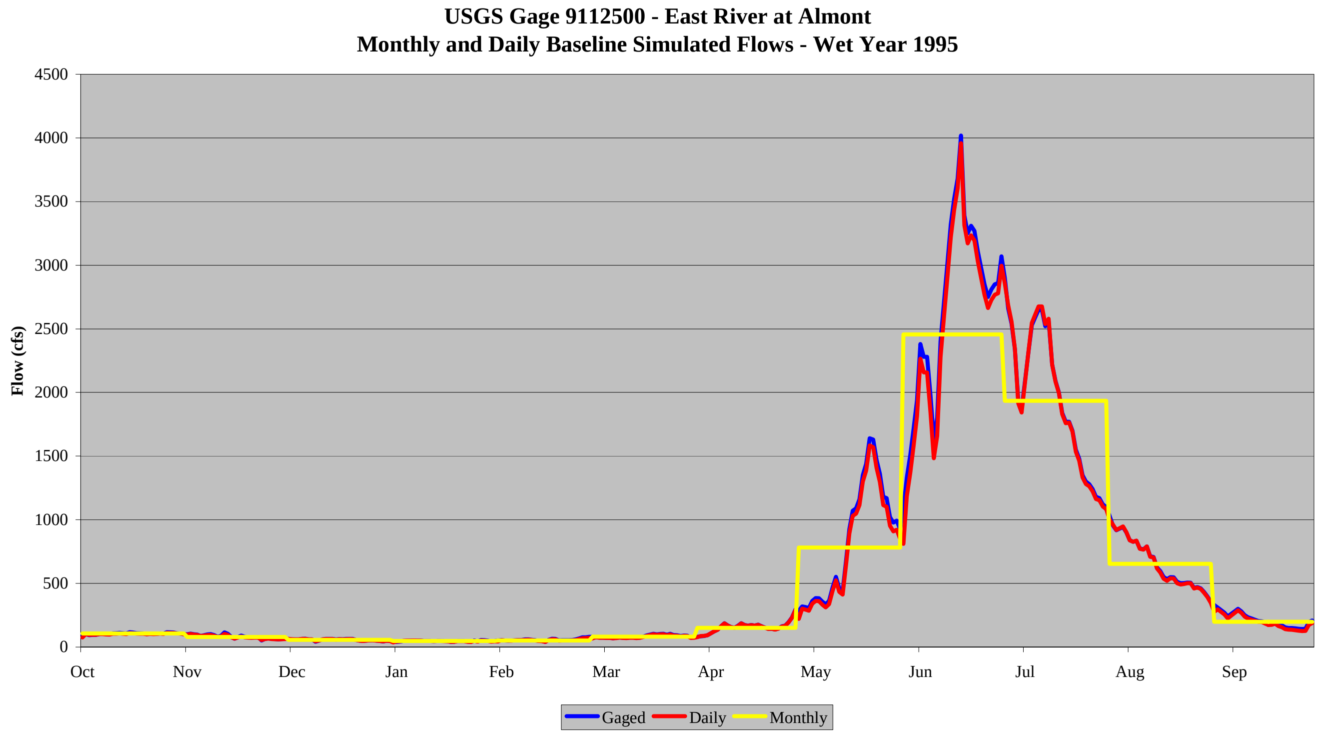


Figure 8.2 Daily Baseline Comparison, Wet Year – East River at Almont

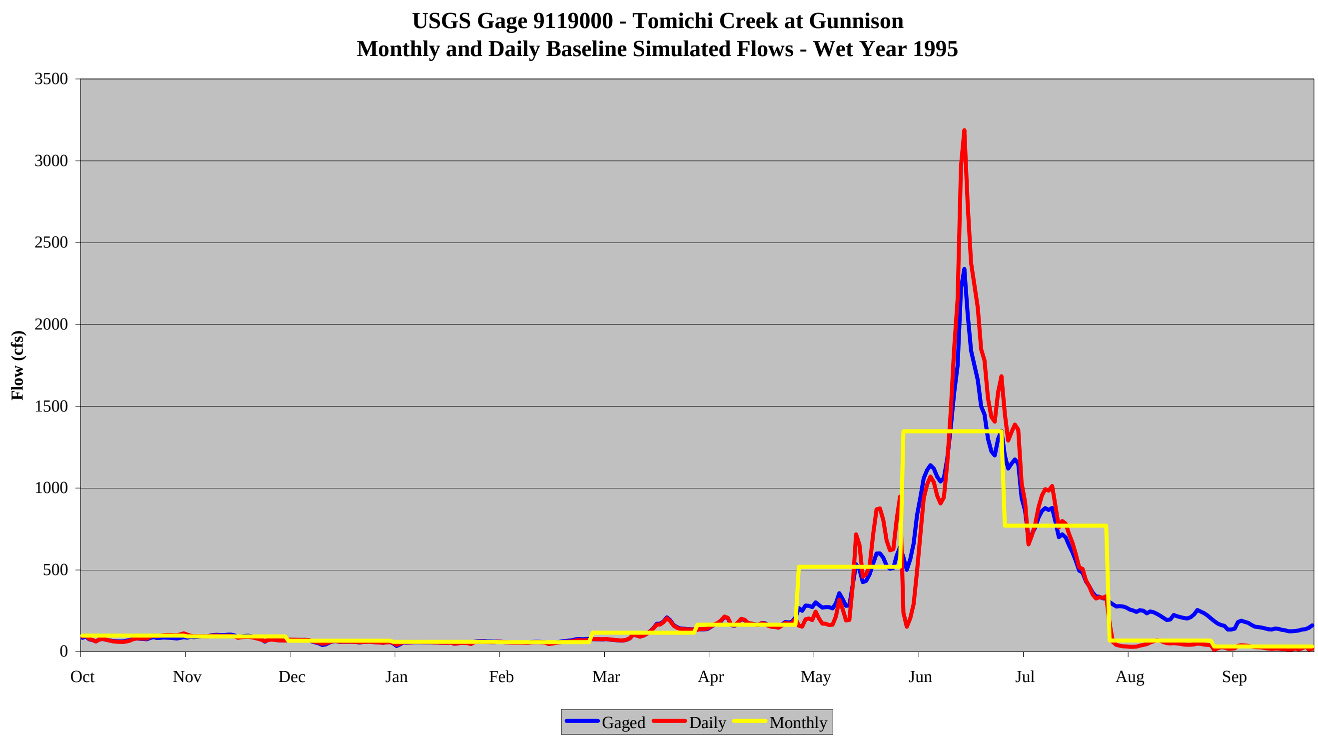


Figure 8.3 Daily Baseline Comparison, Wet Year – Tomichi Creek at Gunnison

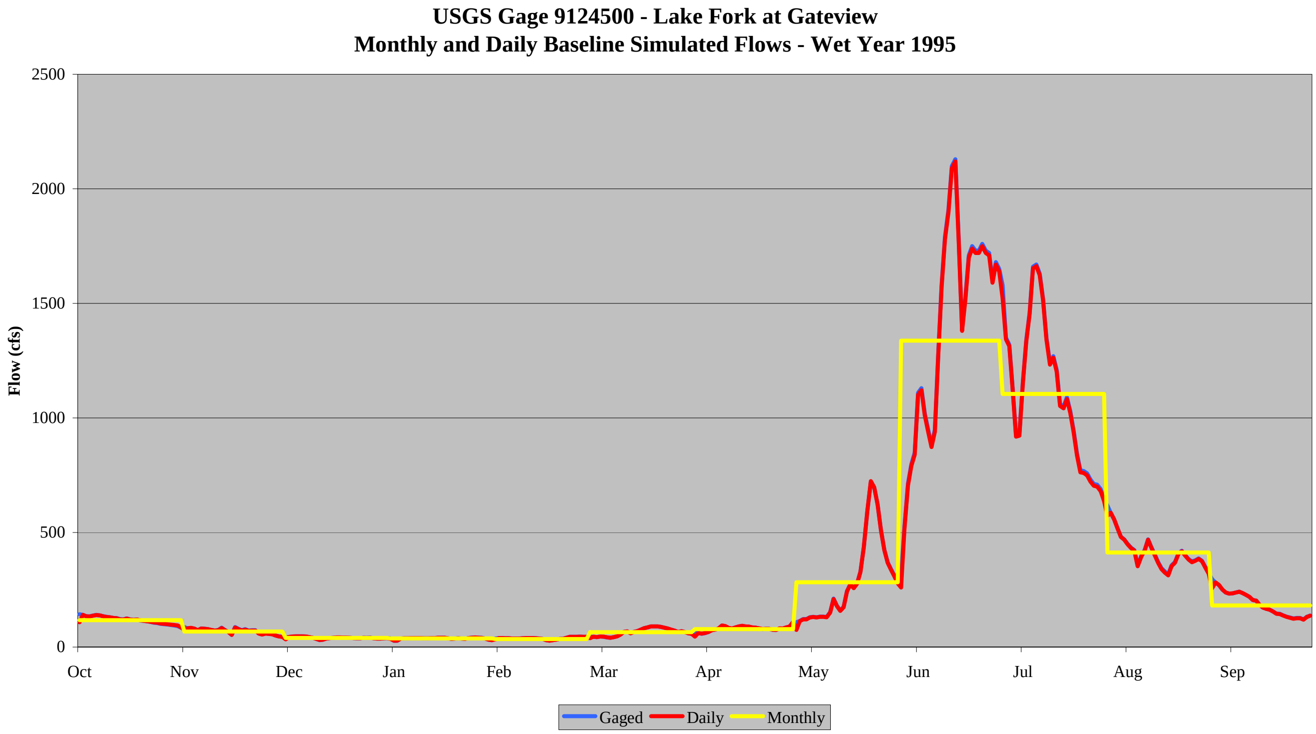


Figure 8.4 Daily Baseline Comparison, Wet Year – Lake Fork at Gateview

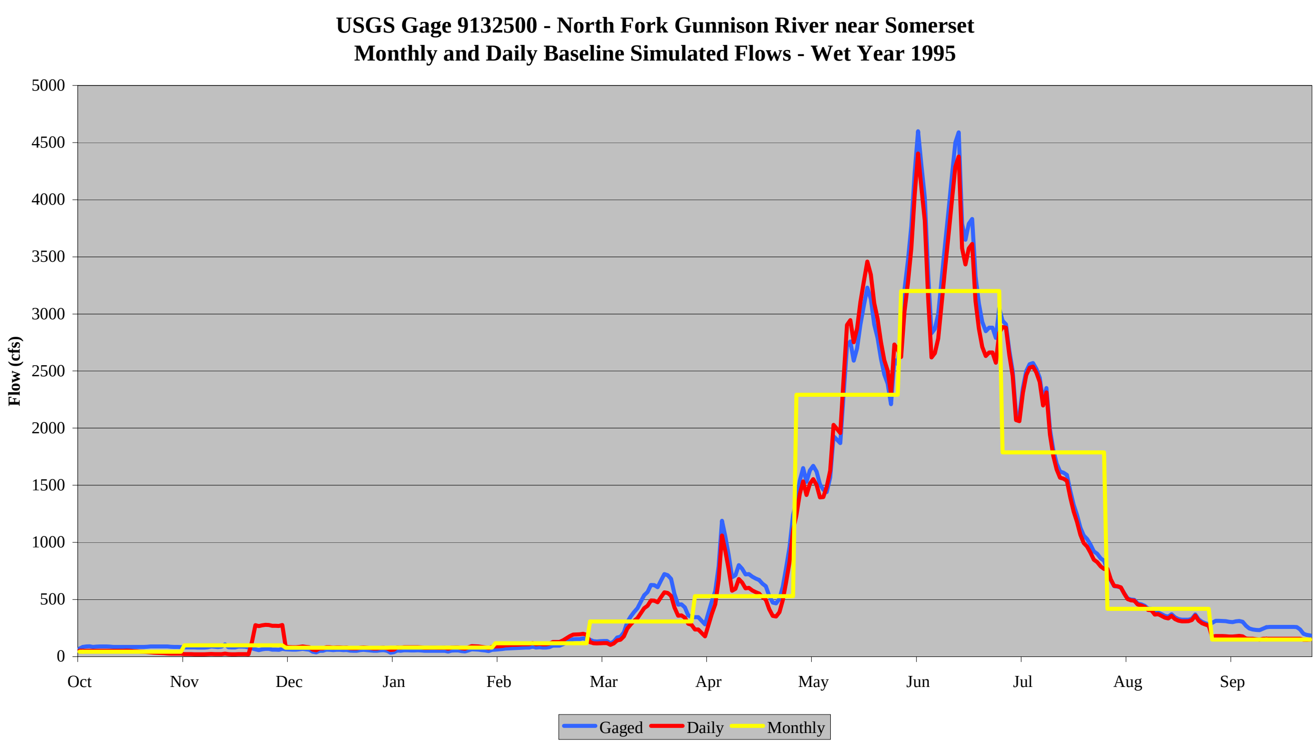


Figure 8.5 Daily Baseline Comparison, Wet Year – North Fork Gunnison River near Somerset

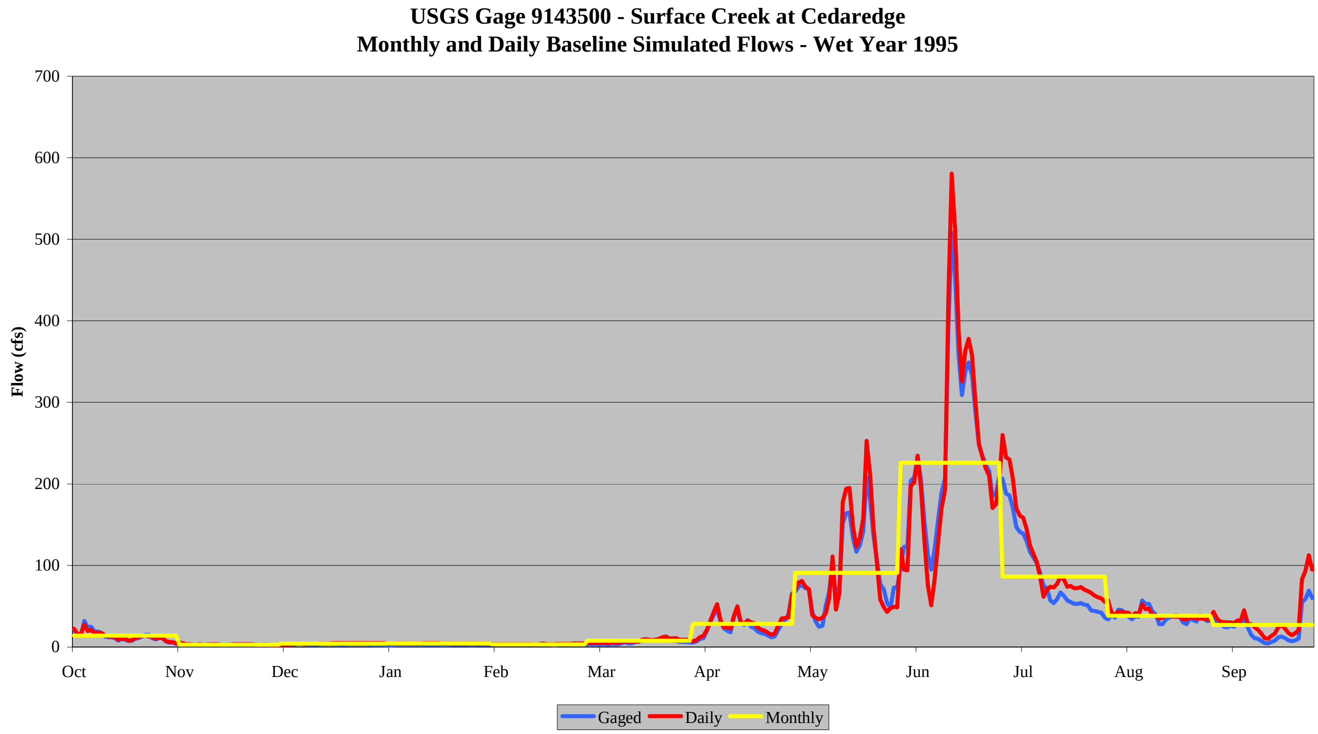


Figure 8.6 Daily Baseline Comparison, Wet Year – Surface Creek at Cedaredge

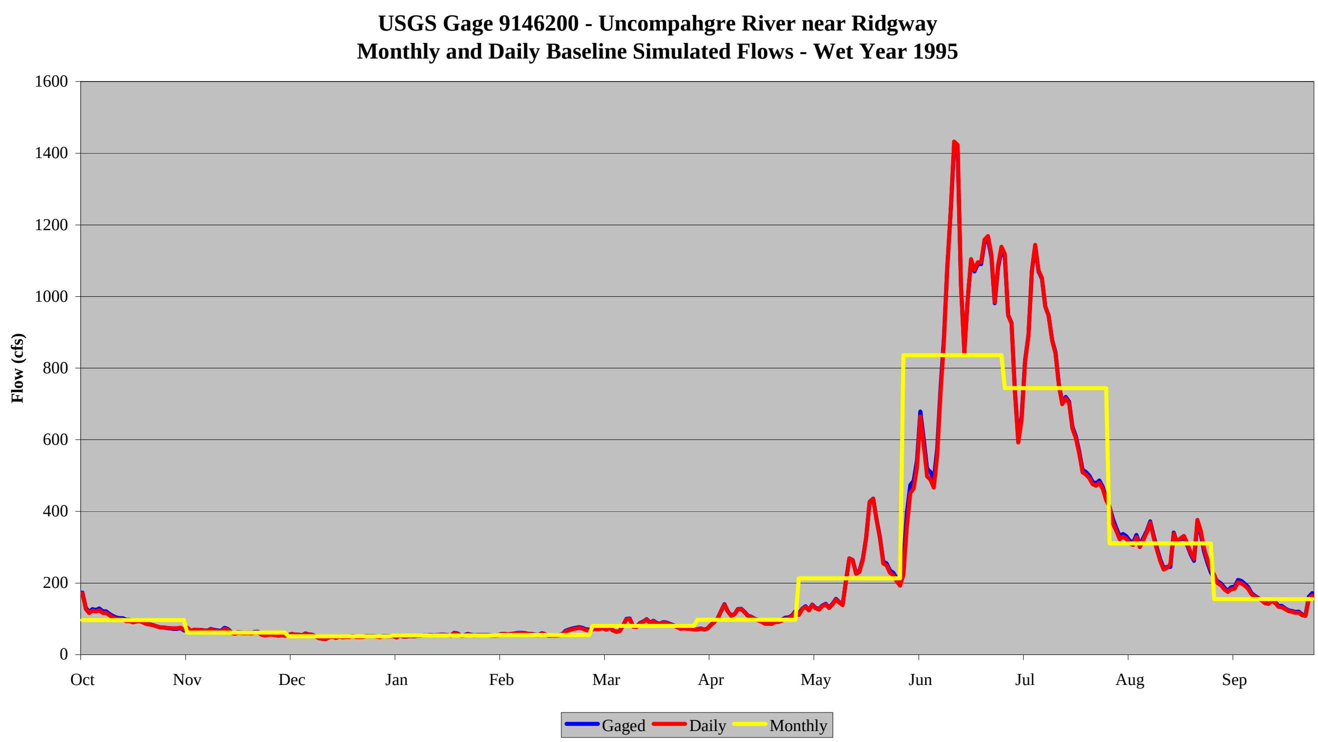


Figure 8.7 Daily Baseline Comparison, Wet Year – Uncompahgre River near Ridgway

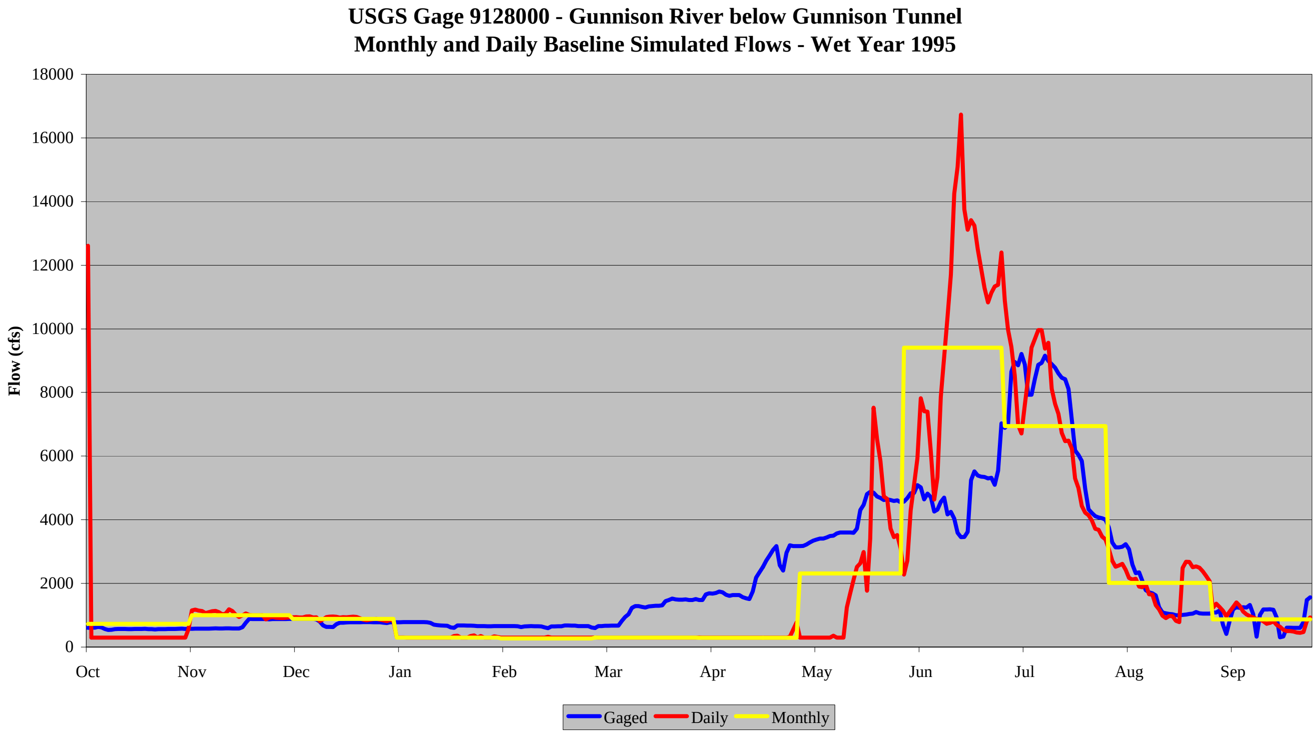


Figure 8.8 Daily Baseline Comparison, Wet Year – Gunnison River below Gunnison Tunnel

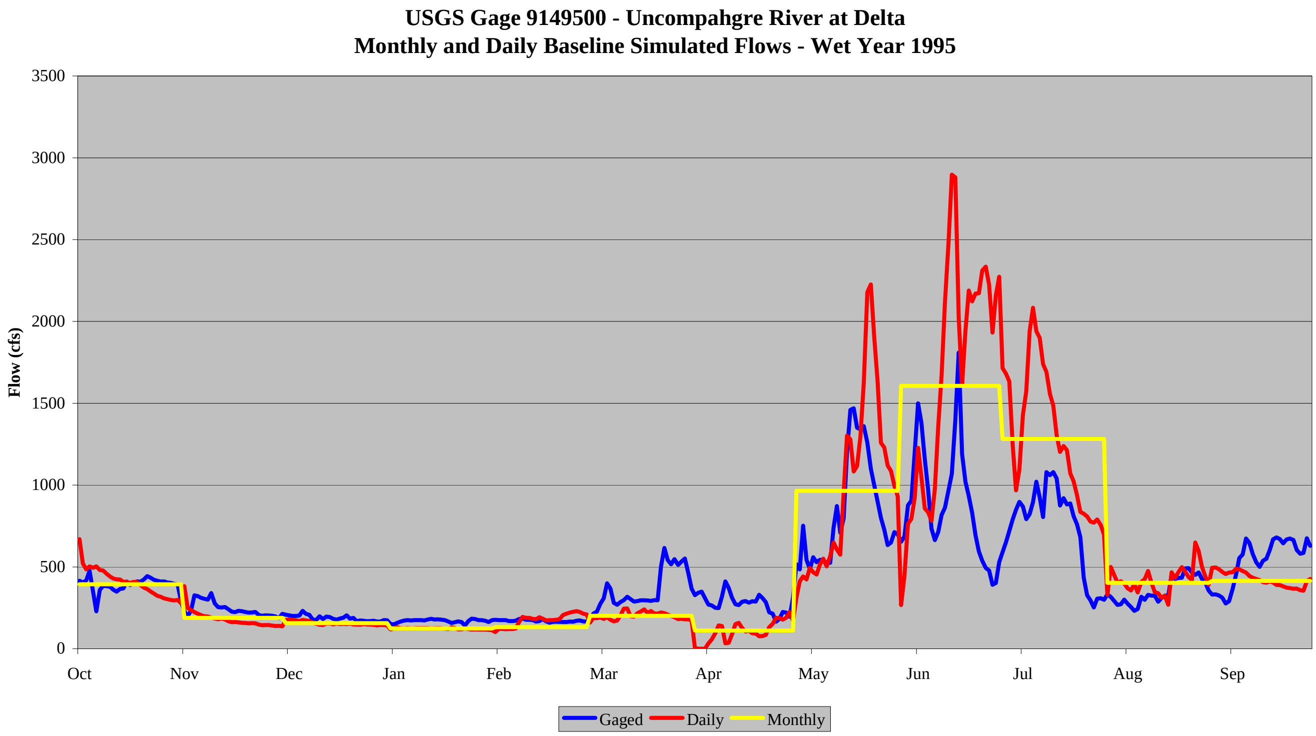


Figure 8.9 Daily Baseline Comparison, Wet Year – Uncompahgre River at Delta

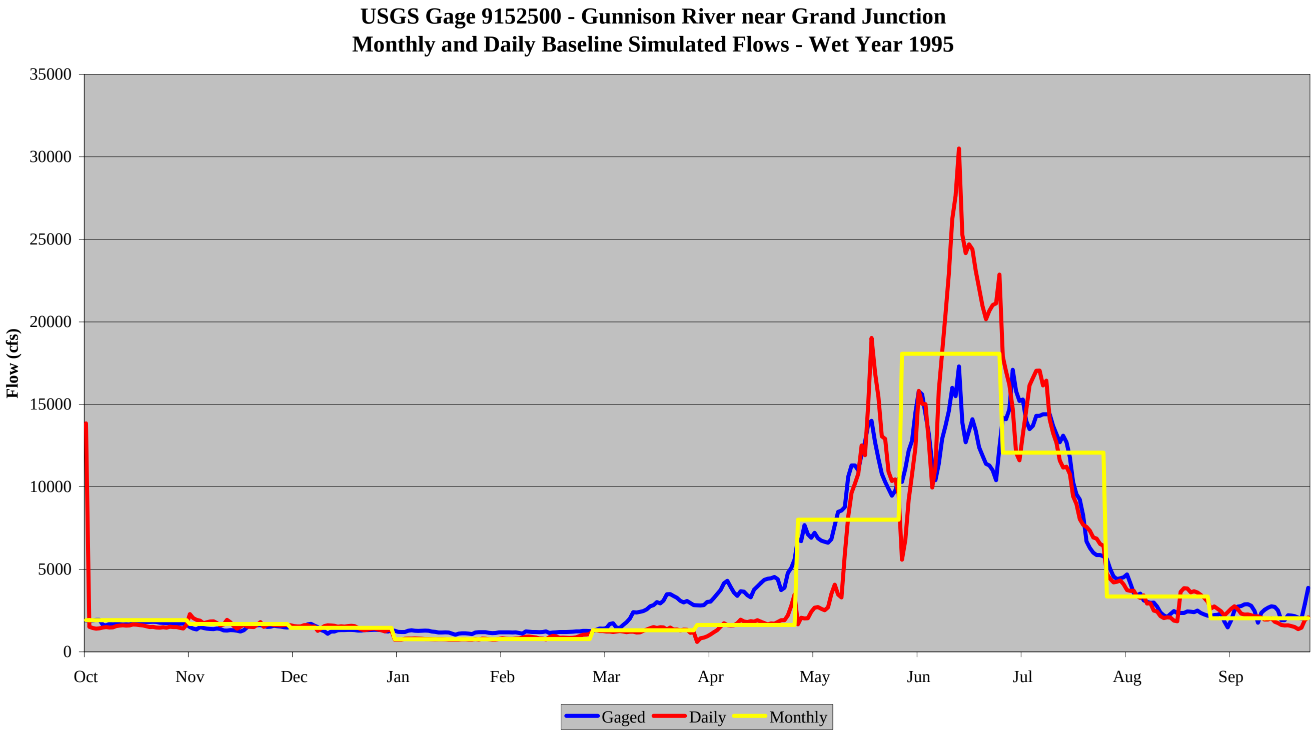


Figure 8.10 Daily Baseline Comparison, Wet Year – Gunnison River near Grand Junction

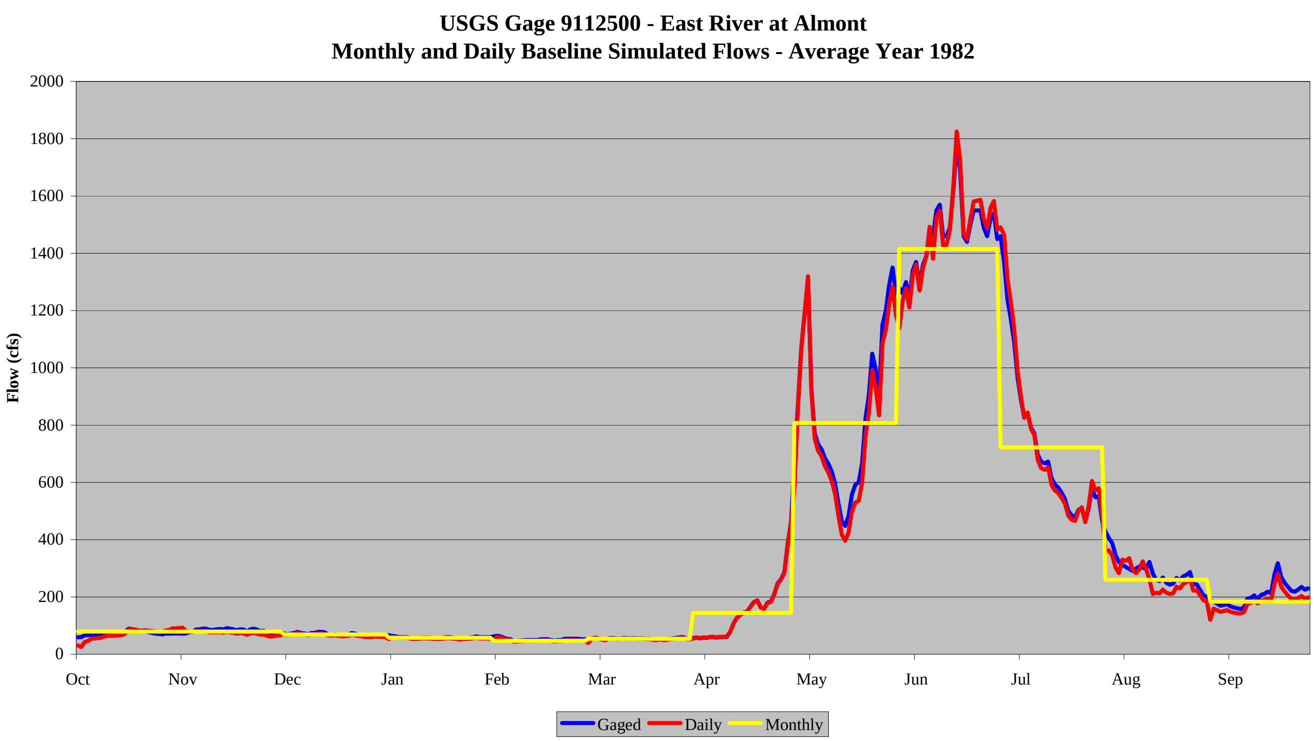


Figure 8.11 Daily Baseline Comparison, Average Year – East River at Almont

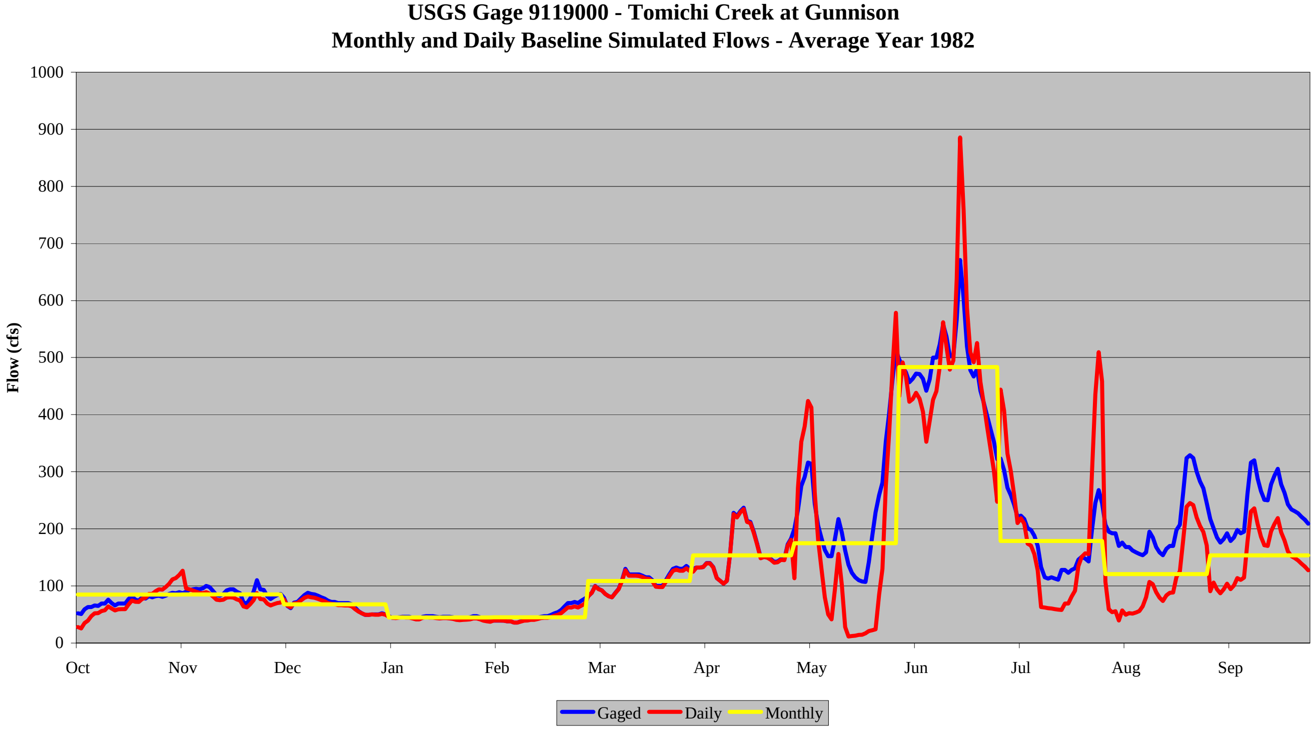


Figure 8.12 Daily Baseline Comparison, Average Year – Tomichi Creek at Gunnison

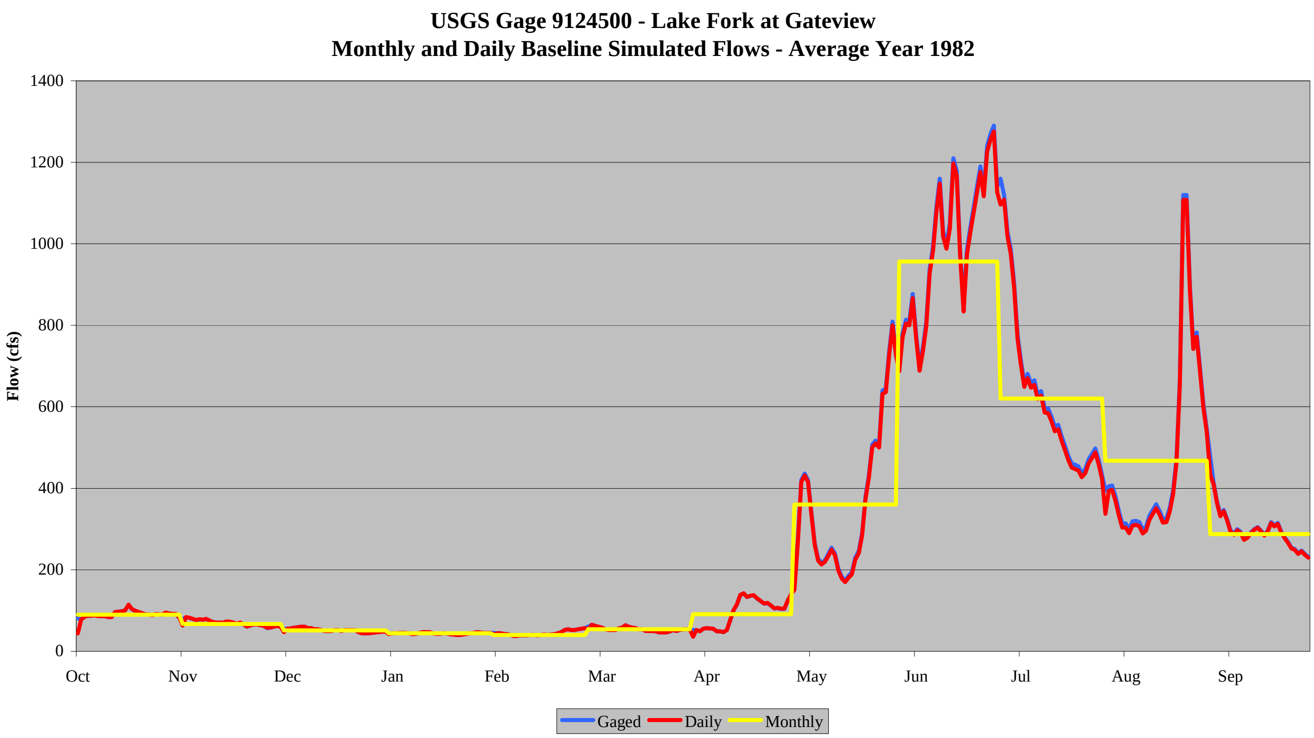


Figure 8.13 Daily Baseline Comparison, Average Year – Lake Fork at Gateview

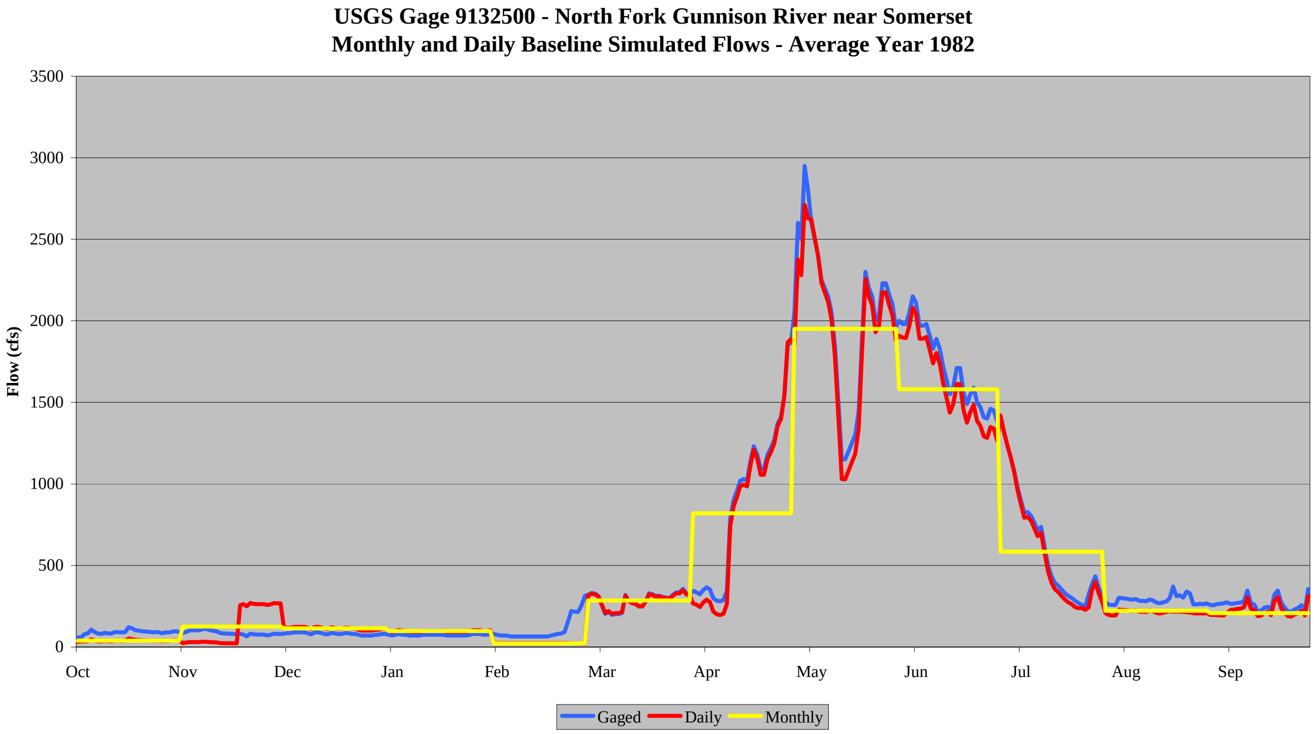


Figure 8.14 Daily Baseline Comparison, Average Year – North Fork Gunnison River nr Somerset

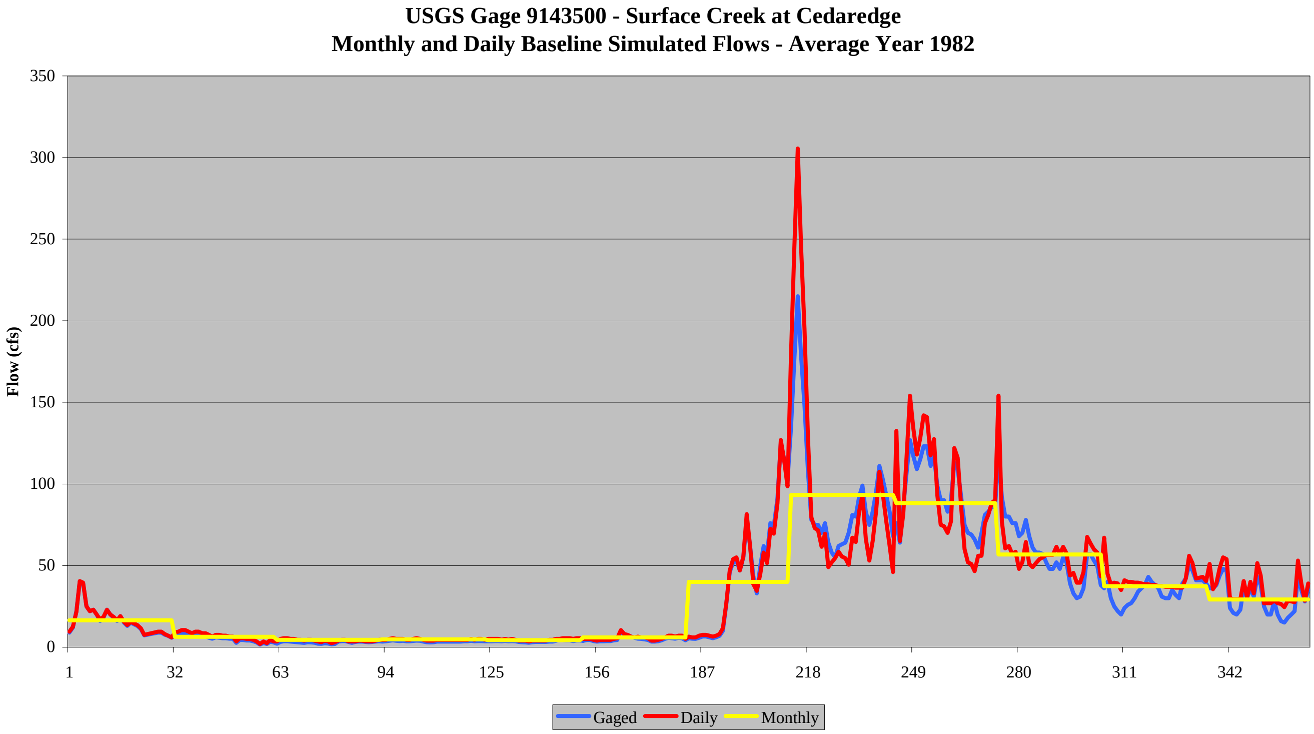


Figure 8.15 Daily Baseline Comparison, Average Year – Surface Creek at Cedaredge

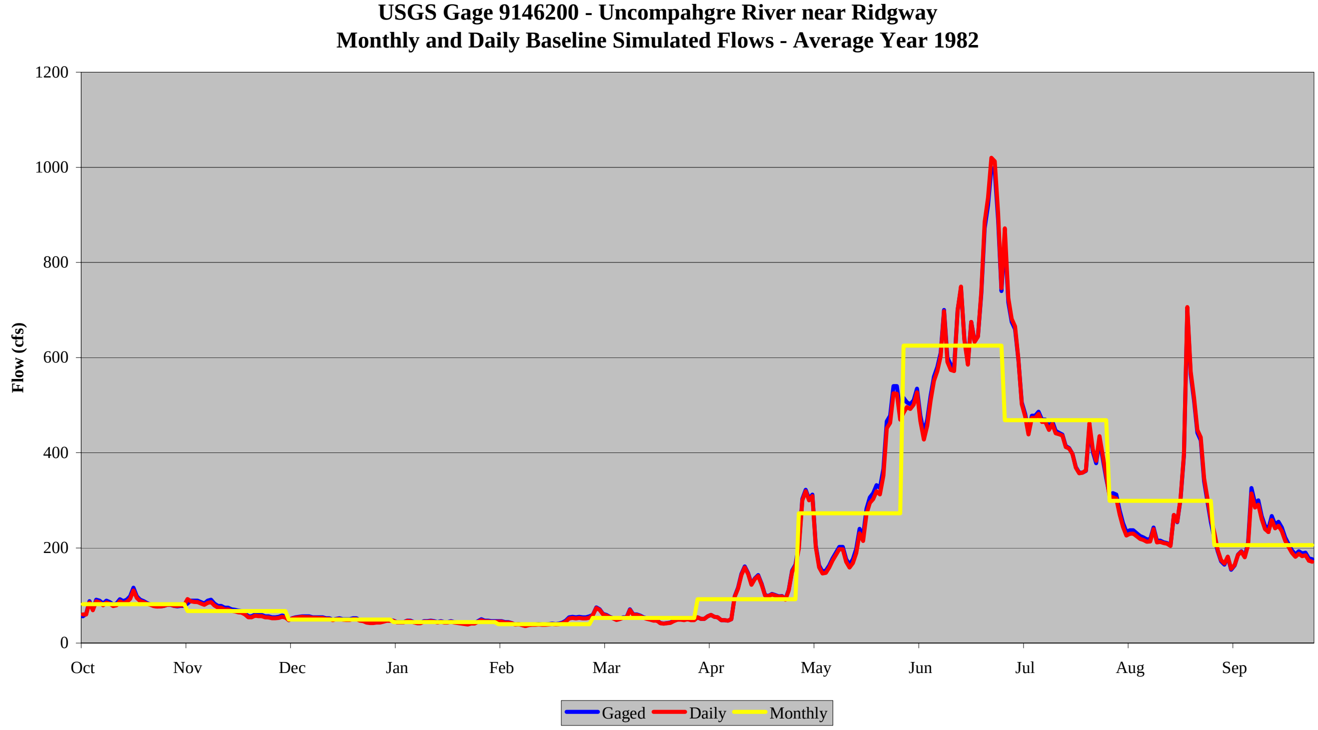


Figure 8.16 Daily Baseline Comparison, Average Year – Uncompahgre River near Ridgway

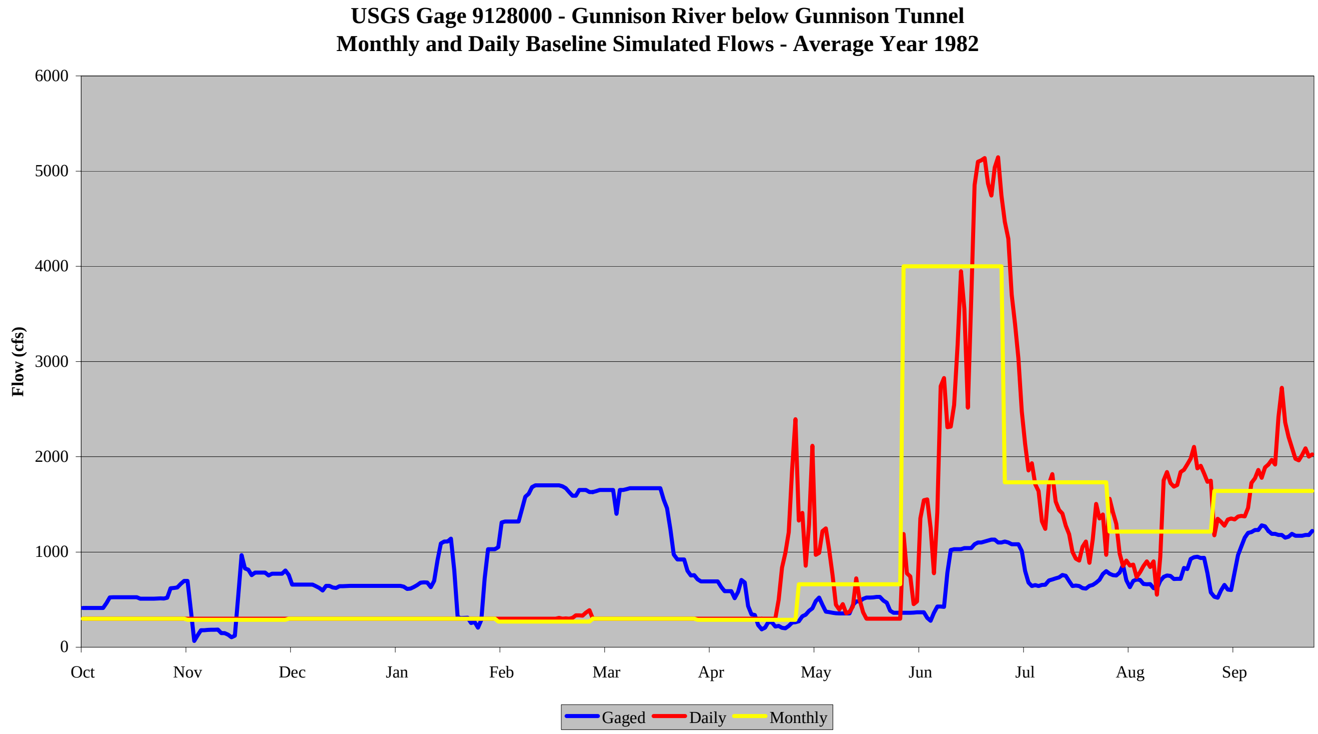


Figure 8.17 Daily Baseline Comparison, Average Year – Gunnison River below Gunnison Tunnel

