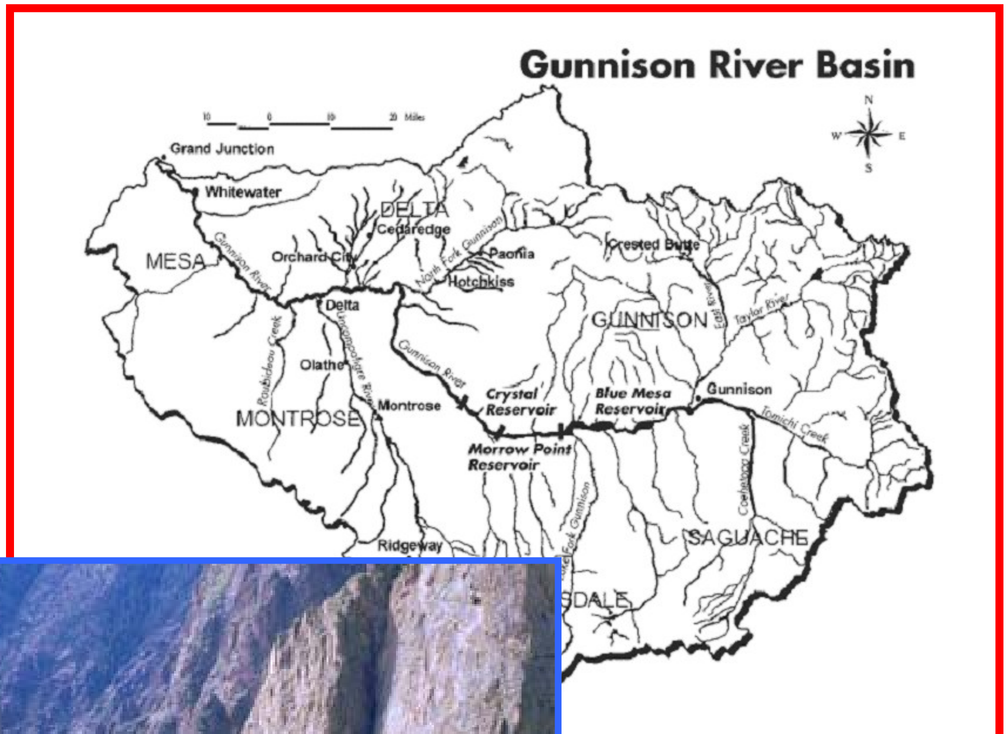
Gunnison River Basin
Water Resources Planning Model
User's Manual



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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.

Information used in the model datasets are based on available data collected and developed through the CDSS, including information recorded by the State Engineer’s Office. The model datasets and results are intended for basin-wide planning purposes. Individuals seeking to use the model dataset or results in any legal proceeding are responsible for verifying the accuracy of information included in the model.

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 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 State refined the Gunnison Model again in 2006, extending the study period through 2005. The model input files were enhanced during the CRWAS project in 2009 to include the following:

- More accurate representation of the North Fork of the Gunnison projects including Overland, Paonia, Crawford, and Fruitland reservoir operations.
- Addition of the Black Canyon of the Gunnison federal instream flow requirements.
- Enhancements to Fruitgrowers Reservoir operations.

The most recent calibration effort extended the study period through 2013, included additional acreage assessments for 2005 and 2010, and re-evaluated the calibration. Additional nodes were added to represent future demands that can be turned on by users to explore "what-if" scenarios.

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 consumptive water use.

- The model has been calibrated for a study period extending from calendar years 1975 to 2013.

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

- A Baseline data set has been prepared which assumes all existing water resources systems were on-line and operational for water years 1909 to 2013. 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.

1.4 Acknowledgements

CDSS is a project of the Colorado Water Conservation Board (CWCB), with support from the Colorado Division of Water Resources. The Upper Colorado River Model was developed and enhanced at different stages by Riverside Technology, Inc., Boyle Engineering Corporation, Leonard Rice Engineers, Inc., and CWCB staff. The model update through 2013 was completed by Wilson Water Group.

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 models, 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.