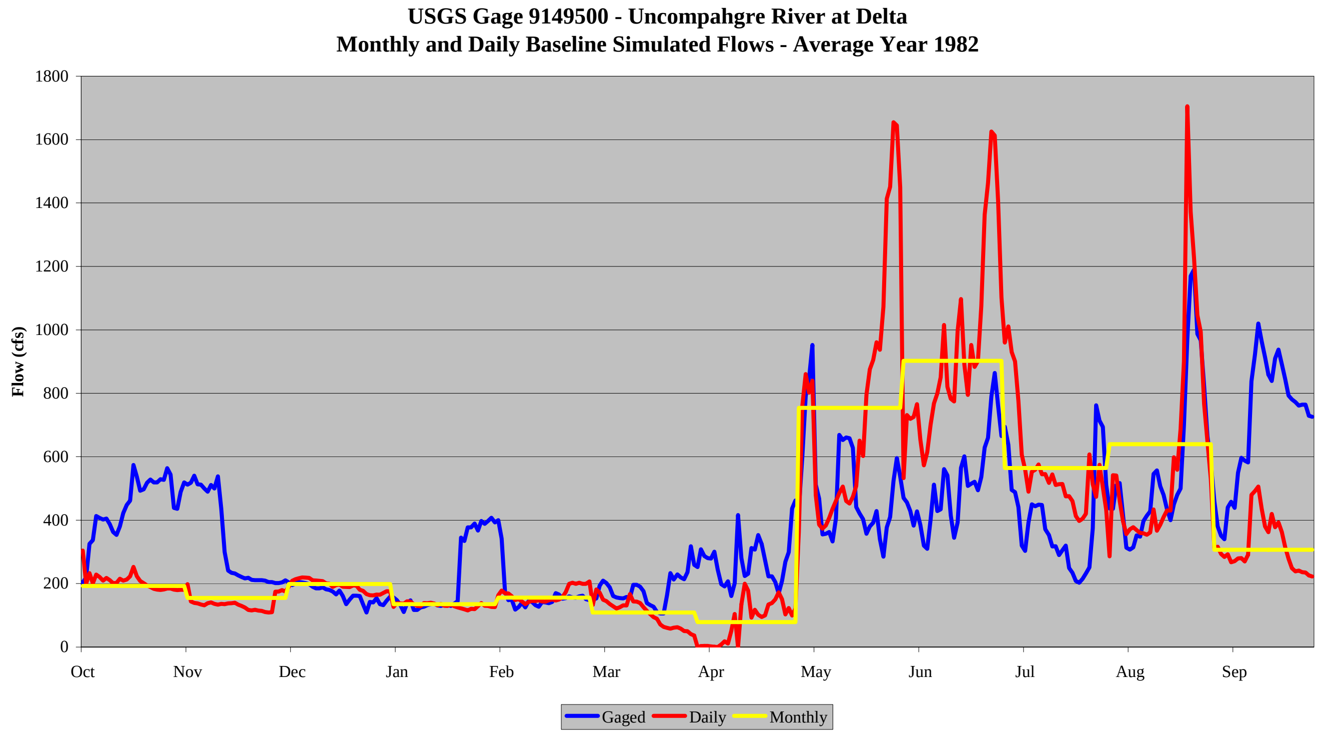


Figure 8.18 Daily Baseline Comparison, Average Year – Uncompahgre River at Delta

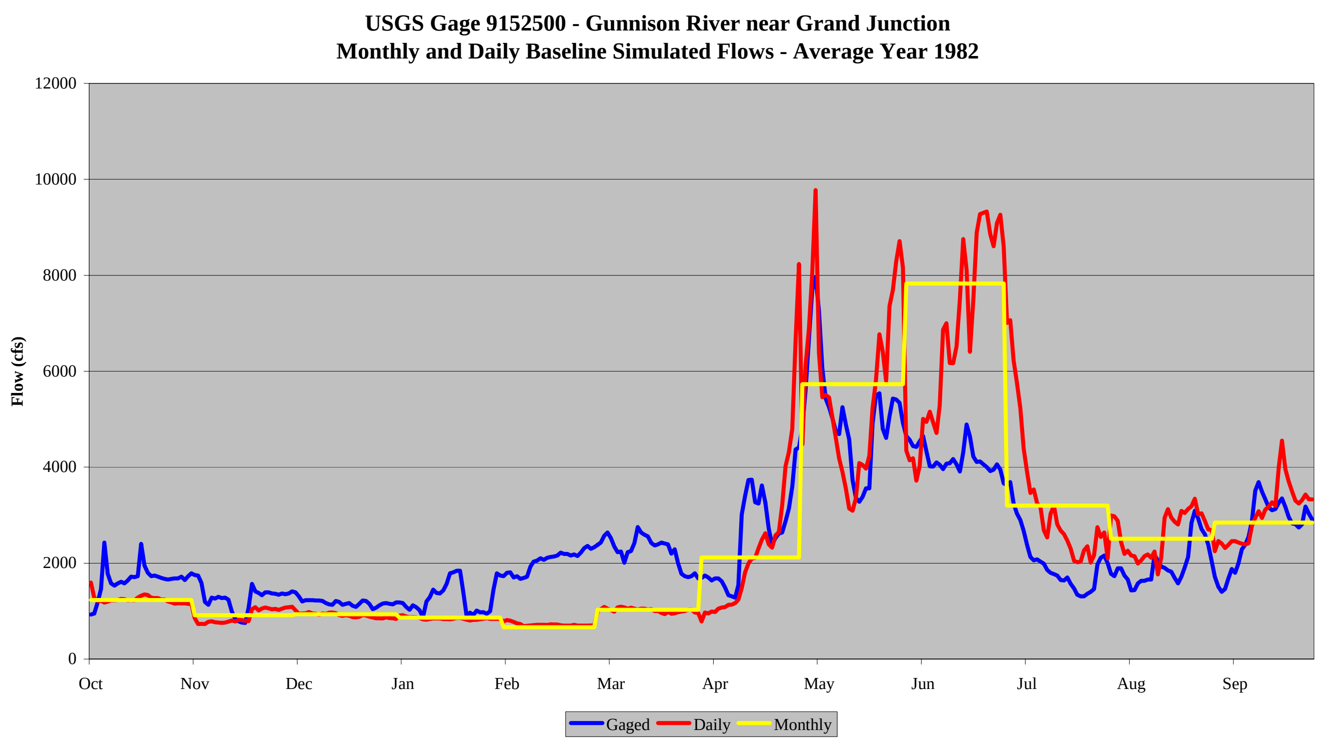


Figure 8.19 Daily Baseline Comparison, Average Year – Gunnison River near Grand Junction

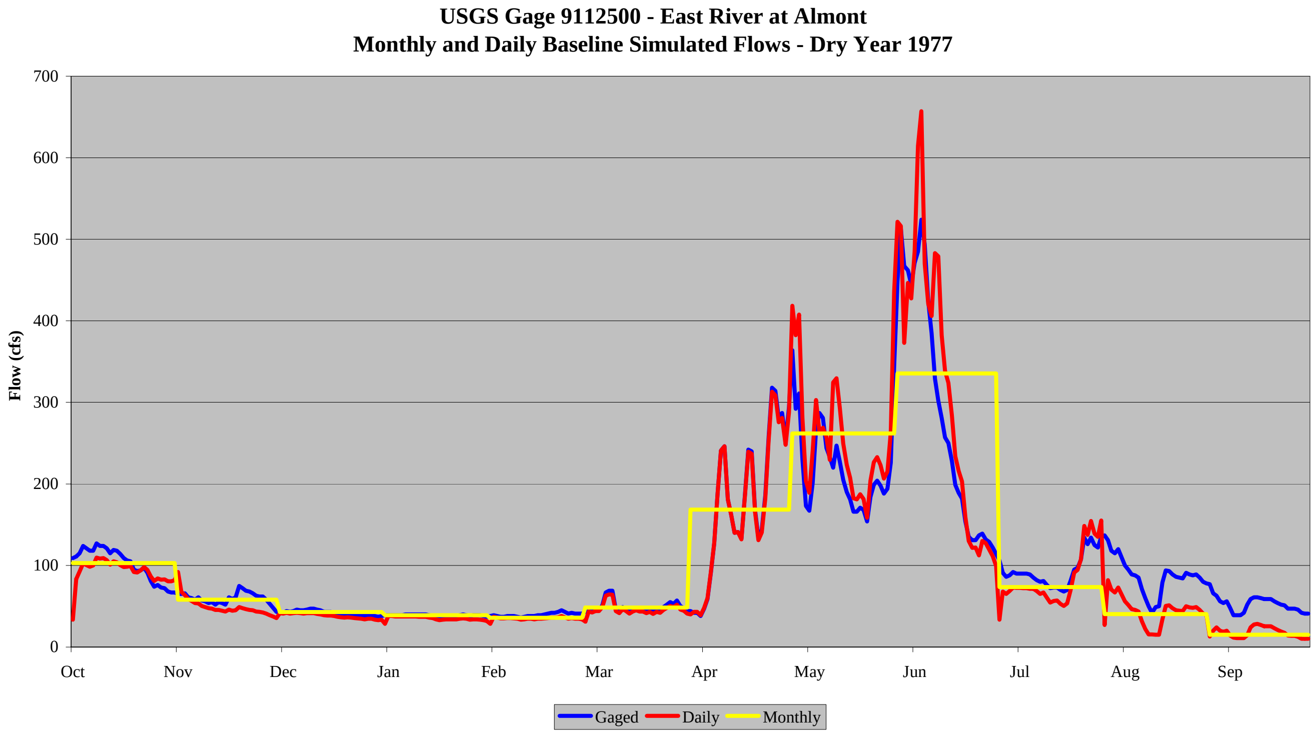


Figure 8.20 Daily Baseline Comparison, Dry Year – East River at Almont

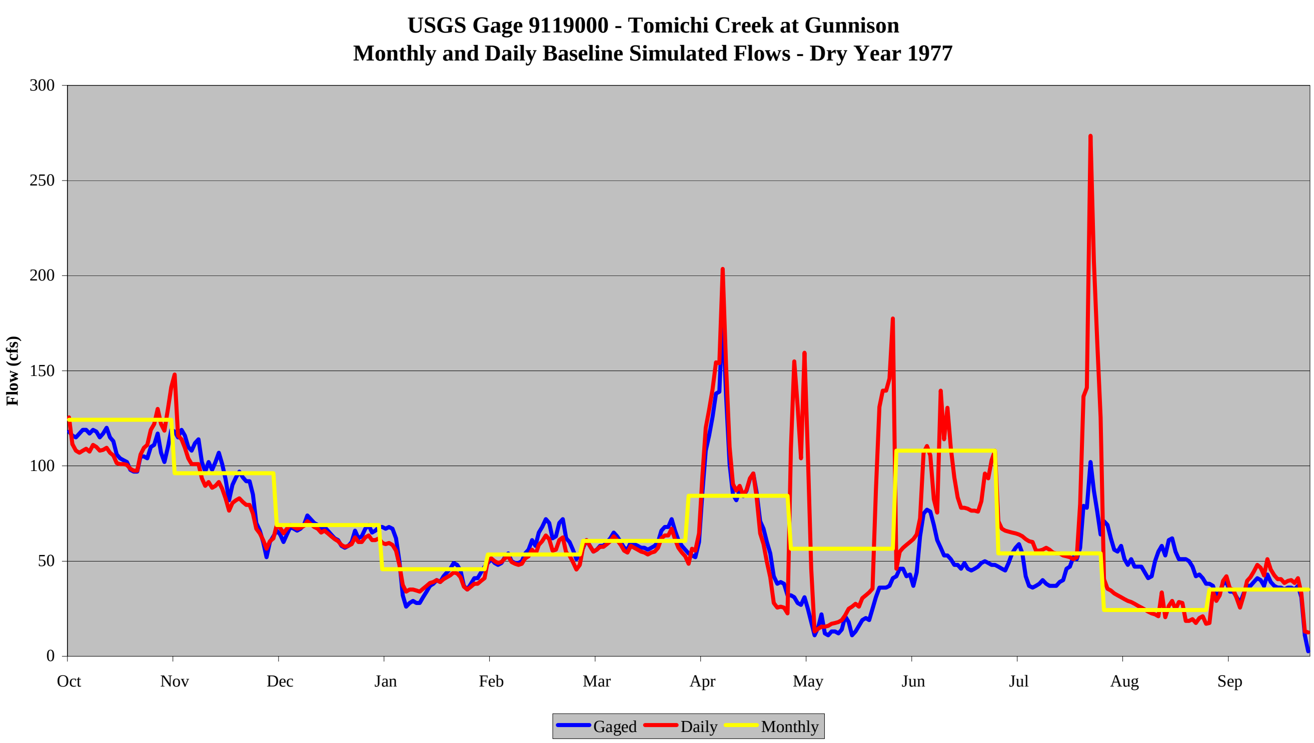


Figure 8.21 Daily Baseline Comparison, Dry Year – Tomichi Creek at Gunnison

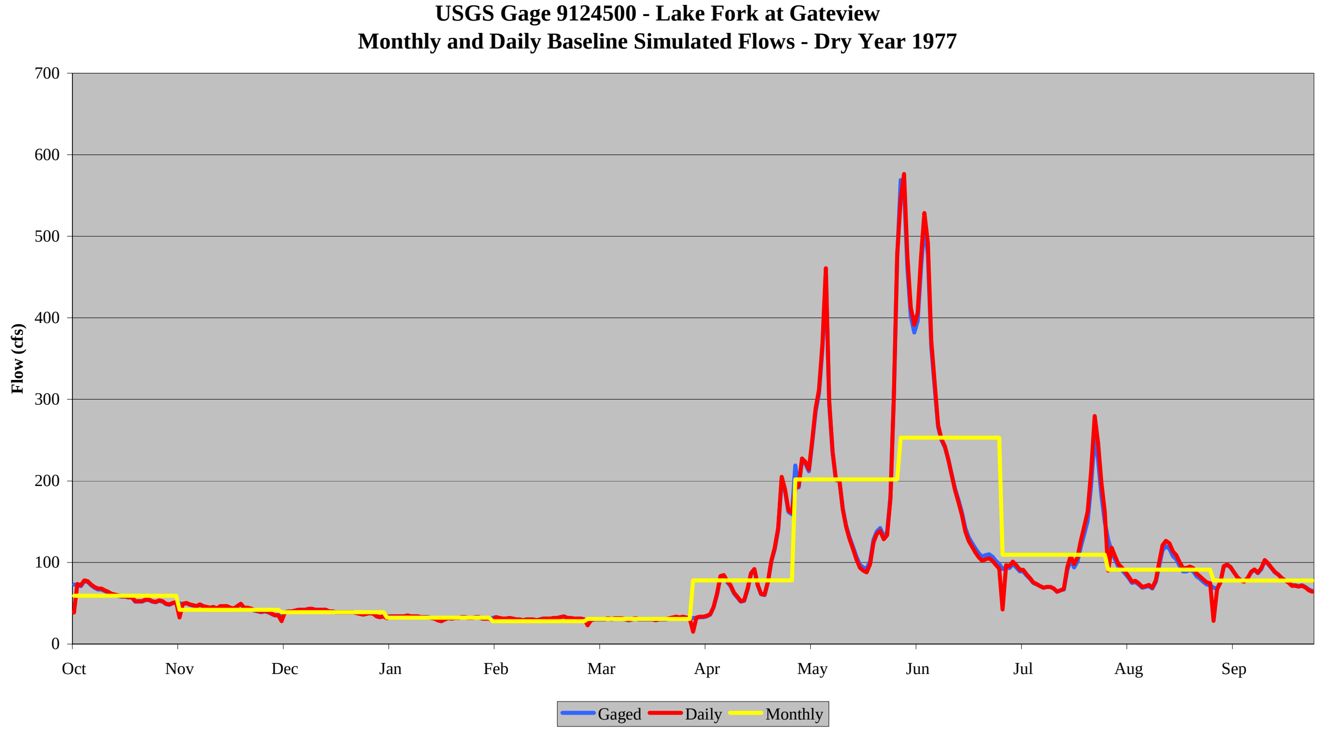


Figure 8.22 Daily Baseline Comparison, Dry Year – Lake Fork at Gateview

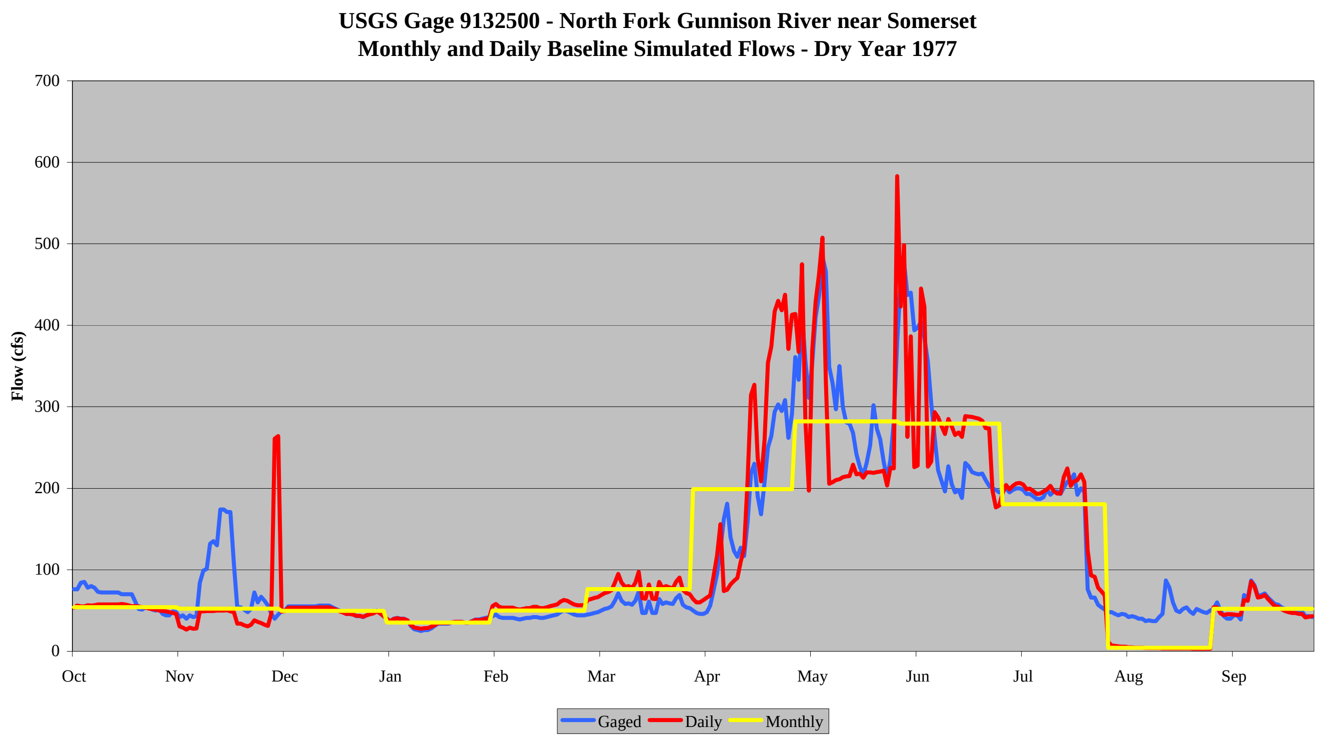


Figure 8.23 Daily Baseline Comparison, Dry Year – North Fork Gunnison River near Somerset

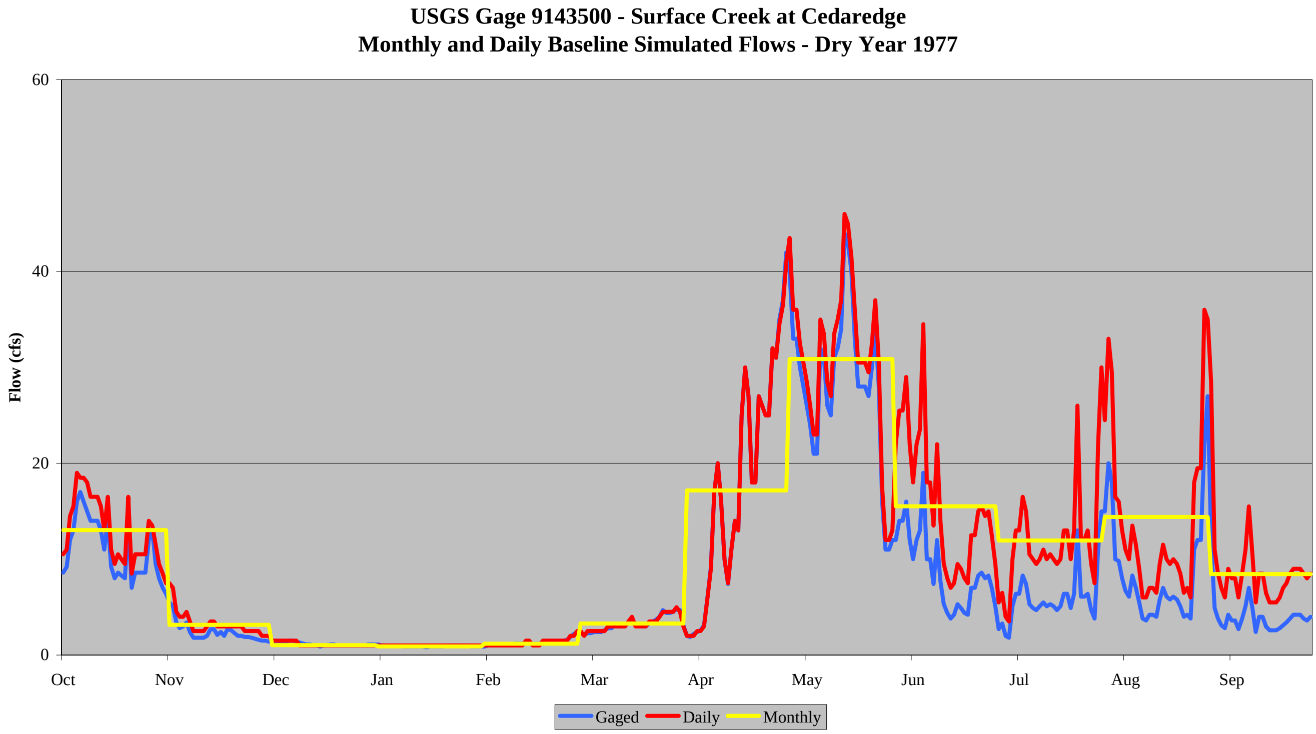


Figure 8.24 Daily Baseline Comparison, Dry Year – Surface Creek at Cedaredge

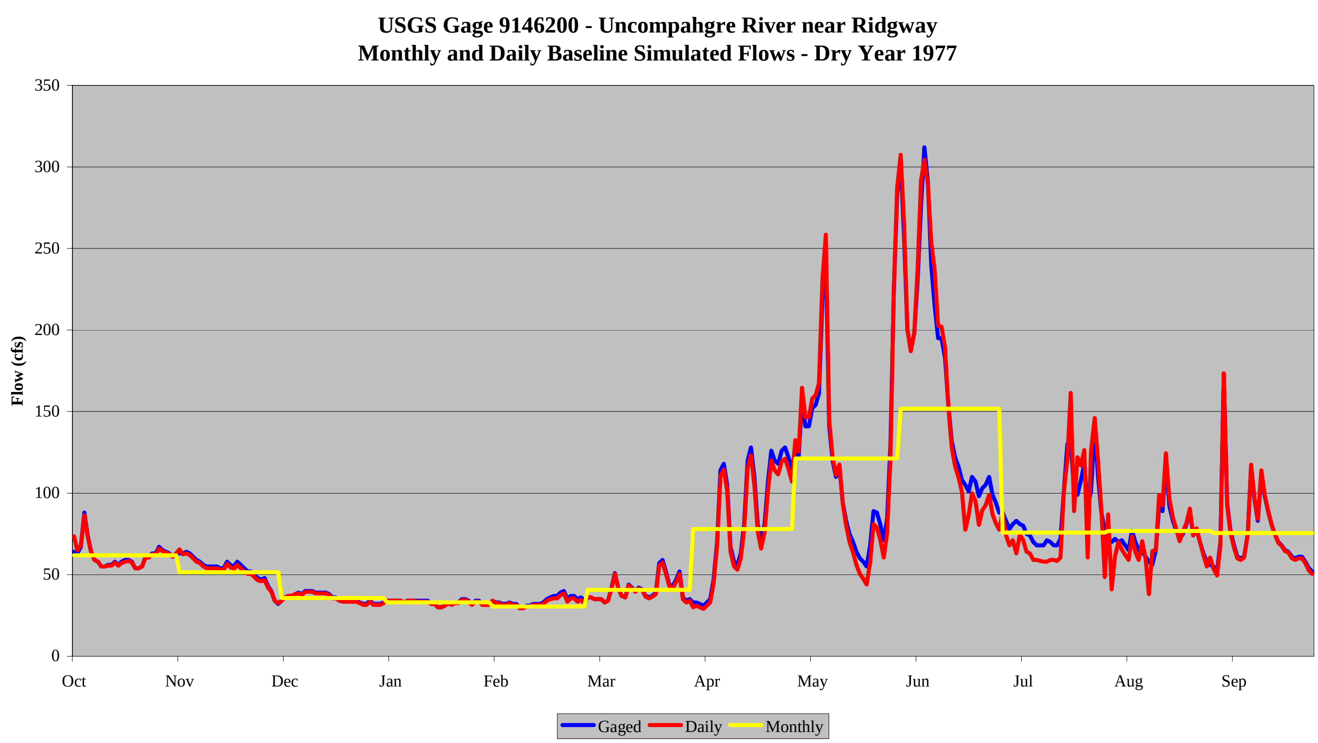


Figure 8.25 Daily Baseline Comparison, Dry Year – Uncompahgre River near Ridgway

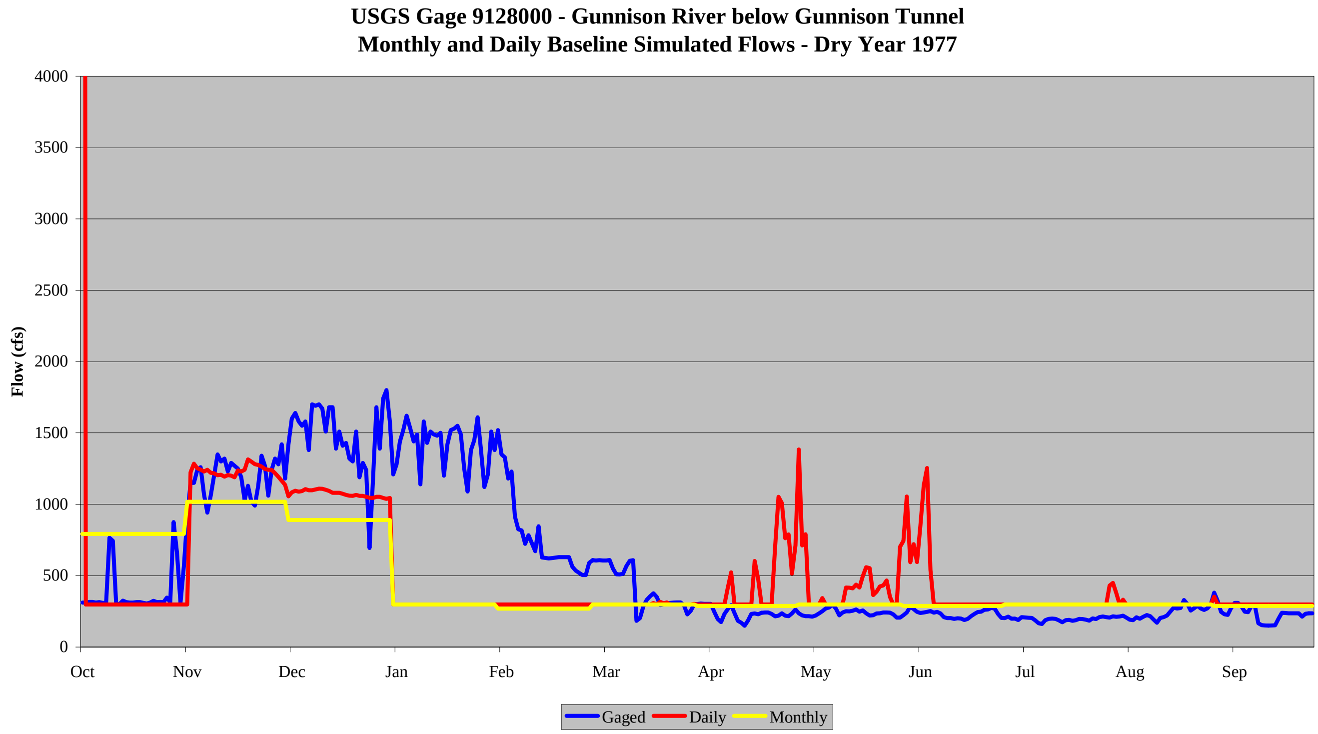


Figure 8.26 Daily Baseline Comparison, Dry Year – Gunnison River below Gunnison Tunnel

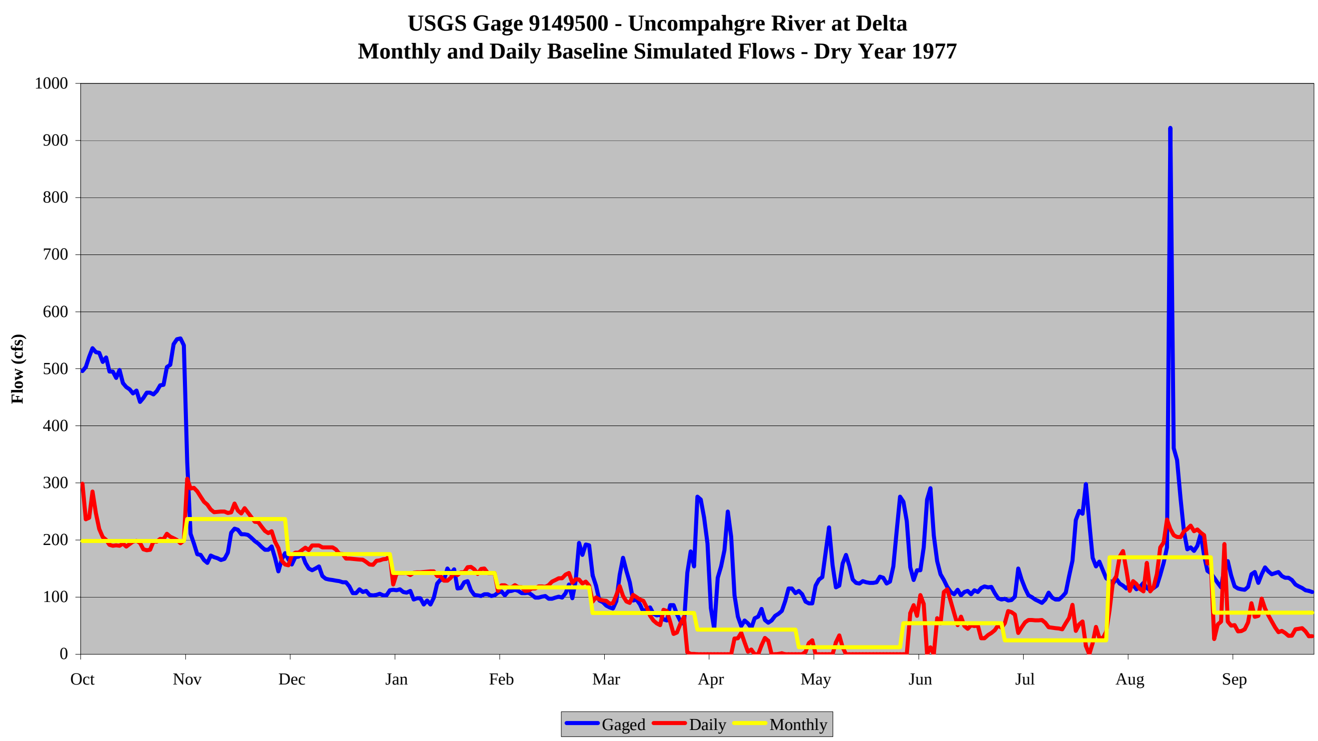


Figure 8.27 Daily Baseline Comparison, Dry Year – Uncompahgre River at Delta

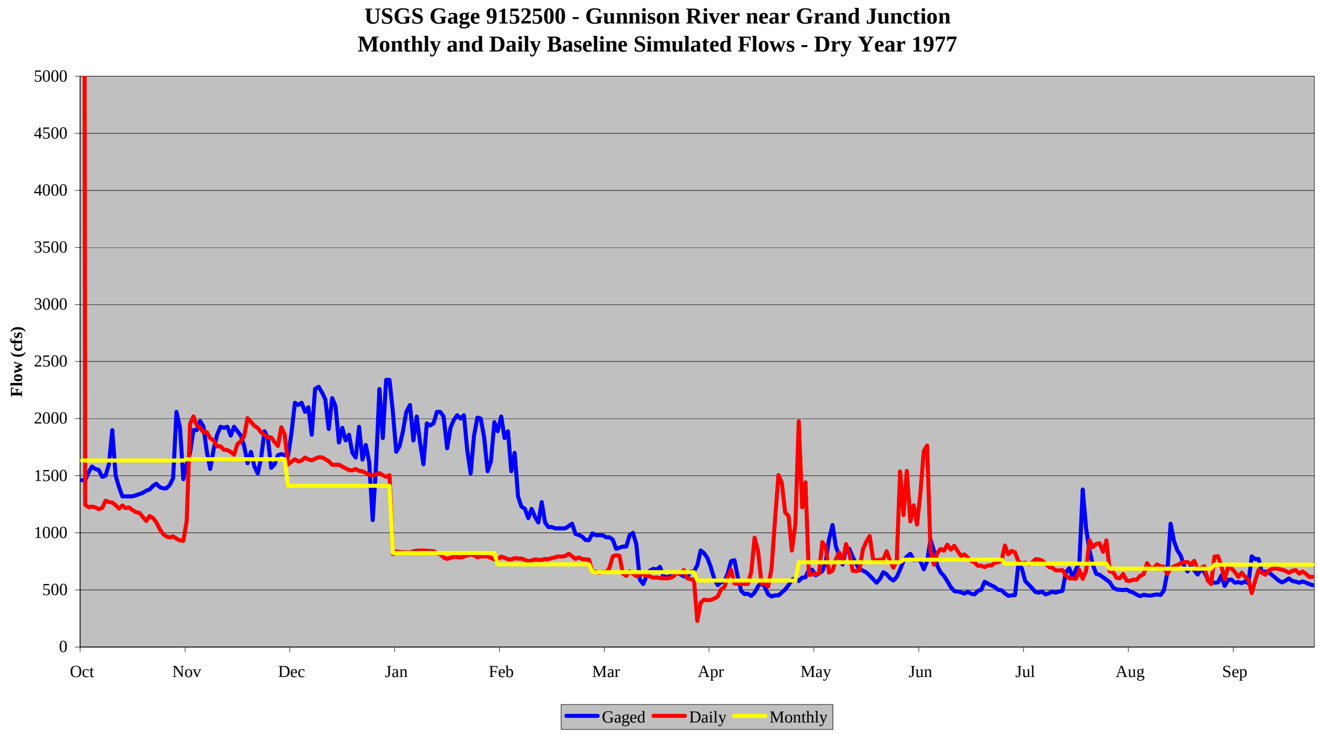


Figure 8.28 Daily Baseline Comparison, Dry Year – Gunnison River near Grand Junction

Appendix A

Aggregation of Irrigation Diversion Structures

Gunnison River Aggregated Irrigation Structures
StateCU and Water Budget Maintenance - Task 5.8

CDSS Memorandum
Final

To: Ray Alvarado

From: LRE, Erin Wilson and Jennifer Ashworth

Subject: Gunnison River Aggregated Irrigation Structures
StateCU and Water Budget Maintenance - Task 10

Date: June 12, 2004

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
- 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 Gunnison 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 Gunnison modeling effort, as described in memorandum “Subtask 5.8 - Gunnison River Aggregated Irrigation Structures, April 22, 2002.”

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	*1.1.1.1 Aggregatio*	# of Structures	Previous Acres	1993 Acres	2000 Acres
59_ADG001	Taylor R @ Almont	15	588	738	709
59_ADG002	East R nr Crested Butte	10	1,296	1,296	587
59_ADG003	Slate R nr Crested Butte	19	1,469	1,469	1,047
59_ADG004	EastR BLCementCkNrCButte	22	2,178	2,178	1,894
59_ADG005	East R @ Almont	12	917	693	824
59_ADG006	Ohio Ck @ Baldwin	21	900	918	1,046
59_ADG007	Ohio Ck nr Baldwin	32	1,944	1,944	2,065
59_ADG008	Gunnison R nr Gunnison	33	2,070	2,056	1,891
28_ADG009	Upper Tomichi Ck	33	1,413	1,413	1,382
28_ADG010	Tomichi Ck @ Parlin	38	2,622	2,681	2,546
28_ADG011	Cochetopa Ck nr Parlin	25	1,941	1,946	1,196
28_ADG012	Tomichi Ck @ Gunnison	77	2,363	2,534	2,430
62_ADG013	Cebolla Ck nr Powderhorn	36	796	780	1,053
62_ADG014	Cebolla Ck @Powderhorn	20	1,115	1,206	1,074
62_ADG015	Lake Fork @ Gateview	42	1,685	1,725	1,710
62_ADG016	GunnisonR abvBlueMesaRes	40	1,609	1,672	1,790
62_ADG017	GunnisonRabvMorrowPtRsvr	5	376	376	1,779
62_ADG018	Cimmarron R @ Cimmarron	9	1,161	875	854
40_ADG019	Gunnison R bl Gunnison Tunnel	6	192	197	75
40_ADG020	Iron Ck nr Crawford	8	1,209	1,209	1,312
40_ADG021	Smith Fork nr Lazear	13	613	601	444
40_ADG022	NForkGunnison nrSomerset	28	1,274	1,556	1,666
40_ADG023	Minnesota Ck @ Paonia	9	382	466	440
40_ADG024	Mid N Fork of Gunnison R	29	2,027	2,160	1,498
40_ADG025	Leroux Ck @ Hotchkiss	12	957	1,011	819
40_ADG026	Gunnison R nr Lazear	35	2,265	1,783	1,772
40_ADG027	Currant Ck nr Read	17	1,235	1,342	1,603
40_ADG028	Upper Tongue Ck	50	2,282	2,640	2,131
40_ADG029	Surface Ck @ Cedaredge	15	825	1,141	946

40_ADG030	Tongue Ck @ Cory	26	2,590	3,172	2,318
40_ADG031	Gunnison R @ Delta	8	937	937	577
68_ADG032	UncompahgreR nr Ridgeway	26	1,042	1,014	1,264
68_ADG033	Dallas Ck nr Ridgeway	21	1,244	1,281	1,530
68_ADG034	Uncompahgre R @ Colona	31	2,315	2,505	2,261
41_ADG035	UncompahgreR abvM&Dcanal	7	1,695	1,557	977
41_ADG036	UncompahgreAbvOlatheGage	27	2,547	2,845	3,928
41_ADG037	Uncompahgre R @ Delta	8	657	767	761
40_ADG038	RoubideauCk@mouth, Delta	10	684	765	642
40_ADG039	Gunnison R BL Delta	32	2,496	2,417	2,098
42_ADG040	Gunnison R nr G Junction	43	2,582	2,823	2,106
28_ADG043	Cochetopa Creek	17	1,054	1,054	917
28_ADG044	Razor Creek	20	1,677	1,586	1,463
Total		987	61,229	63,328	59,424

No structures identified as Key in the previous CDSS efforts were changed to be included in aggregated structures. However, two key structure water rights have recently been transferred to other ditches. Diversions continue to be reported under the original ditch as alternate points. Therefore, these ditches are now modeled as divsystems, with the original ditch WDID, so the water rights associated with both ditches are included as follows:

divsystem(6200809,6200809,6200812)
divsystem(4100568,4100568,4101680)

Figure 1 shows the spatial boundaries of each aggregation. **Exhibit A**, attached, lists the diversion structures represented in each aggregate.

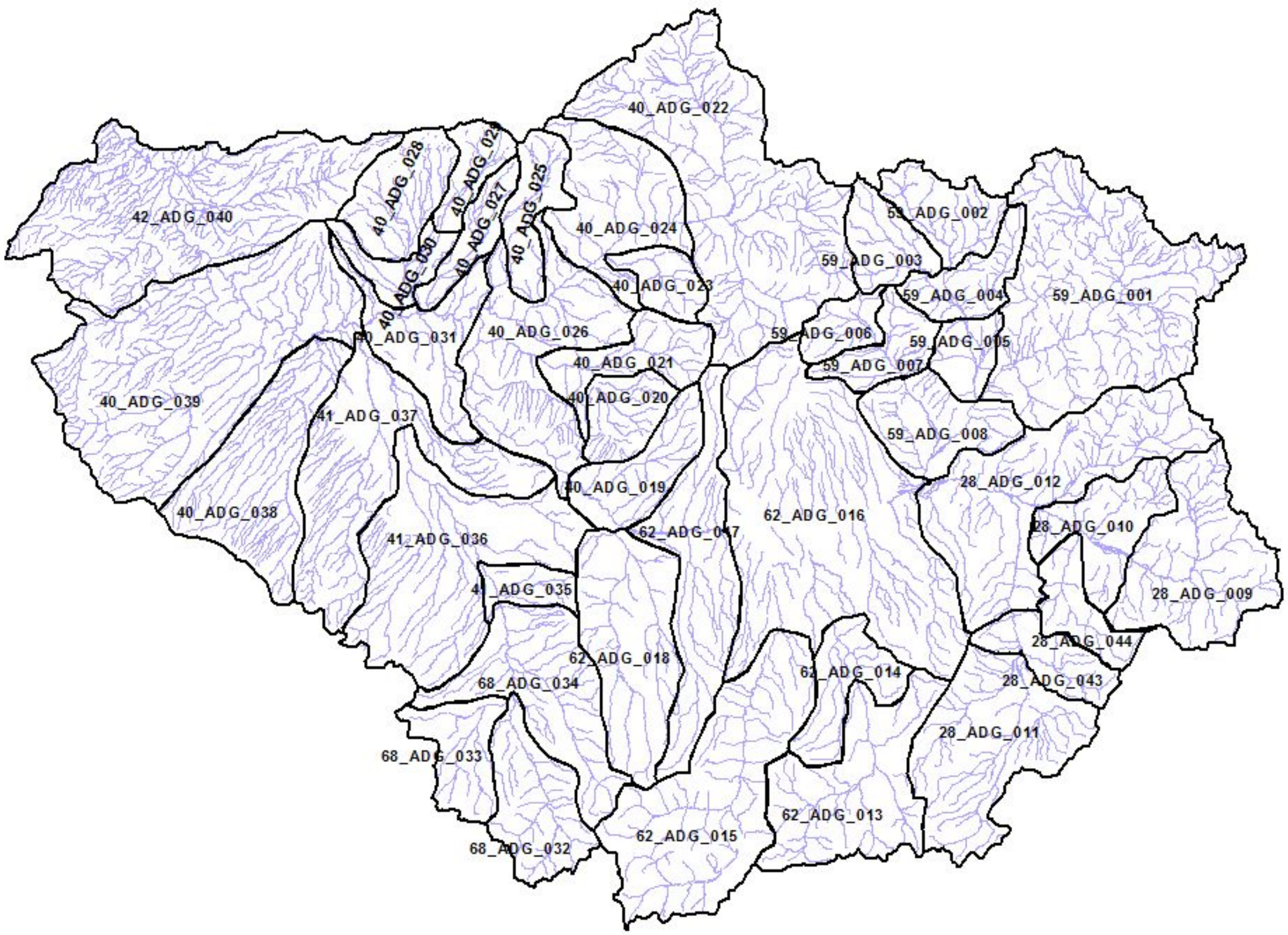


Figure 1 – Aggregate Structure Boundaries

Table 2 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 2 percent between the updated 1993 coverage and the 2000 coverage.

Table 2
Gunnison River Basin Acreage

Water District	Original 1993 Acreage	Updated 1993 Acreage	2000 Acreage
28	28,718	28,441	28,049
40	82,560	90,238	76,145
41	60,493	79,796	84,714
42	4,762	5,261	4,565
59	33,726	33,786	31,605
62	12,681	16,503	22,826
68	14,967	14,926	15,621
Total	237,907	268,951	263,524

Comments and Concerns

None.

Recommendations

We recommend that consultants or State personnel performing future irrigated acreage updates understand the modeling concept of Key versus Aggregated 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
59_ADG001	Taylor R @ Almont	5900513	42.20	30.70
		5900514	19.80	0.00
		5900552	36.30	29.00
		5900618	37.50	45.50
		5900656	70.60	70.50
		5900685	51.50	54.80
		5900714	34.30	53.60
		5900718	94.20	75.70
		5900726	9.30	11.40
		5900861	2.30	2.30
		5900862	6.60	7.70
		5900959	85.20	89.70
		5901026	25.00	30.20
		5901063	149.80	148.60
		5901168	73.30	59.00
59_ADG002	East R nr Crested Butte	5900500	160.60	85.00
		5900517	64.20	24.30
		5900555	84.40	34.40
		5900601	128.50	48.60
		5900635	259.40	162.00
		5900636	21.90	18.00
		5900683	96.30	36.40
		5900751	192.70	48.60
		5901055	34.80	26.30
		5901218	253.10	103.30
59_ADG003	Slate R nr Crested Butte	5900525	358.60	282.50
		5900539	6.50	4.20
		5900575	73.10	66.50
		5900638	150.20	128.60
		5900661	132.10	101.80
		5900665	16.30	0.00
		5900666	31.90	0.00
		5900708	88.20	58.00
		5900830	15.50	12.10
		5900853	15.50	12.10
		5900854	31.00	24.20
		5900912	27.70	29.10
		5900968	15.10	9.70
		5901177	15.50	12.10
		5901208	15.40	0.00
		5901209	46.20	35.00
		5901225	21.90	13.70
		5901376	175.80	75.90
		5903684	232.70	181.90
59_ADG004	EastR BLCementCkNrCButte	5900502	9.30	5.10
		5900515	175.00	168.50

		5900523	391.70	275.90
		5900536	61.50	42.80
		5900540	0.00	36.70
		5900598	28.30	0.00
		5900605	32.00	44.30
		5900612	65.80	14.40
		5900613	304.10	378.50
		5900626	76.30	101.40
		5900637	152.60	207.00
		5900662	26.00	26.90
		5900663	50.30	39.40
		5900706	138.10	137.60
		5900712	196.20	38.30
		5900727	40.40	14.90
		5900757	26.00	21.50
		5900829	246.20	140.60
		5900921	33.80	30.80
		5901140	97.10	126.30
		5901250	22.20	18.20
		5901736	4.80	24.50
59_ADG005	East R @ Almont	5900503	130.90	151.40
		5900506	7.10	10.30
		5900516	245.30	151.50
		5900545	45.40	160.70
		5900576	60.30	64.40
		5900603	24.80	40.00
		5900611	95.00	66.00
		5900628	23.10	90.00
		5900664	0.00	33.70
		5900669	14.70	16.50
		5900703	33.40	24.80
		5900716	13.30	14.40
59_ADG006	Ohio Ck @ Baldwin	5900532	40.30	36.40
		5900533	40.30	36.40
		5900534	14.00	14.70
		5900554	99.90	126.70
		5900559	48.90	47.60
		5900585	60.50	63.80
		5900610	57.10	69.60
		5900652	57.20	66.40
		5900654	78.60	89.60
		5900670	80.40	107.70
		5900687	11.70	23.80
		5900688	8.30	9.70
		5900698	79.50	76.70
		5900705	9.00	8.10
		5900717	57.80	65.70
		5900797	18.60	19.60
		5900974	46.80	35.70

		5901013	19.10	25.00
		5901139	57.20	79.40
		5901171	19.10	25.00
		5901469	14.00	18.60
59_ADG007	Ohio Ck nr Baldwin	5900508	49.60	51.70
		5900511	9.90	9.80
		5900529	152.60	132.30
		5900530	83.50	87.10
		5900535	100.60	111.00
		5900543	46.60	45.60
		5900629	94.70	92.90
		5900632	46.60	45.60
		5900633	246.20	212.50
		5900634	68.30	68.10
		5900639	49.20	53.60
		5900642	18.10	20.40
		5900643	45.00	34.30
		5900648	37.30	40.10
		5900676	46.50	60.10
		5900681	100.70	141.20
		5900682	146.40	100.70
		5900721	28.60	35.90
		5900722	25.40	35.10
		5900723	19.20	23.10
		5900724	47.00	53.10
		5900725	12.60	82.40
		5900776	13.80	13.30
		5900863	167.60	180.60
		5900905	6.20	5.30
		5900954	20.10	16.20
		5901006	9.40	11.10
		5901007	18.20	15.70
		5901141	79.60	114.60
		5901180	91.60	111.10
		5901200	25.70	28.70
		5901361	37.50	31.80
59_ADG008	Gunnison R nr Gunnison	5900519	75.50	75.10
		5900520	75.50	75.10
		5900538	34.30	0.00
		5900547	12.60	15.60
		5900553	69.10	62.90
		5900561	23.10	6.10
		5900562	39.30	35.90
		5900565	43.50	43.50
		5900571	22.50	0.00
		5900577	18.60	21.30
		5900590	144.70	109.10
		5900594	137.20	135.30
		5900595	193.20	167.10

		5900599	92.90	66.10
		5900615	80.40	80.90
		5900647	33.00	30.20
		5900650	12.50	62.40
		5900673	50.50	45.40
		5900674	56.60	76.90
		5900675	72.50	50.00
		5900690	39.20	22.20
		5900694	46.80	45.90
		5900695	93.50	91.80
		5900701	34.30	67.60
		5900710	69.10	62.90
		5900713	138.20	125.90
		5900792	26.80	42.40
		5900793	26.80	10.00
		5900864	10.00	11.10
		5900967	207.40	188.80
		5900982	18.30	6.40
		5901165	34.30	33.80
		5901564	23.40	23.00
28_ADG009	Upper Tomichi Ck	2800502	19.10	0.00
		2800518	22.30	22.90
		2800534	59.90	63.50
		2800563	81.50	85.70
		2800598	107.00	63.90
		2800605	58.60	109.70
		2800606	25.10	42.90
		2800618	93.30	99.50
		2800625	26.00	24.80
		2800626	9.30	12.40
		2800627	1.80	5.50
		2800630	6.10	5.80
		2800639	15.00	20.10
		2800640	15.90	17.00
		2800641	18.20	19.40
		2800666	40.20	43.80
		2800705	23.80	18.20
		2800708	16.90	22.20
		2800746	445.90	329.50
		2800802	3.40	6.10
		2800826	18.80	15.40
		2800849	40.20	43.80
		2800962	59.30	42.10
		2800965	36.30	42.30
		2800969	24.00	25.40
		2800996	13.80	25.40
		2800997	13.80	25.40
		2801118	30.30	54.70
		2801152	9.20	13.60

		2801153	6.10	5.50
		2801162	4.30	6.90
		2801184	44.00	50.00
		2801586	23.80	18.20
28_ADG010	Tomichi Ck @ Parlin	2800513	77.20	118.80
		2800514	14.50	10.20
		2800516	48.80	56.50
		2800537	22.10	36.70
		2800570	15.80	22.80
		2800575	91.30	56.90
		2800589	65.50	70.70
		2800601	39.20	91.70
		2800602	78.30	57.70
		2800603	83.90	65.00
		2800611	85.10	78.10
		2800612	76.40	67.00
		2800613	7.90	8.90
		2800614	7.90	8.90
		2800615	4.70	5.30
		2800616	9.50	10.70
		2800617	43.70	47.10
		2800628	60.20	59.40
		2800629	19.70	14.70
		2800656	9.00	12.60
		2800657	9.20	17.00
		2800658	263.80	86.80
		2800684	39.10	34.80
		2800685	47.90	57.10
		2800694	58.80	68.70
		2800710	64.80	81.40
		2800893	70.40	46.90
		2800936	77.60	88.80
		2800953	58.80	68.70
		2800958	0.00	10.60
		2800985	6.40	10.90
		2801147	81.40	63.10
		2801148	81.40	63.10
		2801151	374.90	225.50
		2801185	1.60	1.80
		2801572	479.20	582.80
		2801580	50.20	69.10
		2801581	54.80	69.30
28_ADG011	Cochetopa Ck nr Parlin	2800517	51.20	158.10
		2800533	344.10	0.00
		2800539	105.50	81.70
		2800540	25.40	11.90
		2800541	29.60	35.30
		2800555	29.70	59.20
		2800556	28.60	0.00

		2800593	97.20	127.40
		2800595	134.40	46.90
		2800596	31.80	11.10
		2800597	134.40	46.90
		2800661	403.80	113.00
		2800717	11.70	19.50
		2800718	49.80	30.60
		2800721	69.30	27.20
		2800748	11.70	11.80
		2800752	13.10	12.80
		2800813	53.00	18.50
		2800884	89.60	94.00
		2800897	8.00	12.30
		2800898	78.40	64.40
		2800928	59.60	49.90
		2800935	20.50	20.70
		2801012	60.60	133.50
		2801050	5.40	9.20
28_ADG012	Tomichi Ck @ Gunnison	2800501	78.20	78.30
		2800504	14.40	14.10
		2800512	10.80	0.00
		2800519	59.00	18.20
		2800521	12.70	10.20
		2800524	36.50	38.30
		2800531	78.60	97.70
		2800548	37.90	45.70
		2800549	42.10	33.90
		2800551	6.50	5.80
		2800552	10.20	30.50
		2800553	32.30	28.80
		2800558	31.00	0.00
		2800559	9.70	70.80
		2800560	17.40	27.90
		2800561	0.00	9.60
		2800569	94.50	77.20
		2800573	26.60	34.30
		2800574	10.00	12.90
		2800579	127.60	120.80
		2800582	17.00	15.70
		2800584	15.40	13.40
		2800585	17.00	15.70
		2800591	15.20	16.40
		2800619	8.20	11.90
		2800620	43.90	42.40
		2800621	42.40	28.80
		2800623	97.60	102.90
		2800653	2.20	2.40
		2800655	39.60	40.80
		2800659	97.60	102.90

		2800664	43.90	43.40
		2800669	75.10	75.70
		2800676	73.40	69.00
		2800677	42.10	38.00
		2800683	16.20	23.00
		2800691	3.70	8.10
		2800695	3.60	3.50
		2800696	36.40	35.90
		2800699	27.10	26.80
		2800704	96.30	90.60
		2800720	41.60	27.00
		2800726	38.50	34.20
		2800774	41.70	41.50
		2800777	12.10	9.90
		2800803	8.90	9.30
		2800804	7.60	4.60
		2800805	11.50	11.80
		2800862	13.90	13.80
		2800869	208.70	215.20
		2800872	10.90	14.00
		2800873	4.10	5.20
		2800874	6.80	8.70
		2800875	5.40	7.00
		2800938	28.40	33.00
		2800943	53.50	45.00
		2800959	73.60	57.20
		2800960	73.60	57.20
		2800970	19.20	0.00
		2801008	9.20	11.10
		2801068	0.80	0.70
		2801069	0.80	0.70
		2801093	5.90	6.90
		2801094	4.60	4.40
		2801585	3.40	4.10
		2801592	77.70	28.90
		2801615	2.10	2.70
		2801616	2.10	2.30
		2801617	16.30	16.10
		2801618	5.30	7.40
		2801619	4.50	5.80
		2801620	7.00	8.10
		2801621	4.90	5.40
		2801622	1.00	1.20
		2801623	2.20	1.90
		5900504	50.40	47.20
		5900697	126.00	117.90
62_ADG013	Cebolla Ck nr Powderhorn	6200501	29.10	36.90
		6200552	22.30	38.20
		6200562	49.40	59.00

		6200563	20.90	24.50
		6200575	24.10	24.10
		6200585	8.90	7.20
		6200596	8.90	7.20
		6200619	28.80	44.60
		6200636	14.30	24.90
		6200645	10.20	16.20
		6200646	12.90	11.70
		6200664	24.50	27.50
		6200669	34.20	48.70
		6200677	19.70	30.50
		6200684	38.70	65.80
		6200685	43.90	53.30
		6200686	9.20	11.30
		6200687	16.70	24.50
		6200696	18.80	26.90
		6200697	17.00	18.60
		6200699	17.00	18.60
		6200730	3.80	13.50
		6200731	26.80	25.80
		6200762	15.10	16.00
		6200792	37.40	38.30
		6200805	1.70	10.30
		6200810	43.10	43.30
		6200811	14.00	31.60
		6200825	23.00	34.10
		6200841	0.80	1.30
		6200894	4.70	9.90
		6201080	6.00	20.10
		6201180	19.20	31.80
		6201187	2.70	0.60
		6201334	112.50	125.30
		6201513	0.00	31.30
62_ADG014	Cebolla Ck @Powderhorn	6200520	32.60	31.10
		6200521	9.90	0.00
		6200565	21.50	32.20
		6200582	341.10	136.10
		6200603	14.00	14.60
		6200637	15.30	19.30
		6200643	20.80	20.60
		6200671	26.80	34.50
		6200693	16.80	26.20
		6200712	48.50	61.40
		6200713	106.60	207.10
		6200719	23.70	34.80
		6200735	76.10	62.70
		6200739	21.80	53.50
		6200741	81.70	61.90
		6200743	152.40	71.70

		6200791	30.00	30.00
		6200813	121.50	101.30
		6201089	44.90	31.70
		6201519	0.00	42.80
62_ADG015	Lake Fork @ Gateview	6200500	0.00	47.00
		6200508	63.00	60.90
		6200519	92.90	103.70
		6200548	29.10	27.50
		6200549	7.60	13.20
		6200551	7.70	9.30
		6200559	9.70	9.90
		6200570	105.40	103.10
		6200580	38.90	18.10
		6200594	6.80	6.60
		6200606	17.20	15.20
		6200607	10.40	10.70
		6200608	41.70	58.40
		6200609	4.60	6.50
		6200611	6.50	5.40
		6200639	96.70	33.00
		6200644	22.30	25.50
		6200652	26.20	21.50
		6200653	116.60	93.50
		6200722	50.80	55.60
		6200723	6.30	7.00
		6200724	6.30	7.00
		6200729	28.90	43.10
		6200746	0.00	12.90
		6200763	12.80	18.60
		6200766	87.50	95.40
		6200775	42.20	37.70
		6200776	168.90	150.90
		6200777	27.60	40.30
		6200785	22.20	11.80
		6200786	26.00	18.00
		6200794	12.00	18.40
		6200802	54.80	52.40
		6200808	42.40	29.80
		6200822	90.60	102.00
		6200876	168.90	27.60
		6201146	31.70	0.00
		6201147	3.30	0.00
		6201459	3.70	0.00
		6201493	107.70	165.60
		6201709	0.00	110.50
		6201794	27.50	36.70
62_ADG016	GunnisonR abvBlueMesaRes	5900505	49.40	58.00
		5900512	82.80	147.80
		5900526	26.00	27.40

		5900531	18.20	17.50
		5900564	89.90	91.40
		5900568	76.20	107.30
		5900604	57.80	66.60
		5900614	56.90	60.60
		5900686	4.60	4.90
		5900693	6.10	5.50
		5900715	1.10	1.30
		5901341	0.00	17.40
		5901473	29.10	44.40
		6200502	14.50	16.10
		6200510	72.20	76.90
		6200525	87.90	69.00
		6200530	39.20	39.70
		6200536	56.90	57.50
		6200547	0.00	4.30
		6200569	205.10	177.10
		6200572	15.70	11.00
		6200576	0.00	63.50
		6200612	128.50	113.90
		6200613	105.40	91.10
		6200641	86.10	61.40
		6200642	105.40	91.10
		6200651	6.90	7.30
		6200661	0.00	14.80
		6200689	11.70	10.40
		6200690	29.30	26.10
		6200752	27.90	31.70
		6200753	27.90	31.70
		6200754	30.10	22.80
		6200756	19.90	21.60
		6200784	20.70	0.00
		6201000	0.00	18.40
		6201008	0.00	11.90
		6201047	0.00	4.30
		6201249	59.00	50.50
		6201250	23.70	15.30
62_ADG017	GunnisonRabvMorrowPtRsvr	6200535	0.00	240.30
		6200537	31.90	0.00
		6200708	238.40	1,539.00
		6200760	52.60	0.00
		6200761	52.60	0.00
62_ADG018	Cimmarron R @ Cimmarron	6200542	438.30	192.60
		6200673	42.40	76.60
		6200674	12.90	0.00
		6200707	43.40	24.30
		6200715	173.70	0.00
		6200742	14.80	114.90
		6200765	148.60	174.50

		6200782	0.40	6.70
		6200892	0.00	264.20
40_ADG019	Gunnison R bl Gunnison Tunnel	4000510	43.60	0.00
		4000539	0.00	50.60
		4000540	18.50	17.60
		4000541	35.40	6.80
		4000542	56.30	0.00
		4000601	43.60	0.00
40_ADG020	Iron Ck nr Crawford	4000519	99.90	121.70
		4000528	325.90	357.00
		4000544	487.70	512.00
		4000550	35.60	0.00
		4000557	0.00	87.00
		4000563	47.50	0.00
		4000569	45.10	52.00
		4000573	166.90	181.90
40_ADG021	Smith Fork nr Lazear	4000507	37.70	31.60
		4000512	82.30	57.80
		4000514	13.60	12.40
		4000518	33.30	29.10
		4000554	72.80	74.20
		4000558	35.20	37.50
		4000561	97.00	83.00
		4000570	78.50	38.30
		4000587	13.50	10.20
		4000594	55.80	0.00
		4000604	52.10	36.80
		4000614	24.60	25.10
		4000619	5.00	7.50
40_ADG022	NForkGunnison nrSomerset	4001071	116.70	0.00
		4001082	0.00	183.80
		4001085	54.40	22.50
		4001086	21.70	12.50
		4001090	118.00	125.40
		4001091	32.00	0.00
		4001108	37.00	0.00
		4001115	0.00	71.10
		4001116	0.00	172.90
		4001121	39.00	91.40
		4001125	61.10	0.00
		4001137	22.30	18.60
		4001138	45.20	0.00
		4001139	0.00	47.00
		4001148	0.00	44.40
		4001151	0.00	88.80
		4001157	199.60	84.30
		4001167	20.20	13.90
		4001175	51.00	50.20

		4001184	124.20	102.40
		4001188	328.20	0.00
		4001194	139.80	0.00
		4001198	0.00	116.00
		4001202	116.70	0.00
		4001203	0.00	125.00
		4001204	0.00	28.50
		4001205	28.50	0.00
		4001212	0.00	267.30
40_ADG023	Minnesota Ck @ Paonia	4000964	70.50	13.30
		4000977	0.00	78.00
		4000981	42.00	25.80
		4000993	24.20	39.60
		4001009	0.00	59.20
		4001048	43.20	0.00
		4001051	134.30	72.60
		4001232	114.40	109.00
		4001250	37.70	42.90
40_ADG024	Mid N Fork of Gunnison R	4000951	65.10	64.50
		4000960	29.30	30.60
		4000962	44.60	0.00
		4000979	89.40	0.00
		4000983	15.90	0.00
		4000988	102.50	0.00
		4000989	13.10	16.00
		4000991	109.10	80.40
		4001018	21.80	24.50
		4001027	137.40	78.90
		4001028	18.90	18.00
		4001033	204.00	384.10
		4001057	34.90	44.30
		4001069	165.90	0.00
		4001089	72.40	0.00
		4001093	63.40	25.20
		4001094	19.70	0.00
		4001113	15.40	89.80
		4001130	12.80	11.40
		4001155	9.40	9.90
		4001169	55.20	50.40
		4001173	15.60	14.10
		4001208	279.80	276.30
		4001215	105.00	88.70
		4001219	43.90	20.90
		4001223	58.30	0.00
		4001276	12.70	15.00
		4001282	89.40	0.00
		4003411	254.60	155.40
40_ADG025	Leroux Ck @ Hotchkiss	4000920	95.00	87.70
		4000921	14.90	13.10

		4000934	43.80	49.30
		4000938	96.40	91.70
		4000939	29.00	34.00
		4000940	53.40	29.40
		4000941	143.50	122.30
		4000943	124.20	46.50
		4001001	163.40	151.30
		4001019	133.30	57.50
		4001034	56.00	84.90
		4001059	58.00	51.40
40_ADG026	Gunnison R nr Lazear	4000537	44.10	40.40
		4000547	44.40	5.80
		4000603	7.80	62.00
		4000606	0.00	61.40
		4000915	224.60	143.50
		4000922	0.00	29.30
		4000925	0.00	61.20
		4000927	12.20	56.50
		4000957	131.20	143.00
		4000961	6.30	0.00
		4000963	79.80	42.10
		4000968	106.30	0.00
		4000971	107.40	63.60
		4000982	50.10	54.90
		4000995	4.80	0.00
		4000998	46.10	76.10
		4000999	25.10	0.00
		4001000	58.60	53.40
		4001004	0.80	0.00
		4001006	69.10	91.30
		4001007	16.20	11.70
		4001023	11.80	0.00
		4001025	140.50	183.50
		4001039	121.80	106.40
		4001045	38.90	0.00
		4001047	38.90	82.70
		4001064	129.20	133.90
		4001066	43.50	46.80
		4001068	47.00	23.30
		4001233	12.00	10.20
		4001247	45.00	41.70
		4001257	14.60	74.20
		4001614	9.40	15.50
		4001678	61.60	18.70
		4002163	34.00	39.10
40_ADG027	Currant Ck nr Read	4000788	8.11	7.98
		4000790	27.27	37.17
		4000792	20.52	38.65
		4000793	107.74	36.88

		4000796	214.63	266.57
		4000799	111.55	129
		4000801	21.14	8.82
		4000802	77.73	75.41
		4000803	171.94	164.67
		4000804	19.96	16.16
		4000807	10.64	11.4
		4000813	305.88	265.41
		4000817	83.37	98.89
		4000823	43.03	106.52
		4000824	9.02	10.83
		4000826	0	211.32
		4001272	109.16	117.49
40_ADG028	Upper Tongue Ck	4000629	5.60	9.30
		4000631	34.80	25.20
		4000640	31.90	26.50
		4000643	6.80	3.10
		4000652	48.90	45.10
		4000657	37.60	22.50
		4000659	7.00	0.00
		4000660	9.10	10.50
		4000697	182.80	59.70
		4000698	66.90	30.90
		4000699	19.60	17.70
		4000700	90.40	81.80
		4000704	9.90	6.30
		4000705	44.80	40.40
		4000707	12.00	17.70
		4000708	48.40	34.60
		4000710	11.80	10.40
		4000712	15.40	19.00
		4000714	11.00	20.70
		4000716	34.00	29.70
		4000724	0.00	24.10
		4000729	14.70	22.40
		4000731	89.90	147.80
		4000734	11.30	11.20
		4000735	45.60	59.10
		4000737	0.00	11.20
		4000738	36.60	37.00
		4000741	283.50	267.40
		4000742	0.00	12.20
		4000743	37.80	41.50
		4000745	54.10	28.30
		4000746	156.60	115.00
		4000747	178.60	196.80
		4000748	0.00	8.00
		4000749	0.00	12.50
		4000841	316.90	211.70

		4000843	65.50	70.70
		4000847	65.20	52.70
		4000848	65.50	27.30
		4000852	95.60	56.60
		4001231	0.00	14.10
		4001235	123.50	0.00
		4001253	13.90	0.00
		4001266	57.50	70.00
		4001269	139.40	72.70
		4001294	22.60	0.00
		4001295	10.60	6.40
		4001296	5.60	12.50
		4001408	15.20	13.80
		4002256	5.60	17.30
40_ADG029	Surface Ck @ Cedaredge	4000638	160.60	159.20
		4000648	103.50	89.70
		4000671	19.50	38.70
		4000672	57.10	54.90
		4000677	65.20	52.50
		4000679	12.30	4.00
		4000680	416.00	374.20
		4000681	25.70	27.40
		4000684	27.00	13.30
		4000685	55.00	69.80
		4000687	3.90	23.20
		4000689	38.50	36.40
		4000690	113.20	0.00
		4000691	11.50	0.00
		4000694	32.40	3.10
40_ADG030	Tongue Ck @ Cory	4000693	243.80	162.20
		4000696	26.10	26.50
		4000706	228.50	168.00
		4000715	58.40	72.40
		4000720	101.90	144.10
		4000726	0.00	28.50
		4000733	186.90	175.20
		4000736	63.10	65.00
		4000752	34.30	29.80
		4000755	327.20	50.30
		4000763	111.10	111.80
		4000773	174.90	215.00
		4000779	9.30	11.70
		4000780	60.50	50.30
		4000782	8.70	9.20
		4000787	76.50	146.40
		4000791	0.00	110.30
		4000839	0.00	15.50
		4000840	0.00	35.20
		4000844	146.40	119.20

		4000845	745.10	278.80
		4000849	151.10	150.20
		4001292	81.00	52.60
		4001293	16.00	0.00
		4001473	233.40	89.30
		4001474	87.80	0.00
40_ADG031	Gunnison R @ Delta	4000646	333.00	121.10
		4000795	0.00	40.70
		4000805	53.30	0.00
		4000811	251.10	99.30
		4000812	257.30	296.40
		4000903	22.90	12.30
		4001341	11.60	0.00
		4001385	7.50	7.20
68_ADG032	UncompahgreR nr Ridgeway	6800516	54.10	63.60
		6800527	0.00	10.40
		6800532	72.00	35.30
		6800570	68.60	49.70
		6800579	11.30	0.00
		6800587	41.30	0.00
		6800590	4.50	0.00
		6800602	0.00	21.60
		6800612	6.50	19.50
		6800617	0.00	38.20
		6800621	57.30	123.80
		6800655	20.10	0.00
		6800656	108.00	0.00
		6800660	41.30	0.00
		6800664	47.40	178.50
		6800690	39.30	12.60
		6800697	15.80	14.30
		6800737	26.00	0.00
		6800747	65.10	128.50
		6800750	6.30	0.00
		6800751	97.70	358.50
		6800771	34.40	13.20
		6800777	69.20	51.70
		6800781	77.20	145.00
		6800907	35.10	0.00
		6801026	15.20	0.00
68_ADG033	Dallas Ck nr Ridgeway	6800506	277.40	0.00
		6800513	15.00	17.10
		6800573	144.60	330.80
		6800597	17.00	18.20
		6800608	11.80	72.30
		6800622	35.00	0.00
		6800640	17.90	0.00
		6800641	34.30	62.00
		6800643	57.30	245.10

		6800663	32.20	0.00
		6800679	145.90	262.50
		6800680	119.70	226.00
		6800708	37.00	11.00
		6800724	84.50	46.60
		6800727	143.90	43.70
		6800731	42.70	43.20
		6800752	42.10	60.60
		6800763	0.00	90.40
		6800766	10.70	0.00
		6800779	10.10	0.00
		6800817	1.90	0.00
68_ADG034	Uncompahgre R @ Colona	6800505	82.40	133.10
		6800510	71.40	68.70
		6800511	144.50	57.30
		6800520	7.20	0.00
		6800522	9.00	0.00
		6800523	74.40	70.80
		6800531	52.30	0.00
		6800542	22.20	0.00
		6800565	71.50	39.60
		6800581	103.50	110.70
		6800601	12.60	0.00
		6800624	83.70	94.70
		6800651	55.10	120.50
		6800673	144.50	141.90
		6800675	66.30	94.40
		6800676	68.80	43.20
		6800677	17.00	0.00
		6800701	23.40	38.50
		6800704	82.20	34.80
		6800715	30.60	69.40
		6800716	12.30	0.00
		6800717	41.00	34.80
		6800725	27.80	0.00
		6800744	125.20	95.30
		6800749	50.40	65.00
		6800755	120.50	103.70
		6800756	448.70	362.60
		6800767	233.80	267.90
		6800778	69.60	50.40
		6800945	0.00	164.00
		6801041	152.60	0.00
41_ADG035	UncompahgreR abvM&Dcanal	4100506	200.80	0.00
		4100509	515.70	373.10
		4100550	59.30	77.10
		4100681	13.50	0.00
		4100692	243.20	0.00

		6800604	228.80	149.50
		6800657	295.40	377.20
41_ADG036	UncompahgreAbvOlatheGage	4100500	156.10	136.00
		4100503	204.20	203.70
		4100511	9.20	7.80
		4100512	0.00	21.90
		4100518	76.40	0.00
		4100521	512.10	480.00
		4100522	87.70	222.30
		4100529	58.00	17.90
		4100533	43.30	29.40
		4100535	216.40	210.40
		4100536	20.80	23.90
		4100539	0.00	27.20
		4100541	335.50	264.00
		4100543	17.80	72.60
		4100544	50.00	54.10
		4100546	25.00	23.30
		4100551	77.20	91.70
		4100555	45.40	50.80
		4100556	70.50	73.20
		4100569	30.00	35.90
		4100572	40.60	1,009.50
		4100579	43.70	0.00
		4100686	24.30	53.00
		4100772	0.00	27.20
		6800566	39.50	0.00
		6800759	563.40	748.60
		6800784	97.70	43.80
41_ADG037	Uncompahgre R @ Delta	4100505	36.10	36.30
		4100517	109.80	98.90
		4100524	257.60	286.30
		4100531	184.80	159.50
		4100565	109.50	100.60
		4100567	64.60	79.20
		6200610	2.90	0.00
		6200714	1.40	0.00
40_ADG038	RoubideauCk@mouth, Delta	4000534	80.10	52.60
		4001307	23.50	0.00
		4001313	14.20	0.00
		4001324	23.50	0.00
		4001425	17.70	20.10
		4001426	148.60	142.20
		4001428	14.20	0.00
		4001435	315.10	256.80
		4001436	42.10	50.20
		4002495	85.70	120.00
40_ADG039	Gunnison R BL Delta	4000516	182.90	214.20
		4000854	208.10	219.70

		4000857	19.20	0.00
		4000858	116.20	108.50
		4000859	108.00	38.90
		4000860	0.00	67.10
		4000862	41.50	9.90
		4000864	7.80	4.70
		4000866	74.00	80.60
		4000867	77.50	21.20
		4000872	78.70	42.90
		4000875	122.40	61.70
		4000876	90.70	43.50
		4000878	27.00	65.60
		4000882	0.00	117.80
		4000884	142.60	3.30
		4000887	98.60	75.10
		4000888	42.40	15.50
		4000890	10.60	7.00
		4000892	289.10	278.90
		4000894	192.10	239.50
		4000897	98.30	22.60
		4000898	22.80	21.80
		4000899	53.80	44.70
		4000901	43.70	0.00
		4000905	39.50	38.80
		4000907	63.40	60.90
		4000910	56.30	64.90
		4000911	0.00	33.20
		4001244	19.90	40.20
		4001997	53.50	40.70
		4002269	36.80	14.20
42_ADG040	Gunnison R nr G Junction	4200501	52.50	52.30
		4200502	17.50	0.00
		4200503	39.30	44.40
		4200504	391.20	451.90
		4200505	2.70	0.00
		4200507	98.90	107.80
		4200508	7.60	0.00
		4200509	381.60	228.70
		4200515	23.00	26.30
		4200516	4.90	7.90
		4200517	24.20	20.10
		4200521	91.00	90.90
		4200522	83.30	44.20
		4200525	38.80	0.00
		4200526	67.30	80.90
		4200527	18.50	27.70
		4200528	93.10	94.60
		4200530	339.80	324.70
		4200531	39.90	47.80

		4200532	54.70	0.00
		4200536	148.30	108.60
		4200538	23.30	27.90
		4200540	32.10	33.00
		4200542	39.10	31.30
		4200543	101.30	0.00
		4200546	51.60	22.80
		4200547	34.90	24.80
		4200548	48.30	0.00
		4200549	66.40	54.70
		4200550	20.20	0.00
		4200551	4.30	0.00
		4200552	11.60	12.70
		4200553	92.30	0.00
		4200554	26.20	31.00
		4200556	12.50	17.90
		4200608	7.50	0.00
		4200609	49.80	71.00
		4200622	23.60	0.00
		4200631	10.50	0.00
		4200635	91.00	0.00
		4200639	18.80	20.40
		4200684	36.00	0.00
		4200723	4.00	0.00
28_ADG043	Cochetopa Creek	2800505	27.30	32.70
		2800522	74.80	86.10
		2800523	48.40	60.60
		2800546	101.80	103.10
		2800547	20.70	21.40
		2800562	100.20	76.80
		2800578	2.90	3.50
		2800792	90.10	79.10
		2800793	48.40	60.60
		2800794	43.00	27.00
		2800814	7.90	7.70
		2800851	30.80	38.10
		2800883	48.40	60.60
		2800887	111.40	30.10
		2800892	140.20	107.50
		2801011	90.10	79.10
		2801027	67.30	42.60
28_ADG044	Razor Creek	2800507	62.90	98.70
		2800508	31.40	73.70
		2800509	12.50	11.60
		2800511	48.20	60.00
		2800586	55.30	14.20
		2800672	76.80	89.20
		2800687	219.00	182.90
		2800689	16.70	12.40

		2800719	82.40	77.60
		2800781	47.10	64.10
		2800806	138.20	92.20
		2800807	207.20	70.90
		2800808	46.10	17.80
		2800809	76.80	25.00
		2800810	107.50	124.90
		2800880	82.40	121.90
		2801055	24.20	32.00
		2801146	30.30	16.80
		2801272	13.80	100.00
		2801273	207.20	177.40
Total			63,328	59,424

Appendix B

Aggregation of Non-Irrigation Structures

1. CDSS Memorandum 4.10
Gunnison River Basin Aggregated Municipal and Industrial Use

2. CDSS Memorandum 4.11
Gunnison River Basin Aggregated Reservoirs and Stock Ponds

CDSS Memorandum
Final

TO: File

FROM: Ray Bennett

SUBJECT: **Subtask 4.10 – Gunnison River Basin Aggregated Municipal and Industrial Use**

Introduction

This memo describes the results of Subtask 4.10 Gunnison 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

Explicitly Modeled M&I Use The following table presents the 1975 to 1991 average annual Municipal and Industrial depletions that are explicitly modeled. These were determined by identifying structures with no irrigated acreage, and structures with a non-agricultural return flow pattern, excluding exports from the basin.

Explicitly Modeled M&I Consumptive Use

ID	**Name**	**Total**
Proj_7	Project 7	706
Total		**706**

Phase II Consumptive Uses and Loss Estimates The following table presents the categories and values of M&I consumptive use presented in the task memorandum 1.14-23, Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison River Basin (05/01/95). Note that this table does not include exports from the basin, which is why exports (*e.g.,* Redlands Power Canal and City of Grand Junction) were excluded from the search for explicitly model M&I users above.

Phase II Consumptive Use and Loss M&I Consumptive Use

Category	Total
Municipal	3,680
Mineral	0
Livestock	1,610
Thermal	0
Total	**5,290**

Aggregated M&I Diversion Based on the above data a total aggregated demand of **4,584 acft/yr** (5,290 - 706) was added in Phase IIIa. Based on the county information provided in the Consumptive Uses and Losses memo, three aggregated M&I demands were added to the model; one (62_AMG001) for the Upper Gunnison River Basin just above the Gunnison River below the Tunnel gage (09128000); one (40_AMG002) for the Lower Gunnison at the Gunnison River at Delta gage (09144250) and one (41_AMG003) for the Uncompahgre River Basin located at the Uncompahgre River at Delta gage. Section D.6 has a network diagram which includes the aggregated M&I nodes.

As summarized below, the Upper Gunnison Aggregated M&I Demand (62_AMG001) was assigned a depletive demand (efficiency of 100%) of **1,532 af/yr**. The Lower Gunnison Aggregated M&I Demand (40_AMG002) was assigned depletive demand (efficiency of 100%) of **1,780 af/yr**. The Uncompahgre Aggregated M&I Demand (41_AMG003) was assigned depletive demand (efficiency of 100%) of **1,272 af/yr**. Each aggregated M&I demand was distributed evenly over 12 months, assigned a water right of 2 cfs and a senior administration number of 1.

The monthly aggregated demand files were built in an editor using a StateMod format. They were named 62_AMG001.stm, 40_AMG002.stm and 41_AMG003.stm for the Upper Gunnison, Lower Gunnison and Uncompahgre Aggregated M&I demands respectively.

Phase IIIa Aggregated M&I Consumptive Use Summary

Aggregated Node	Aggregated M&I ID	Depletive Demand af/yr.	Water Right cfs
Upper Gunnison	62_AMG001	1,532	2
Lower Gunnison	40_AMG002	1,780	2
Uncompahgre	41_AMG003	1,272	2
Total		**4,584**	**6**

CDSS Memorandum
Final

TO: File

FROM: Ray Alvarado

SUBJECT: **Subtask 4.11-Gunnison River Basin**
Aggregate Reservoirs and Stock Ponds

Introduction

This memorandum describes the approach and results obtained under Subtask 4.11, Aggregate Reservoirs and Stock Ponds. The objective of this task was as follows:

> *Aggregate reservoirs 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 are explicitly modeled and those to be added as aggregated reservoirs in Phase IIIa, and stock ponds to be added as aggregated stock ponds in Phase IIIa. Running **watright** for storage structures (see Section D.8) produced the absolute decree amount presented in Table 1 for "Total Aggregated Reservoirs". The storage presented in Table 1 for the "Total Aggregated Stock Ponds" was taken from the year 1 Task Memorandum 1.14-23 "Consumptive Use Model Non-Evaporation (Other Uses) Consumptive Uses and Losses in the Gunnison River Basin" (5/1/95).

TABLE 1

Reservoir	Absolute Decree	Percent of Total
FRUIT GROWERS RES	7,360	<1%
FRUITLAND RES(GOULD)	10,168	<1%
OVERLAND RES. NO. 1	6,120	<1%
PAONIA RESERVOIR	284,424	14%
CRAWFORD RESERVOIR	14,395	<1%
TAYLOR PARK RESERVOIR	155,964	8%
BLUE MESA RESERVOIR	940,800	46%
MORROW POINT RESRVOIR	119,053	6%
SILVERJACK RESERVOIR	140,000	7%
CRYSTAL RESERVOIR	30,000	2%
RIDGWAY	223,061	11%
Subtotal	1,931,345	94%
Total Aggregated Reservoirs	105,168	5%
Total Aggregated Stock Ponds	8,635	<1%
Subtotal	113,803	6%
Total	2,045,148	100%

Number of Structures and Locations: Based on general location, the Phase IIIa reservoirs and stock ponds were incorporated into the model as 14 aggregated structures. Nine operational reservoirs were used to model the net absolute decreed storage. Storage was assigned to the nine nodes by summing the decreed amounts of the absolute storage rights in each Water District, excepting the explicitly modeled structure rights. Using a criterion that no aggregated reservoir should be greater than 25,000 af, the storage for Water District 40 was divided into two nodes. In District 62, the storage was divided into two nodes to allow more realistic location representation. Results of the capacity assignment are shown in **Table 2**. The five non-operational reservoirs were used to model the stock ponds, also shown in **Table 2**.

Each aggregated reservoir and stock pond was assigned one account and an initial storage equal to their capacity. Each aggregated reservoir was assumed to be 25 feet deep, based on available dam safety records, stock ponds were 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 by 25 feet for reservoirs and 10 feet for stock ponds. The net evaporation station as described in Phase II Gunnison 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

Operational Reservoirs

Model ID	Name	Capacity (AF)	Percent
28_ARG001	28_ARG001	6,395	6
40_ARG001	40_ARG001	23,268	22
40_ARG002	40_ARG002	23,268	22
41_ARG001	41_ARG001	3,226	4
42_ARG001	42_ARG001	17,876	17
59_ARG001	59_ARG001	9,826	9
62_ARG001	62_ARG001	6,475	6
62_ARG002	62_ARG002	6,475	6
68_ARG001	68_ARG001	8,359	8
	Total	105,168	100

Stock Ponds

Model ID	Name	Capacity (AF)	Percent
42_ASG001	42_ASG001	1,727	20
62_ASG001	62_ASG001	1,727	20
40_ASG001	40_ASG001	1,727	20
68_ASG001	68_ASG001	1,727	20
41_ASG001	41_ASG001	1,727	20
	Total	8,635	100

Target Contents, and End-of-Month Data: The maximum targets for both aggregated reservoirs and aggregated stock ponds were set to structure capacity in the target (*.tar*) file. Capacities were also used in the end-of-month data file (**.eom*) used in the baseflow calculation.

Water Rights: Water rights associated with each aggregated reservoir and stock pond were assigned an administration number equal to 1.

Appendix C

Pattern Streamgages

CDSS Daily Gunnison Model – Task 6.1 Recommendation of Pattern Streamgages for Full Basin Model

CDSS MEMORANDUM
FINAL

TO: File – 1111CWB01

FROM: Jennifer Ashworth

DATE: December 20, 2002

RE: CDSS Daily Gunnison Model – Task 6.1 Recommendation of Pattern Streamgages for Full Basin Model

Introduction

The purpose of this memorandum is to outline the approach used to select pattern streamgages within the Gunnison Basin for the daily model. The objective of Task 6.1 was to "select streamgages 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 study period chosen for the Daily Gunnison Model was 1975 through 2000. The start of the period, 1975, is consistent with the start of the Daily Yampa Model. The end of the study period is last year of the most recent updated Monthly Gunnison Model.

Approach and Results

The daily streamflow pattern gages were selected for use in the Gunnison Model by using the following approach:

1) ***Review Completeness of Daily Records*** - The streamflow gages within the Gunnison Model were reviewed for completeness of daily records over the 1975 through 2000 study period.
2) ***Select Representative Gages*** - Representative gages were selected based on the location and minimal upstream effects.
3) ***Compare Historic Flows and StateMod Calculated baseflows*** – Average historical monthly flows were compared to the average baseflows calculated using StateMod to quantify the upstream effects and verify the gage selections from Step 2.
4) ***Fill Missing Daily Data*** – Selected pattern gages missing daily data over the 1975 through 2000 study period were filled using the monthly regression models from Phase IIIa.
5) ***Generate the Historic Daily Streamflow File*** – The historic daily streamflow file, *gunndaily.rid*, was created using the command file *filldaily.cmd* in TSTool.

Approach - Review Completeness of Daily Records

Within the Monthly Gunnison Model, a total of fifty-two streamgages are used. Each of these gages was reviewed to determine which gages would be selected for the 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 – 2000),
(2) Location of the gage.

Of the fifty-two gages in the Gunnison Model, only thirteen gages had a complete daily data set over the 1975 – 2000 study period. Additionally, two gages were missing only 2% of the daily data over the study period, and one gage was missing 6%. The remaining thirty-six gages were missing 20% or more of the daily data over the 1975 – 2000 study period, which was considered to be an unreasonably high number of missing data to serve as a pattern gage. The sixteen gages with a complete or near complete data set are listed below:

- 09109000 Taylor River below Taylor Reservoir
- 09110000 Taylor River at Almont
- 09112500 East River at Almont
- 09114500 Gunnison River near Gunnison
- 09119000 Tomichi Creek at Gunnison
- 09124500 Lake Fork at Gateway
- 09126000 Cimarron River near Cimarron
- 09128000 Gunnison River below Gunnison Tunnel
- 09132500 North Fork Gunnison River near Somerset
- 09143000 Surface Creek near Cedaredge (missing 2% of daily data during study period)
- 09143500 Surface Creek at Cedaredge (missing 2% of daily data during study period)
- 09144250 Gunnison River at Delta (missing 6% of daily data during study period)
- 09146200 Uncompahgre River near Ridgeway
- 09147500 Uncompahgre River at Colona

- 09149500 Uncompahgre River at Delta
- 09152500 Gunnison River near Grand Junction

Approach - 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.

Six streamflow gages from the bulleted list above were identified as being located where historic flows would be similar to baseflow conditions. These gages are as follows:

- 09112500 – East River at Almont
- 09119000 – Tomichi Creek at Gunnison
- 09124500 – Lake Fork at Gateway
- 09143000 – Surface Creek near Cedaredge
- 09143500 – Surface Creek at Cedaredge
- 09146200 – Uncompahgre River near Ridgeway

Five of the six gages listed above were assigned to represent an appropriate sub-basin. Gage 09143000 was not assigned to a sub-basin due to its close proximity to gage 09143500. Since gage 09143500 is missing 2% of the data set over the study period, the missing data will be filled using the monthly regression models used in Phase IIIa. Once the missing data is filled, gage 09143500 can be used as a pattern gage.

The five selected pattern gages were assigned to represent all of the sub-basins in the Gunnison model, with the exception of the North Fork, Smith Fork, and Crystal Creek sub-basins. Gage 09132500 was selected as the pattern gage for these sub-basins. Although 09132500 has a complete data set and was part of the original sixteen gages identified as possible pattern gages, it is located downstream of Paonia Reservoir. After reviewing the effects from Paonia Reservoir, it was determined that the historic flow at gage 09132500 would be representative of baseflow conditions. Table 1 summarizes the pattern gages selected for each sub-basin in the Gunnison Model.

Table 1
Recommended Daily Pattern Gages for Gunnison River Sub-basins

Basin Subdivision	Recommended Pattern Gage
Uncompahgre River (Districts 41 & 68)	09146200 - Uncompahgre River near Ridgeway, CO
Surface, Currant, Kannah, and Lereaux Creeks, along with the Fruit Growers Area	09143500 - Surface Creek at Cedaredge, CO
Lake Fork, Cimarron, and Cebolla Creeks (District 62)	09124500 - Lake Fork at Gateway, CO
E. Muddy, W. Muddy, North Fork, Smith Fork, Iron, Alum, Virginia, and Crystal Creeks	09132500 - North Fork Gunnison River near Somerset, CO
Tomichi Creek (District 28)	09119000 - Tomichi Creek at Gunnison, CO
East, Slate, Cement, Ohio, and Castle Creeks (District 59)	09112500 - East River at Almont, CO

A brief description of why each pattern gage was chosen to represent the corresponding sub-basins follows:

- Gage 09146200 was selected to represent the entire Uncompahgre basin and its tributaries because the gage is located above Ridgeway Reservoir and the imports from the Cimarron Project and the Gunnison Tunnel. The Roubideau Creek sub-basin is also represented by this gage because of its close proximity to the Uncompahgre basin and because Roubideau has the same North facing aspect as the Uncompahgre.
- Gage 09143500 was selected to represent Surface Creek and its tributaries, along with Currant Creek, Kannah Creek, Lereaux Creek, and the Fruit Growers area because these sub-basins all are within close proximity and have the same South facing aspect.
- Gage 09124500 was selected to represent all of District 62, which includes Lake Fork, Cimarron and Cebolla. This was the only gage within this sub-basin that had a complete data set over the study period, and was not located below a key reservoir. These sub-basins all have the same North facing aspect and are within close proximity to each other.
- Gage 09119000 was selected to represent all of District 28, Tomichi Creek, because it was the only gage in this basin that had a complete data set. The gage does not have any key reservoirs, imports or exports located above it.
- Gage 09112500 was selected to represent all of District 59 (East, Slate, Cement, Ohio, Castle, and Taylor), along with the mainstem Gunnison River. This gage was the only streamflow gage within District 59 which had a complete data set over the study period. Additionally, the gage does not have any key reservoirs, imports or exports located above it. To determine which gage would best represent the mainstem of the Gunnison River, average monthly baseflows (determined using StateMod) for mainstem gages 09152500 and 09144250 were compared to the historic average monthly flows for gages 09112500, 09146200, and 09132500. The 09112500 gage most closely matched both 09152500 and 09144250. An example of this comparison is provided below in Figure 1.
- Gage 09132500 was selected to represent E. Muddy, W. Muddy, North Fork Gunnison, Iron Creek, Alum, Virginia, and Crystal Creek because this gage was the only gage within these sub-basins that had a complete data set over the period of record.

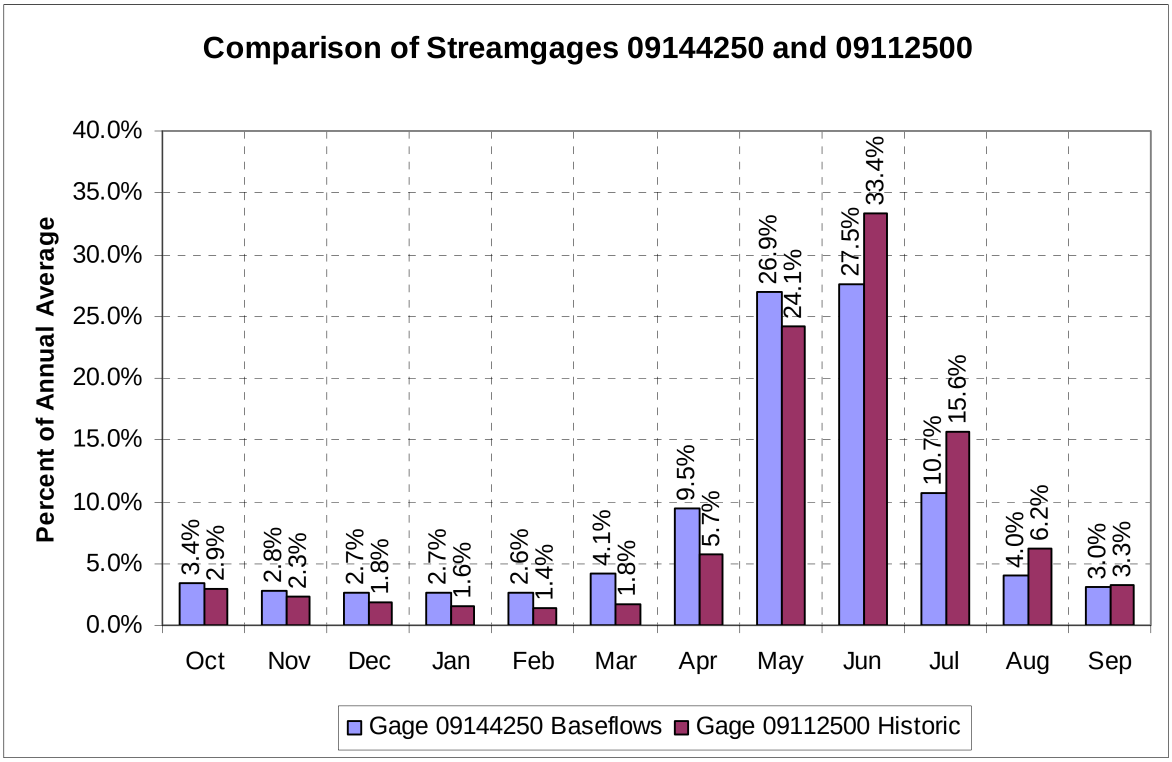


Figure 1 – Comparison of 09144250 baseflows and 09112500 historic flows. An example of the comparison used to determine which gage would best represent the mainstem of the Gunnison River.

Figure 2, attached, illustrates all of the gages with in the Gunnison Model and the recommended pattern gages that will be used to represent them in the daily model.

Approach - Compare Historic Flows and StateMod Calculated Baseflows

Each of the selected pattern gages was analyzed to determine how well the historical flow at the gage represented the calculated baseflow at the gage. Table 2 compares the historic flow and StateMod determined baseflow at each of these selected pattern gages. The difference between the baseflow and the historical flow represents the amount of consumptive use above the selected gage.

Table 2
Potential Pattern Gages for Gunnison Daily Model

Station No.	Station Name	Period of Record	Average Annual Baseflow (af)(2)	Average Annual Historical Flow (af)(3)	Difference (af)	Difference (%)
09146200	Uncompahgre River near Ridgeway, CO	1975 - 2000	126,645	124,937	1,708	1.3
09143500	Surface Creek at Cedaredge, CO	1975-2000(1)	29,968	22,603	7,365	24.6
09124500	Lake Fork at Gateway, CO	1975-2000	173,968	172,503	1,465	0.8
09132500	North Fork Gunnison River near Somerset, CO	1975-2000	380,133	367,874	12,259	3.2
09119000	Tomichi Creek at Gunnison, CO	1975-2000	184,993	132,717	52,276	28.3
09112500	East River at Almont, CO	1975-2000	259,068	246,556	12,512	4.8

(1) Gage 09143500 does not have any data for Nov. through Dec. 1999 and Jan. through Mar 2000. This missing data accounts for approximately 2% of study period.
(2) Averaging period is 1975 through 2000. Source is file gunnvx.xbm, dated 12/05/02.
(3) Averaging period is 1975 through 2000. Source file is gunnvh.xsc dated 12/05/02.

Approach - Fill Missing Daily Data

Gage 09143500, Surface Creek at Cedaredge, was missing 2% of the daily data over the 1975 through 2000 study period. The missing daily data was filled in using the monthly regression models used in Phase IIIa. Gage 09112500 was selected as the independent gage for correlating to gage 09143500 because of the high correlation coefficient determined from the file *gunnv.sum*. The non-cyclical correlation coefficient between gage 09112500 and gage 09143500 was 0.89. Although two other gages had a slightly better non-cyclical correlation coefficient with gage 09143500, gage 09112500 had a correlation coefficient for each month in the cyclical correlation, whereas the others did not. The following commands were used in TSTool to fill the missing daily data in gage 09143500:

- FillRegression() – used to fill in the missing monthly data for gage 09143500 with monthly logarithmic regression equations using gage 09112500.
- FillDayTSFrom2MonthTSAnd1DayTS() – used to fill in the missing daily data for gage 09143500 using the relationship: $D_{1i} = D_{2i}*(M_{1i}/M_{2i})$,

  where D_{1i} is the daily data for gage 09143500, D_{2i} is the daily data for gage 09112500, M_{1i} is the monthly data for gage 09143500, and M_{2i} is the monthly data for gage 09112500.

Approach - Generate the Historic Daily Streamflow File

The daily historic streamflow file was created using a new command file, *filldaily.cmd*, in TSTool. The resulting output file, *gunndaily.rid*, calculates the daily streamflow for each gage in the basin over the 1975 through 2000 study period based on the representative pattern gages.

Conclusions

The Daily Pattern approach was used to develop the daily model for the Gunnison River Basin. Six streamgages within the basin were selected as pattern gages, which will be used to represent the remaining gages in the daily model. These six streamgages were selected based on the completeness of the daily data set over the study period (1975 – 2000), and the location of the streamgage. The streamgages selected and the sub-basin that they will represent are summarized in Table 1 and illustrated in Figure 2.

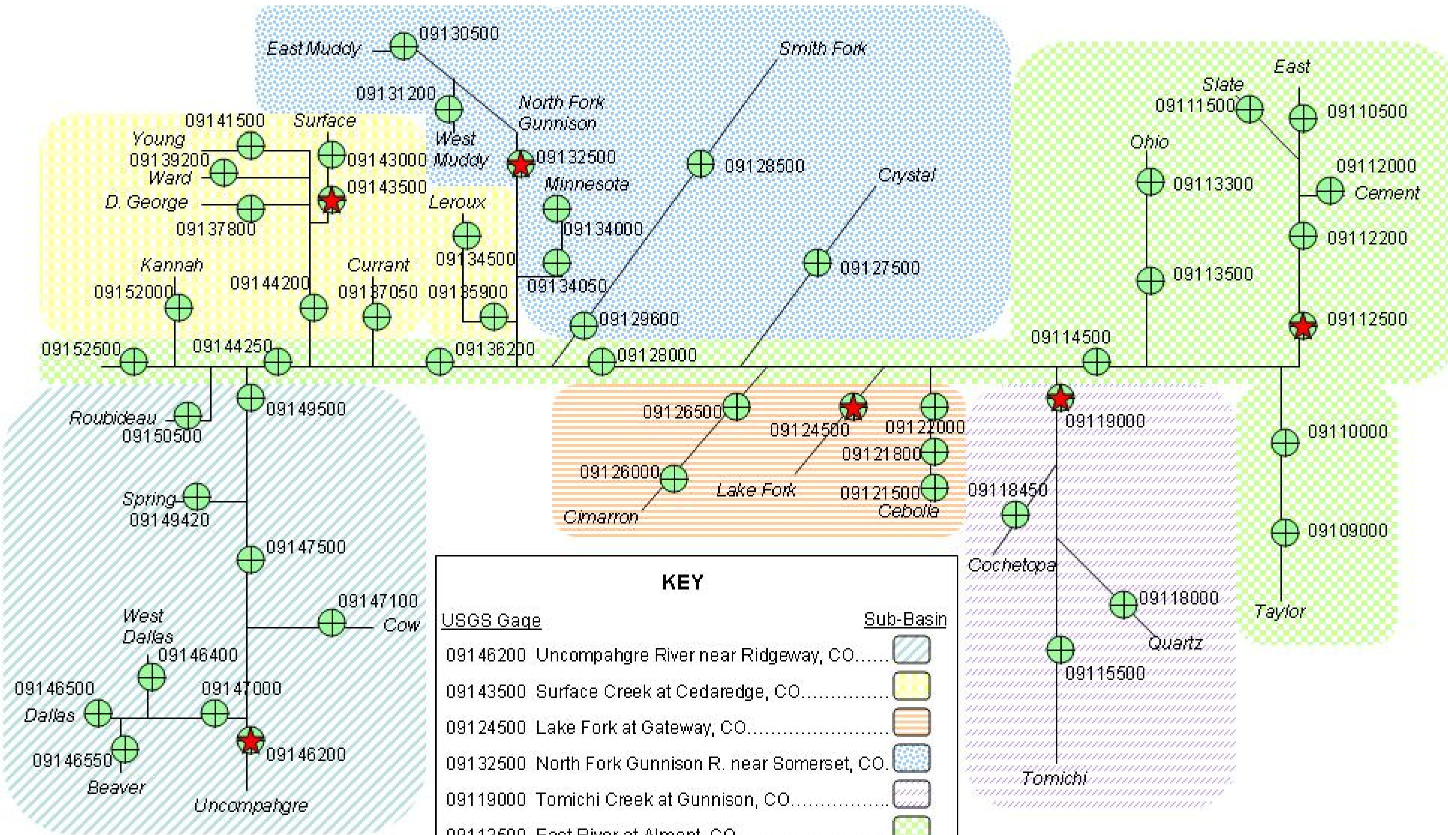
Comments and Concerns

When comparing the historical streamgage flows to the baseflows calculated from StateMod (see Table 2), the following two gages showed a high percent difference:

- Gage 09143500 – 24.6% difference
- Gage 09119000 – 28.3% difference

For these two gages, most of the difference between historic flows and calculated baseflows is attributed to upstream depletions. Even with the depletions upstream, the average monthly pattern for these gages is similar between the historic flows and calculated baseflows.

Figure 2. Division 4 - Recommended Application of Daily Pattern Gages



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Appendix D

Simulation Results with Calculated Irrigation Demand

Calculated Data Set

The “Calculated Data Set” is a data set that was created to further look at simulation of the Gunnison River basin 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 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, 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 2002 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 (50 percent), however, which represents an estimated practical upper limit on efficiency for flood irrigation systems in the Gunnison 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.

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 Gunnison basin.

Basinwide Calculated demand over the calibration period (1975-2002) amounts to 2,725,600 acre-feet per year on average. This compares with historical diversion which averaged 2,264,400 acre-feet per year over the same period. The Calculated demand represents an increase of more than 17 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 water rights, whereas Baseline demands reflect the current water right regime.

Calculated Data Set Calibration Efforts

In preliminary simulations of the Calculated data set, the Gunnison Tunnel exported less water to the Uncompahgre basin than it did historically, and Uncompahgre users were significantly shorted. The UVWUA attempts to operate its system to avoid, to the extent possible, placing an administrative call against junior rights in the Uncompahgre and Gunnison River basins. When project demand is not satisfied by direct flow water, UVWUA can elect to take water from storage (Ridgway Reservoir in any case, and Blue Mesa if the Tunnel is flowing less than full) or to place a call against junior water rights.

This is a subjective decision considering the amount of water in storage, climatic conditions, and how much of the irrigation season remains. If UVWUA places a call against Uncompahgre junior rights, the UVWUA and Division Engineer have an informal agreement whereby UVWUA will only call up to approximately 245 cfs. This amount will be delivered to the headgate of the M&D Canal, the largest and most upstream project structure. All other project demands are supplied from UVWUA's other sources, including the Gunnison Tunnel direct flow rights, and from upgradient irrigation return flows.

Simulating the good neighbor policy with the Historical Data set was not an issue, because the Gunnison Tunnel demand is set to the tunnel's historical diversions. Decisions about how soon to bring Gunnison Tunnel water to the Uncompahgre, or how much to bring over, are reflected in the diversion record. In the Calculated Data set, however, Gunnison Tunnel diversions are driven by the unmet UVWUA demand after direct flow rights have been used to their full extent. To simulate UVWUA's practice of limiting their calls under their Uncompahgre direct flow rights, some of the UVWUA direct flow rights were turned off.

Direct flow rights for UVWUA structures were turned off in successive runs, beginning with the most junior administration number (other than free water rights) and working toward the most senior. The amount of water diverted through the Gunnison Tunnel was compared to historical tunnel diversions until the comparison was reasonable. The best match between simulated and historical Gunnison Tunnel diversions was achieved when rights at or junior to and administration number of 14198.00000, which corresponds to a priority date of November 5, 1888, were turned off.

Calculated Data Set Simulation Results

Simulation of the Calculated Gunnison River model is considered good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. The basinwide shortage, determined to be simulated diversions divided by Calculated demand, is about 6.5 percent per year, on average. Basinwide, 12 percent more water is being diverted during Calculated simulation, determined by dividing simulated diversions by historic diversions. Simulated reservoir contents are representative of historical values.

Water Balance Results

Table D.1 summarizes the water balance for the Gunnison River model, for the calibration period (1975-2002). Following are observations based on the summary table:

- Surface water inflow to the basin averages 2.40 million acre-feet per year, and stream outflow averages 1.86 million acre-feet per year.

- Annual diversions amount to approximately 2.53 million acre-feet on average. Note that even though basinwide diversions are approximately 12 percent greater than historical diversions, the 2,530,000 acre-feet value is less than reported water balance diversion simulated under the historical simulation. This is because historical demands for carriers were included in the historical calibration model - the Gunnison Tunnel alone accounted for around 333,000 acre-feet of diversions reported in the historical water balance.