Appendices– 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.

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.

Consumptive Use Report – the report "Historical Crop Consumptive Use Analysis: Gunnison River Basin 2015" provides information on the consumptive use analysis that was used as input to the Baseline Demand scenario.

DMI user documentation – user documentation for **StateDMI** and **TSTool** is currently available, and covers aspects of executing these codes against the HydroBase database. The DMIs preprocess some of the StateMod input data, and TSTool provides summary and graphic review of both input and output. For example, StateDMI computes coefficients for distributing baseflow gains throughout the model and aggregates water rights for numerous small structures. TSTool fills missing time series data. Thus the documentation, which explains algorithms for these processes, is helpful in understanding the planning model estimates. In addition, the documentation is essential for the user who is modifying and regenerating input files using the DMIs.

StateCU documentation – StateCU is the CDSS irrigation consumptive use analysis tool. It is used to generate structure-specific time series of irrigation water requirement, an input to StateMod. A model change that involves modified irrigated acreage or crop-type would require re-execution of StateCU

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 one is modifying input files, one 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 and reports for these activities are available on the CDSS website:

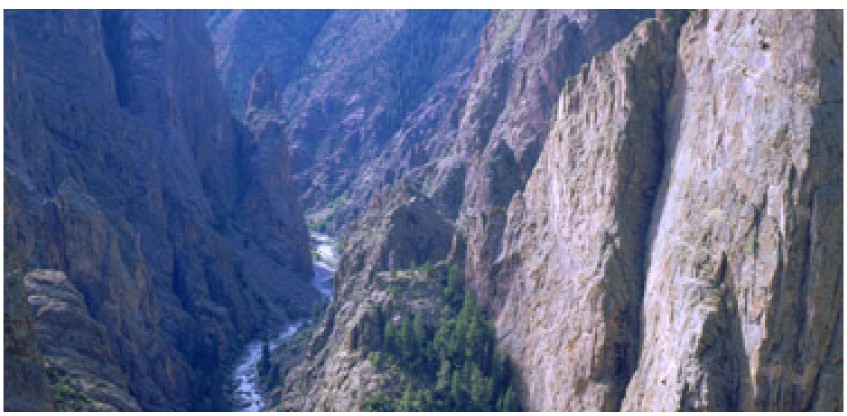
- Phase IIIb Task Memorandum 10.1 – Data Extension Feasibility
- Task Memorandum 10.2 – Evaluate Extension of Historical Data
- Task Memorandum 11.5 – Characterize Streamflow Data
- Task Memorandum 11.7 – Verify Diversion Estimates
- Task Memorandum 11.10 – Fill Missing Baseflow data (include Mixed Station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

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. **Error! Reference source not found.** 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 505,100 acre-feet per year (United States Geological Survey [USGS] gage near Gunnison) for 1950-2013.

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 218,000 acre-feet (USGS gage at Delta) for 1950-2013. The average annual flow of the Gunnison River near Grand Junction is over 1.7 million acre-feet (USGS gage near Grand Junction) for 1950-2013. Approximately 60 percent of this flow is attributable to snowmelt runoff in May, June, and July

Source: Colorado Water Conservation Board

Figure 3.1 Gunnison River Basin

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.

The area remains relatively sparsely populated, with the 2010 census estimates placing the combined populations of Gunnison, Delta, and Ouray Counties at approximately 50,712. Montrose and Delta are the major population centers in the basin, with approximately 19,132 and 8,915 residents respectively. Gunnison, Delta, and Ouray Counties grew by 10 percent from 2000 to 2010.

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 240,520 acres for the year 2010, 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 330,000 acre-feet per year to supply large irrigators in the Uncompahgre River Basin.

Hydropower generation, is also an important non-consumptive use of water in the basin. The Aspinall Unit of the Colorado River Storage Project encompasses the major power plants within the basin. The reservoirs are operated by Reclamation. 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. They have combined water rights for 3 million acre-feet of water per year. However, our understanding is that Reclamation does not actively manage the reservoirs for hydropower. Releases to other downstream users or for flood control operations are used to generate hydropower. Recently, irrigation companies have been installing “micro-hydro” power plants on their ditch systems.