- Approximately 495,000 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 (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	90,413	164,014	236	254,663	163,294	1,875	131,130	-41,872	2,555	-2,319	254,663	0	12,890
NOV	67,182	84,583	8	151,773	56,382	711	133,243	-38,570	583	-575	151,773	0	1,855
DEC	61,706	68,815	0	130,521	51,419	291	116,429	-37,618	351	-351	130,520	0	1,142
JAN	59,552	61,031	0	120,583	48,885	364	83,900	-12,567	250	-250	120,583	0	1,191
FEB	56,427	53,501	0	109,928	45,816	699	79,869	-16,456	188	-188	109,928	0	1,429
MAR	87,816	56,342	92	144,249	55,060	1,451	95,486	-7,839	281	-190	144,249	0	3,710
APR	214,684	123,959	293	338,936	162,229	3,248	125,597	47,570	832	-539	338,936	0	19,706
MAY	612,543	267,840	1,878	882,262	389,506	5,386	368,283	117,209	2,876	-998	882,262	0	69,014
JUN	625,364	356,241	2,355	983,960	517,647	7,158	323,826	132,974	2,213	141	983,960	0	113,870
JUL	291,394	328,969	4,178	624,541	462,479	6,109	172,128	-20,353	716	3,462	624,541	0	120,860
AUG	133,796	251,139	5,248	390,183	330,351	5,067	119,540	-70,022	626	4,622	390,183	0	93,464
SEP	99,433	209,202	4,557	313,192	249,568	4,041	110,828	-55,801	719	3,838	313,192	0	56,267
AVG	2,400,308	2,025,639	18,845	4,444,792	2,532,634	36,399	1,860,259	-3,345	12,192	6,653	4,444,792	-1	495,396

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 2002, as estimated in the Calculated 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 D.1 through D.11 (at the end of this appendix) graphically present monthly streamflow estimated by the model compared to historical observations at key streamgages 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 calibration based on streamflow simulation is generally very good in terms of both annual volume and monthly pattern, and similar to the historical calibration results. Exceptions include the Uncompahgre River at Delta gage, where simulated streamflows are 4 percent more than historical streamflows, and the Gunnison River at Delta gage, where simulated streamflows are 5 percent less than historical streamflows. The average efficiencies for all the large irrigation diversions in the Uncompahgre Valley are less than 23 percent, therefore, in many months when the basin operated more efficiently, calculated demand is higher than historical diversions – in fact 14 percent higher on average for the Water District 41. More than 98 percent of that increased demand is met, much of it from direct diversions. The remaining demands are met from the Gunnison Tunnel, which is delivering 15 percent more than historical to the Uncompahgre. The increase in flows on the Uncompahgre is, in part, the results of return flows from this increased import.

Table D.2
Historical and Simulated Average Annual Streamflow Volumes (1975-2002)
Calculated Simulation (acre-feet/year)

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9109000	147,968	148,493	-525	0	Taylor River Below Taylor Park Reservoir
9110000	236,375	236,633	-259	0	Taylor River at Almont
9110500	*No gage during simulation period*			0	East River Near Crested Butte
9111500	98,931	97,500	1,431	1	Slate River Near Crested Butte
9112000	*No gage during simulation period*			0	Cement Creek Near Crested Butte
9112200	231,532	229,057	2,474	1	East River Below Cement Creek NR Crested Butte
9112500	238,733	235,275	3,457	1	East River at Almont
9113300	*No gage during simulation period*			0	Ohio Creek at Baldwin
9113500	56,954	46,618	10,335	18	Ohio Creek Near Baldwin
9114500	529,302	516,106	13,196	2	Gunnison River Near Gunnison
9115500	45,797	45,298	499	1	Tomichi Creek at Sargents
9118000	*No gage during simulation period*			0	Quartz Creek Near Ohio City
9118450	33,105	30,073	3,032	9	Cochetopa Creek Below Rock Creek Near Parlin
9119000	127,952	116,045	11,908	9	Tomichi Creek at Gunnison
9121500	*No gage during simulation period*			0	Cebolla Creek Near Lake City

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9121800	*No gage during simulation period*			0	Cebolla Creek Near Powderhorn
9122000	*No gage during simulation period*			0	Cebolla Creek at Powderhorn
9124500	167,999	167,460	539	0	Lake Fork at Gateview
9126000	70,457	71,543	-1,086	-2	Cimarron River Near Cimarron
9126500	*No gage during simulation period*			0	Cimarron River at Cimarron
9127500	*No gage during simulation period*			0	Crystal Creek Near Maher
9128000	888,915	810,093	78,822	9	Gunnison River Below Gunnison Tunnel
9128500	33,416	34,225	-809	-2	Smith Fork Near Crawford
9129600	28,116	28,659	-543	-2	Smith Fork Near Lazear
9130500	*No gage during simulation period*			0	East Muddy Creek Near Bardine
9131200	*No gage during simulation period*			0	West Muddy Creek Near Somerset
9132500	352,863	342,203	10,660	3	North Fork Gunnison River Near Somerset
9134000	15,138	15,266	-128	-1	Minnesota Creek Near Paonia
9134050	10,181	9,683	499	5	Minnesota Creek at Paonia
9134500	*No gage during simulation period*			0	Leroux Creek Near Cedaredge
9135900	20,892	22,374	-1,482	-7	Leroux Creek at Hotchkiss
9136200	1,446,348	1,363,258	83,090	6	Gunnison River Near Lazear
9137050	10,560	11,981	-1,421	-13	Currant Creek Near Read
9137800	*No gage during simulation period*			0	Dirty George Creek Near Grand Mesa
9139200	*No gage during simulation period*			0	Ward Creek Near Grand Mesa
9141500	*No gage during simulation period*			0	Youngs Creek Near Cedaredge
9143000	32,964	32,964	-1	0	Surface Creek Near Cedaredge
9143500	22,602	24,460	-1,858	-8	Surface Creek at Cedaredge
9144200	52,622	54,607	-1,985	-4	Tongue Creek at Cory
9144250	1,501,545	1,420,875	80,670	5	Gunnison River at Delta
9146200	121,827	121,678	149	0	Uncompahgre River Near Ridgway
9146400	*No gage during simulation period*			0	West Fork Dallas Creek nr Ridgway
9146500	*No gage during simulation period*			0	East Fork Dallas Creek nr Ridgway
9146550	*No gage during simulation period*			0	Beaver Creek nr Ridgway
9147000	29,636	29,727	-91	0	Dallas Creek nr Ridgway
9147100	*No gage during simulation period*			0	Cow Creek Near Ridgway
9147500	192,969	192,336	633	0	Uncompahgre River at Colona
9149420	39,882	39,882	0	0	Spring Creek Near Montrose
9149500	236,296	246,854	-10,558	-4	Uncompahgre River at Delta
9150500	88,628	87,947	682	1	Roubideau Creek at Mouth, Near Delta
9152000	17,377	17,491	-113	-1	Kannah Creek Near Whitewater
9152500	1,910,511	1,868,806	41,706	2	Gunnison River Near Grand Junction

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 2002. Table D.5 (at the end of this appendix) shows the average annual shortages for water years 1975 through 2002 by structure. On a basin-wide basis, average annual diversions are greater than historical diversions by about 13 percent in the Calculated calibration run. Note that both Table D.3 and D.5 include diversions through the Gunnison Tunnel and other carriers, compared to the water carried historically. These structures do not have specific demand in the Calculated data set, the demand is modeled at the final destination. Therefore, both tables show greater simulated diversions than the Calculated demands discussed above, and the diversion shown in Table D.1.

Table D.3
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2002)
Calculated Simulation (acre-feet/year)

			Historical minus Simulated	
Tributary or Sub-basin	Historical	Simulated	Volume	Percent
Taylor River	9,264	10,205	-941	-10
East River	103,025	118,117	-15,092	-15
Ohio Creek	47,065	69,287	-22,222	-47
Tomichi Creek	198,034	235,774	-37,740	-19
Cebolla Creek, Lake Fork, and Cimarron River	70,891	81,925	-11,034	-16
Crystal River	19,688	22,406	-2,718	-14
Smith Fork	69,108	89,389	-20,281	-29
N.F. Gunnison River	168,663	206,732	-38,069	-23
Currant Creek	20,626	19,464	1,162	6
Surface Creek	77,987	76,166	1,821	2
Uncompahgre River	761,681	860,958	-99,277	-13
Roubideau Creek	2,942	4,490	-1,548	-53
Kannah Creek	16,700	18,481	-1,781	-11
Gunnison River Mainstem	1,074,732	1,178,840	-104,108	-10
Basin Total	2,640,406	2,992,234	-351,828	-13

As noted previously, the Calculated demand (not shown in Table D.3) represents an increase of more than 17 percent over historical diversions, compared to the Calculated simulated diversions shown in Table D.3 which represent a 13 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 basin-wide.

Reservoir Results

Figures D.12 through D.20 (located at the end of this appendix) present reservoir EOM 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.

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, the StateMod structure summary file (*.xss) results were "filtered" to only include the structures in the StateCU analysis.

Table D.4 shows the comparison of StateCU estimated potential crop consumptive use, StateCU estimated water-supply limited crop consumptive, and StateMod simulated crop consumptive use for the Calculated calibration. Table D.4 presents these values for explicit structures, aggregated structures, and total for the basin. 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 analyses. 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 approximately 7 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 (1975-2002)
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	374,514	318,883	15%	337,674	10%
Aggregate Structures	114,746	92,167	20%	107,211	7%
Basin Total	489,260	411,050	16%	444,885	9%

Not that the simulated crop consumptive use presented here represents only a portion of the approximately 495,000 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, 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 (1975-2002)
Calculated Simulation (acre-feet/year)

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
280500	1,553	1,824	-271	-17	ADAMS NO 1 DITCH
280503	500	310	190	38	AGATE NO 2 DITCH
280510	14,099	15,913	-1,814	-13	ARCH IRRIGATING DITCH
280515	4,260	5,479	-1,219	-29	BIEBEL DITCHES NOS 1&2
280520	1,891	2,161	-270	-14	CAIN BORSUM DITCH
280526	2,716	3,036	-320	-12	CHITTENDEN DITCH
280527	346	370	-24	-7	CLARK NO 1 DITCH
280528	604	647	-43	-7	CLARK NO 2 DITCH
280529	777	872	-95	-12	CLARK NO 3 DITCH
280530	811	941	-130	-16	CLOVIS METROZ NO 1 DITCH
280532	1,830	2,142	-312	-17	COATS BROS DITCH
280535	609	483	126	21	COLE NOS 1 2 & 3 DITCHES
280536	1,667	1,847	-180	-11	COX AND MCCONNELL DITCH
280542	1,651	1,983	-332	-20	CUTJO DITCH
280543	586	699	-113	-19	D A MCCONNELL DITCH
280550	2,651	2,319	332	13	DUNN AND WATTERS DITCH
280554	1,473	1,827	-354	-24	ELSEN VADER DITCH
280557	894	1,122	-228	-26	FIELD AND VADER DITCH
280564	1,280	1,378	-98	-8	TOMI_GILBERTSON NO 1
280566	1,990	2,507	-517	-26	GOODRICH DITCH
280567	2,542	2,612	-70	-3	GOODWIN AND WRIGHT DITCH
280568	4,491	5,928	-1,437	-32	LOS _GOVERNMENT DITC
280571	3,930	4,809	-879	-22	TOMI_GRIFFING NO 1 D
280576	3,025	3,969	-944	-31	GULLETT TOMICHI IRG D
280577	1,357	1,518	-161	-12	HANNAH J WINTERS NO 2D
280580	1,179	1,293	-114	-10	HAWES-BERGEN-GILBERTSON
280581	1,542	1,775	-233	-15	HAZARD DITCH
280583	876	1,061	-185	-21	HEAD AND CORTAY NO 4 D
280587	1,166	1,353	-187	-16	HOME DITCH DITCH NO 81
280588	915	1,149	-234	-26	HOME DITCH DITCH NO 182
280590	361	440	-79	-22	HOT SPRINGS NOS 1&2 D
280604	522	480	42	8	KANE DITCH
280607	456	440	16	4	KENDALL NO 3 DITCH
280608	514	463	51	10	KENDALL NO 4 DITCH
280622	283	382	-99	-35	LOBDELL NO 2 DITCH
280624	2,846	3,718	-872	-31	LOCKWOOD MUNDELL DITCH
280631	1,912	2,680	-768	-40	MCCANNE NO 1 DITCH
280632	3,464	4,117	-653	-19	MCCANNE 2 DITCH
280633	1,278	1,429	-151	-12	MCCANNE 3 DITCH
280636	2,363	2,534	-171	-7	MCDONOUGH DITCH
280638	1,898	1,857	41	2	TOMI_MCGOWAN IRRIGAT
280642	605	564	41	7	MEANS BROS NO 13 DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
280645	333	331	2	1	MEANS BROS NO 4 DITCH
280646	387	421	-34	-9	MEANS BROS NO 5 DITCH
280647	448	349	99	22	MEANS BROS NO 6 DITCH
280648	334	290	44	13	MEANS BROS NO 7 DITCH
280649	604	605	-1	0	MEANS BROS NO 12 DITCH
280650	1,147	1,406	-259	-23	MEANS BROS NO 8 DITCH
280651	6,921	7,447	-526	-8	MESA DITCH
280652	977	1,184	-207	-21	MILLER DITCH
280654	1,668	2,280	-612	-37	MONSON & MCCONNELL D
280660	834	955	-121	-15	NORMAN DITCH
280662	1,103	1,314	-211	-19	OFALLON NO 3 DITCH
280663	823	908	-85	-10	OFALLON NO 4 DITCH
280665	603	688	-85	-14	O'REGAN NO 1 DITCH
280667	1,185	1,429	-244	-21	OWEN NO 1 DITCH
280668	3,449	4,384	-935	-27	OWEN REDDEN DITCH
280670	1,086	1,566	-480	-44	PARLIN NO 2 DITCH
280671	3,992	4,359	-367	-9	PARLIN QUARTZ CREEK D
280673	3,072	3,409	-337	-11	PERRY IRRIGATING DITCH
280674	3,967	5,366	-1,399	-35	PIONEER DITCH
280679	1,624	1,781	-157	-10	ROGERS METROZ DITCH
280680	2,628	1,838	790	30	S DAVIDSON&CO FDR D NO 1
280681	314	243	71	23	SARGENTS NO 1 D
280682	337	313	24	7	SARGENTS NO 2 D
280686	3,538	4,193	-655	-19	SMITH FORD NO 2 DITCH
280690	2,150	2,713	-563	-26	SORRENSON IRRIGATING D
280692	1,642	1,919	-277	-17	SOUTH SIDE DITCH
280693	2,162	2,682	-520	-24	STEPHENSON DITCH
280697	63	76	-13	-21	SUTTON NO 3 AMENDED D
280703	917	1,141	-224	-24	TARBELL & ALEXANDER D
280707	3,377	3,457	-80	-2	TORNAY HIGHLINE DITCH
280709	958	1,227	-269	-28	VADER RAUSIS DITCH
280711	1,055	1,199	-144	-14	WATERMAN METROZ DITCH
280714	228	322	-94	-41	WICKS ROWSER DITCH
280715	1,611	2,076	-465	-29	WOOD AND GEE DITCH
280716	965	1,125	-160	-17	WOODBRIDGE DITCH
280823	266	271	-5	-2	MCDONALD BERDEL EX D
400500	15,732	20,195	-4,463	-28	CRAWFORD CLIPPER DITCH
400501	6,428	7,372	-944	-15	NEEDLE ROCK DITCH
400502	3,393	2,614	779	23	SADDLE MT HIGHLINE D
400503	6,891	16,816	-9,925	-144	GRANDVIEW CANAL
400504	7,514	8,755	-1,241	-17	CEDAR CANON IRON SPR D
400506	1,539	2,121	-582	-38	ALUM GULCH DITCH
400508	6,356	3,358	2,998	47	ASPEN DITCH
400509	1,097	2,100	-1,003	-91	ASPEN CANAL
400533	1,084	1,413	-329	-30	CRYSTAL VALLEY DITCH
400536	2,132	2,106	26	1	DAISY DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
400543	950	876	74	8	DYER FORK DITCH
400549	10,140	11,362	-1,222	-12	FRUITLAND CANAL
400566	1,450	1,730	-280	-19	LARSON BROTHERS DITCH
400568	771	834	-63	-8	LONE ROCK DITCH
400585	6,627	9,957	-3,330	-50	OVERLAND DITCH
400586	1,269	1,859	-590	-46	PILOT ROCK DITCH
400605	3,827	6,349	-2,522	-66	SMITH FORK FEEDER CANAL
400616	1,153	983	170	15	VIRGINIA DITCH
400632	3,377	2,845	532	16	CHILDS DITCH
400661	10,438	10,684	-246	-2	SURFACE CR D AKA BIG D
400675	4,027	2,777	1,250	31	CEDAR MESA DITCH
400683	1,147	1,133	14	1	HORSESHOE DITCH
400686	3,036	2,316	720	24	LONE PINE DITCH
400701	4,927	3,854	1,073	22	CEDAR PARK DITCH
400703	824	538	286	35	DIRT_EAGLE DITCH
400713	1,346	1,004	342	25	GRANBY DITCH FR WARD CR
400751	8,361	8,157	204	2	ALFALFA DITCH
400753	1,596	1,544	52	3	SURF_BONITA DITCH
400754	2,282	2,374	-92	-4	BUTTES DITCH
400758	2,972	2,346	626	21	FORREST DITCH
400774	2,415	2,408	7	0	ORCHARD RANCH DITCH
400778	983	1,565	-582	-59	SETTLE DITCH
400797	2,214	1,027	1,187	54	DURKEE DITCH
400808	780	758	22	3	MORTON DITCH
400820	8,826	9,851	-1,025	-12	ALFA_STELL DITCH
400821	1,583	1,899	-316		TRANSFER DITCH
400863	22,074	26,044	-3,970	-18	BONAFIDE DITCH
400879	16,642	18,904	-2,262	-14	HARTLAND DITCH
400891	19,511	21,976	-2,465	-13	GUNN_NORTH DELTA CAN
400900	18,623	21,916	-3,293	-18	RELIEF DITCH
400918	1,011	1,860	-849	-84	COW CREEK DITCH
400919	3,025	3,550	-525	-17	CURRANT CREEK DITCH
400923	8,143	7,481	662	8	HIGHLINE DITCH
400926	6,240	8,945	-2,705	-43	LEROUX CREEK DITCH
400929	1,084	1,498	-414	-38	JESSIE DITCH
400932	1,752	1,469	283	16	MIDKIFF & ARNOLD D
400944	10,320	23,903	-13,583	-132	LERO_OVERLAND DITCH
401012	574	503	71	12	LONE CABIN DITCH
401020	6,076	6,196	-120	-2	MINNESOTA CANAL
401056	1,890	1,715	175	9	TURNER DITCH
401087	432	520	-88	-20	BLACK SAGE DITCH
401105	429	1,242	-813	-190	COYOTE DITCH
401106	421	1,015	-594	-141	COYOTE DITCH
401112	474	398	76	16	DEER DITCH
401114	311	384	-73	-23	DITCH NO 2 DITCH
401118	609	1,600	-991	-163	DRIFT CREEK DITCH

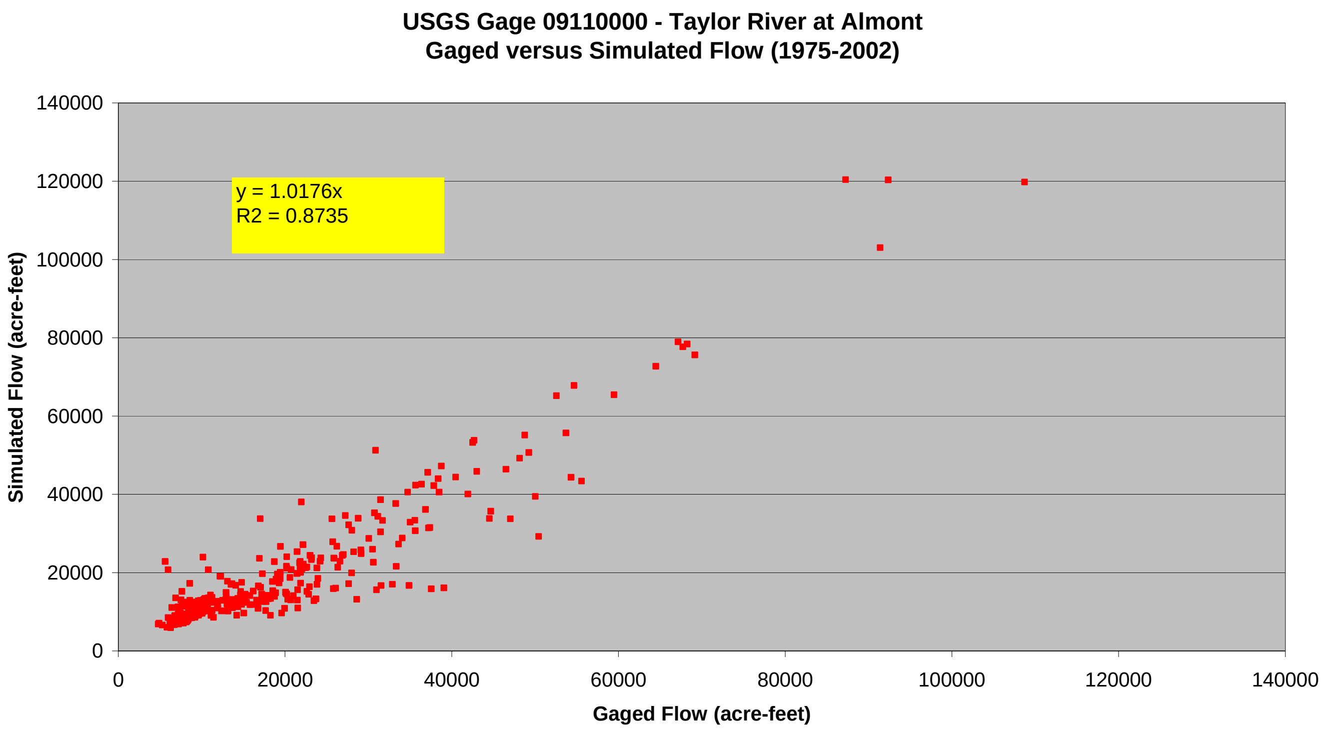
WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
401119	226	1,081	-855	-378	DUGOUT DITCH
401120	631	766	-135	-21	DOWNING DITCH
401122	195	215	-20	-10	DYKE NO 2 DITCH
401127	317	367	-50	-16	ELKS BEAVER DITCH
401132	1,627	1,918	-291	-18	FILMORE DITCH
401133	45,470	47,284	-1,814	-4	FIRE MT CANAL
401145	432	519	-87	-20	GROUSE CREEK DITCH
401166	134	621	-487	-363	MUDD_LARSON NO 2 DIT
401168	383	529	-146	-38	LEE CREEK D NO 2
401172	641	741	-100	-16	LOST CABIN DITCH
401183	2,285	2,620	-335	-15	MONITOR DITCH
401185	8,697	9,952	-1,255	-14	NORTH FORK FARMERS D
401189	6,359	6,561	-202	-3	PAONIA DITCH
401190	107	248	-141	-132	PILOT KNOB DITCH
401195	2,836	3,227	-391	-14	SHEPARD & WILMONT DITCH
401196	4,994	5,593	-599	-12	SHORT DITCH
401197	1,606	2,203	-597	-37	SMITH AND MCKNIGHT DITCH
401201	242	252	-10	-4	SPATAFORE DITCH NO 1
401206	14,716	16,363	-1,647	-11	STEWART DITCH
401207	1,452	1,243	209	14	STREBER DITCH
401213	1,815	2,148	-333	-18	VANDEFORD DITCH
401214	97	186	-89	-92	WADE DITCH
401218	942	1,235	-293	-31	WELCH MESA DITCH
401221	111	680	-569	-513	WILLIAMS CR DITCH
401437	498	757	-259	-52	ROUB_HAWKINS DITCH
410508	3,302	4,212	-910	-28	BOLES & MANNEY D
410515	3,619	4,496	-877	-24	CHIPETA BEAUDRY DITCH
410519	6,843	8,109	-1,266	-19	EAGLE DITCH
410520	49,844	55,725	-5,881	-12	EAST CANAL
410527	22,870	25,575	-2,705	-12	GARNET DITCH
410534	114,743	129,619	-14,876	-13	UNCO_IRONSTONE CANAL
410537	46,974	54,308	-7,334	-16	LOUTSENHIZER CANAL
410538	2,627	3,149	-522	-20	LYRA DITCH
410545	181,440	200,998	-19,558	-11	MONTROSE & DELTA CANAL
410549	4,164	5,396	-1,232	-30	OURAY DITCH
410554	2,882	3,671	-789	-27	ROSS BROS DITCH
410559	69,557	79,391	-9,834	-14	SELIG CANAL
410560	1,150	1,617	-467	-41	SHAVANO VALLEY DITCH
410568	1,748	2,208	-460	-26	SUNRISE DITCH(HAPPY CYN)
410577	54,732	63,924	-9,192	-17	WEST CANAL
410578	44,362	49,718	-5,356	-12	SOUTH CANAL
420510	2,918	3,904	-986	-34	BROWN & CAMPION D
420529	5,886	5,920	-34	-1	KANNAH CREEK HIGHLINE D
420541	426,860	426,584	276	0	REDLANDS POWER CANAL
420545	1,315	2,138	-823	-63	SMITH IRR DITCH
590501	3,631	3,838	-207	-6	ACME DITCH

WDID	Historical	Simulated	Historical minus Simulated Volume	Percent	Structure Name
590509	358	364	-6	-2	ANDERS BOTTOM D
590510	1,138	1,119	19	2	ANNA ROZMAN DITCH
590522	3,560	3,984	-424	-12	BOCKER DITCH
590524	541	795	-254	-47	BOURNE DITCH
590527	780	1,454	-674	-86	BUCKEY DITCH
590528	313	595	-282	-90	BUCKEY LEHMAN DITCH
590537	3,555	3,893	-338	-10	CEMENT CREEK DITCH
590542	616	1,672	-1,056	-171	CUNNINGHAM DITCH
590544	1,023	1,332	-309	-30	DEAN IRRIGATING DITCH
590546	6,728	6,642	86	1	DILLSWORTH DITCH
590549	15,168	16,495	-1,327	-9	EAST RIVER NO 1 DITCH
590550	9,707	10,178	-471	-5	EAST RIVER NO 2 DITCH
590556	3,856	4,476	-620	-16	FISHER DITCH ENLARGEMENT
590558	3,047	3,684	-637	-21	FRANK ADAMS NO 1 DITCH
590560	2,698	3,043	-345	-13	GARDEN DITCH
590563	1,553	2,171	-618	-40	GLEASON IRRIGATING DITCH
590566	3,066	3,834	-768	-25	GOOSEBERRY MESA IRG D
590569	13,817	15,725	-1,908	-14	GUNNISON & OHIO CR CANAL
590570	17,011	18,269	-1,258	-7	GUNNISON R OHIO CR IRG D
590572	6,691	7,574	-883	-13	GUNNISON TOWN DITCH
590578	4,081	5,392	-1,311	-32	HARRIS BOHM POTATO DITCH
590580	190	604	-414	-218	HENRY PURRIER OHIO CR D
590581	260	494	-234	-90	HENRY PURRIER OHIO CR 2D
590584	512	562	-50	-10	HIGHLAND DITCH
590587	1,133	1,601	-468	-41	HILDEBRAND NO 2 DITCH
590588	1,534	2,065	-531	-35	HINKLE HAMILTON DITCH
590589	683	978	-295	-43	HINKLE IRG DITCH
590591	1,077	1,477	-400	-37	HOPE RESICH DITCH
590593	2,177	2,709	-532	-24	HOWE & SHERWOOD IRR D
590596	949	1,685	-736	-78	HYZER VIDAL MILLER D
590597	2,756	2,848	-92	-3	IMOBERSTEG DITCH
590600	5,212	5,894	-682	-13	JAMES WATT DITCH
590602	1,974	2,804	-830	-42	JOHN B OUTCALT NO 2 D
590606	1,335	1,614	-279	-21	JUDY NORTH HIGH LINE D
590607	5,740	6,751	-1,011	-18	KELMEL OWENS NO 1 DITCH
590608	3,269	3,719	-450	-14	KELMEL OWENS NO 2 DITCH
590609	2,907	3,114	-207	-7	KUBIACK DITCH
590616	3,081	3,558	-477	-15	LIGHTLEY D & LINTON ENLT
590617	3,059	4,464	-1,405	-46	LONE PINE DITCH
590622	1,807	2,152	-345	-19	MARSHALL NO 1 DITCH
590623	2,702	3,245	-543	-20	MARSHALL NO 2 DITCH
590624	1,390	1,695	-305	-22	MARSTON DITCH
590625	3,502	5,378	-1,876	-54	MAY BOHM & ENLD M B H P
590627	437	854	-417	-95	MCCORMICK DITCH
590630	232	485	-253	-109	MCGLASHAN N SIDE MILL CR
590631	402	651	-249	-62	MCGLASHAN S SIDE MILL CR

WDID	Historical	Simulated	Historical minus Simulated Volume	Percent	Structure Name
590644	497	809	-312	-63	OHIO CREEK NO 2 DITCH
590645	423	1,099	-676	-160	OTIS MOORE DITCH
590646	793	998	-205	-26	PALISADES DITCH
590649	796	804	-8	-1	PASS CREEK DITCH
590651	1,329	2,388	-1,059	-80	PILONI DITCH
590653	4,375	4,371	4	0	POWER DITCH
590655	430	711	-281	-65	PURRIER DITCH
590658	4,161	4,674	-513	-12	RICHARD BALL DITCH
590667	713	871	-158	-22	SCHUPP DITCH
590668	5,336	6,340	-1,004	-19	SEVENTY FIVE DITCH
590671	343	816	-473	-138	SIMINEO DITCH
590672	4,297	4,268	29	1	SLIDE DITCH
590679	3,988	4,201	-213	-5	SPRING CR IRG DITCH
590680	431	480	-49	-11	SQUIRREL CREEK NO1 DITCH
590684	2,357	2,461	-104	-4	STRAND DITCH NO 1
590691	3,116	4,380	-1,264	-41	TEACHOUT DITCH
590692	1,226	1,707	-481	-39	TEACHOUT-FAIRCHILD DITCH
590699	5,374	5,623	-249	-5	VERZUH DITCH
590700	5,756	5,483	273	5	VERZUH YOUNG BIFANO D
590704	3,860	4,276	-416	-11	WHIPP DITCH
590707	412	674	-262	-64	WILLOW RUN DITCH
590709	826	1,056	-230	-28	WILSON DITCH
590711	1,070	1,676	-606	-57	WILSON OHIO CREEK DITCH
590720	536	838	-302	-56	PIONEER DITCH
590847	2,220	1,908	312	14	CUNNINGHAM WASTEWATER D
620506	711	780	-69	-10	ANDREWS DITCH
620528	5,322	6,317	-995	-19	BIG BLUE DITCH
620529	2,999	3,484	-485	-16	BIG DITCH
620560	28,726	29,807	-1,081		CIMARRON CANAL
620567	1,521	1,957	-436	-29	COLLIER DITCH
620602	719	893	-174	-24	FOSTER DITCH NO 1
620604	223	332	-109	-49	FOSTER IRG D NO 4
620605	2,180	2,776	-596	-27	FRANK ADAMS D NO 2
620617	332,759	383,656	-50,897	-15	GUNNISON TUNNEL&S CANAL
620670	1,867	2,446	-579	-31	M B & A DITCH
620672	4,517	5,272	-755	-17	MCKINLEY DITCH
620732	1,458	1,765	-307	-21	RUDOLPH IRG DITCH
620734	600	689	-89	-15	SAMMONS DITCH NO 2
620736	716	832	-116	-16	CEBO_SAMMONS IRG D N
620737	648	759	-111	-17	SAMMONS IRG D NO 5
620738	578	720	-142	-25	SAMMONS IRG D NO 6
620779	1,417	1,861	-444	-31	UPPER CEBOLLA DITCH
620783	1,818	2,208	-390	-21	VEO DITCH
620789	905	1,006	-101	-11	WARRANT DITCH
620809	1,015	1,149	-134	-13	YOUMANS IRG D NO 1
680501	5,411	5,649	-238	-4	ALKALI DITCH D NO 80

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
680502	4,432	4,137	295	7	ALKALI NO 2 DITCH
680514	1,840	2,172	-332	-18	BURKHART EDDY DITCH
680526	3,094	3,557	-463	-15	CHARLEY LOGAN DITCH
680538	469	434	35	7	CRONENBERG DITCH
680543	3,774	3,389	385	10	DALLAS DITCH
680559	1,849	2,143	-294	-16	DOC WADE DITCH
680603	1,106	1,215	-109	-10	HENRY TRENCHARD DITCH
680607	3,866	4,255	-389	-10	HOMESTRETCH DITCH
680609	1,997	2,344	-347	-17	HOSNER BROWNYARD DITCH
680610	1,983	2,260	-277	-14	HOSNER ROWELL DITCH
680613	2,261	2,482	-221	-10	HYDE SNEVA DITCH
680636	2,035	2,570	-535	-26	LEOPARD CREEK DITCH
680647	969	1,055	-86	-9	MARTIN DITCH
680652	865	1,012	-147	-17	MAYOL LATERAL DITCH
680653	807	986	-179	-22	MAYOL SISSON DITCH
680668	2,048	2,375	-327	-16	MOODY DITCH
680669	2,393	2,863	-470	-20	MOODY NO1 DITCH
680671	1,421	1,493	-72	-5	MORRISON DITCH
680681	2,137	2,524	-387	-18	OLD AGENCY DITCH
680683	1,294	1,472	-178	-14	OWL CREEK DITCH
680685	2,373	2,633	-260	-11	PARK DITCH
680692	3,891	3,955	-64	-2	PINION DITCH
680703	1,133	1,505	-372	-33	REED OVERMAN DITCH
680710	647	710	-63	-10	RIDGWAY DITCH
680720	1,035	1,237	-202	-20	ROSWELL HOTCHKISS DITCH
680729	609	731	-122	-20	SHORTLINE D COW CREEK
680738	3,551	4,286	-735	-21	SNEVA DITCH
680765	2,670	3,134	-464	-17	UPPER UNCOMPAHGRE DITCH
960050	79,630	91,453	-11,823	-15	REDLANDS_POWER_CANAL-IRR
960051	6,581	6,519	62	1	Grand_Junction_Demand
28_ADG009	6,776	8,306	-1,530	-23	28_ADG009_UTOMICHI
28_ADG010	13,538	17,772	-4,234	-31	28_ADG010_TOMICHI1
28_ADG011	6,268	9,037	-2,769	-44	28_ADG011_COCHETOPA
28_ADG012	26,830	31,508	-4,678	-17	28_ADS_012_TOMICHI2
28_ADG043	2,180	2,489	-309	-14	28_ADG043_COCHET
28_ADG044	5,961	8,964	-3,003	-50	28_ADG044_RAZOR
40_ADG019	389	978	-589	-151	40_ADG019_GUNNTUN
40_ADG020	4,264	5,128	-864	-20	40_ADG020_IRON
40_ADG021	3,083	3,558	-475	-15	40_ADG021_SMITH
40_ADG022	6,952	8,941	-1,989	-29	40_ADG022_NFGUNN
40_ADG023	1,736	2,008	-272	-16	40_ADG023_MINN
40_ADG024	7,453	9,136	-1,683	-23	40_ADG024_NFGUNN2
40_ADG025	3,800	4,008	-208	-5	40_ADG025_LEROUX
40_ADG026	8,940	10,594	-1,654	-19	40_ADG026_GUNNL
40_ADG027	7,223	5,929	1,294	18	40_ADG027_CURRANT
40_ADG028	12,299	12,949	-650	-5	40_ADG028_UTONGUE

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
40_ADG029	2,443	2,582	-139	-6	40_ADG029_SURFACE
40_ADG030	13,773	15,349	-1,576	-11	40_ADG030_TONGUE
40_ADG031	5,890	6,753	-863	-15	40_ADG031_GUNND
40_ADG038	2,444	3,733	-1,289	-53	40_ADG038_ROUBIN
40_ADG039	9,208	11,403	-2,195	-24	40_ADG039_GUNNBLD
40_AMG002	1,449	1,448	1	0	Lower_M&I
40_Fruitl	12,712	16,117	-3,405	-27	Fruitland
41_ADG035	6,332	7,639	-1,307	-21	41_ADG035_UNCOMPH3
41_ADG036	13,087	17,626	-4,539	-35	41_ADG036_UNCOMPH4
41_ADG037	7,846	9,777	-1,931	-25	41_ADG037_UNCOMPH5
41_AMG003	1,272	1,272	0	0	Uncomp_M&I
42_ADG040	12,074	17,932	-5,858	-49	42_ADG040_GUNNGJ
59_ADG001	4,764	5,442	-678	-14	59_ADG001_TAYLOR
59_ADG002	3,370	5,203	-1,833	-54	59_ADG002_EAST1
59_ADG003	1,818	5,242	-3,424	-188	59_ADS_003_SLATE
59_ADG004	10,119	12,826	-2,707	-27	59_ADG004_EAST2
59_ADG005	6,111	7,201	-1,090	-18	59_ADG005_EAST3
59_ADG006	2,747	3,702	-955	-35	59_ADG006_OHIO1
59_ADG007	3,055	7,380	-4,325	-142	59_ADG007_OHIO2
59_ADG008	15,362	16,361	-999	-7	59_ADG008_GUNN
62_ADG013	5,861	6,768	-907	-15	62_ADG013_CEBOLLA1
62_ADG014	6,988	9,411	-2,423	-35	62_ADG014_CEBOLLA2
62_ADG015	4,981	6,613	-1,632	-33	62_ADG015_LAKE
62_ADG016	16,176	19,430	-3,254	-20	62_ADG016_GUNNBM
62_ADG017	1,641	2,638	-997	-61	62_ADG017_GUNNM
62_ADG018	2,623	3,173	-550	-21	62_ADG018_CIM
62_AMG001	1,449	1,448	1	0	Upper_M&I
62_IrrCim	28,124	28,331	-207	-1	Cimmaron_Canal
68_ADG032	11,212	12,843	-1,631	-15	68_ADG032_UNCOMPH1
68_ADG033	7,480	8,509	-1,029	-14	68_ADG033_DALLAS
68_ADG034	8,765	10,767	-2,002	-23	68_ADG034_UNCOMPH2
95CSUB_I	0	0	0	0	Default information
95CSUB_M	0	0	0	0	Subordinate_Crystal_M&I
95L_MY	0	0	0	0	Default information
95MSUB_I	0	0	0	0	Default information
95MSUB_M	0	0	0	0	Subordinate_Morrow_M&I
95U_MY	0	0	0	0	Upper_Market_Yield
95USUB_I	0	0	0	0	Default information
95USUB_M	0	0	0	0	Subordinate_Upper_M&I
Proj_7	6,487	5,241	1,246	0	Project_7
Basin Total	2,640,406	2,992,234	-351,828	-13.32	



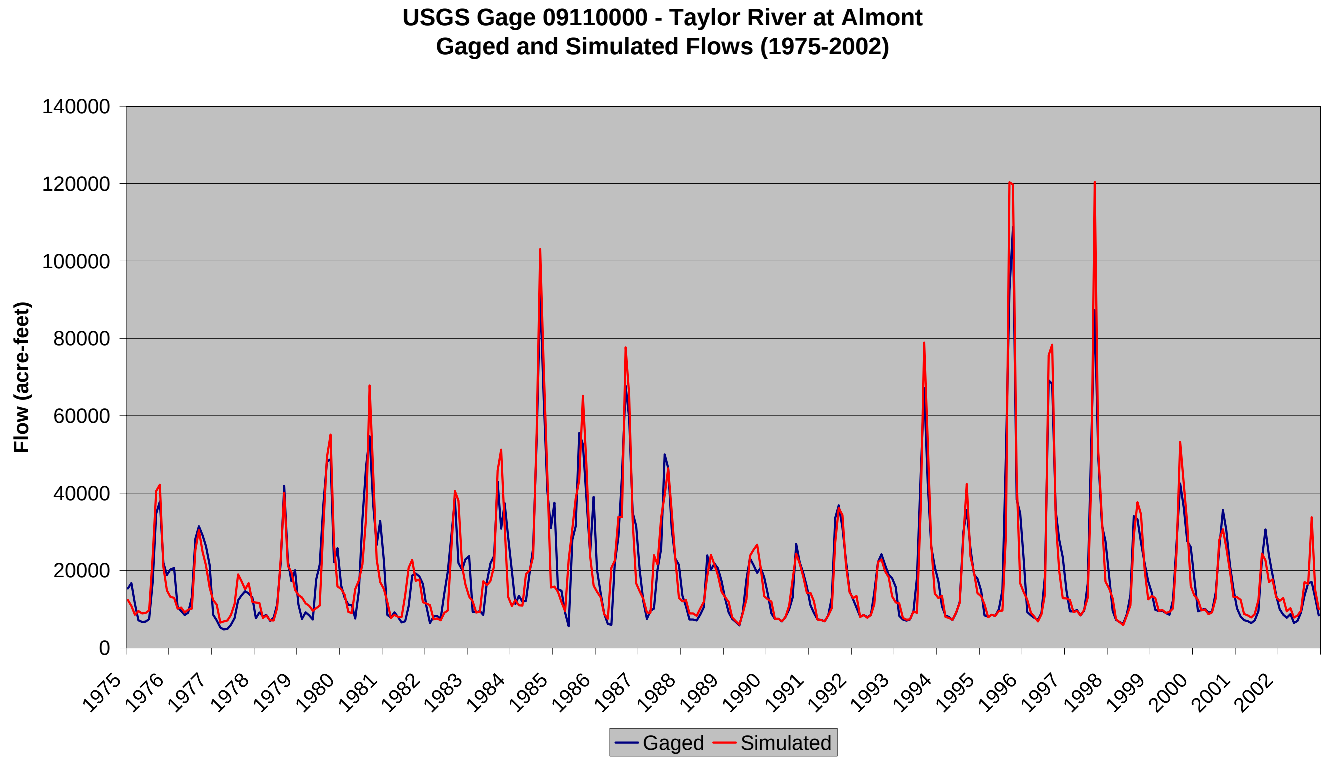
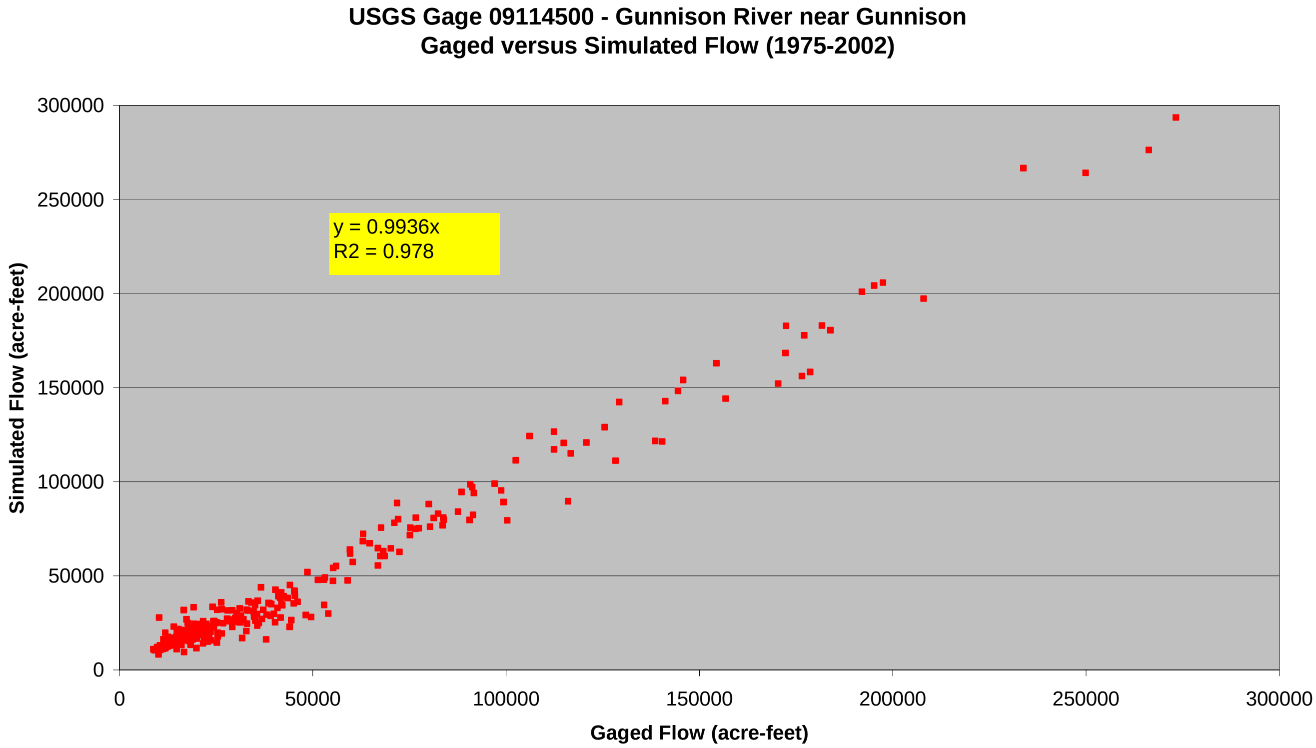


Figure D.1 Calculated Streamflow Simulation – Taylor River at Almont



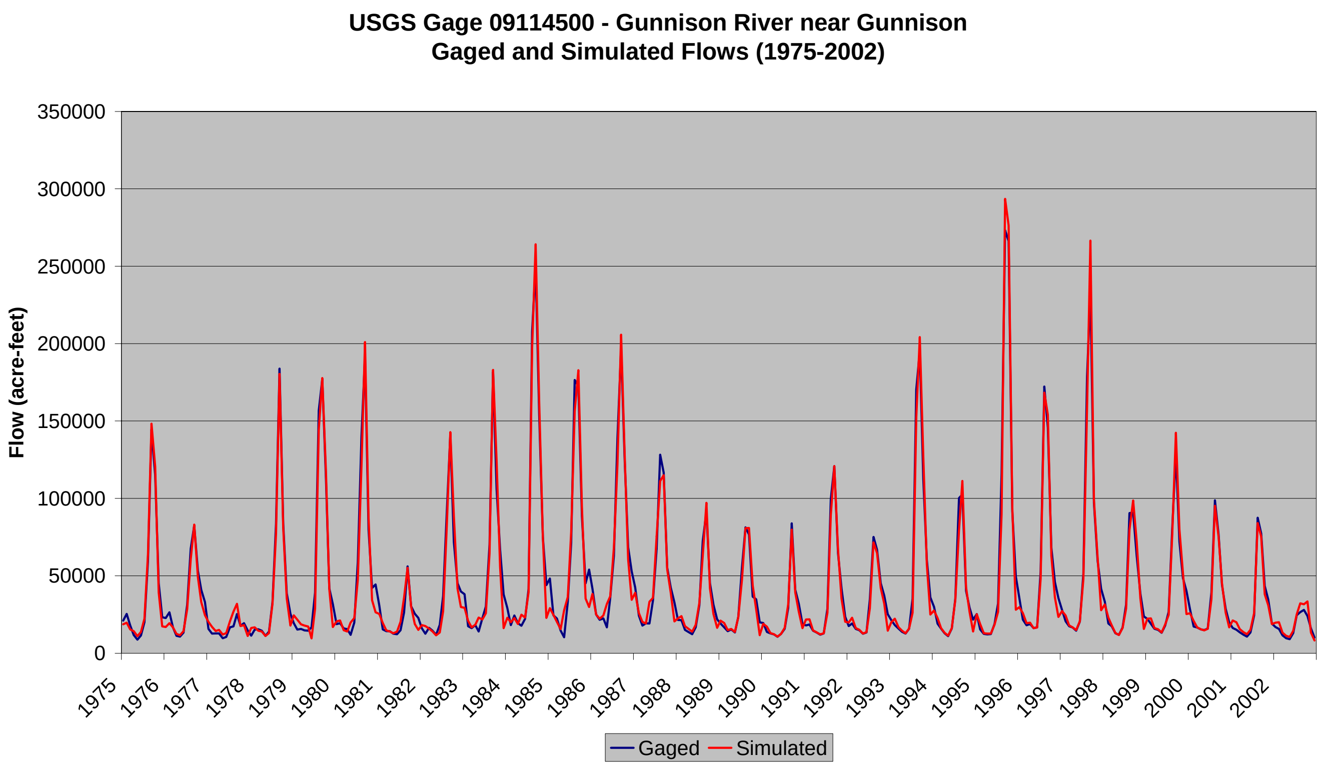
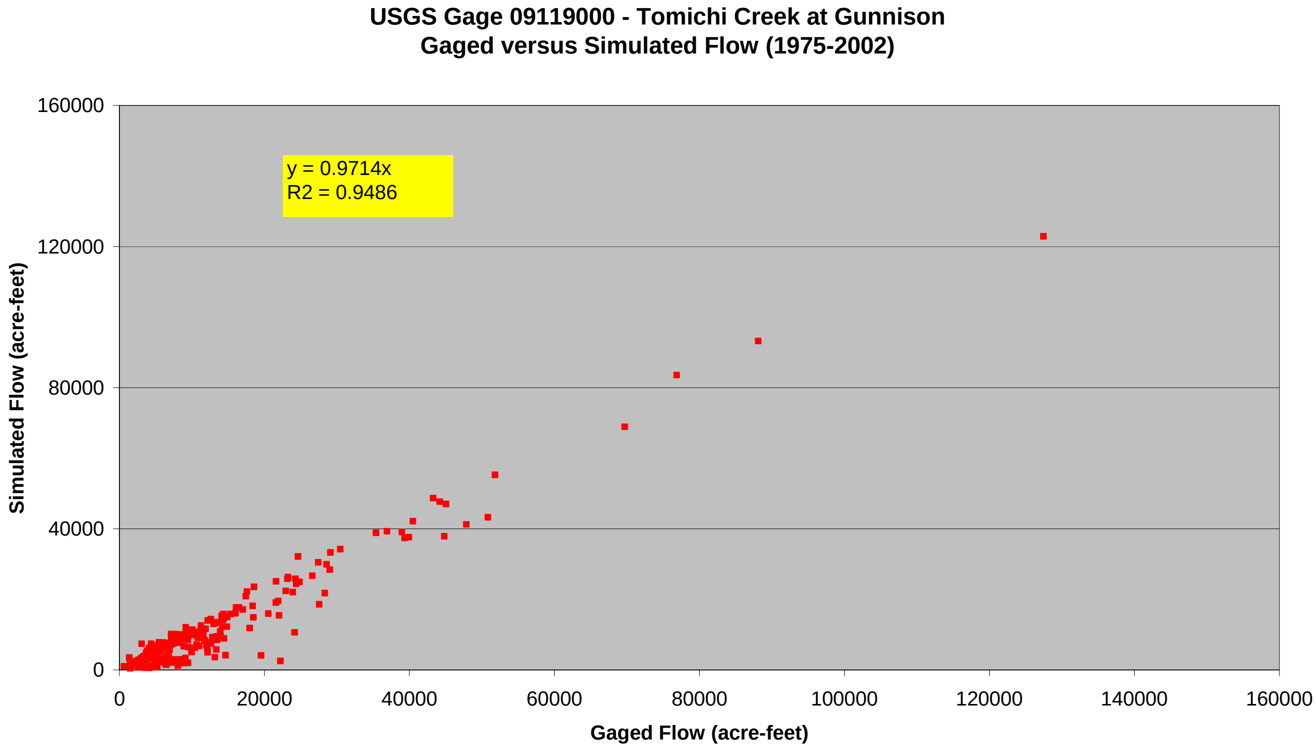


Figure D.2 Calculated Streamflow Simulation – Gunnison River near Gunnison



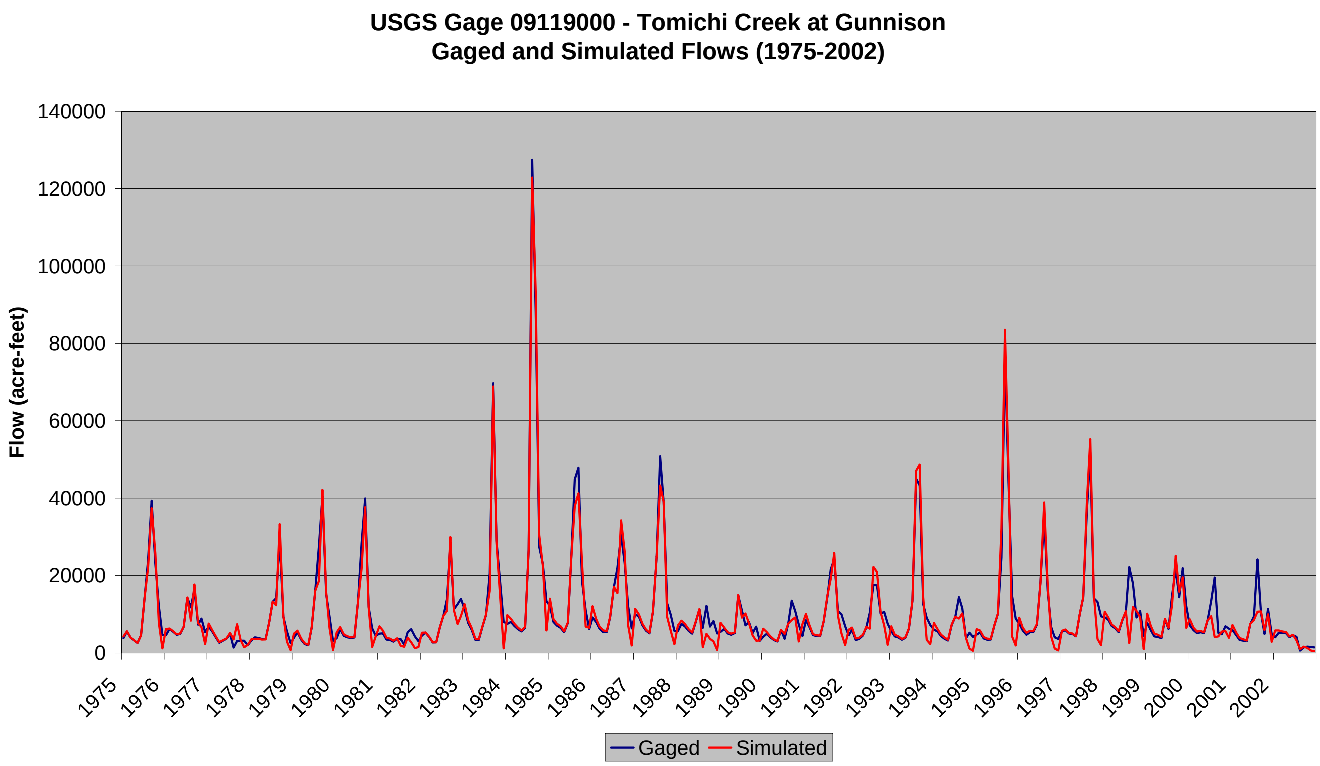
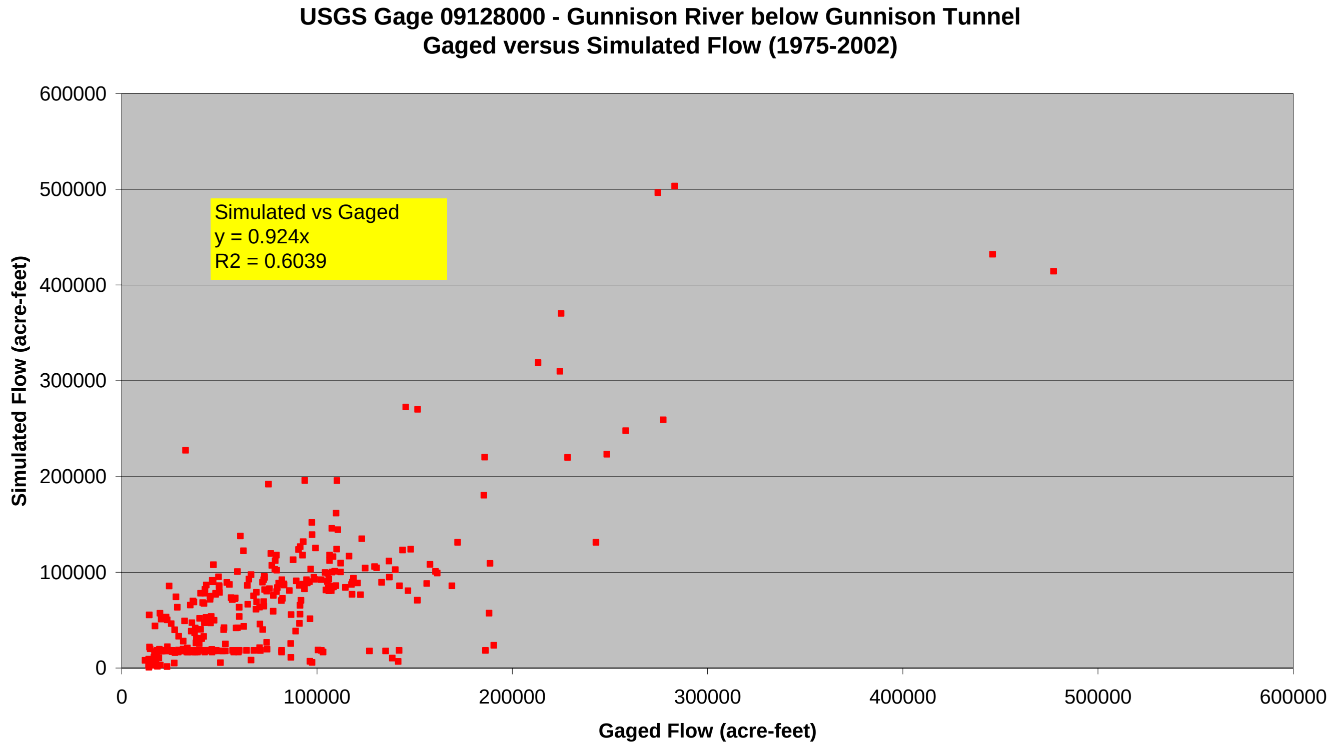


Figure D.3 Calculated Streamflow Simulation – Tomichi Creek at Gunnison



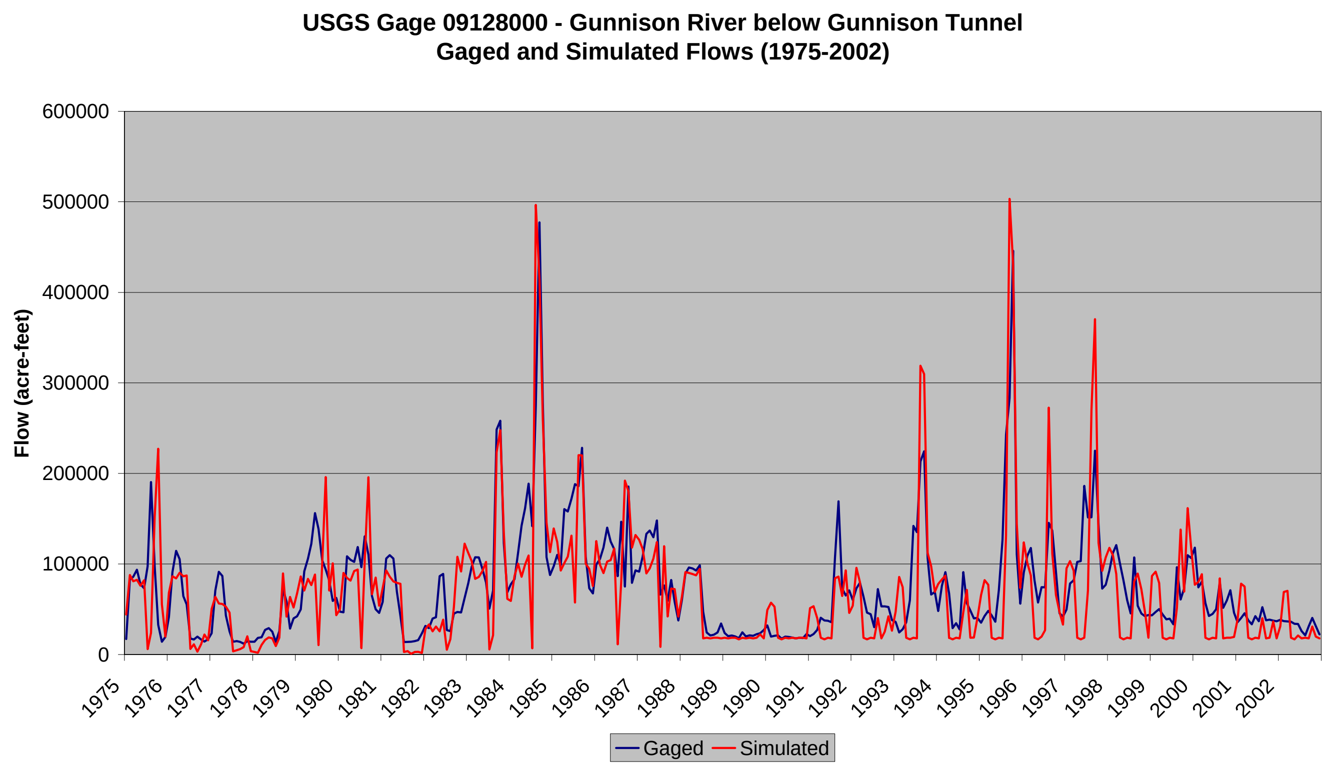
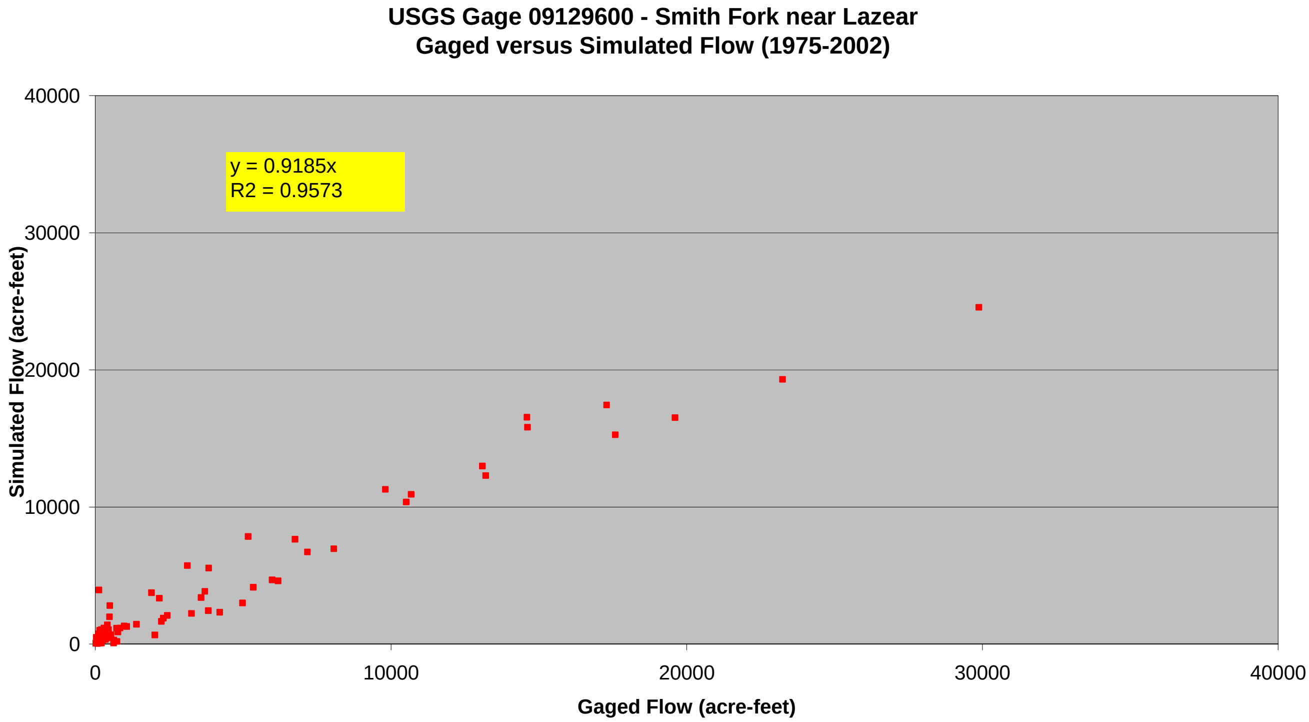


Figure D.4 Calculated Streamflow Simulation – Gunnison River below Gunnison Tunnel



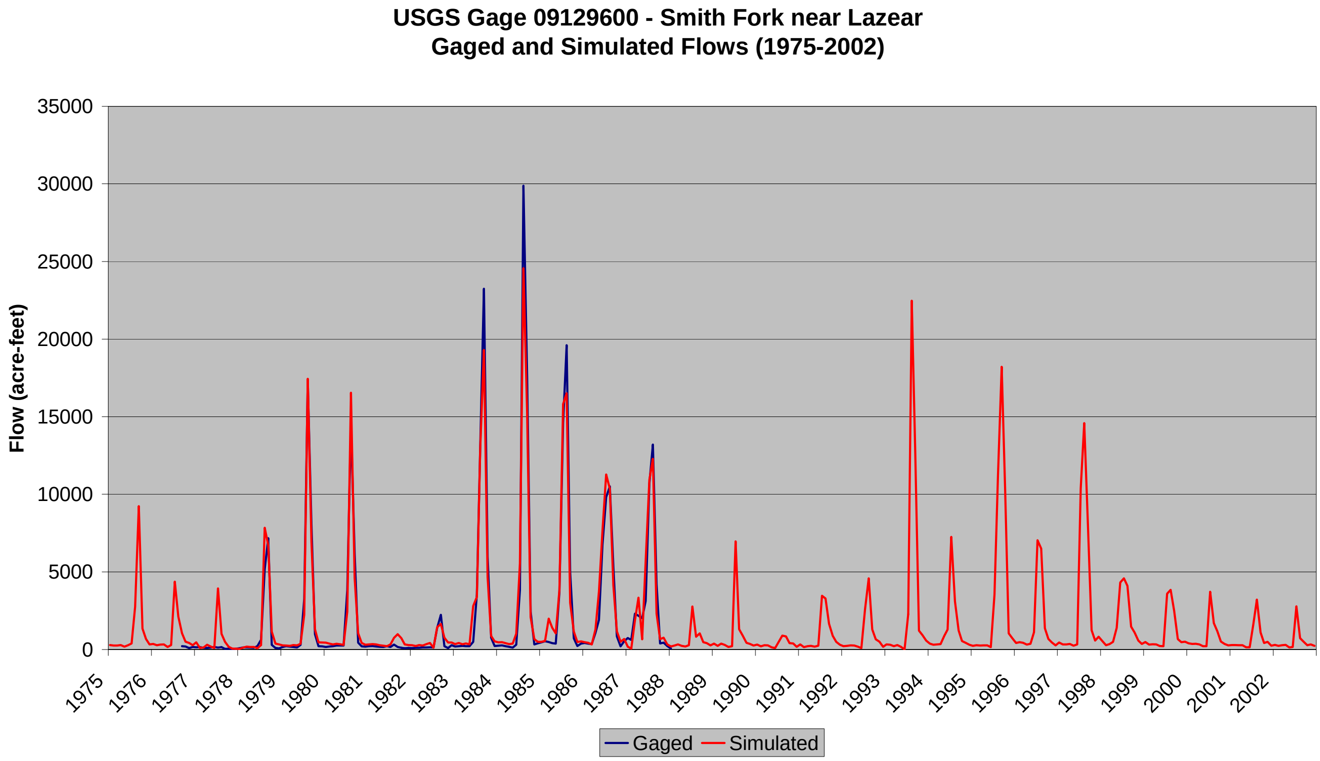
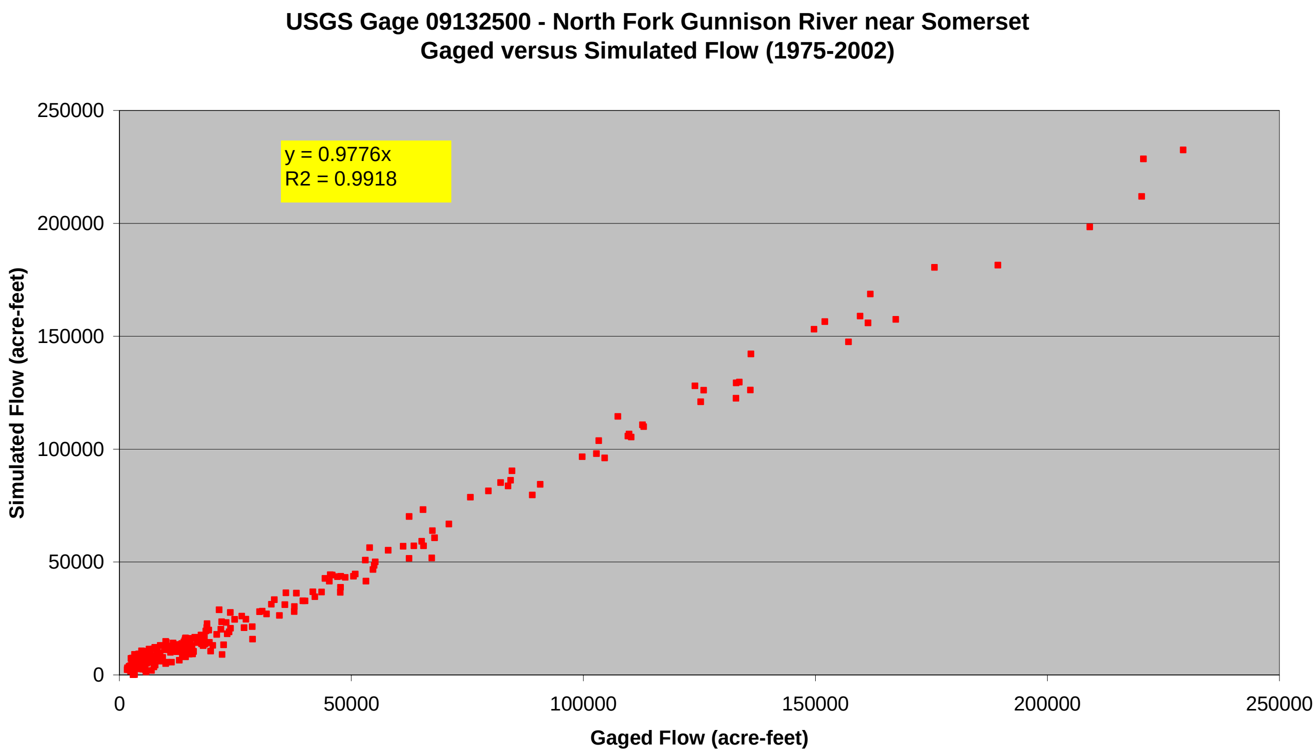


Figure D.5 Calculated Streamflow Simulation – Smith Fork near Lazear



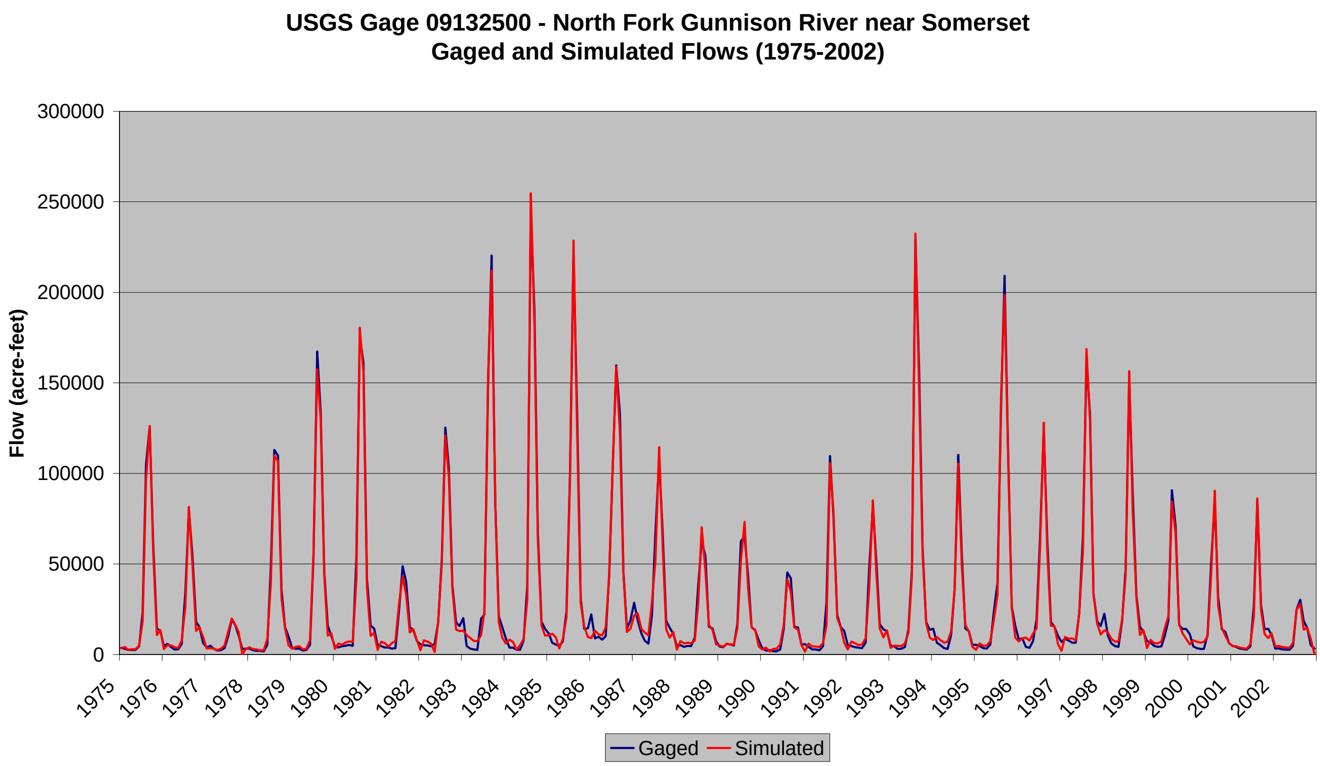
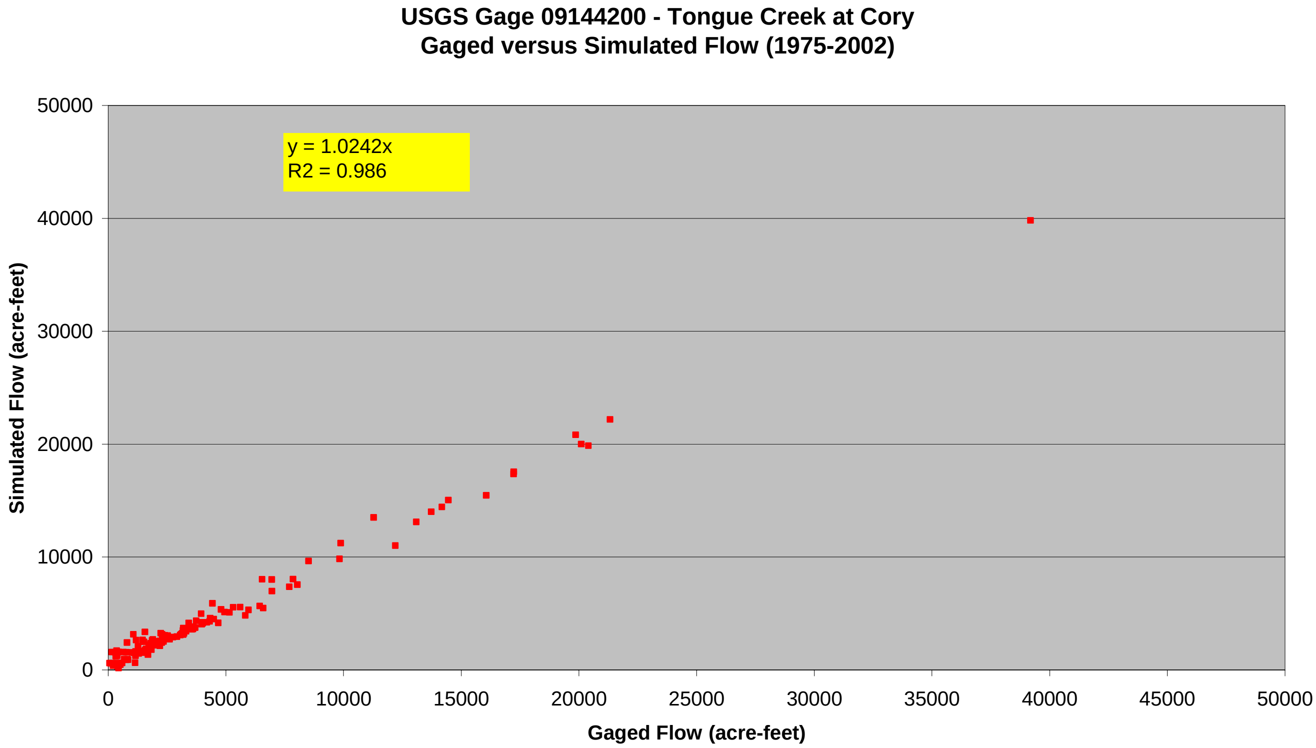


Figure D.6 Calculated Streamflow Simulation – North Fork Gunnison River near Somerset



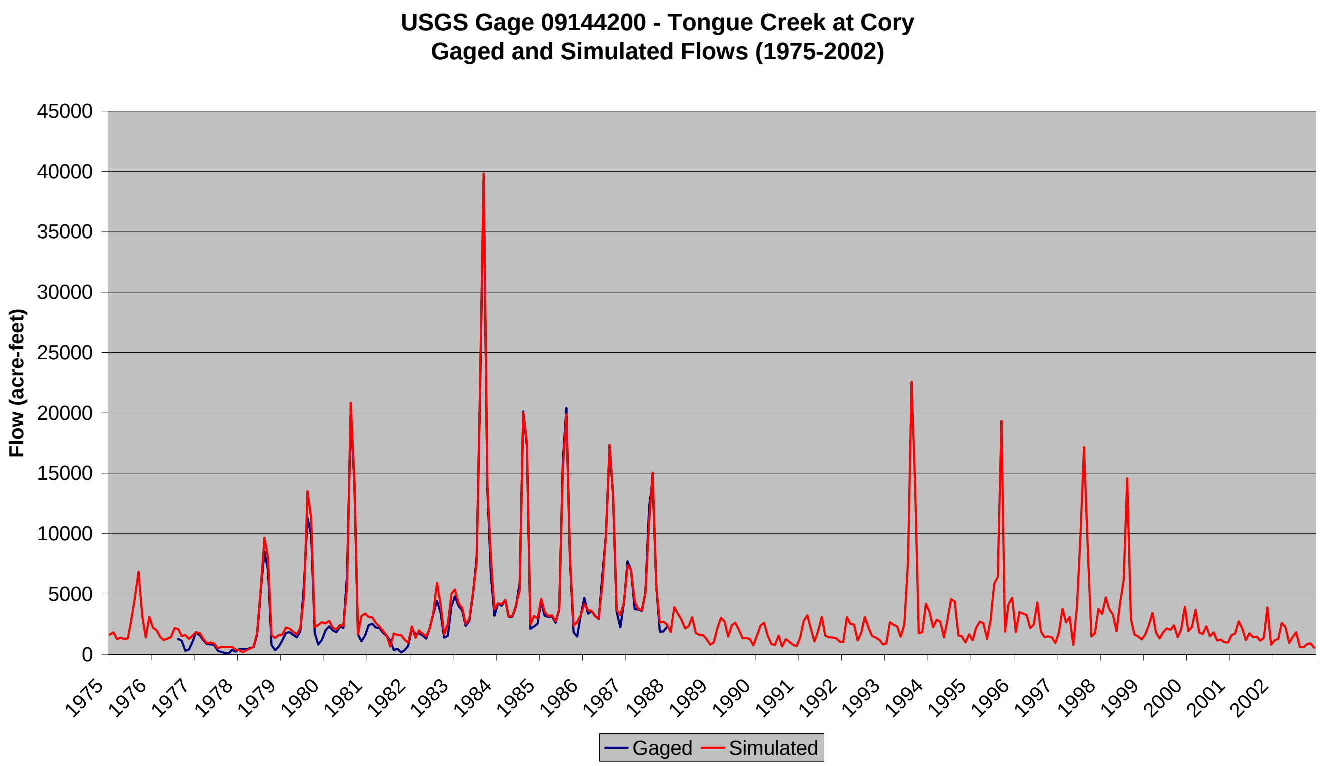
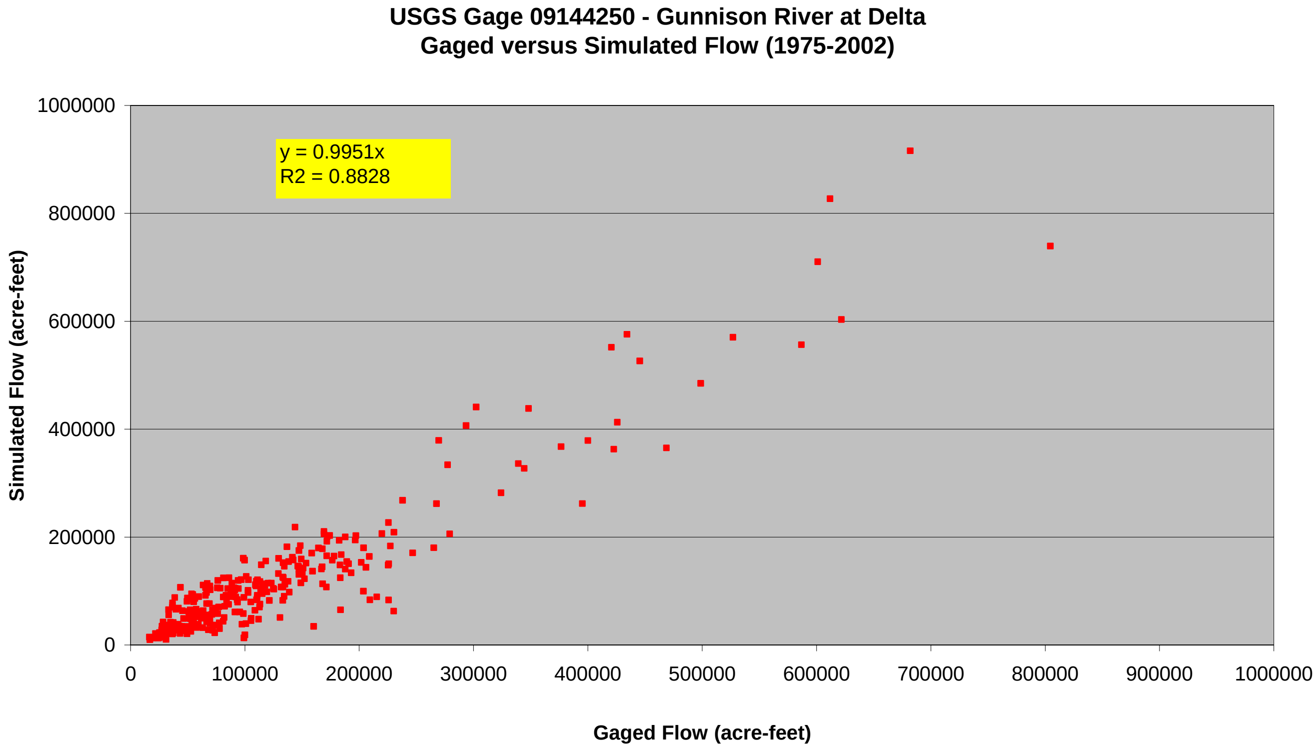


Figure D.7 Calculated Streamflow Simulation – Tongue Creek at Cory



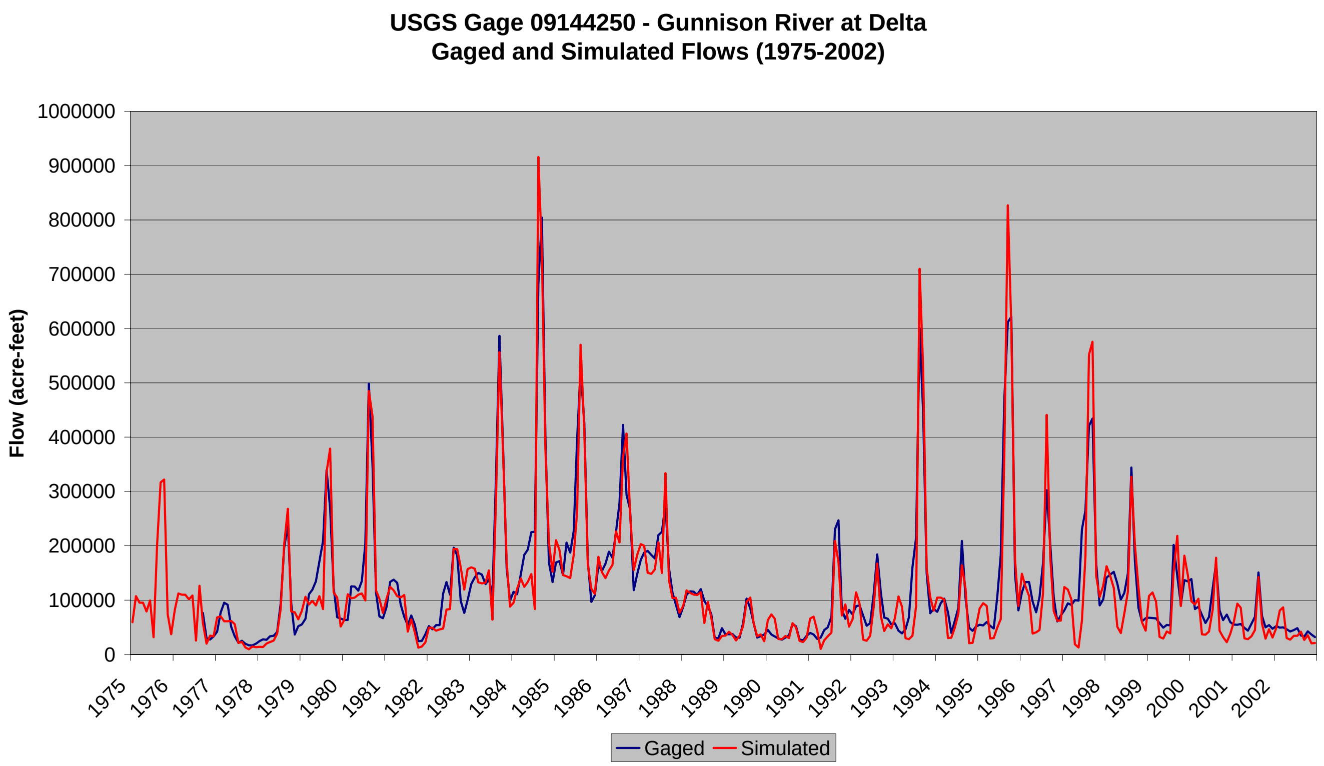
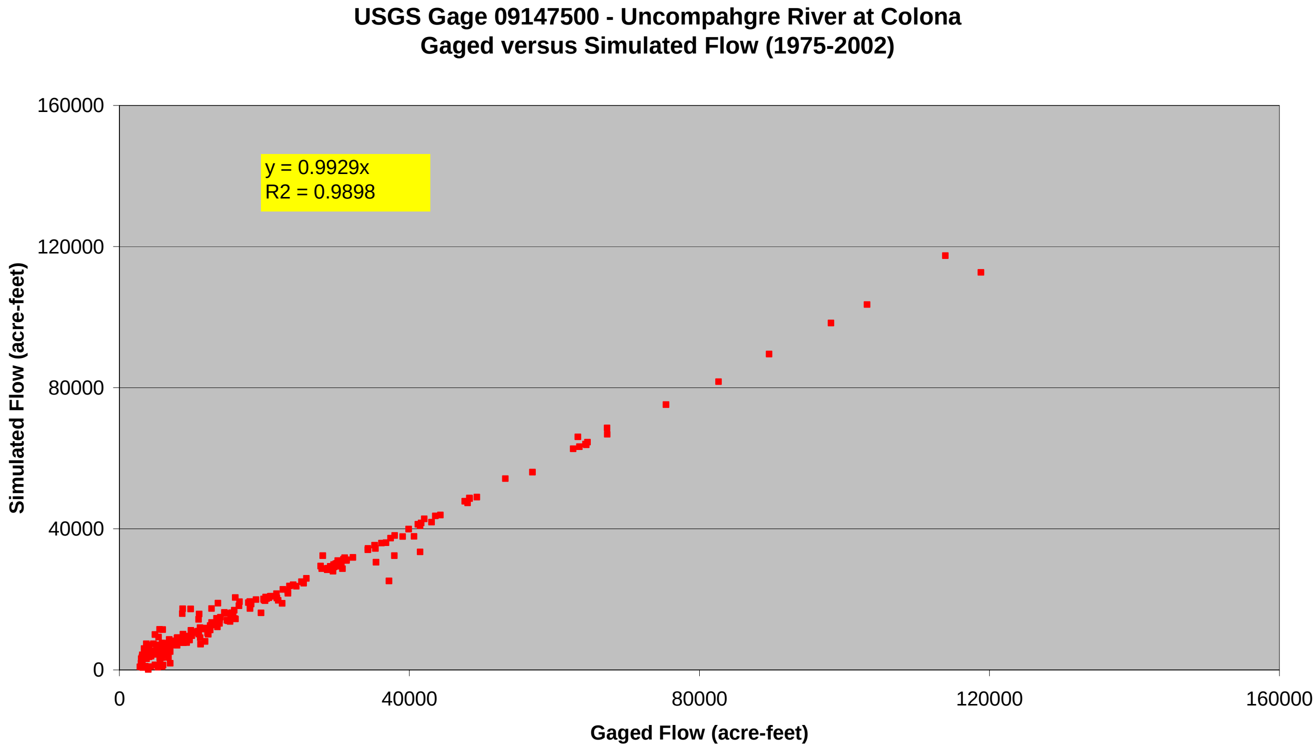


Figure D.8 Calculated Streamflow Simulation – Gunnison River at Delta



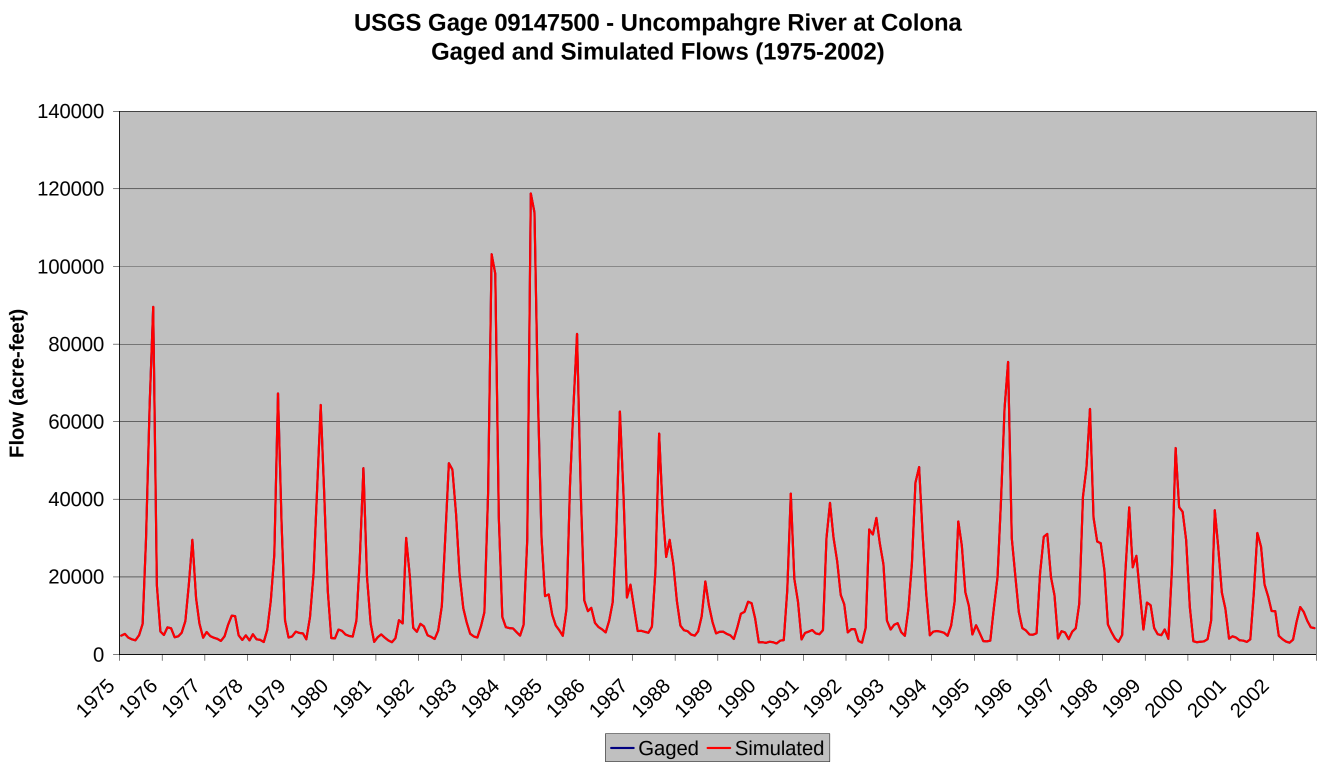
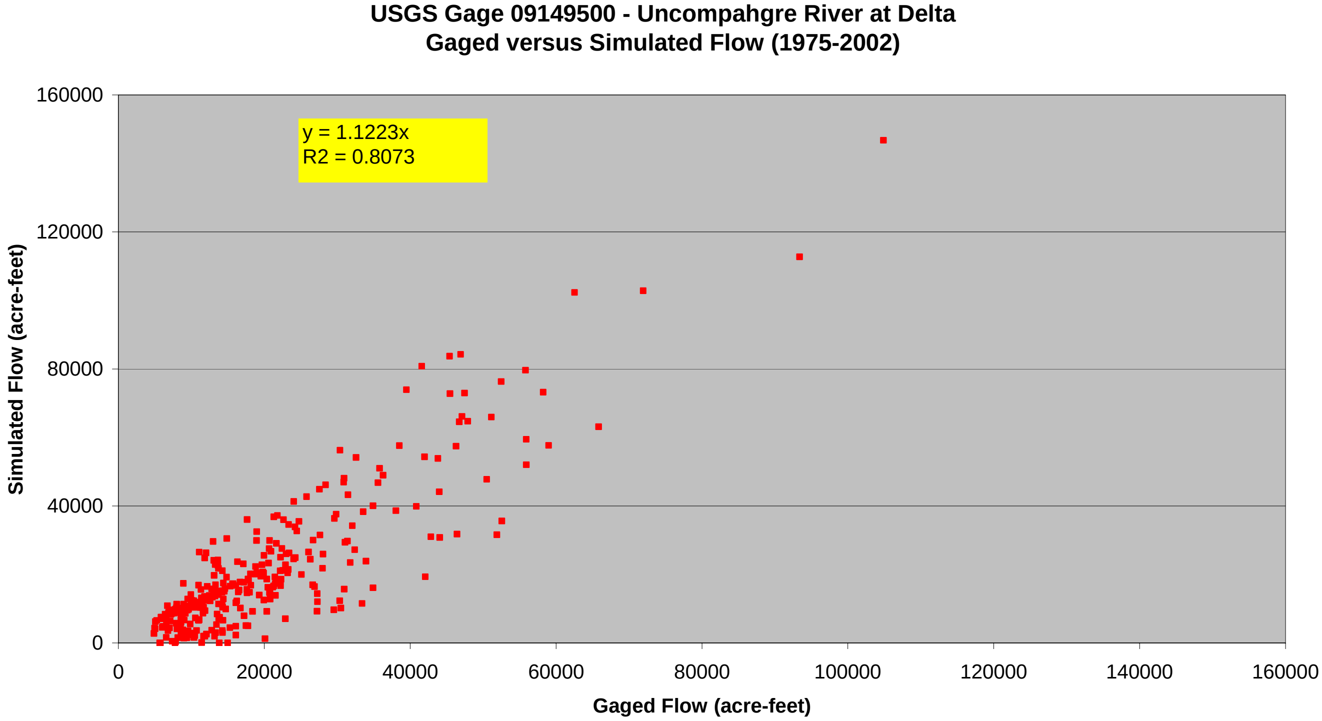


Figure D.9 Calculated Streamflow Simulation – Uncompahgre River at Colona



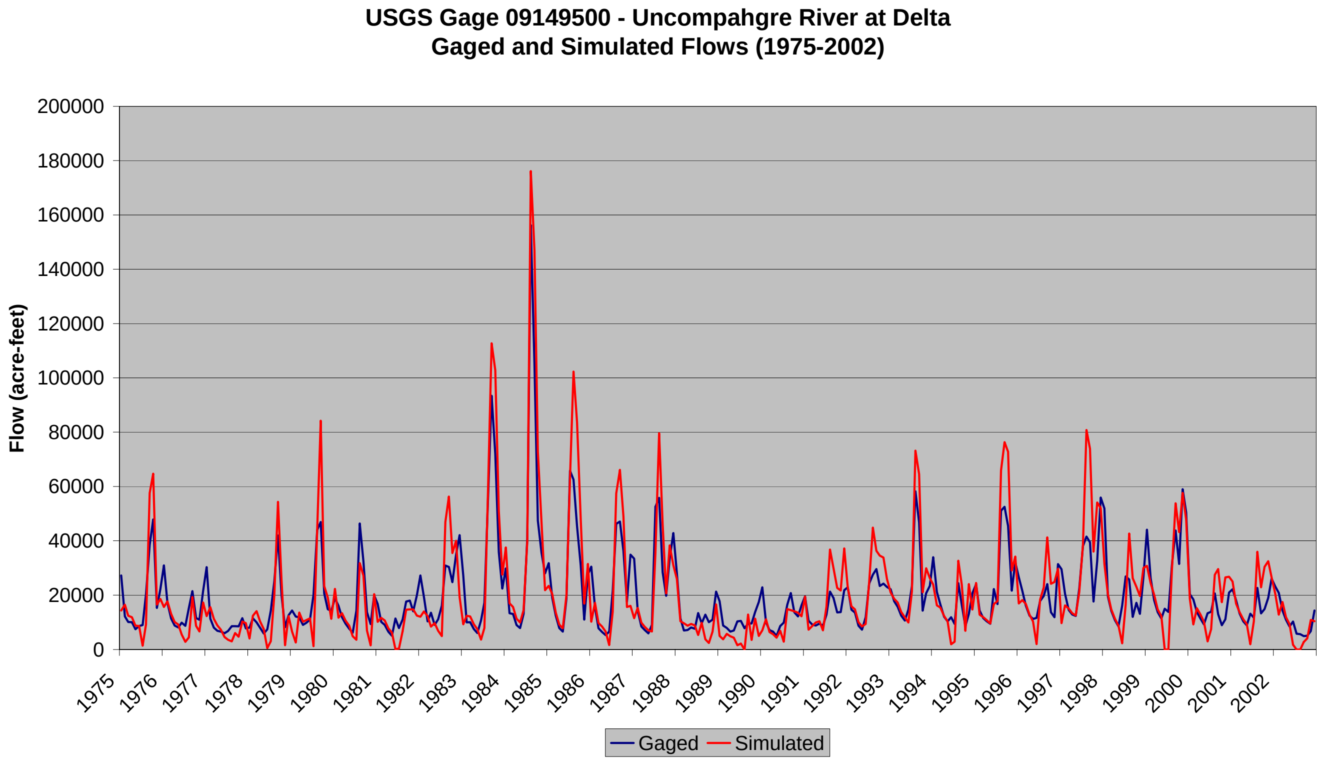
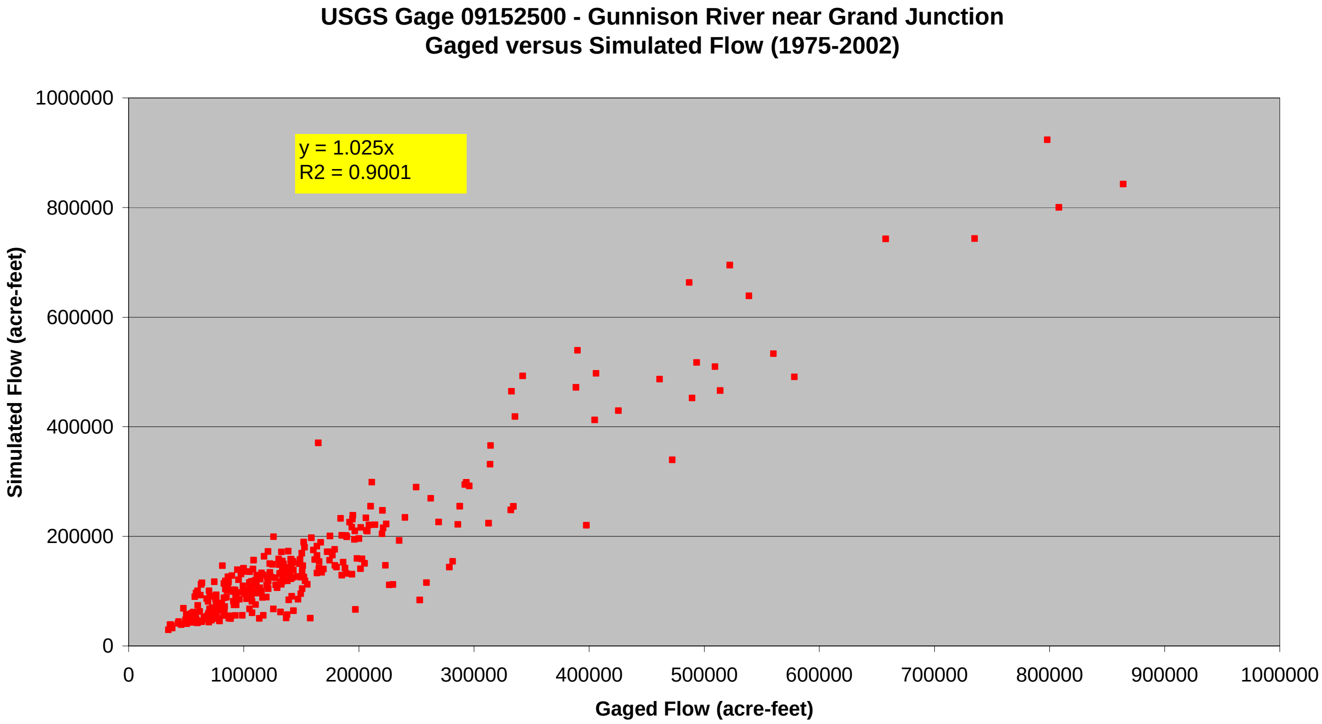


Figure D.10 Calculated Streamflow Simulation – Uncompahgre River at Delta



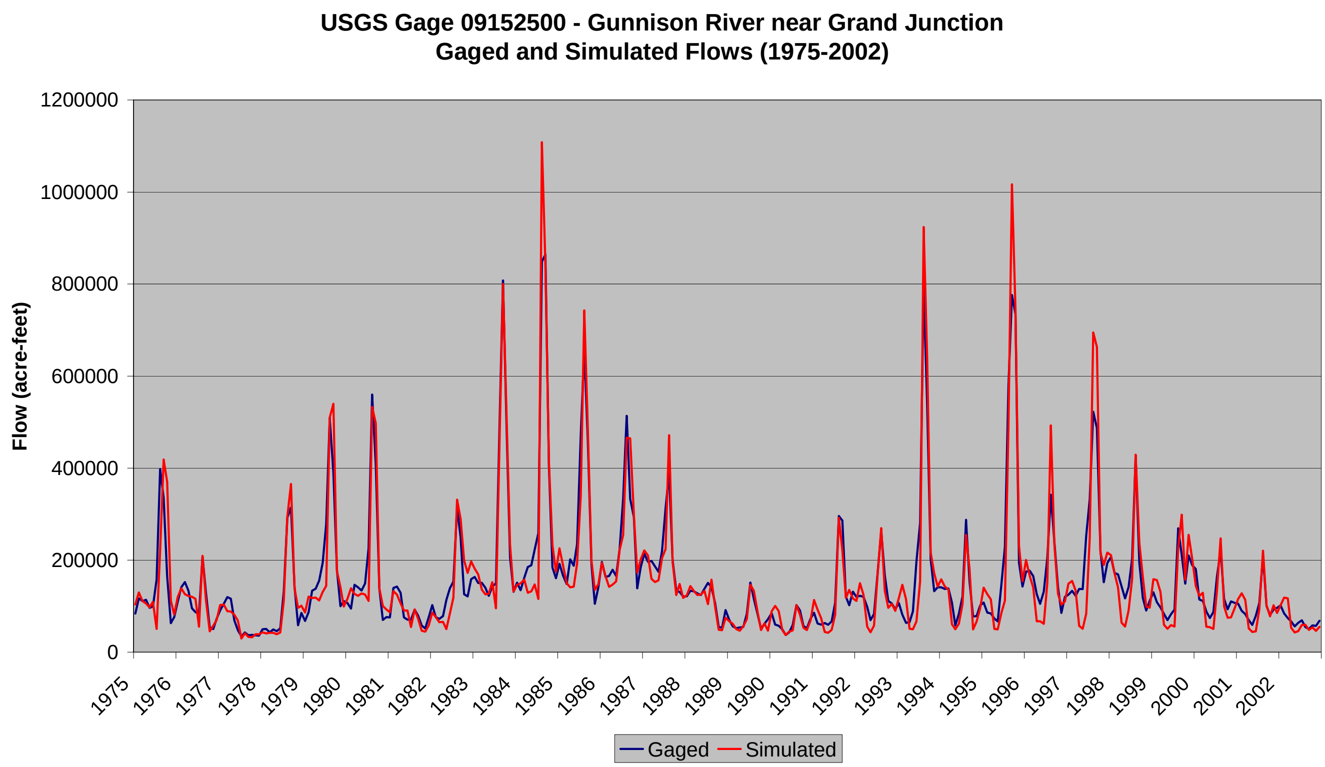


Figure D.11 Calculated Streamflow Simulation – Gunnison River near Grand Junction