Diversions for municipal and industrial use are primarily for Delta and Montrose and secondarily for 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 a number of transbasin diversions from one tributary drainage basin to another.

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 are Paonia, Crawford, Silverjack, Gould (aka Fruitland), Overland, and Fruit Growers reservoirs, which are predominantly used for irrigation.

3.2 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. **Error! Reference source not found.** summarizes key development and agreements within the basin over time.

Table 3.1 Key Water Resources Developments

Date	Description
1908	Gunnison Tunnel and Diversion Dam
1937	Taylor Park Reservoir
1962	Paonia and Crawford Reservoirs
1966	Blue Mesa Reservoir
1968	Morrow Point Reservoir
1971	Silverjack Reservoir

Date	Description
1973	Vader Right Adjudicated
1975	Taylor Park Exchange Agreement
1976	Crystal Reservoir
1986	Taylor Park Refill
1987	Ridgway Reservoir

3.3 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.

Current and future administration of the Gunnison will 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 Service has also adopted flow recommendations for the Gunnison River at the Redlands Canal. These recommend flows have been incorporated into the 2012 Aspinall Unit Operations Final EIS and Record of Decision. The administration of the new flow recommendations started outside of the calibration period for this model update, however the demands and operations associated with the Record of Decision have been included in the Baseline data set.

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, humpback chub, bonytail, and razorback sucker. In 1988, the States of Colorado, Utah, and Wyoming, water users, hydropower interests, 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.

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.

3.4 Section 3 References

1. Gunnison River Basin Facts, Colorado Water Conservation Board, available at http://cwcb.state.co.us
2. USBR: Colorado River Storage Project, available at http://www.usbr.gov/dataweb/html/crsp.html
3. Black Canyon of the Gunnison National Park Reserved Water Right Facts, Colorado Water Conservation Board, 2001.
4. Aspinall Unit Operations Final EIS and Record of Decision, U.S. Bureau of Reclamation, 2012

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 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. For additional information on the level of the historical calibration, refer to Section 7.

4.2 Model coverage and extent

4.2.1. Network Diagram

The network diagram for the Gunnison Model can be viewed in StateDMI. It includes almost 700 nodes, beginning near the headwaters of 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 470 key diversion structures.

Additionally, Tomichi Creek was a basin of interest and has been modeled in greater detail. Structures with smaller water right decrees than the 9 cfs cutoff are represented explicitly.

Where to find more information

- Gunnison Historical Crop Consumptive Use Analysis: Gunnison River Basin 2015 Report and Appendix A contains a detailed description of the method used to identify key structures.
- 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".

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, 70 aggregated nodes were identified, representing over 53,000 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 describes how aggregate structures were created and a complete lists of all structures included in aggregates.
- Gunnison Historical Crop Consumptive Use Analysis: Gunnison River Basin 2015 Report contains a detailed description of the method used to create aggregate structures and complete lists of all structures included in aggregates

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. Reservoirs that are smaller than 6,000 acre-feet but play an importance role in water administration and project deliveries are also considered key reservoirs. Additionally, Tomichi Creek was a basin of interest and has been modeled in greater detail. Nine reservoirs with decreed capacities below 6,000 are represented explicitly in the Tomichi Creek basin. In total, 24 key reservoirs are modeled explicitly and represent 1,354,803 acre-feet of storage volume, or 93 percent of the total storage volume in the Gunnison Basin Model.

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. **Error! Reference source not found.** 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	156	0.2
40_ARG001	40	AGG_RES_Surface	23,268	24
40_ARG002	40	AGG_RES_Ngunn	23,268	24
41_ARG001	41	AGG_RES_Uncomp	3,226	3
42_ARG001	42	AGG_RES_Kannah	17,876	18
59_ARG001	59	AGG_RES_East	9,826	10
62_ARG001	62	AGG_RES_Lake	6,475	7
62_ARG002	62	AGG_RES_Main	6,475	7
68_ARG001	68	AGG_RES_Upper Uncomp	8,359	8
Total			98,929	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 model. 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 46 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 2013 and operates on USGS water year (October 1 through September 30). The calibration period was 1975 through 2013, a period selected because historical diversion data were readily available in electronic format for key structures. In addition, the period reflects most recent operations in the basin, and includes both drought (1977, 1989-1992, 2000-2007) and wet cycles (1983-1985, 2011).