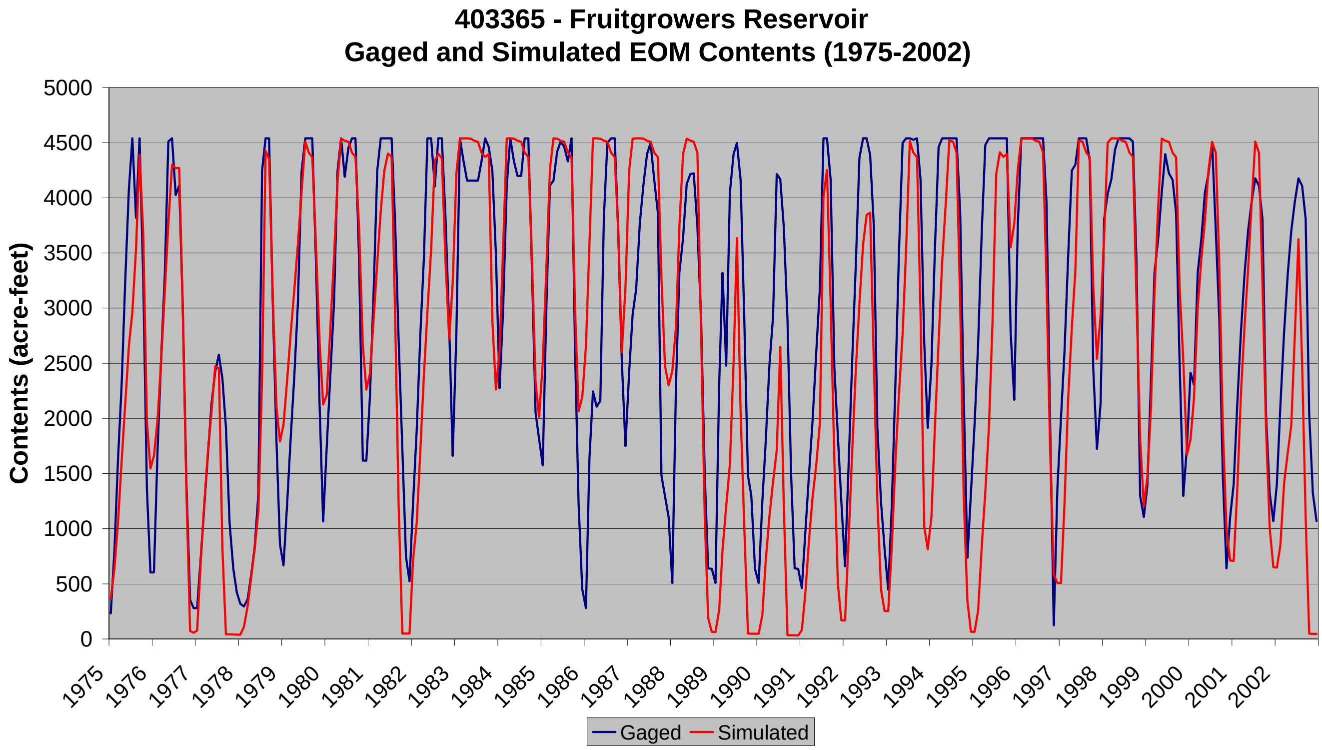


Figure D.12 Calculated Reservoir Simulation – Fruitgrowers Reservoir

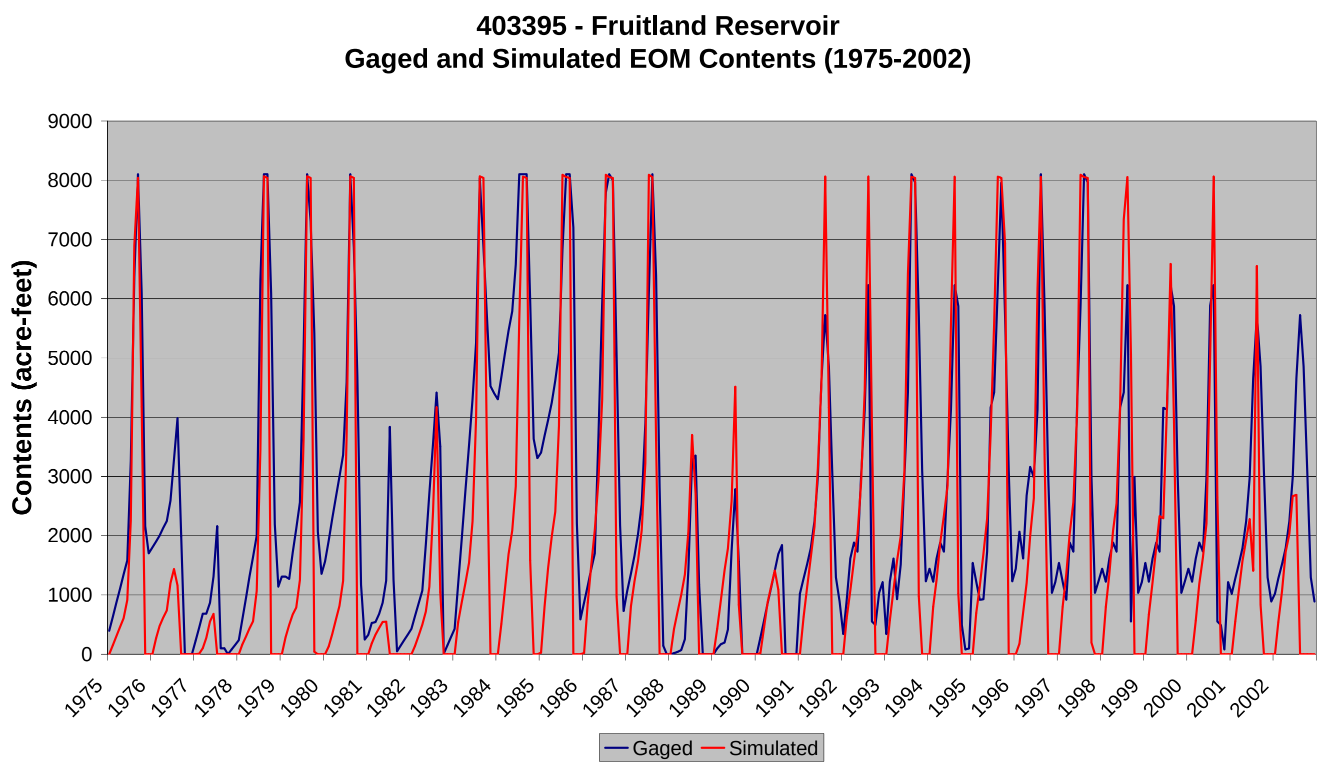


Figure D.13 Calculated Reservoir Simulation – Fruitland Reservoir

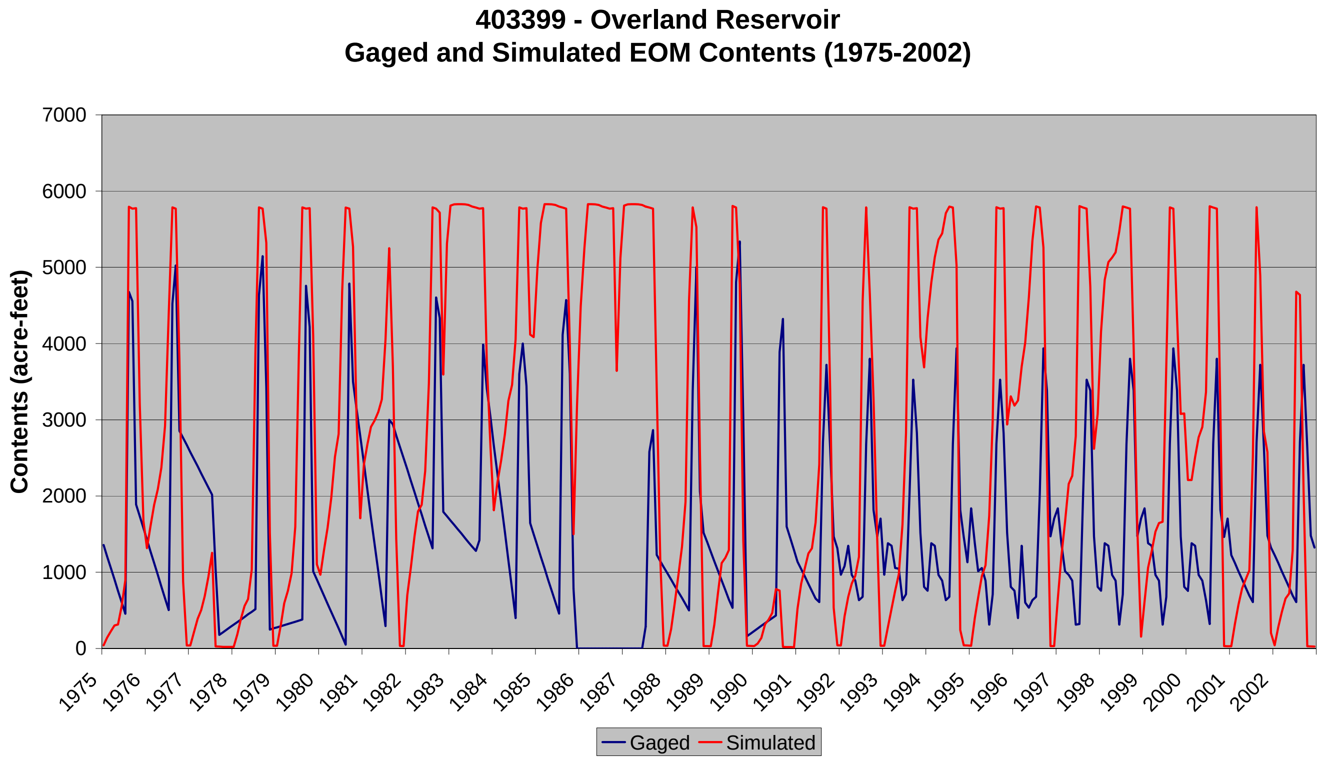


Figure D.14 Calculated Reservoir Simulation – Overland Reservoir

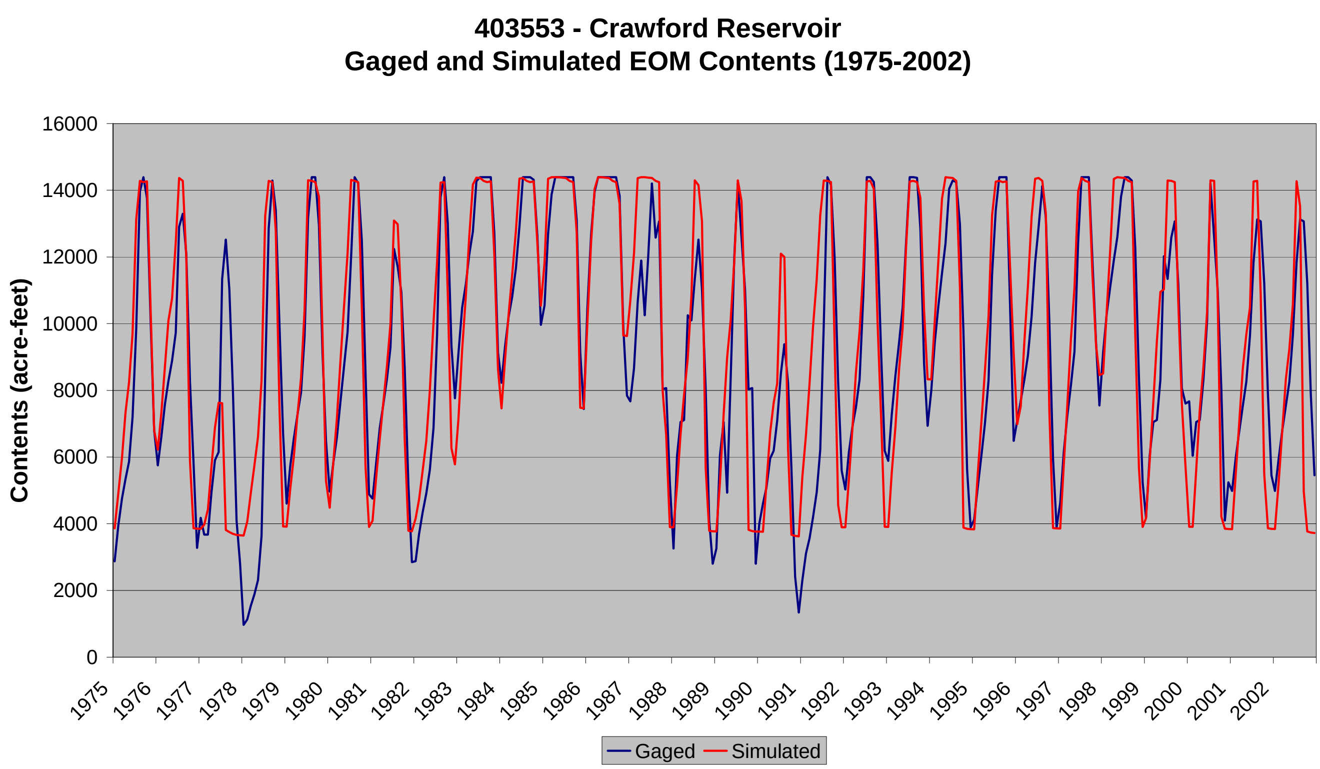


Figure D.15 Calculated Reservoir Simulation – Crawford Reservoir

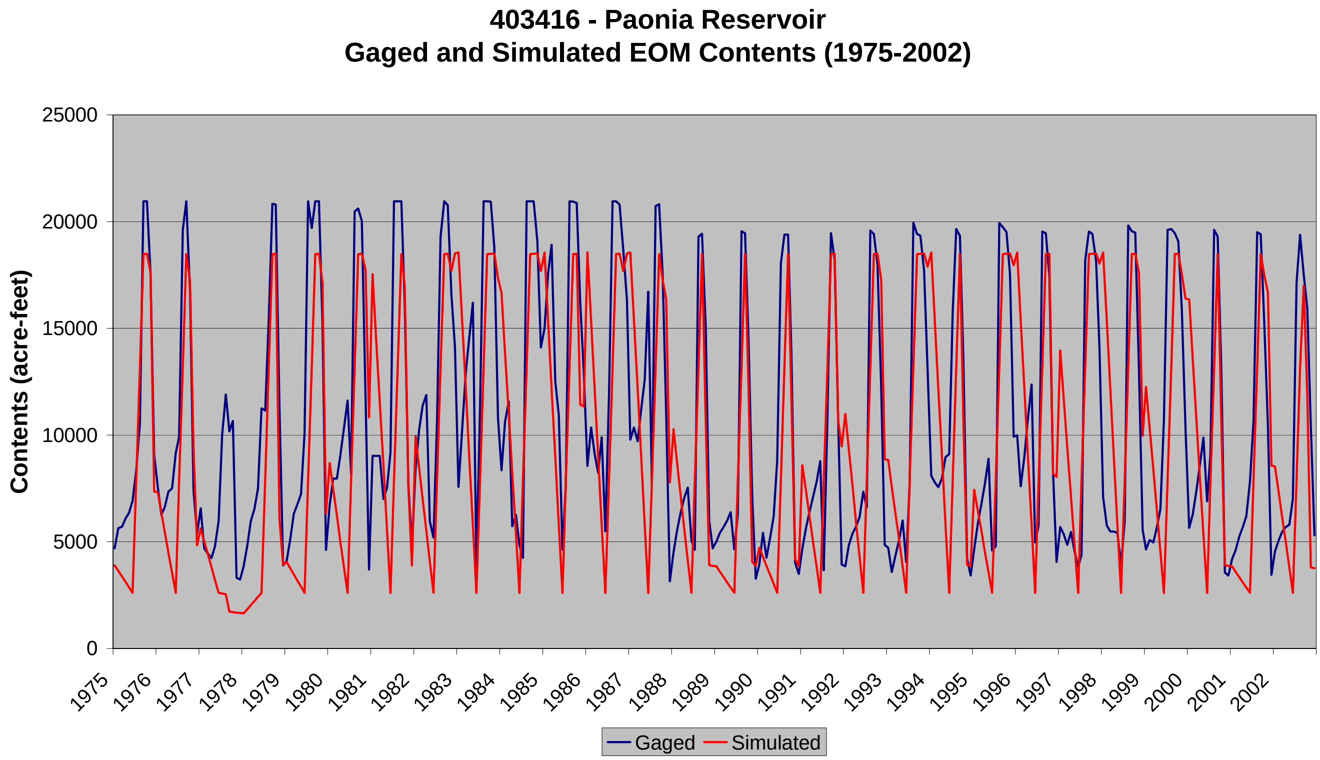


Figure D.16 Calculated Reservoir Simulation – Paonia Reservoir

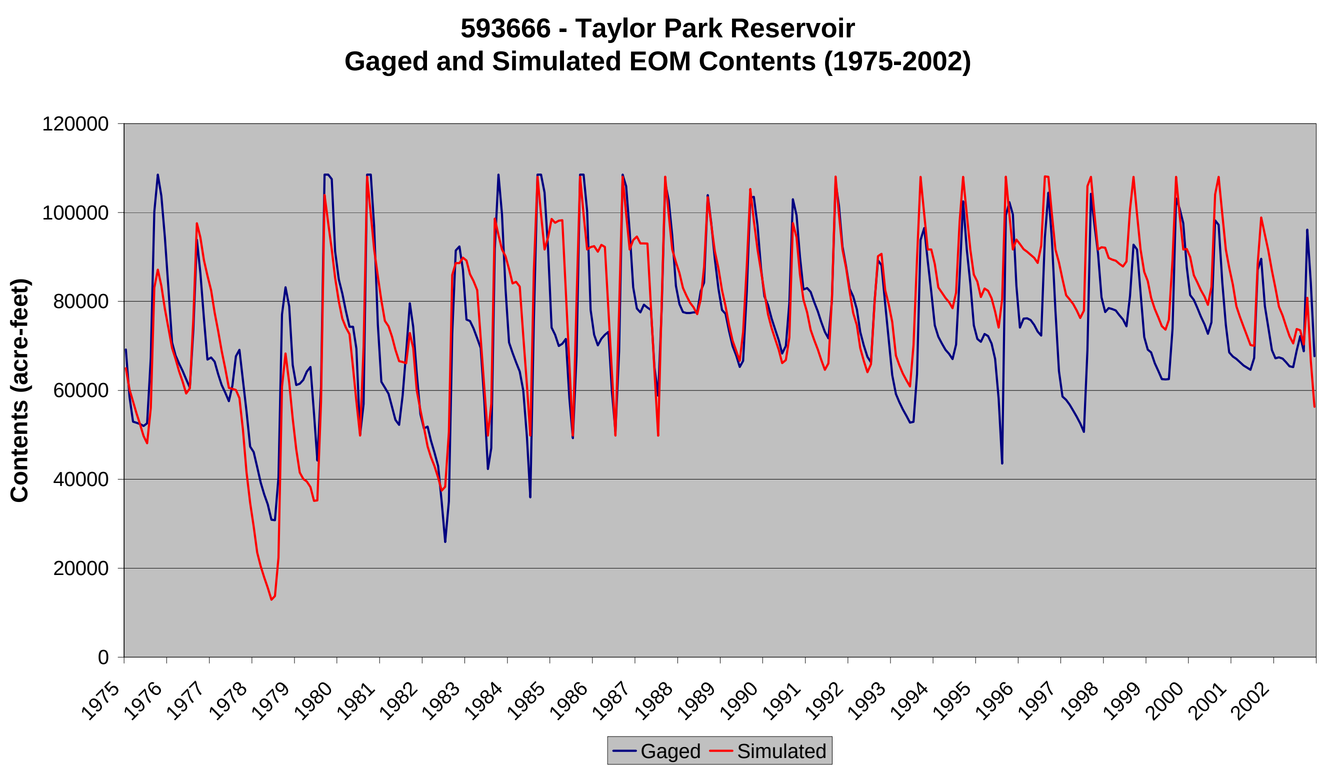


Figure D.17 Calculated Reservoir Simulation – Taylor Park Reservoir

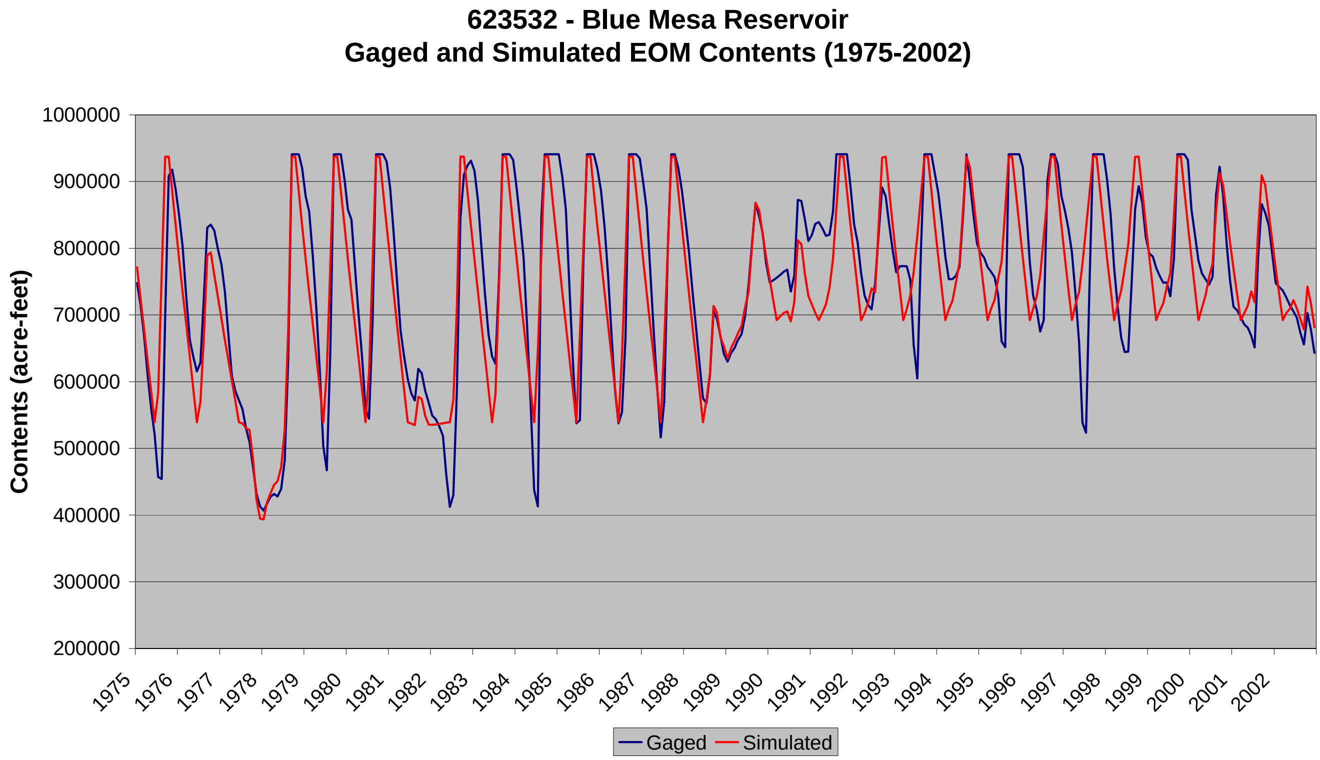


Figure D.18 Calculated Reservoir Simulation – Blue Mesa Reservoir

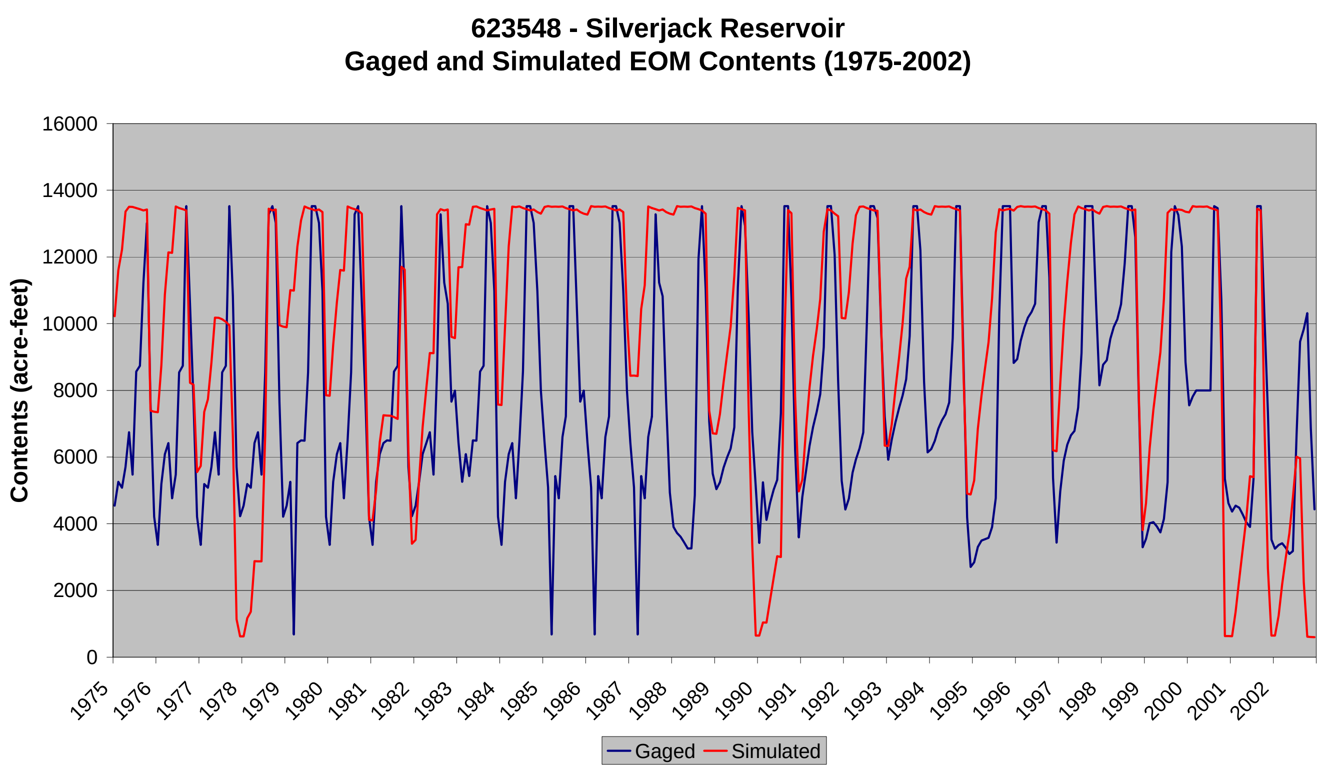


Figure D.19 Calculated Reservoir Simulation – Silverjack Reservoir

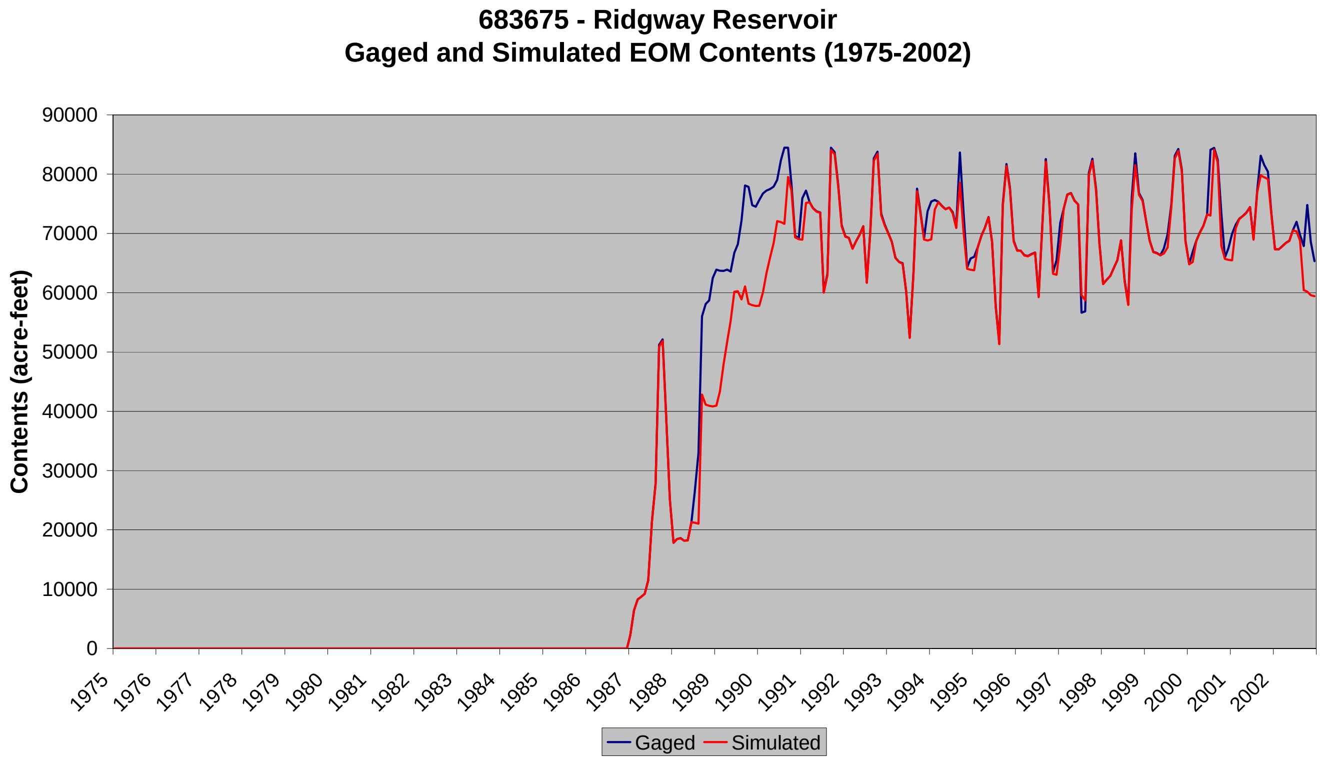


Figure D.20 Calculated Reservoir Simulation – Ridgway Reservoir

Appendix E

Historical Daily Simulation Results

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 2002. 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 Gunnison River basin. The selection and use of pattern gages is discussed in Section 8 Historical Daily Results.

Historical Daily Data Set Calibration Efforts

The Historical Daily data set used existing input from the Historical Calibration data set. No additional calibration efforts were considered necessary for the Historical Daily Gunnison model.

Historical Daily Simulation Results

Simulation of the Historical Daily Gunnison River model is considered good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. The basinwide shortage, 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 Gunnison River model, for the calibration period (1975-2002). Following are observations based on the summary table:

- Surface water inflow to the basin averages 2.40 million acre-feet per year, and stream outflow averages 1.88 million acre-feet per year.
- Annual diversions amount to approximately 2.52 million acre-feet on average.

- Approximately 448,000 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 (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	90,413	166,740	755	257,907	171,974	1,882	129,554	-46,250	6,018	-5,264	257,915	-8	11,952
NOV	67,182	68,525	130	135,836	49,106	717	125,017	-39,125	1,163	-1,033	135,844	-8	1,751
DEC	61,706	62,534	0	124,239	51,303	273	111,555	-38,890	929	-929	124,240	-1	1,155
JAN	59,552	56,821	0	116,373	49,091	355	81,093	-14,166	764	-764	116,373	0	1,176
FEB	56,427	49,523	0	105,950	45,914	699	77,586	-18,241	619	-619	105,959	-9	1,419
MAR	87,816	55,119	641	143,577	53,765	1,462	100,038	-12,324	589	52	143,583	-6	3,315
APR	214,684	134,227	2,353	351,264	166,006	3,234	138,685	40,993	2,881	-528	351,270	-6	16,373
MAY	612,543	259,547	3,679	875,770	370,617	5,368	377,298	118,813	11,160	-7,480	875,775	-5	60,055
JUN	625,364	352,557	5,808	983,729	507,842	7,215	322,551	140,316	12,903	-7,095	983,732	-3	106,992
JUL	291,394	342,253	10,960	644,607	458,853	6,198	181,479	-12,878	6,923	4,038	644,611	-4	110,207
AUG	133,796	273,112	9,878	416,785	342,195	5,151	124,456	-64,890	4,830	5,048	416,790	-5	82,129
SEP	99,433	220,520	4,318	324,271	257,899	4,100	111,647	-53,686	3,257	1,060	324,278	-7	45,716
AVG	2,400,308	2,041,478	38,522	4,480,309	2,524,565	36,654	1,880,959	-329	52,036	-13,514	4,480,369	-62	442,241

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 2002, 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 better streamflow calibration on most tributaries than the monthly simulation.

Temporal variability of the Historical Daily simulated flows are illustrated in Figures E.1 through E.27 for three selected years for each of the daily pattern gages and for three downstream gages; Gunnison River below Gunnison Tunnel, Uncompahgre River at Delta, and Gunnison River near Grand Junction. The selected years represent wet (1995), average (1982), and dry (1977) years in the Gunnison 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 Historical Monthly calibration, streamflow at the gages below Blue Mesa Reservoir (Gunnison River below Gunnison Tunnel and Gunnison River near Grand Junction) represent annual volume, but daily patterns vary from gages. Blue Mesa is modeled using a forecasting curve provided by the USBR that is intended to mimic hydropower operations. It is clear that the rule curve is used only as a guideline by the USBR, and decisions based on other factors drive actual operations. Because of the large volume of water stored and released from the reservoir, relatively small deviations from historic reservoir operations result in large deviations in down stream flow.

In the daily modeling efforts, the release-to-target rule used to mimic hydropower operations uses a monthly storage target. At this time, there appears to be a discrepancy between the releases to this monthly target on the first day of each simulated year (October 1) compared to the releases to this monthly target for the remaining months in the year. This is particularly noticeable downstream of Blue Mesa Reservoir, due to the relatively large amount of monthly target releases. Therefore, as shown on Figures E.7, E.9, E.16, E.25, and E.27, in some years large flows are seen at the downstream gages on October 1. It is important to note that this “spike” flow does not affect overall results or usefulness of the model. It is expected that future StateMod code enhancements will correct this discrepancy.

Table E.2
Historical and Simulated Average Annual Streamflow Volumes (1975-2002)
Historical Daily Simulation (acre-feet/year)

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9109000	147,968	148,680	-711	0	Taylor River Below Taylor Park Reservoir
9110000	236,375	236,812	-437	0	Taylor River at Almont
9110500	*No gage during simulation period*			0	East River Near Crested Butte
9111500	98,931	98,934	-3	0	Slate River Near Crested Butte
9112000	*No gage during simulation period*			0	Cement Creek Near Crested Butte
9112200	231,532	231,756	-224	0	East River Below Cement Creek Near Crested Butte
9112500	238,733	237,404	1,328	1	East River at Almont
9113300	*No gage during simulation period*			0	Ohio Creek at Baldwin
9113500	56,954	56,759	195	0	Ohio Creek Near Baldwin
9114500	529,302	526,348	2,954	1	Gunnison River Near Gunnison
9115500	45,797	46,087	-290	-1	Tomichi Creek at Sargents
9118000	*No gage during simulation period*			0	Quartz Creek Near Ohio City
9118450	33,105	33,062	43	0	Cochetopa Creek Below Rock Creek Near Parlin
9119000	127,952	126,558	1,395	1	Tomichi Creek at Gunnison
9121500	*No gage during simulation period*			0	Cebolla Creek Near Lake City
9121800	*No gage during simulation period*			0	Cebolla Creek Near Powderhorn
9122000	*No gage during simulation period*			0	Cebolla Creek at Powderhorn
9124500	167,999	167,912	87	0	Lake Fork at Gateview
9126000	70,457	71,319	-862	-1	Cimarron River Near Cimarron
9126500	*No gage during simulation period*			0	Cimarron River at Cimarron
9127500	*No gage during simulation period*			0	Crystal Creek Near Maher
9128000	888,915	882,372	6,543	1	Gunnison River Below Gunnison Tunnel
9128500	33,416	34,873	-1,457	-4	Smith Fork Near Crawford
9129600	28,116	29,740	-1,624	-6	Smith Fork Near Lazear
9130500	*No gage during simulation period*			0	East Muddy Creek Near Bardine
9131200	*No gage during simulation period*			0	West Muddy Creek Near Somerset
9132500	352,863	353,143	-280	0	North Fork Gunnison River Near Somerset
9134000	15,138	15,421	-283	-2	Minnesota Creek Near Paonia
9134050	10,181	10,415	-234	-2	Minnesota Creek at Paonia
9134500	*No gage during simulation period*			0	Leroux Creek Near Cedaredge

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9135900	20,892	23,132	-2,240	-11	Leroux Creek at Hotchkiss
9136200	1,446,348	1,441,457	4,891	0	Gunnison River Near Lazear
9137050	10,560	11,329	-769	-7	Currant Creek Near Read
9137800	*No gage during simulation period*			0	Dirty George Creek Near Grand Mesa
9139200	*No gage during simulation period*			0	Ward Creek Near Grand Mesa
9141500	*No gage during simulation period*			0	Youngs Creek Near Cedaredge
9143000	32,964	32,964	-1	0	Surface Creek Near Cedaredge
9143500	22,602	24,948	-2,346	-10	Surface Creek at Cedaredge
9144200	52,622	55,993	-3,371	-6	Tongue Creek at Cory
9144250	1,501,545	1,479,042	22,503	1	Gunnison River at Delta
9146200	121,827	121,616	211	0	Uncompahgre River Near Ridgway
9146400	*No gage during simulation period*			0	West Fork Dallas Creek Near Ridgway
9146500	*No gage during simulation period*			0	East Fork Dallas Creek Near Ridgway
9146550	*No gage during simulation period*			0	Beaver Creek Near Ridgway
9147000	29,636	29,671	-34	0	Dallas Creek Near Ridgway
9147100	*No gage during simulation period*			0	Cow Creek Near Ridgway
9147500	192,969	191,565	1,404	1	Uncompahgre River at Colona
9149420	39,882	39,882	0	0	Spring Creek Near Montrose
9149500	236,296	243,294	-6,998	-3	Uncompahgre River at Delta
9150500	88,628	88,639	-10	0	Roubideau Creek at Mouth, Near Delta
9152000	17,377	18,256	-879	-5	Kannah Creek Near Whitewater
9152500	1,910,511	1,889,226	21,285	1	Gunnison River Near Grand Junction

Diversion Results

Table E.3 summarizes the average annual simulated diversions, by tributary or sub-basin, compared to historical diversions for water years 1975 through 2002. On a basin-wide basis, average annual diversions differ from historical diversions by about 3.5 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. Basin-wide diversions are shorted by about 2 percent more when simulated using a daily time-step.

Table E.3
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2002)
Historical Daily Simulation (acre-feet/year)

Tributary or Sub-basin	Historical	Simulated	Historical minus Simulated	
			Volume	Percent
Taylor River	9,264	8,916	348	4%
East River	103,025	93,460	9,565	9%
Ohio Creek	47,065	45,398	1,667	4%
Tomichi Creek	198,034	178,434	19,600	10%
Cebolla Creek, Lake Fork, and Cimarron River	70,891	68,281	2,610	4%
Crystal River	19,688	17,521	2,167	11%
Smith Fork	69,108	68,880	228	0%
N.F. Gunnison River	168,663	160,913	7,750	5%
Currant Creek	20,626	16,295	4,331	21%
Surface Creek	77,987	67,590	10,397	13%
Uncompahgre River	761,681	734,894	26,787	4%
Roubideau Creek	2,942	2,904	38	1%
Kannah Creek	16,700	14,770	1,930	12%
Gunnison River Mainstem	1,074,732	1,069,478	5,254	0%
Basin Total	2,640,406	2,547,734	92,672	3.5%

Reservoir Results

Figures E.29 through E.35 (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, the StateMod structure summary file (*.xss) results were "filtered" to only include the structures in the StateCU analysis.

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 4.6 percent difference is close to the overall basin diversion shortages simulated by the model.

Table E.4
Average Annual Crop Consumptive Use Comparison (1975-2002)

Comparison	StateCU Results (af/yr)	Calibration Run Results (af/yr)	% Difference
Explicit Structures	318,883	304,038	4.66
Aggregate Structures	92,167	87,946	4.58
Basin Total	411,050	391,984	4.64

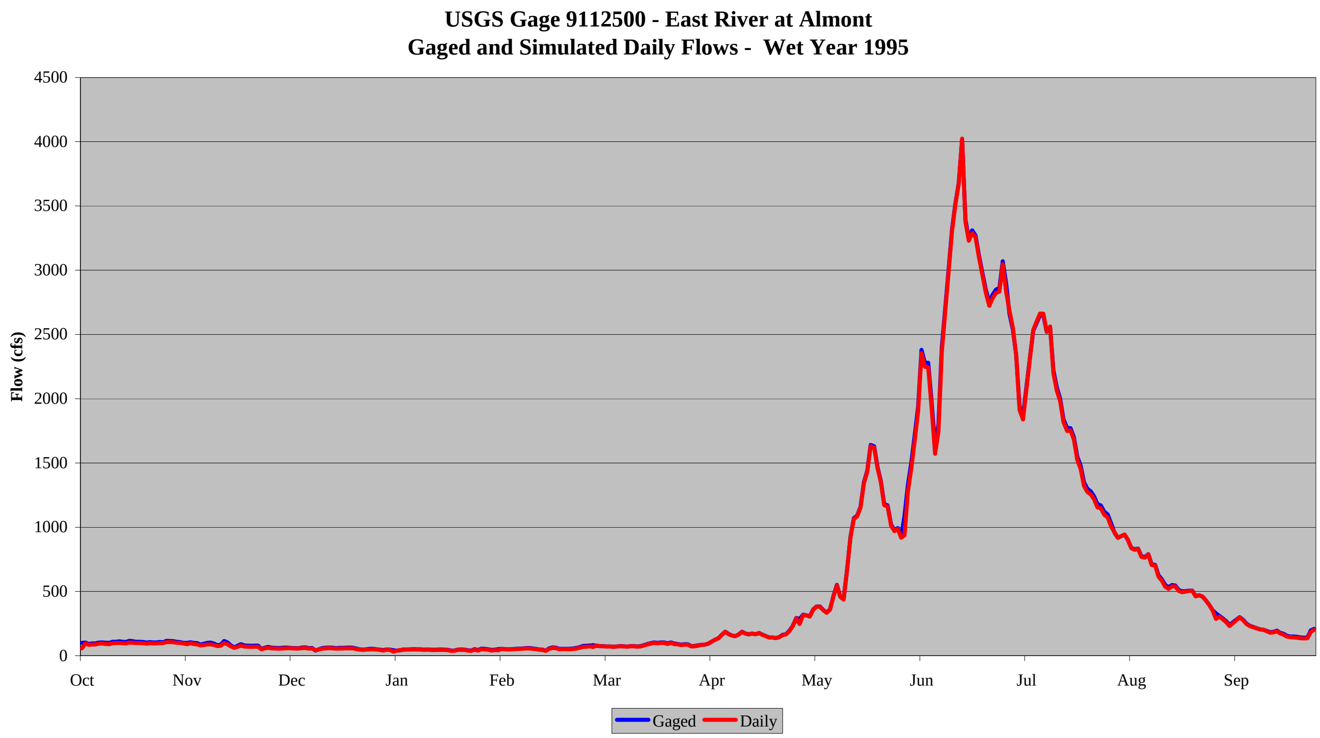


Figure E.1 Historical Daily Comparison, Wet Year – East River at Almont

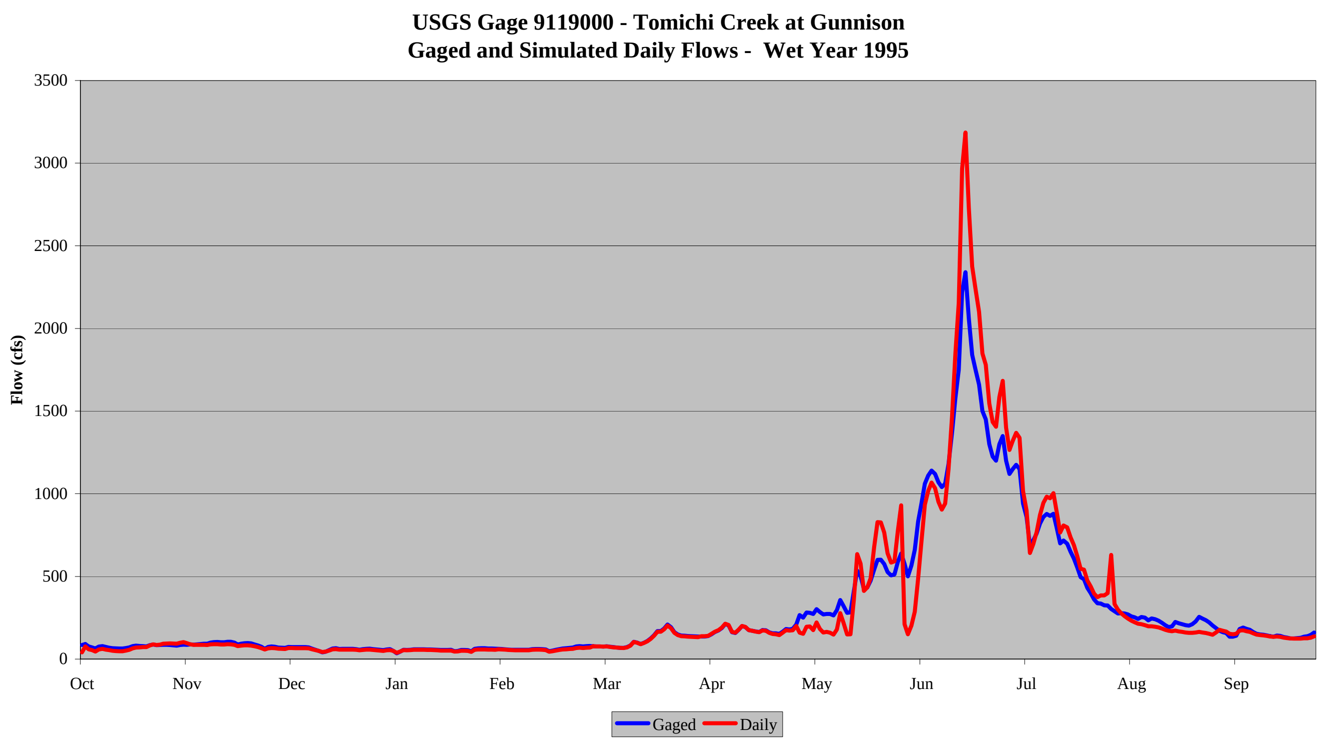


Figure E.2 Historical Daily Comparison, Wet Year – Tomichi Creek at Gunnison

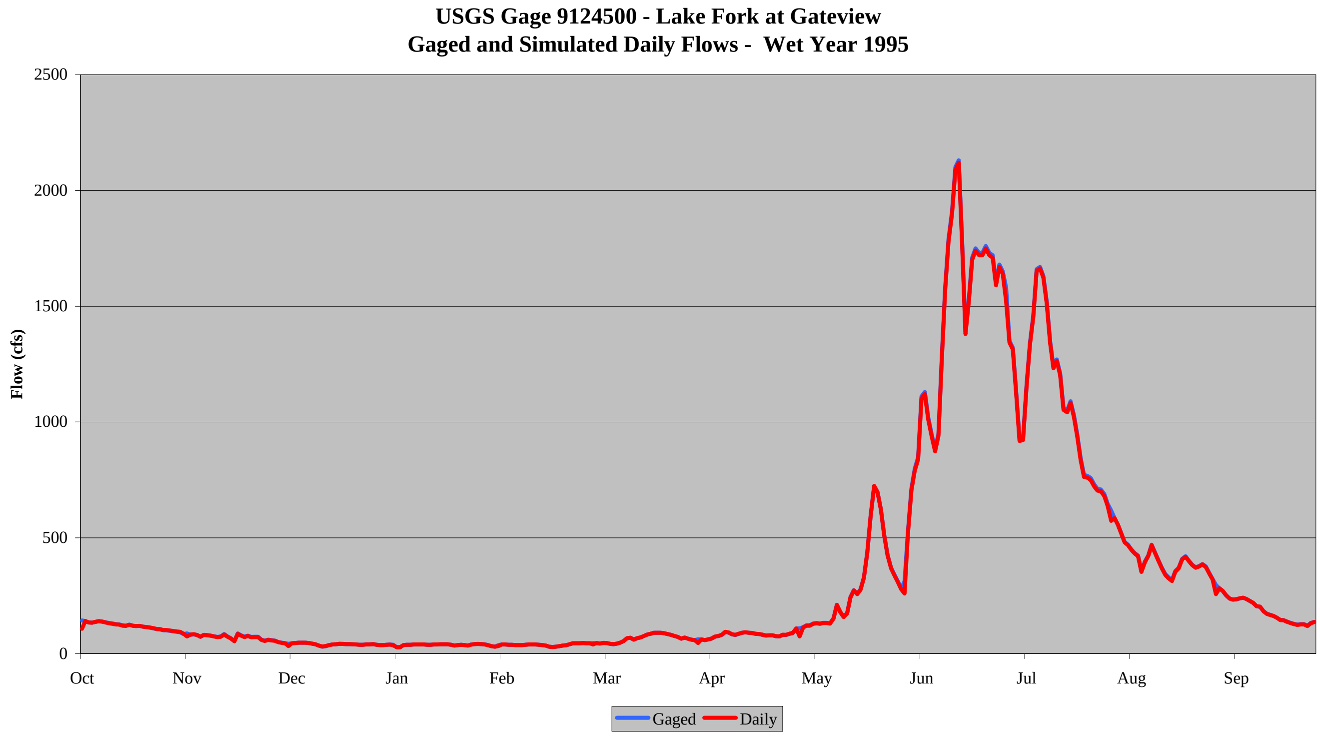


Figure E.3 Historical Daily Comparison, Wet Year – Lake Fork at Gateview

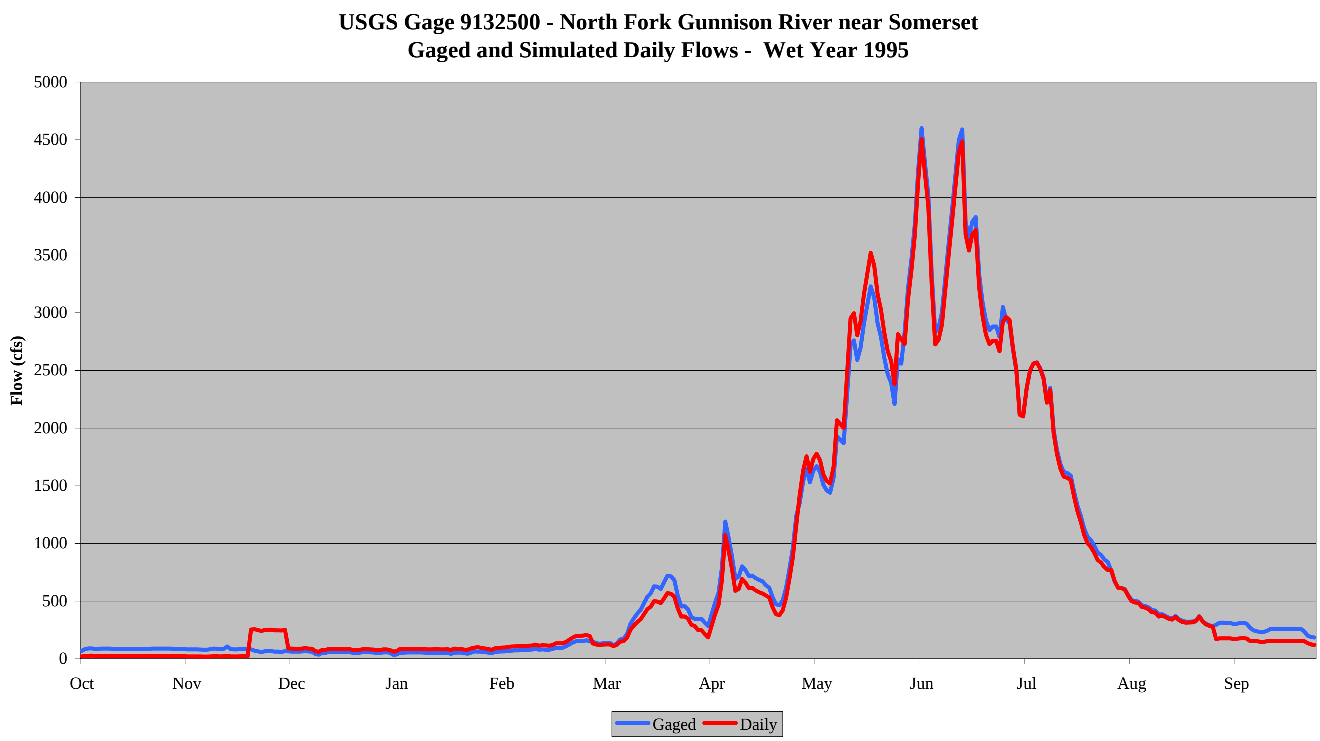


Figure E.4 Historical Daily Comparison, Wet Year – North Fork Gunnison River near Somerset

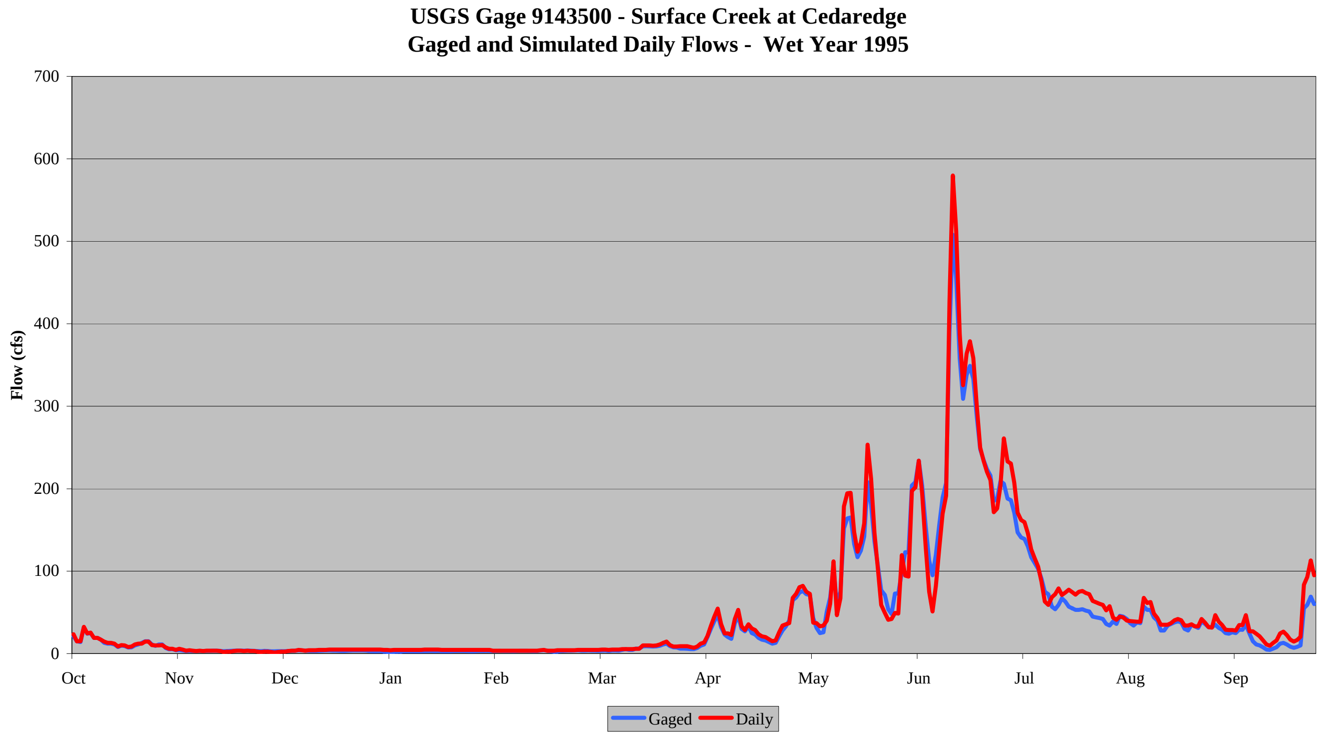


Figure E.5 Historical Daily Comparison, Wet Year – Surface Creek at Cedaredge

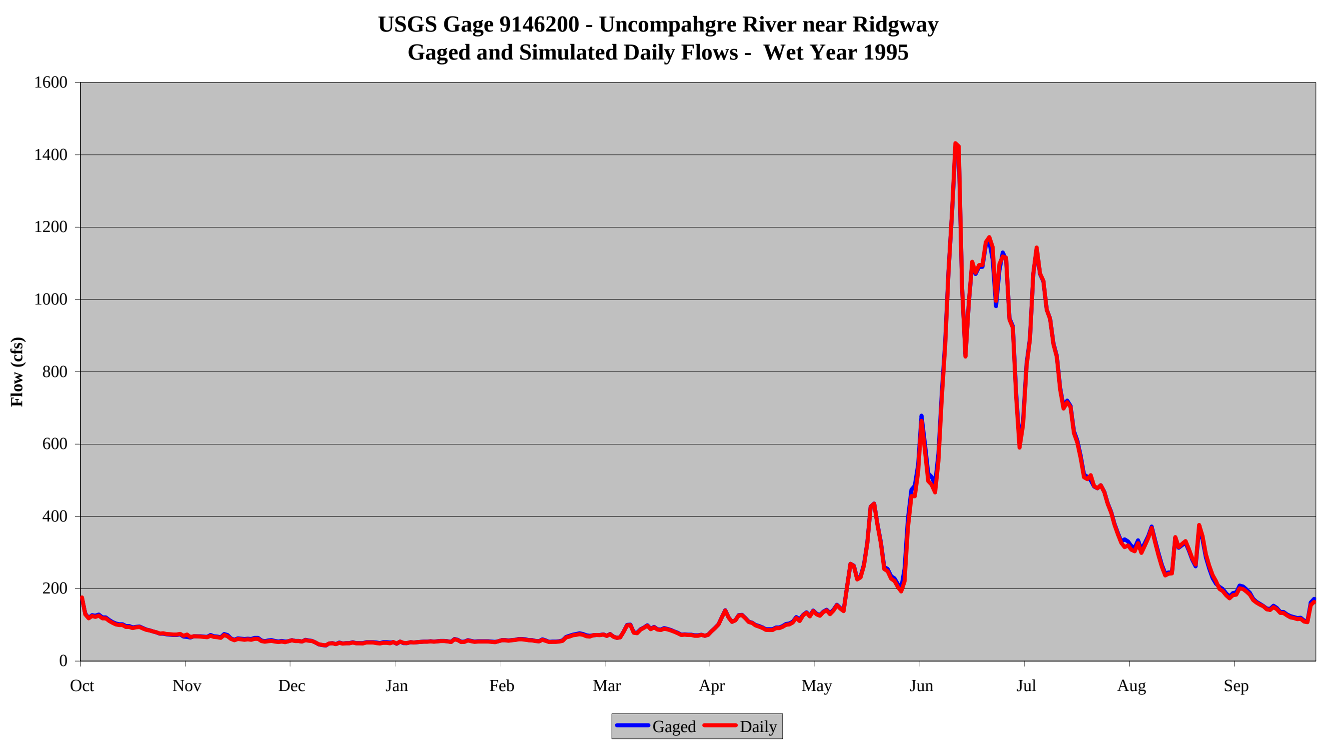


Figure E.6 Historical Daily Comparison, Wet Year – Uncompahgre River near Ridgway

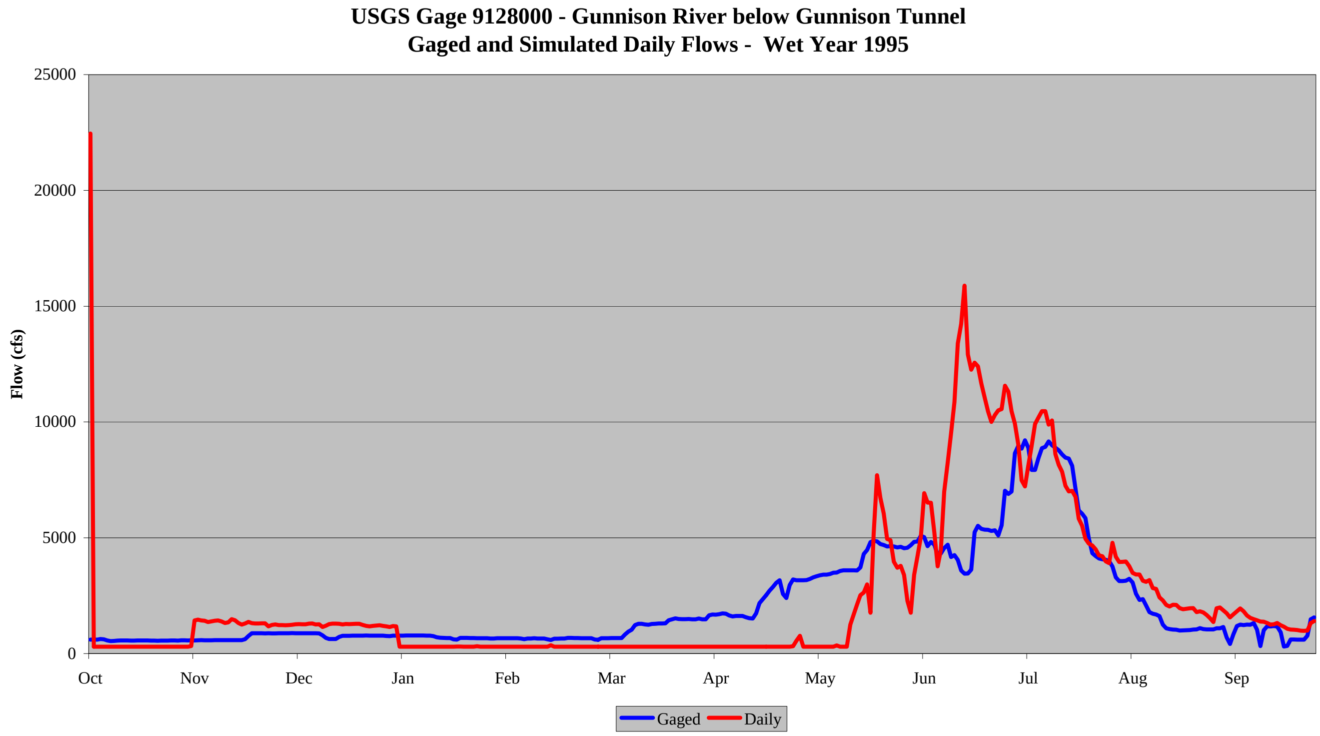


Figure E.7 Historical Daily Comparison, Wet Year – Gunnison River below Gunnison Tunnel

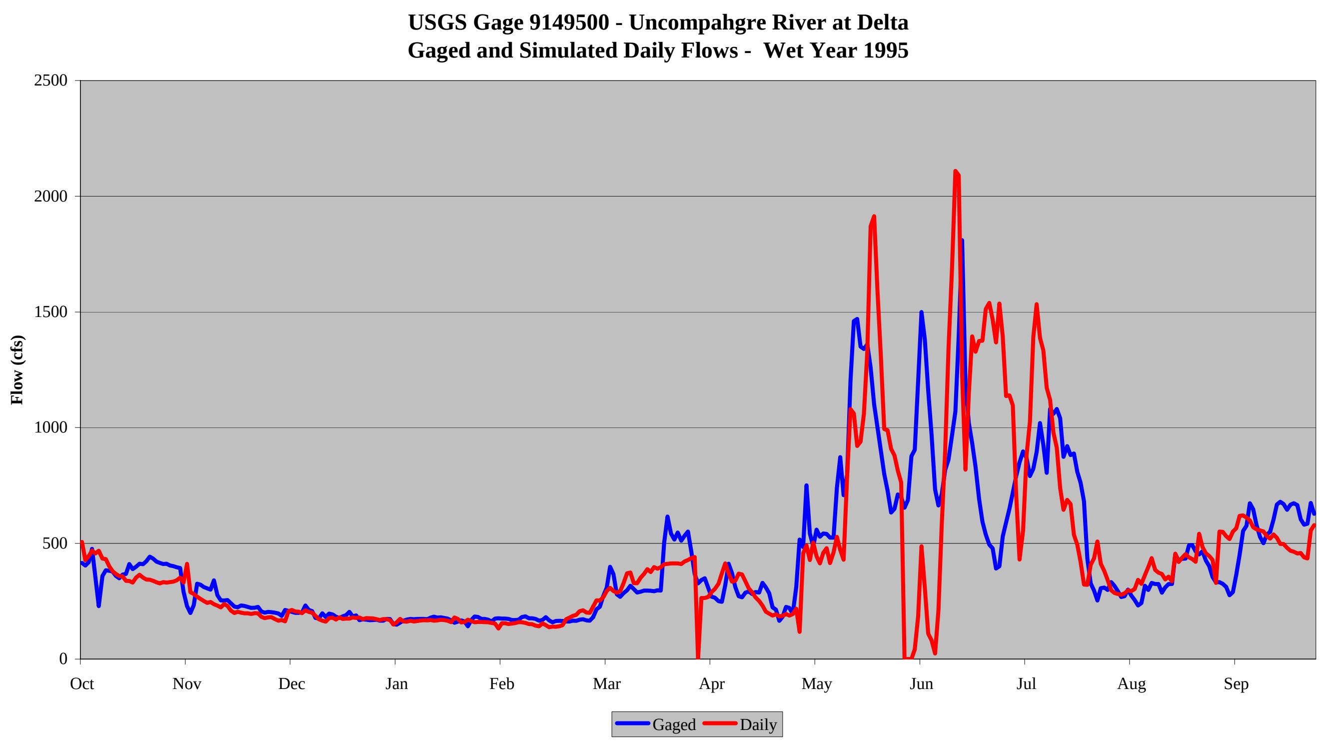


Figure E.8 Historical Daily Comparison, Wet Year – Uncompahgre River at Delta

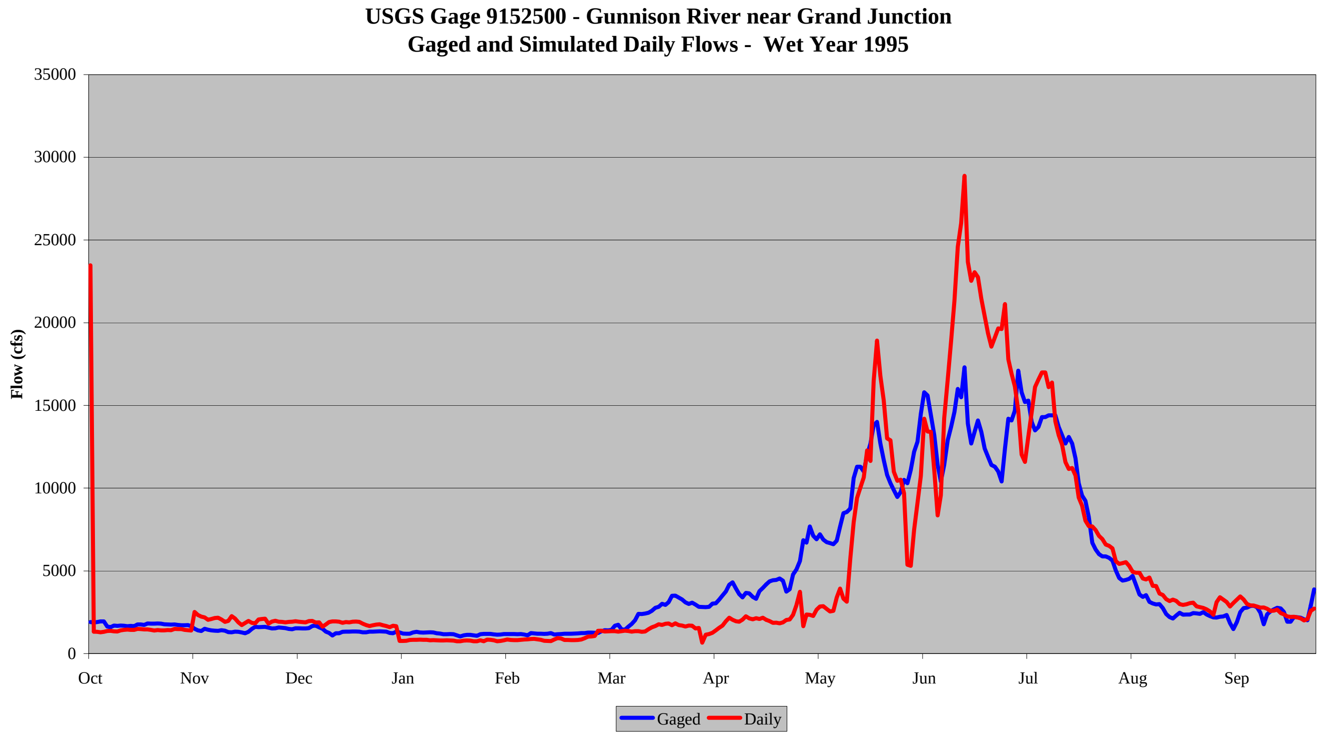


Figure E.9 Historical Daily Comparison, Wet Year – Gunnison River near Grand Junction

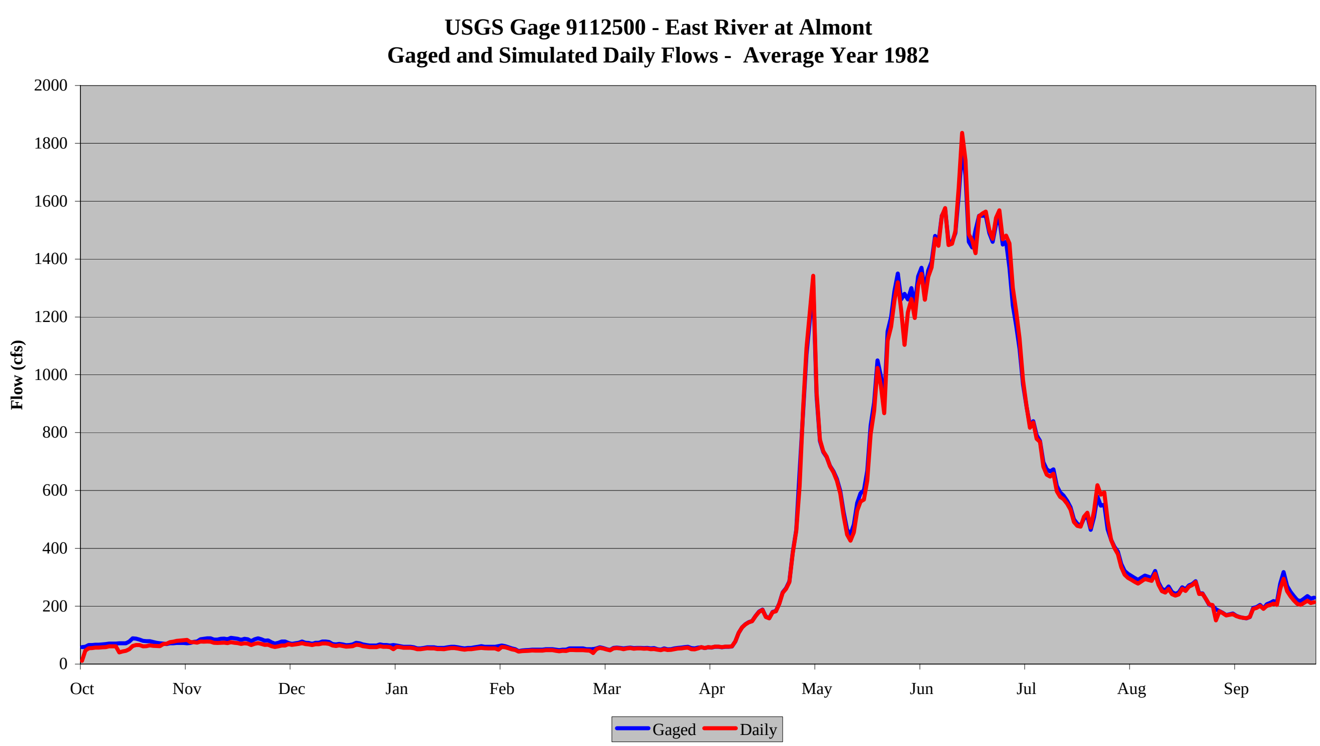


Figure E.10 Historical Daily Comparison, Average Year – East River at Almont

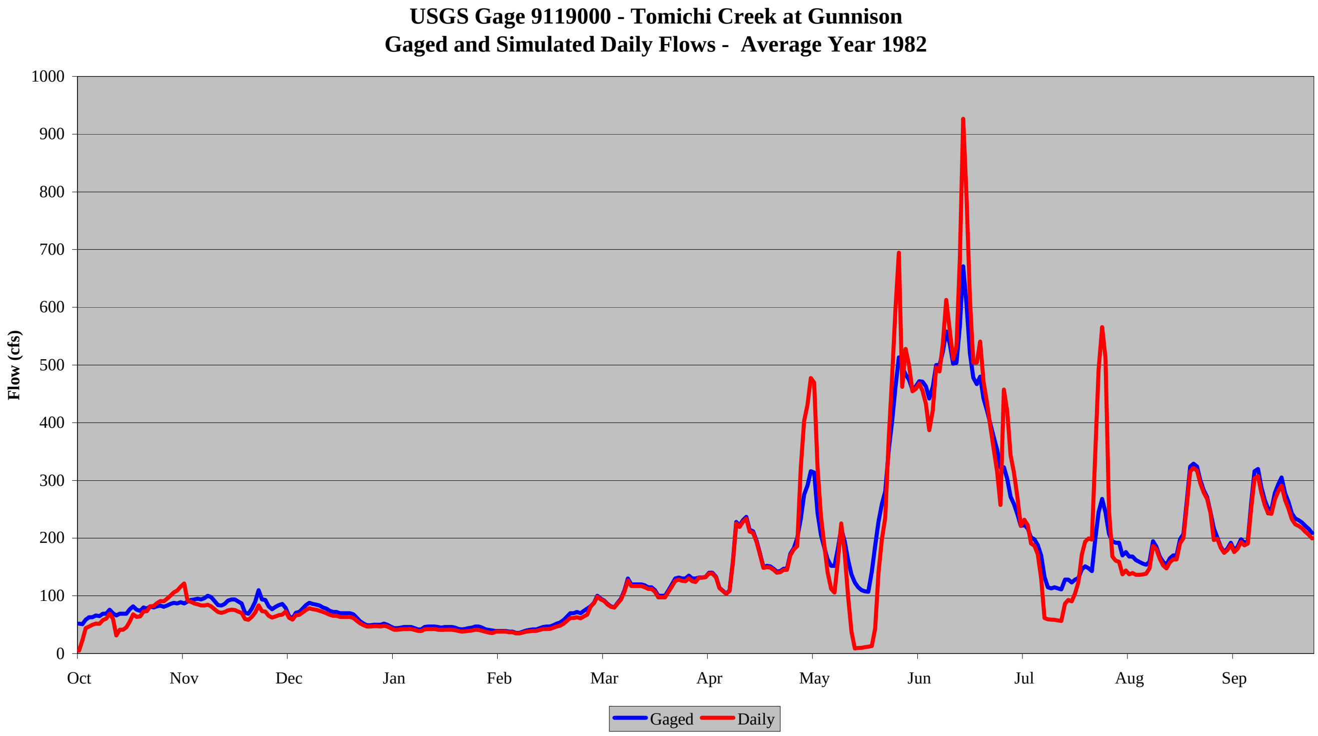


Figure E.11 Historical Daily Comparison, Average Year – Tomichi Creek at Gunnison

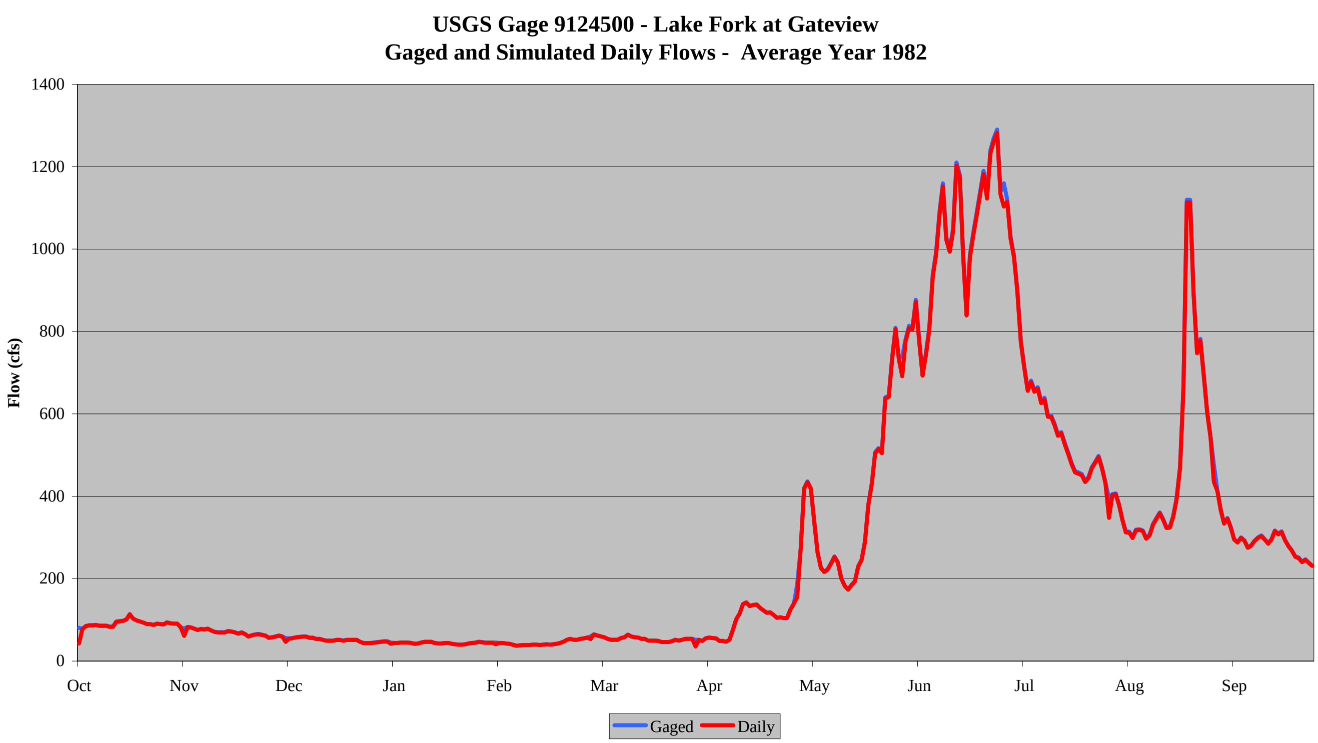


Figure E.12 Historical Daily Comparison, Average Year – Lake Fork at Gateview

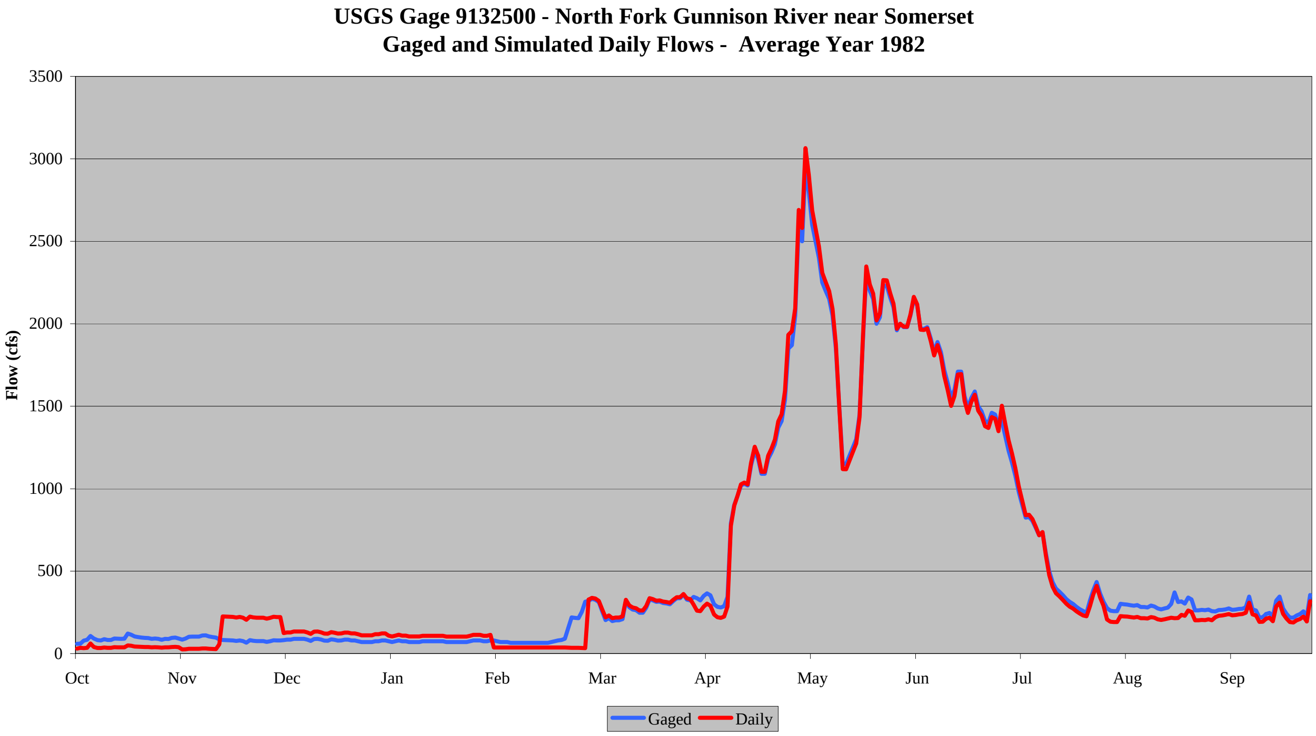


Figure E.13 Historical Daily Comparison, Average Year – N. Fork Gunnison River nr Somerset

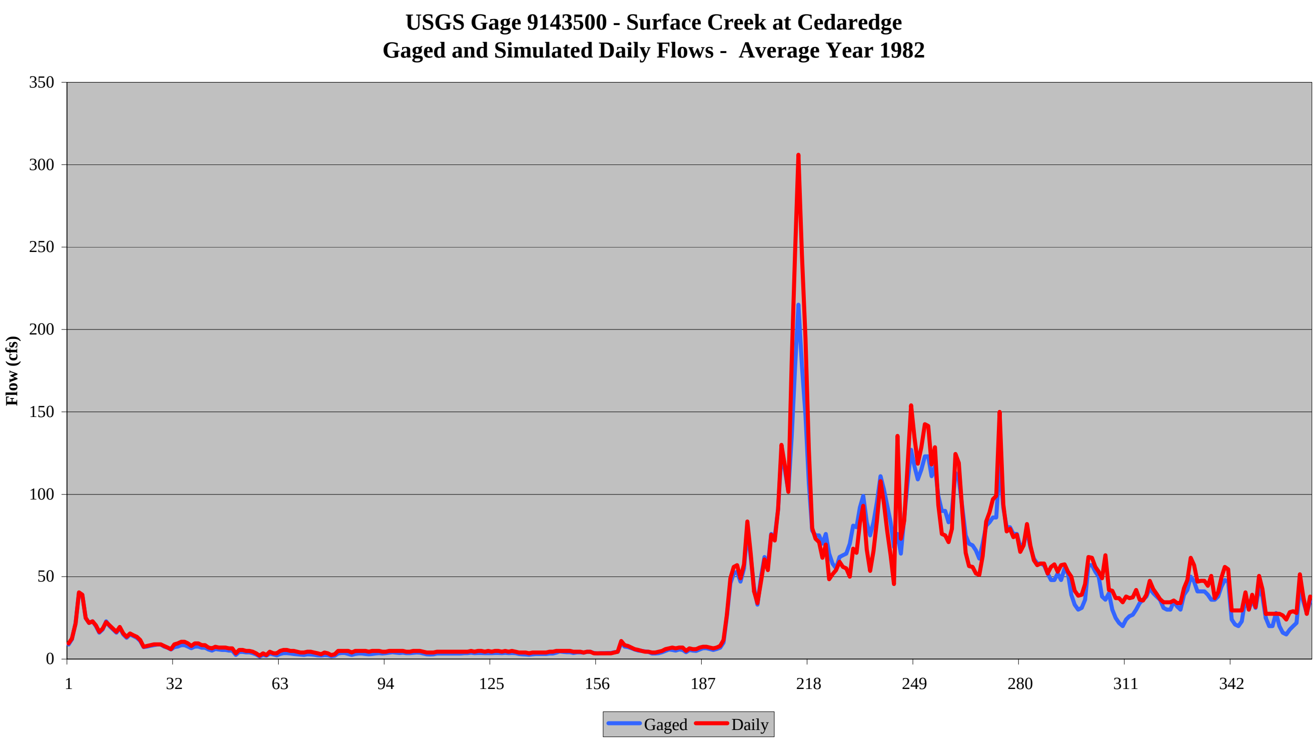


Figure E.14 Historical Daily Comparison, Average Year – Surface Creek at Cedaredge

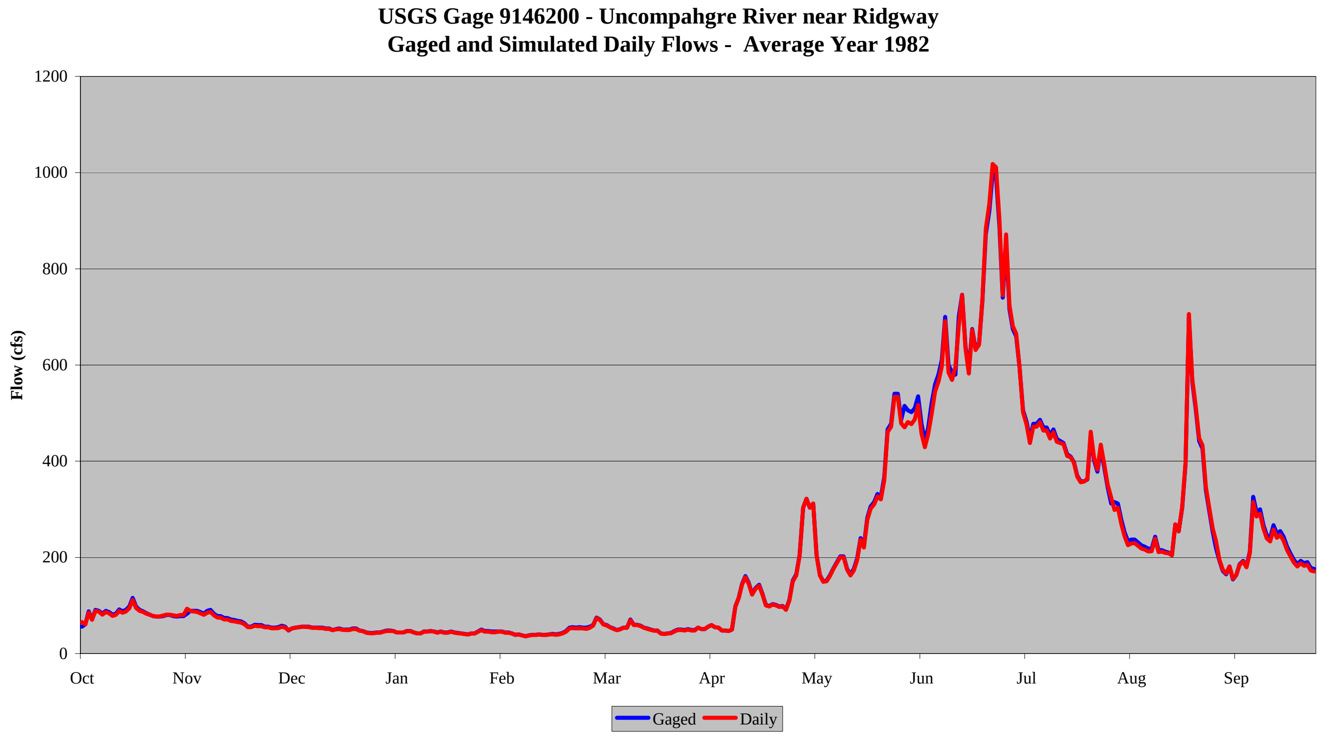


Figure E.15 Historical Daily Comparison, Average Year – Uncompahgre River near Ridgway

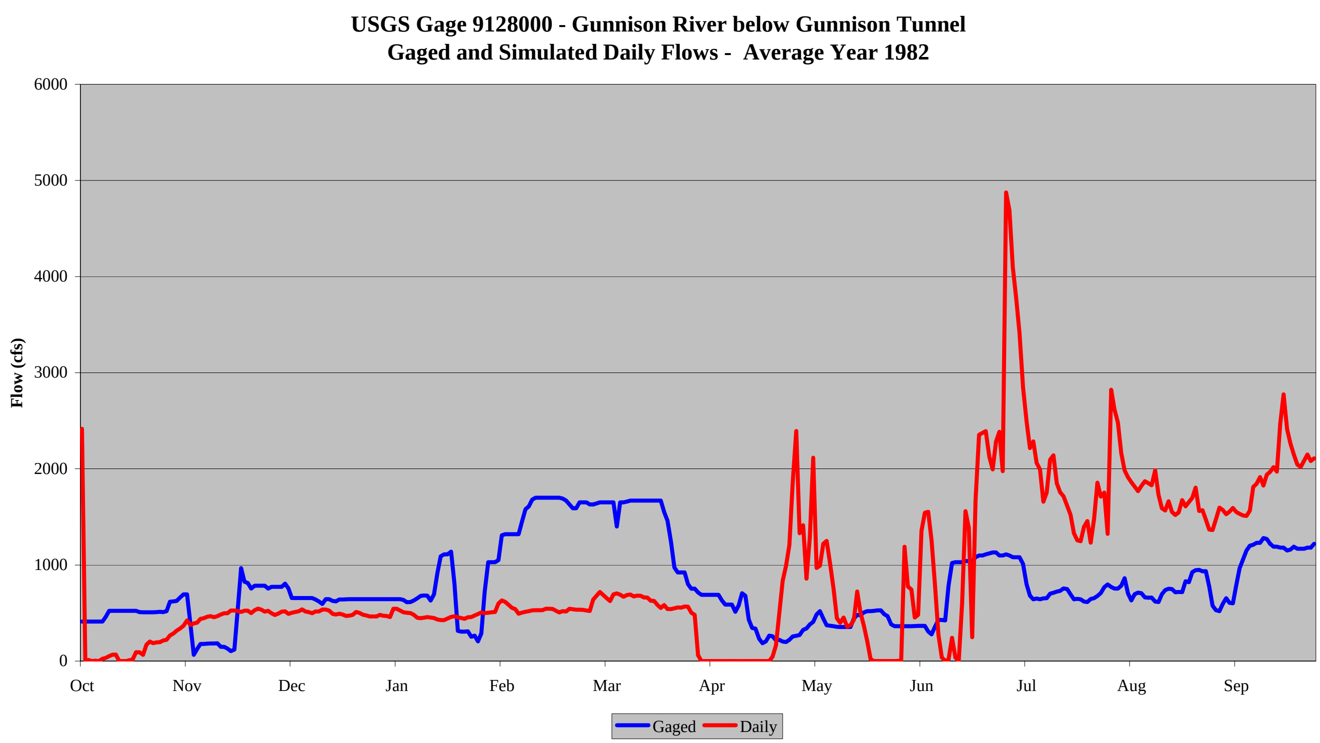


Figure E.16 Historical Daily Comparison, Average Year – Gunnison River bl Gunnison Tunnel

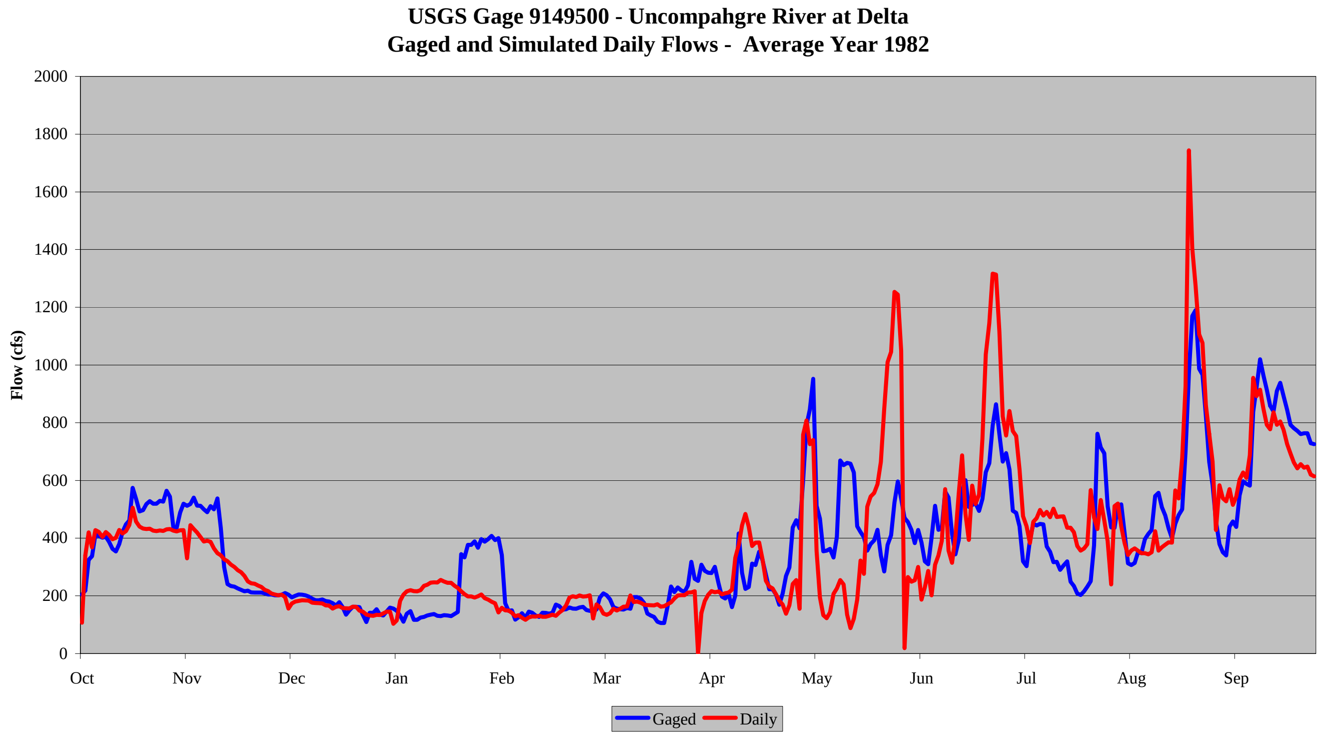


Figure E.17 Historical Daily Comparison, Average Year – Uncompahgre River at Delta

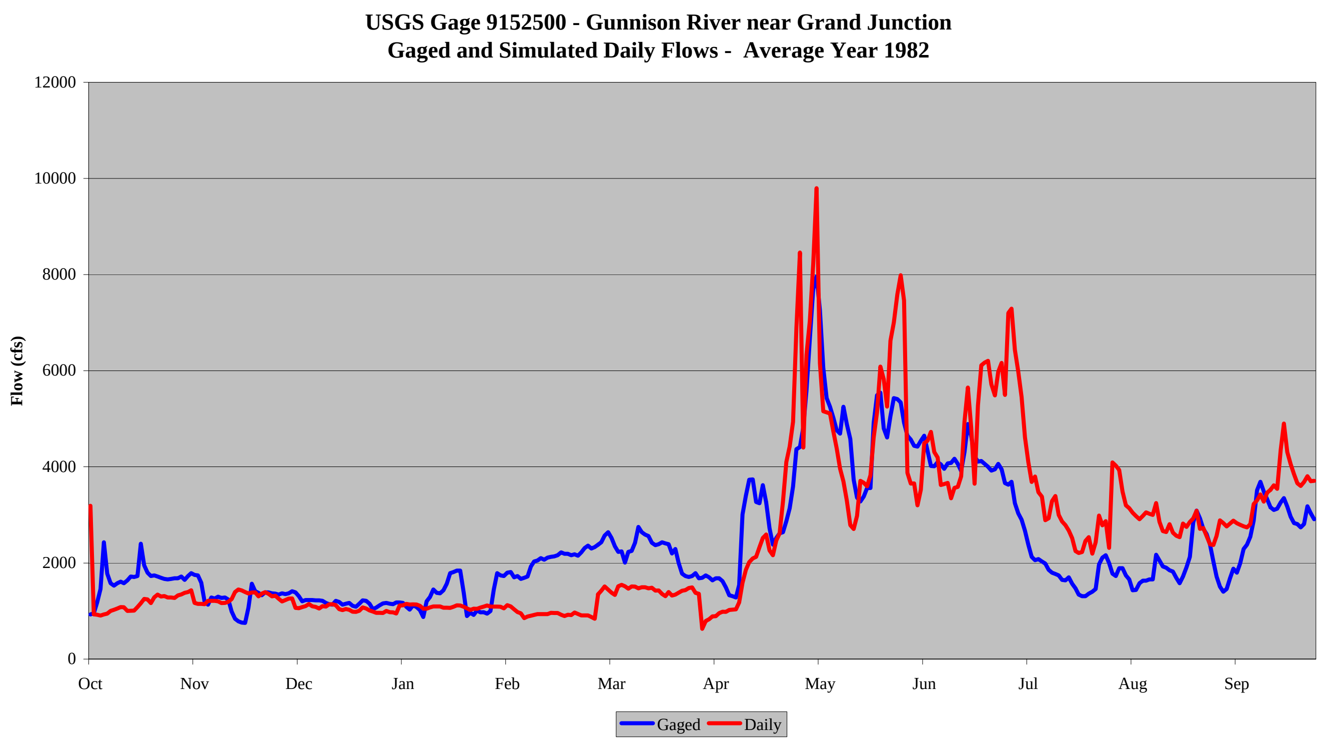


Figure E.18 Historical Daily Comparison, Average Year – Gunnison River near Grand Junction