Further 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 available at the CDSS website:

  - Phase IIIb Task Memo 10.1 Data Extension Feasibility

  - Phase IIIb Task Memo 10.2 Evaluate Extension of Historical Data

4.4 Data Filling

In order to extend the data set to 1909, a substantial amount of reservoir content, diversion, demand, and baseflow time series data needed to be estimated. In many areas of the 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 **Error! Reference source not found.**. 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 historical 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 historical Montrose and Delta Canal diversions.

Table 4.3 Investigated and Extended Major Structures

WDID	Name	1909-2013 Annual Diversion
4200541	Redlands Power Canal	423,603
6200617	Gunnison Tunnel + S Canal	310,605
4100545	Montrose + Delta Canal	161,350
4100534	Ironstone Canal	96,219

4100559	Selig Canal	59,973
4100577	West Canal	47,137
4100520	East Canal	45,722
4100537	Loutsenhizer Canal	39,192
4100578	South Canal	36,222
4001133	Fire Mountain Canal	35,734
6200560	Cimmaron Canal	28,820
4100527	Garnet Canal	20,135
4000863	Bonafide Ditch	19,036
4000900	Relief Ditch	16,805

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 some of the explicitly modeled reservoirs.

4.4.2. Automated Time Series Filling

An automated procedure was adopted to fill time series (i.e., historical diversions, demand, historical reservoir contents, reservoir targets, and irrigation water requirement) input to the model. It is a refinement over using an overall monthly average as the estimated value. Each month of the modeling period 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".

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 available at the CDSS website:

  - Phase IIIb Task Memo 10.1 Data Extension Feasibility
  - Phase IIIb Task Memo 10.2 Evaluate Extension of Historical Data
  - Phase IIIb Task Memo 11.5 Characterize Streamflow Data
  - Phase IIIb Task Memo 11.7 Verify Diversion Estimates

  These memos describe rationale for the data-filling approach, explore availability of basic gage data, explain the streamflow characterization procedure, and provide validation of the methods.
- TSTool documentation describes the SetPatternFile() commend, which categorizing months as Average, Wet, or Dry
- TSTool and StateDMI 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" and is available at the CDSS website. 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 non-crop consumptive use, and 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 Gunnison basin.

The Gunnison 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 Gunnison 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.

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

$\mathbf{CU_w}$ is water supply limited consumptive use;

$\mathbf{SS_m}$ is the maximum soil moisture reservoir storage;

$\mathbf{SS_i}$ is the initial soil moisture reservoir storage;

$\mathbf{SS_f}$ 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 100 percent 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 100 percent in all months. These feeders include the following:

- Aspen Ditch
- Aspen Canal
- Fruitland Canal
- Overland Ditch
- Smith Fork Feeder Canal
- Sooner Ditch (supplies a future reservoir)

- Alfalfa Ditch
- Transfer Ditch
- Elk Home Ditch
- Elk Home No. 2 Ditch
- Farris Creek Carrier (supplies a future reservoir)
- Mill Carrier to Cunningham (supplies a future reservoir)
- Meridian Carrier (supplies a future reservoir enlargement)
- Cimarron Canal
- Gunnison Tunnel

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 Return Flows

4.6.1. Return Flow Timing

Return flow timing is specified to the model as the percentage of the return flow accruing from a diversion reaching 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 **Error! Reference source not found.** and graphed in **Error! Reference source not found..** 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. Available at the CDSS website.