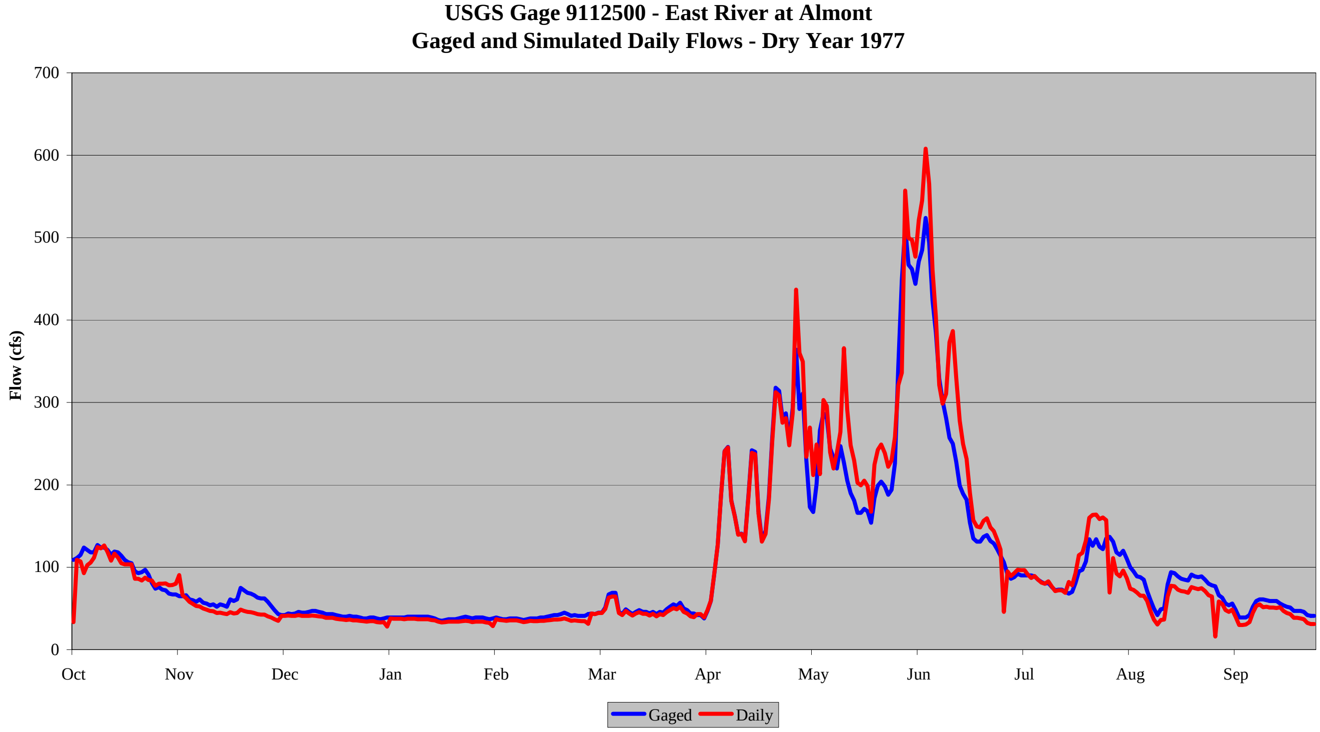


Figure E.19 Historical Daily Comparison, Dry Year – East River at Almont

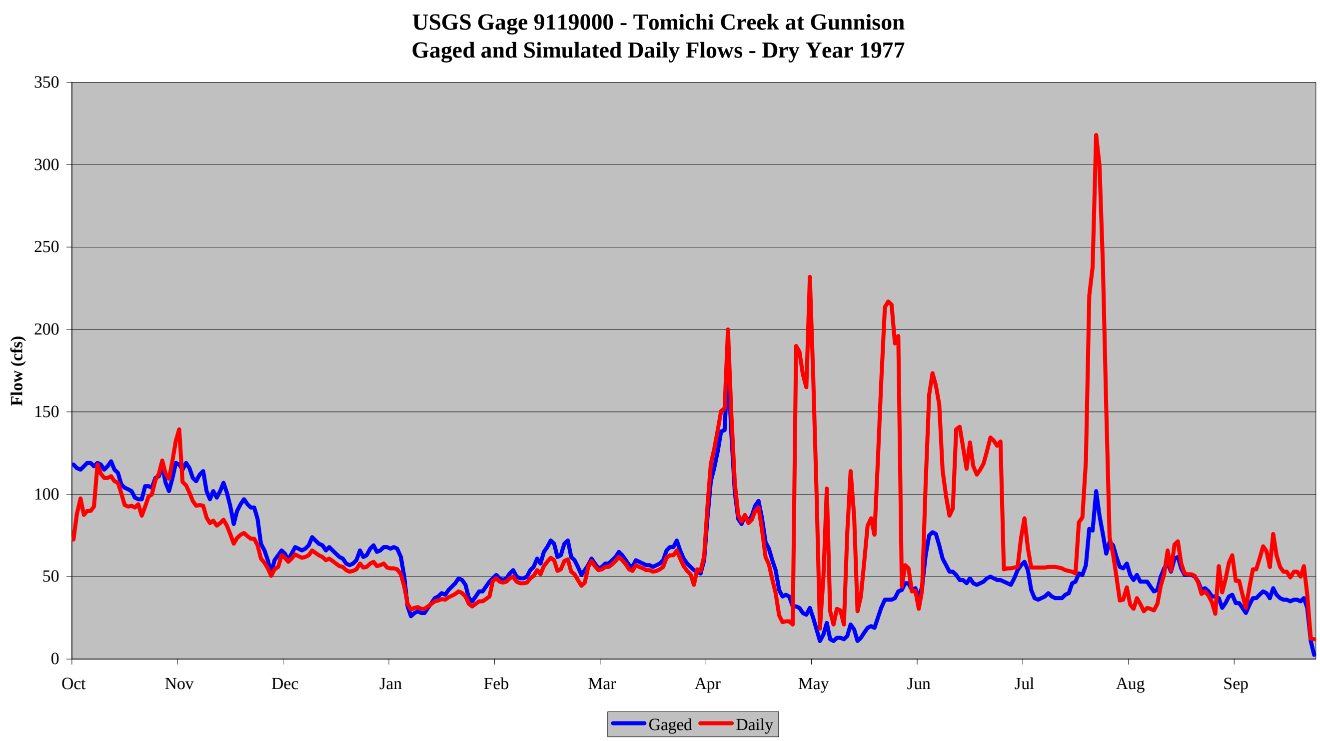


Figure E.20 Historical Daily Comparison, Dry Year – Tomichi Creek at Gunnison

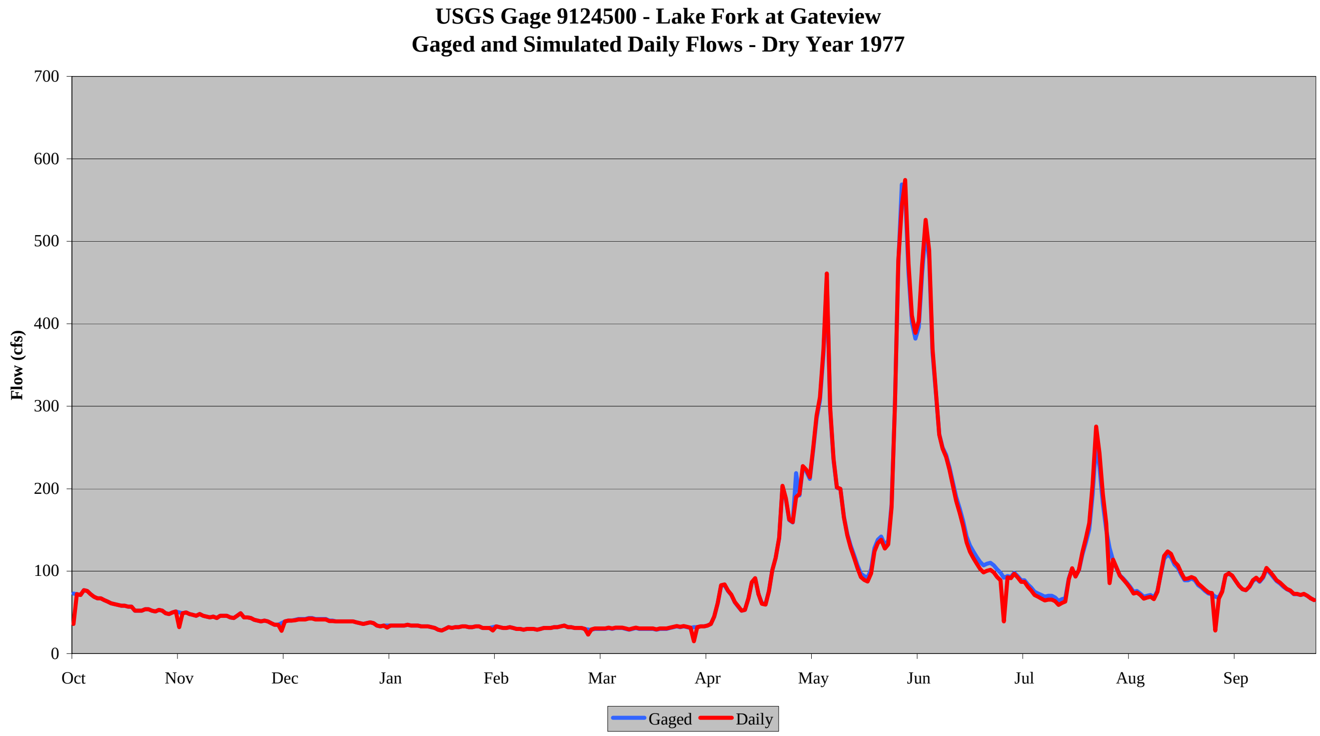


Figure E.21 Historical Daily Comparison, Dry Year – Lake Fork at Gateview

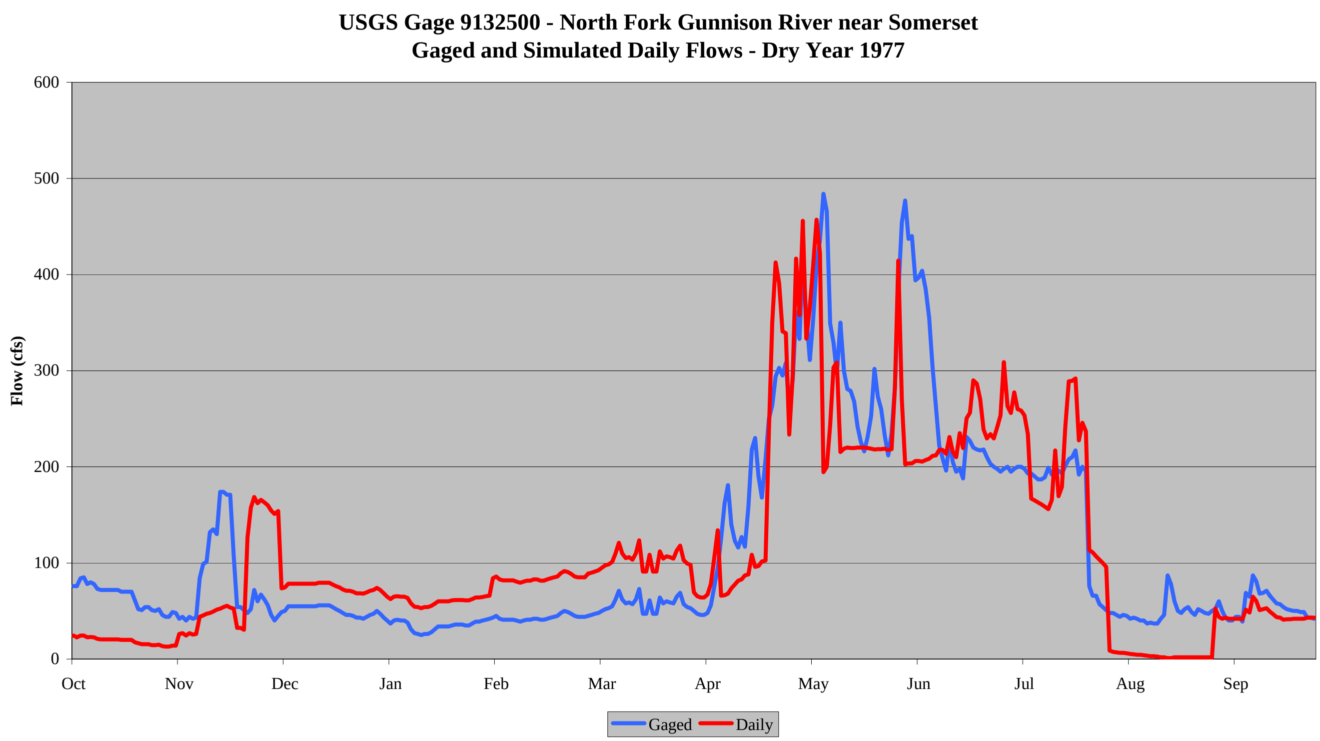


Figure E.22 Historical Daily Comparison, Dry Year – North Fork Gunnison River near Somerset

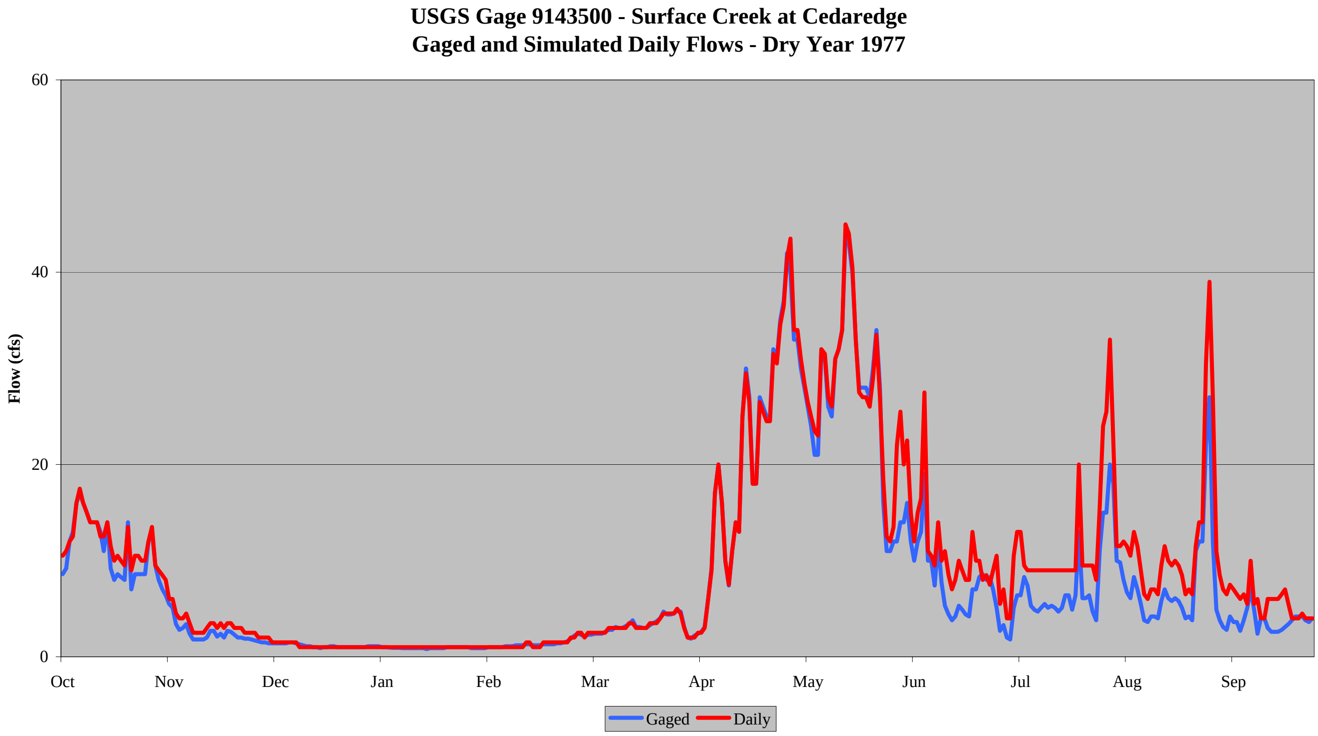


Figure E.23 Historical Daily Comparison, Dry Year – Surface Creek at Cedaredge

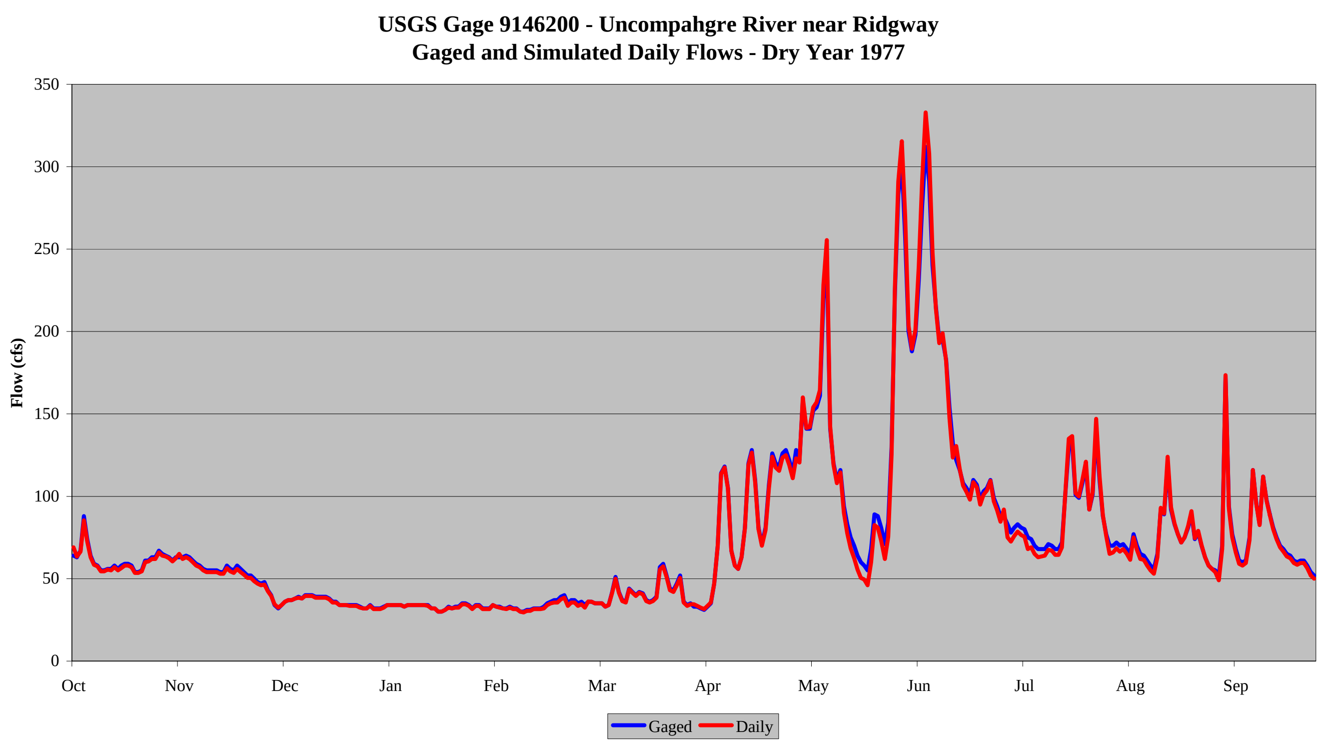


Figure E.24 Historical Daily Comparison, Dry Year – Uncompahgre River near Ridgway

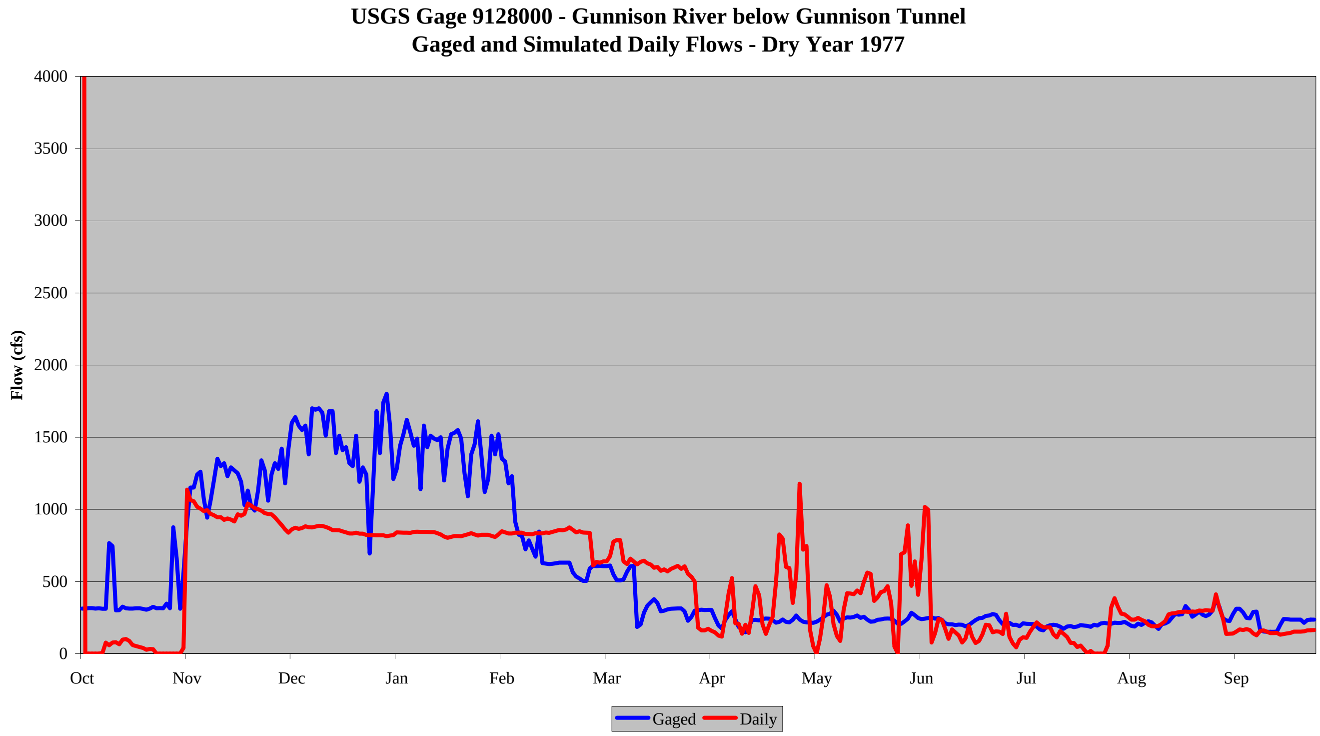


Figure E.25 Historical Daily Comparison, Dry Year – Gunnison River below Gunnison Tunnel

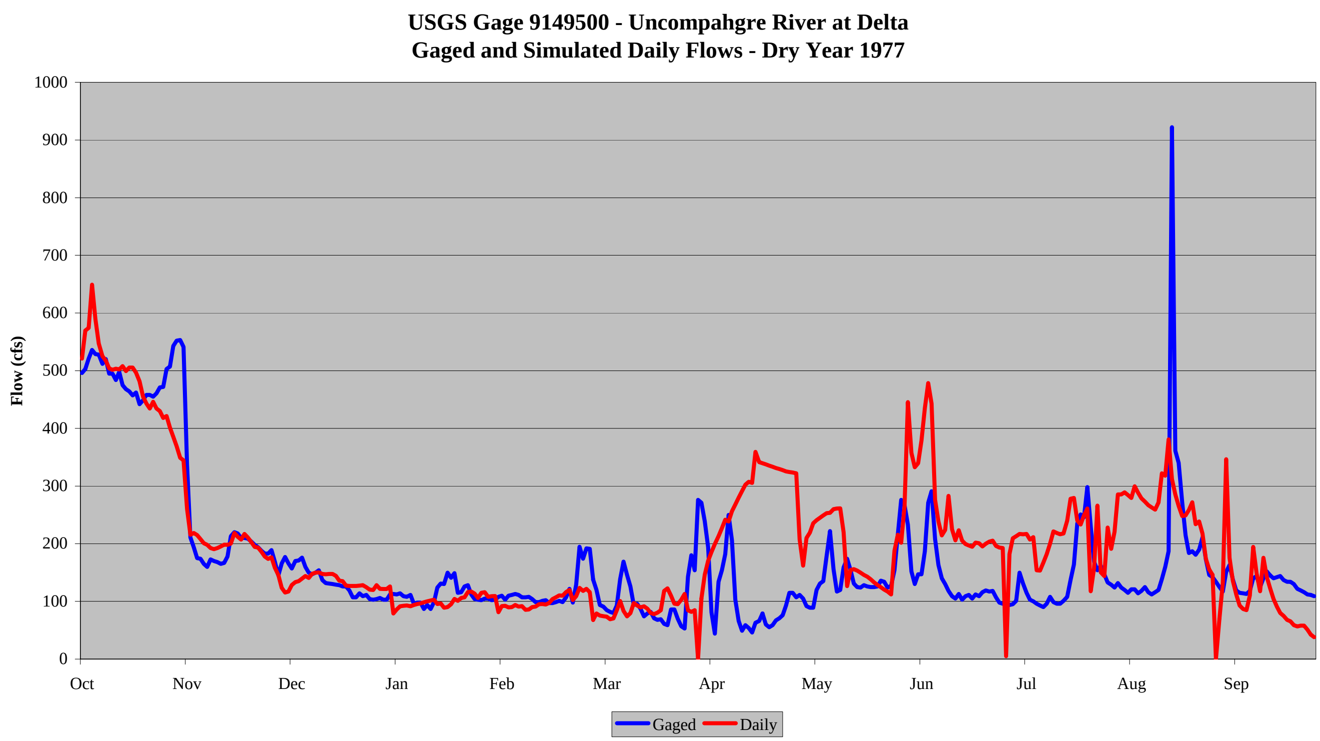


Figure E.26 Historical Daily Comparison, Dry Year – Uncompahgre River at Delta

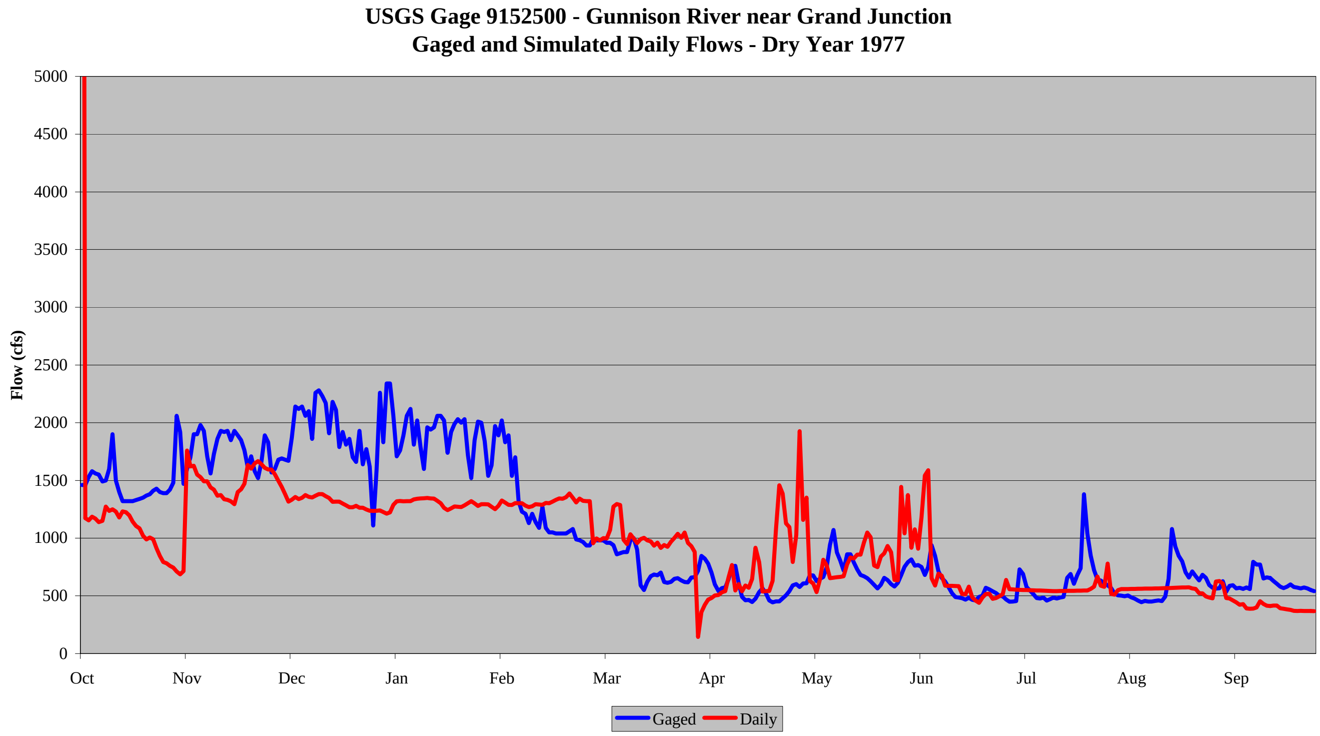


Figure E.27 Historical Daily Comparison, Dry Year – Gunnison River near Grand Junction

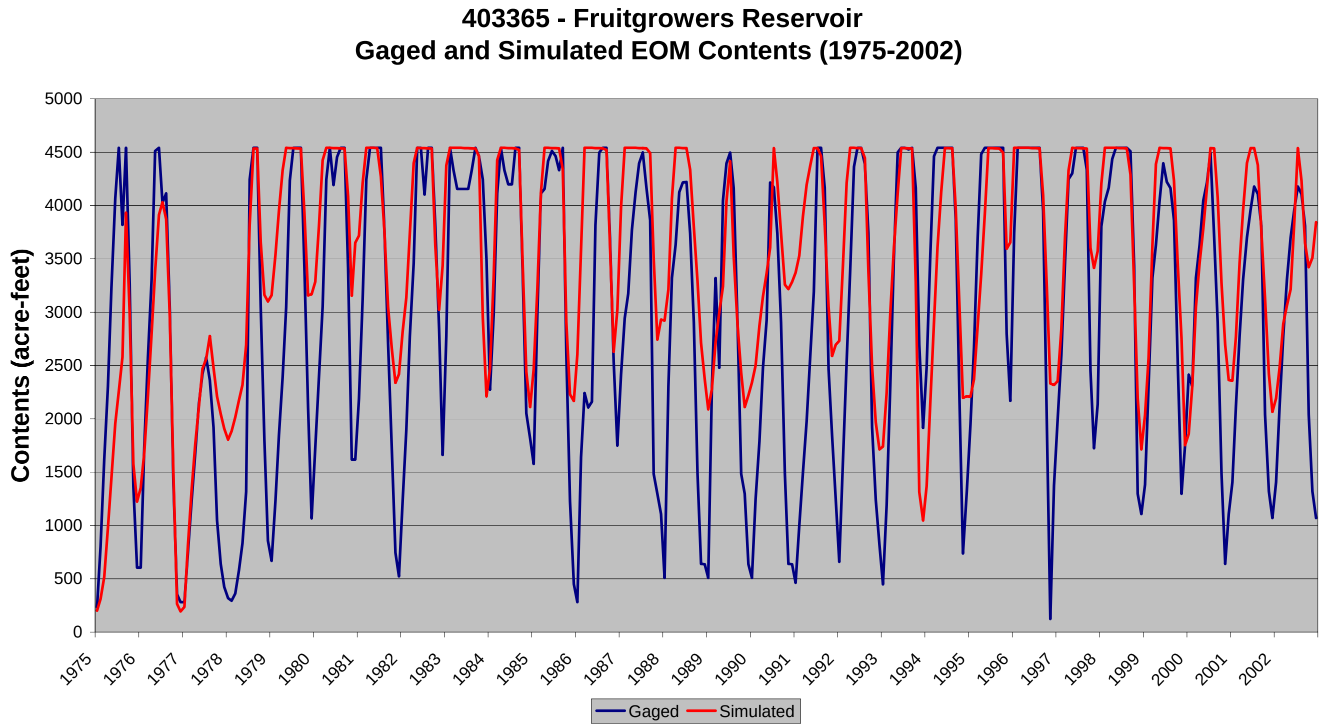


Figure E.28 Historical Daily Reservoir Simulation – Fruitgrowers Reservoir

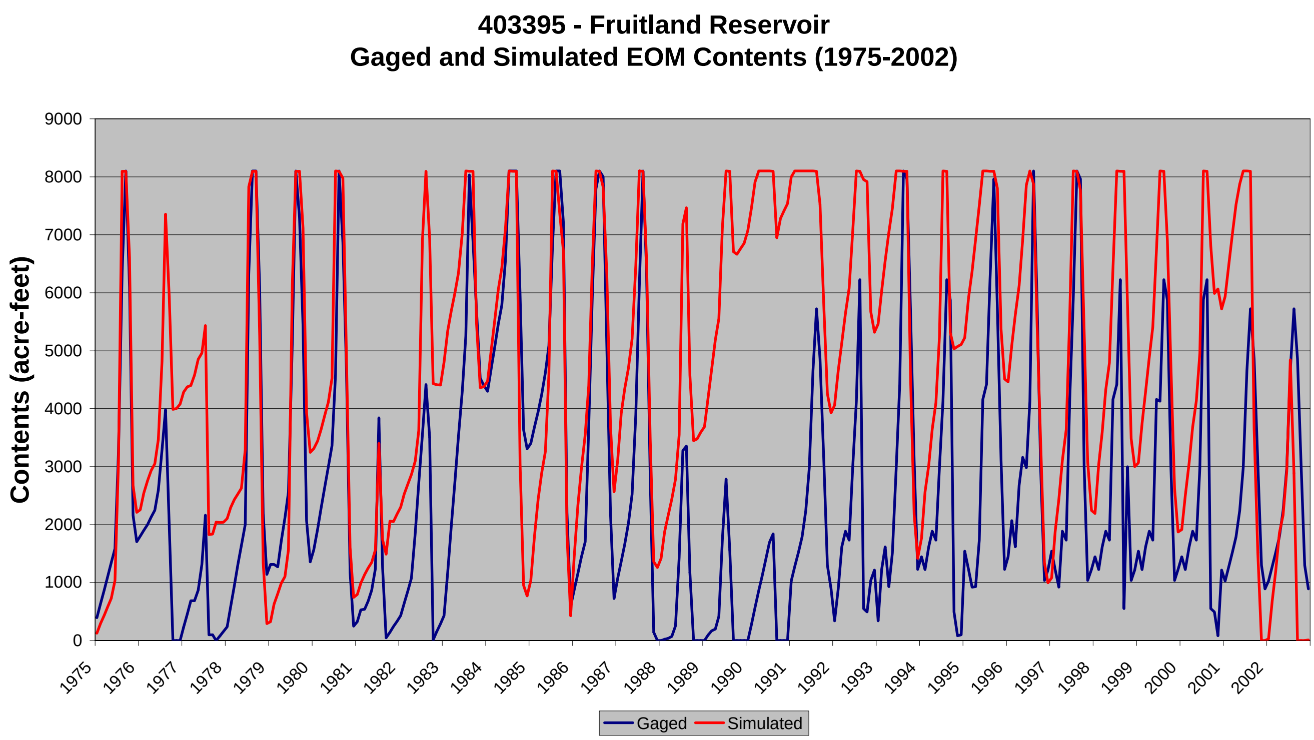


Figure E.29 Historical Daily Reservoir Simulation – Fruitland Reservoir

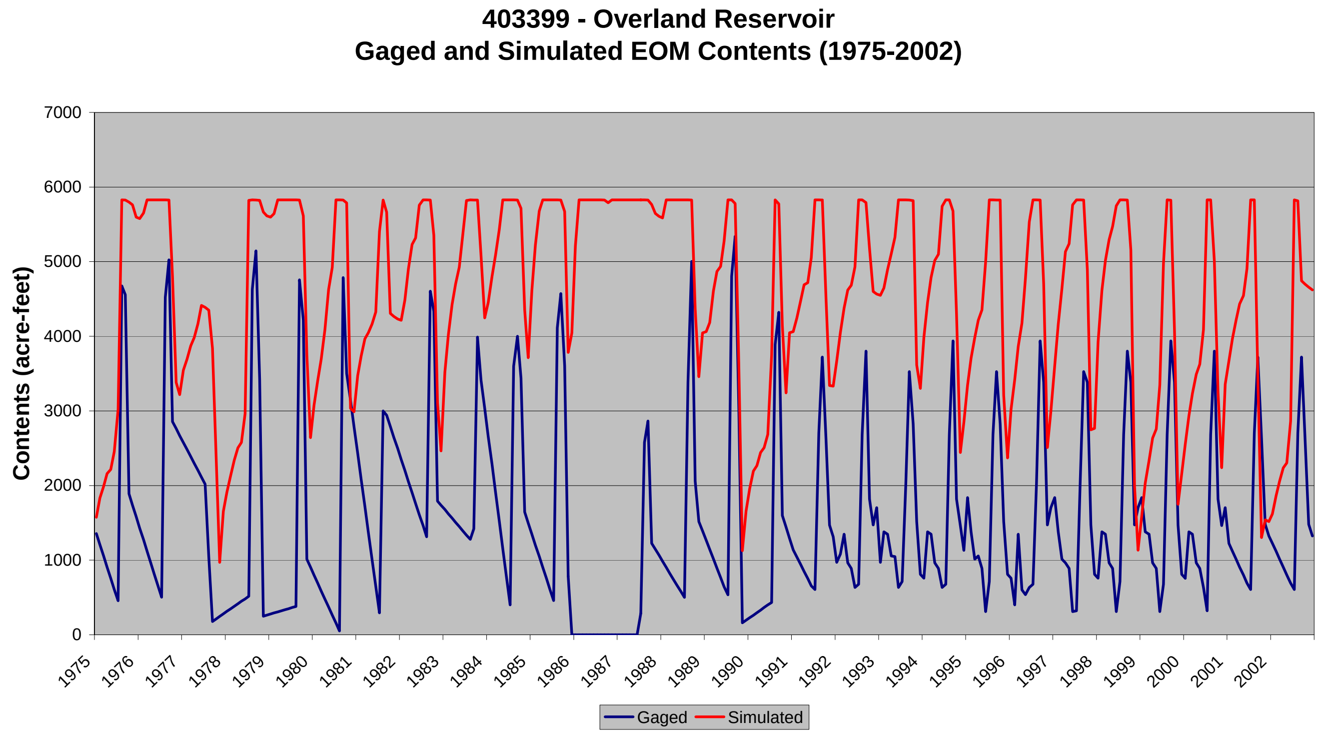


Figure E.30 Historical Daily Reservoir Simulation – Overland Reservoir

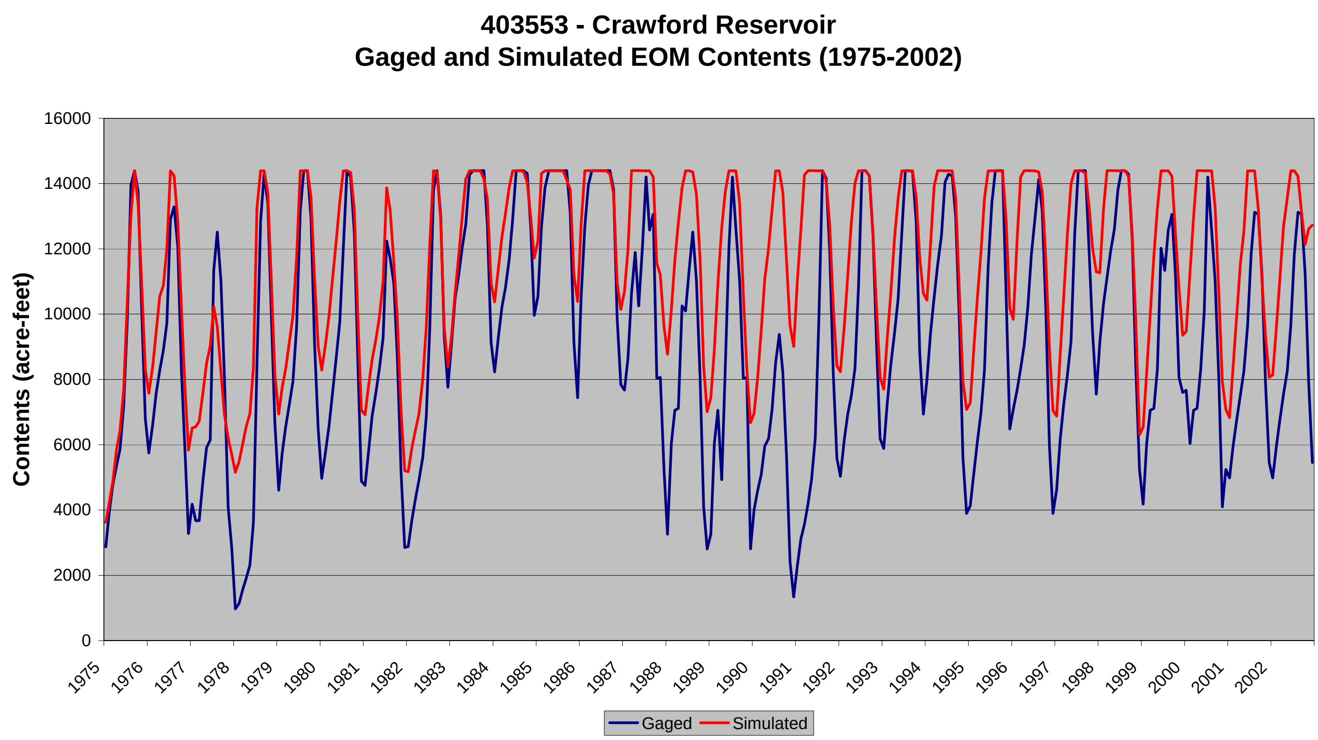


Figure E.31 Historical Daily Reservoir Simulation – Crawford Reservoir

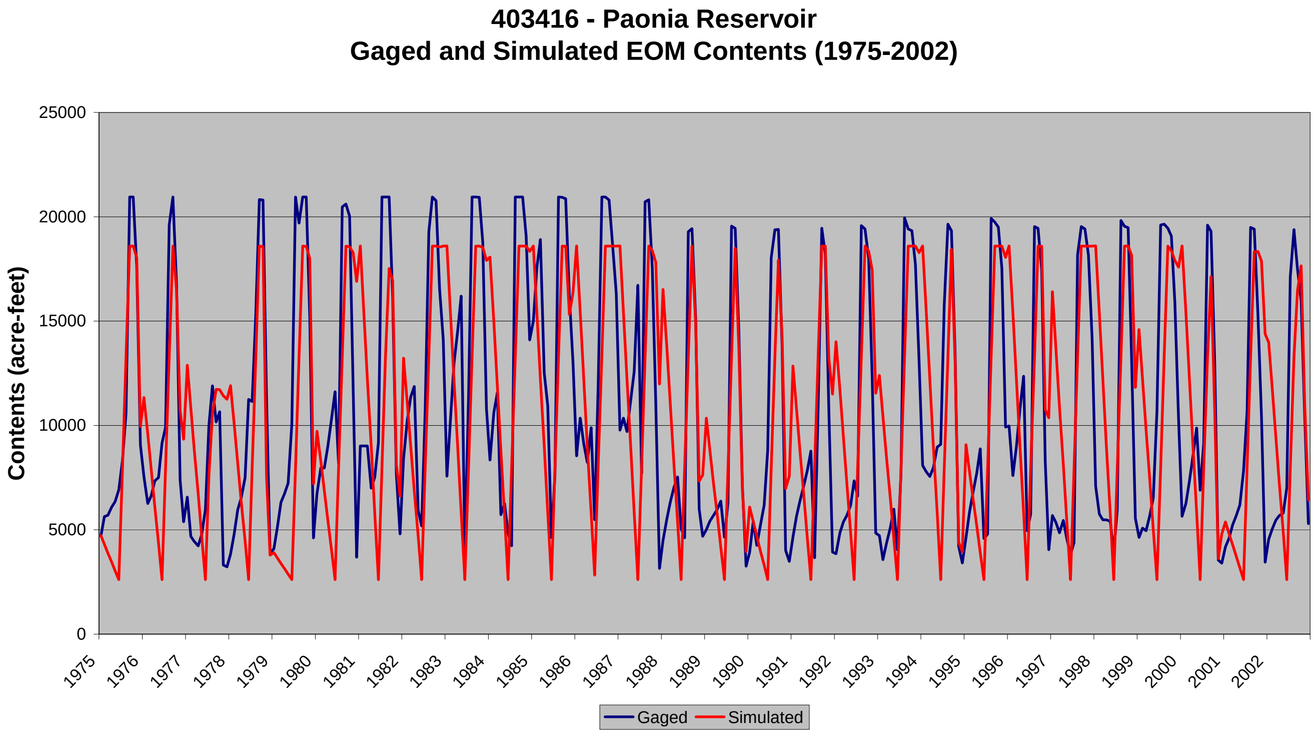


Figure E.32 Historical Daily Reservoir Simulation – Paonia Reservoir

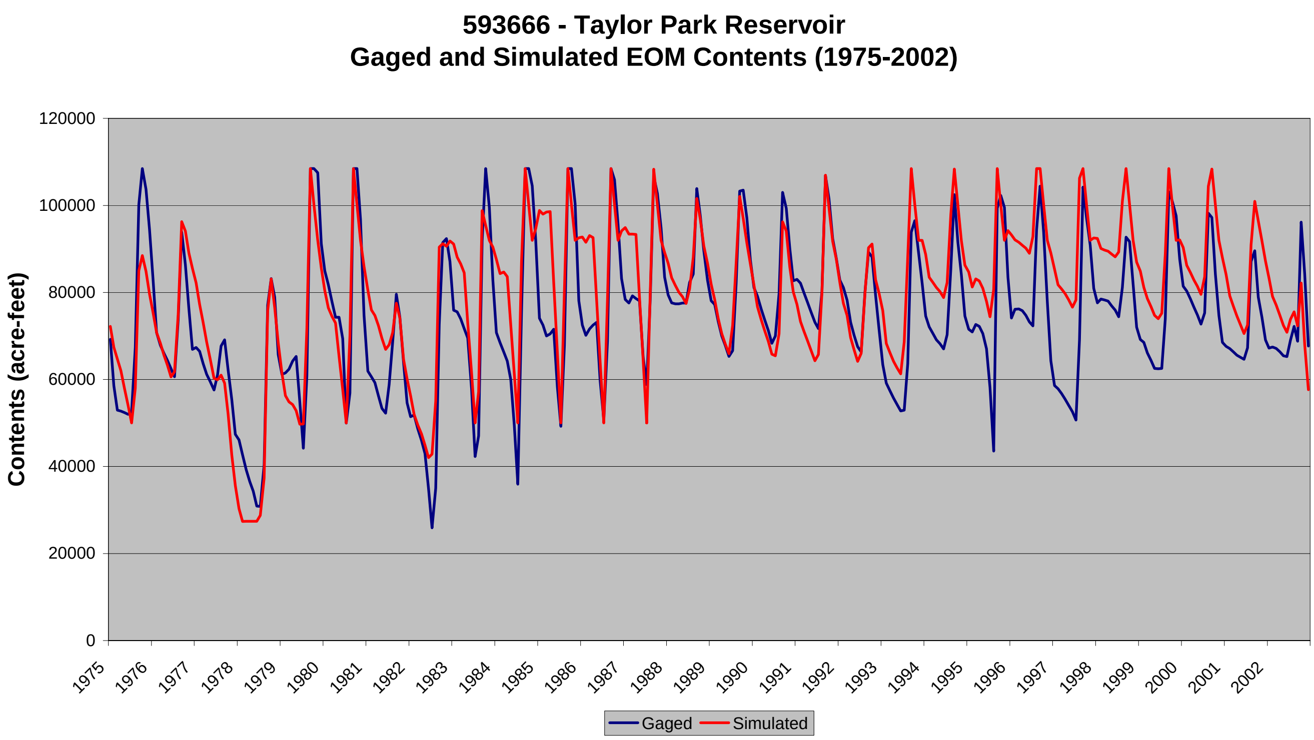


Figure E.33 Historical Daily Reservoir Simulation – Taylor Park Reservoir

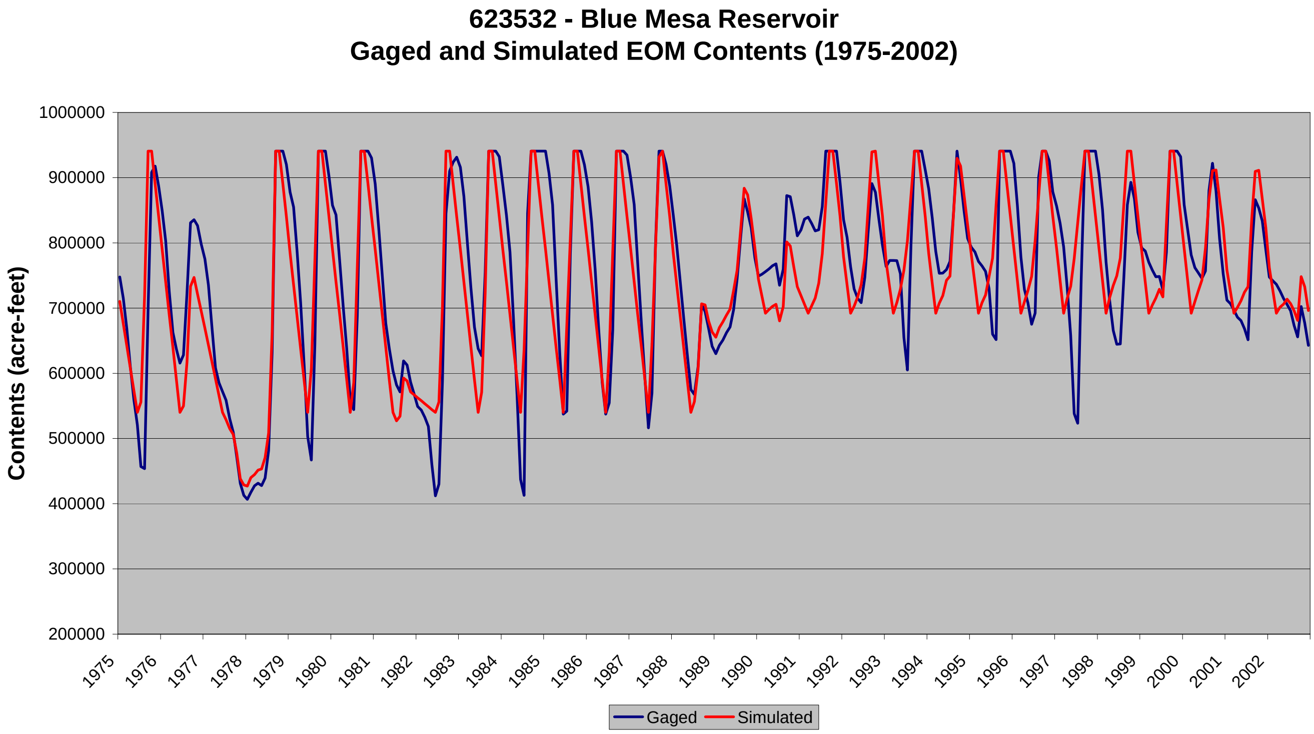


Figure E.34 Historical Daily Reservoir Simulation – Blue Mesa Reservoir

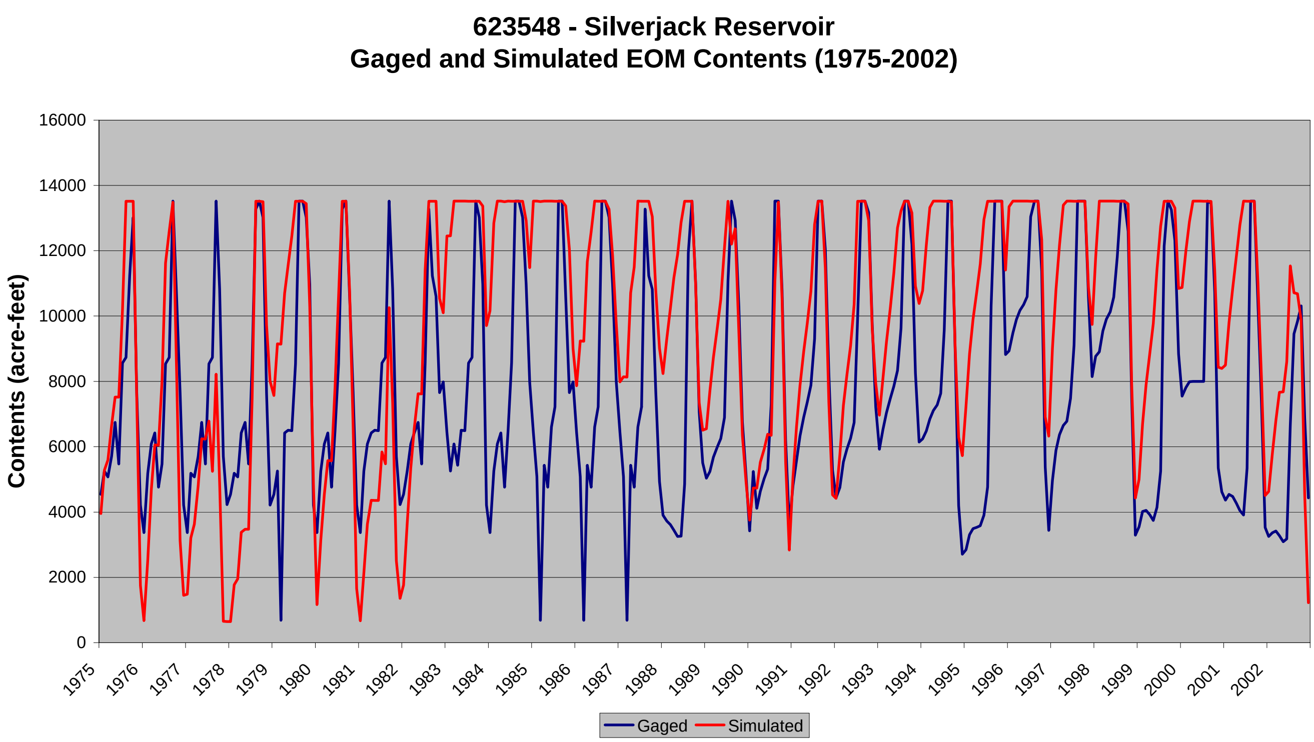


Figure E.35 Historical Daily Reservoir Simulation – Silverjack Reservoir

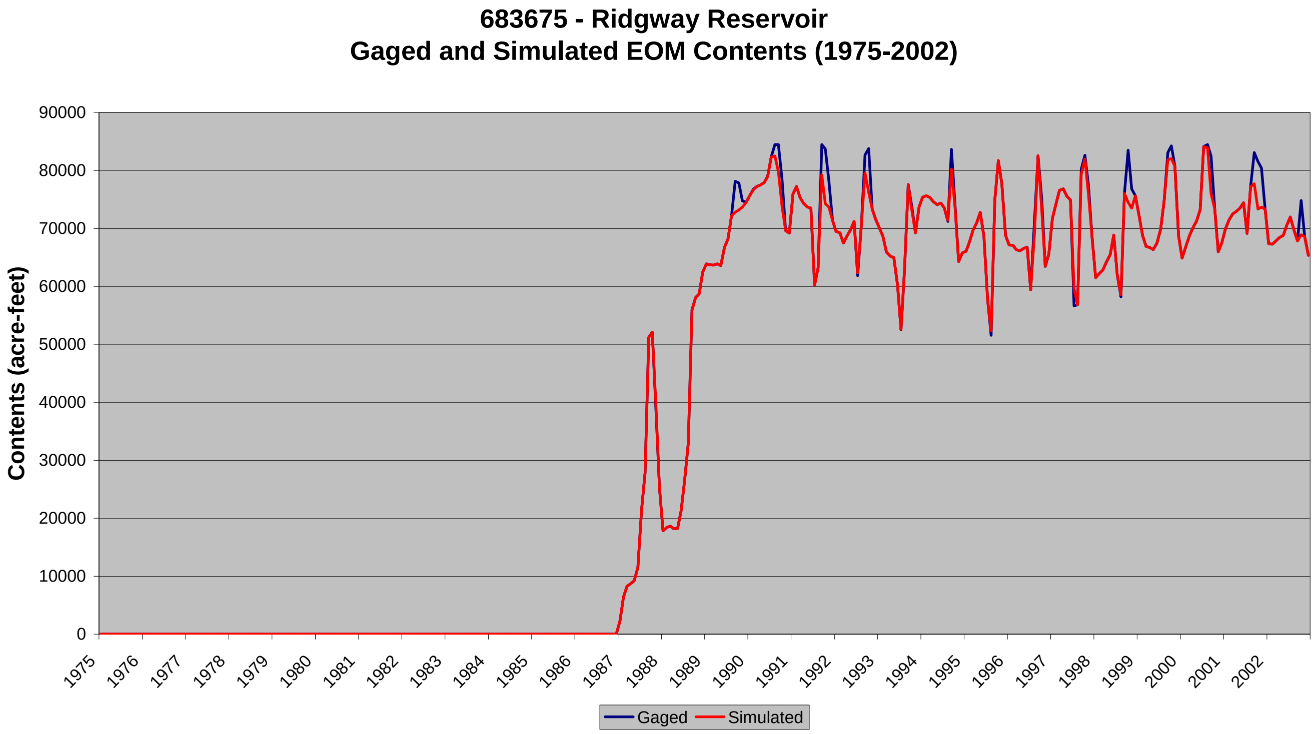


Figure E.36 Historical Daily Reservoir Simulation – Ridgway Reservoir

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