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

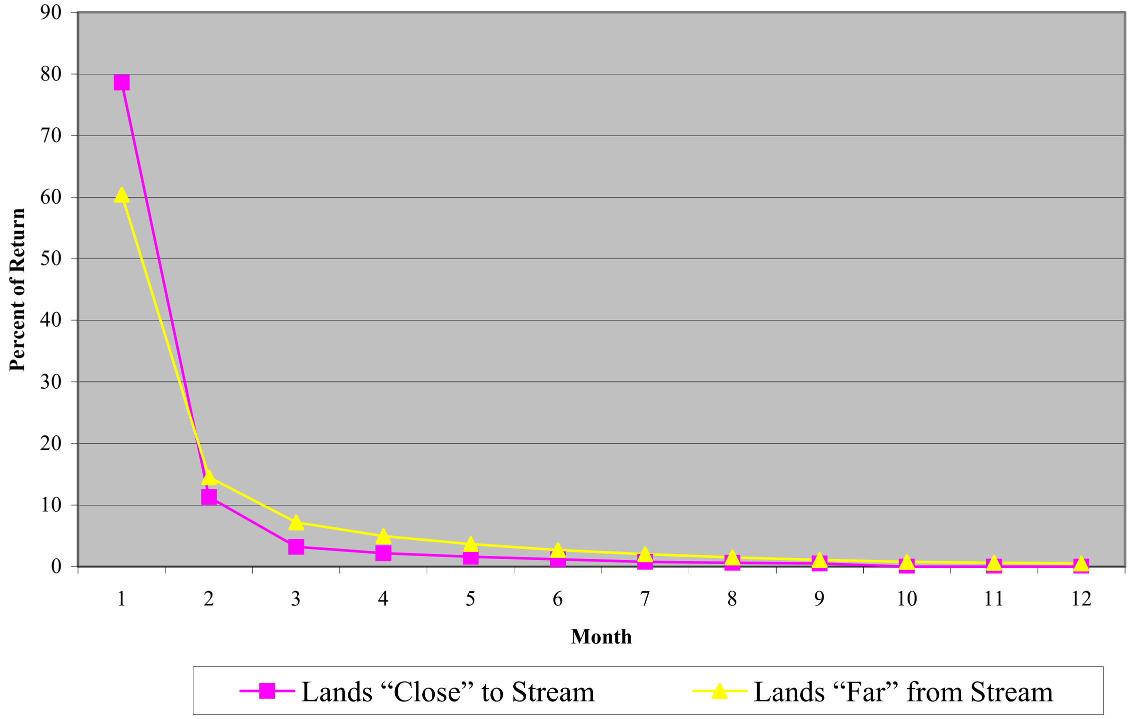


Figure 4.1 Percent of Return in Months After Division

4.7 Baseflow Estimation

In order to simulate river basin operations, the model starts with 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:

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

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 are 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 flow on tributary headwaters, baseflow must be estimated at all ungaged headwater nodes. In addition, gains between gages are modeled as entering the system at locations to reflect increased flow due to unmodeled tributaries. Most key reservoirs were represented as baseflow nodes in order for the model to "see" all available water supply at the site. During calibration, other baseflow nodes were added to better simulate a water supply that would support historical operations.

StateMod has an operating mode that distributes a portion of baseflows at gaged locations to ungaged locations based on drainage area and average annual precipitation. The default method is the "gain approach". In this approach, StateMod pro-rates baseflow gain above or between gages to ungaged locations using the product of drainage area and average annual precipitation.

Error! Reference source not found. illustrates a hypothetical basin and the areas associated with three gages and three ungaged baseflow nodes.support historical operations.

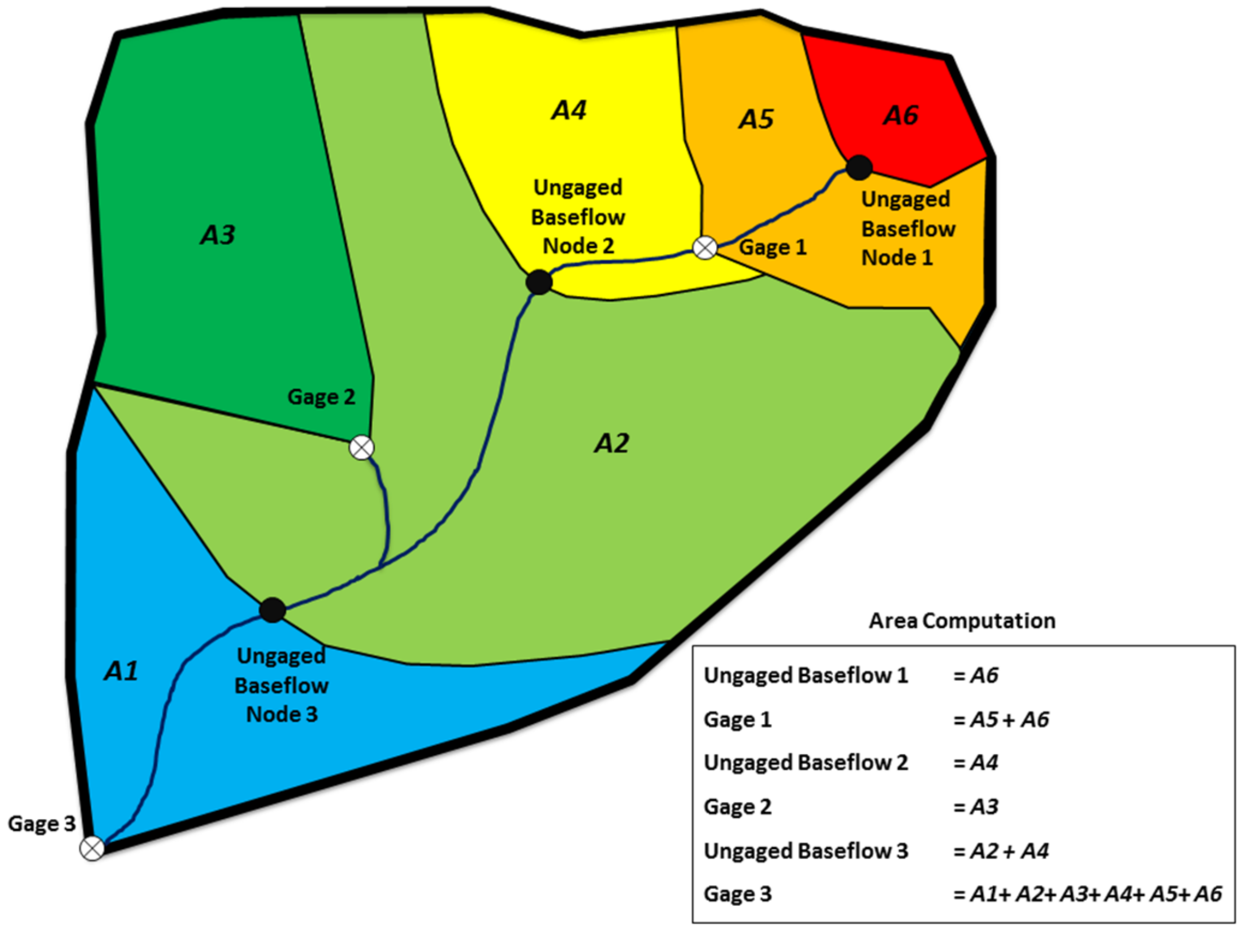


Figure 4.2 Hypothetical Basin Illustration

The area associated with gages is the total upstream area. The area associated with ungaged nodes only includes the incremental area from the ungaged location to the next upstream gage or gages. For example, Gage 3 area includes the entire basin. Ungaged Baseflow Node 3 area (light green) includes the upstream area between the Ungaged Baseflow Node 3 and Gage 2 and Gage 1.

In **Error! Reference source not found.** there are three ungaged baseflow nodes; the StateMod "gain approach" computes the total baseflow at each ungaged node based on the following:

The baseflow gain distributed to Ungaged Baseflow Node 1 is the baseflow gain above Gage 1 pro-rated on the A*P terms.

$$Gain_{ungaged,1} = \left(\frac{(A*P)_{ungaged,1}}{(A*P)_{gage,1}}\right)\left(BF_{gage,1}\right)$$

Total baseflow at Ungaged Node 1 is equal to the $Gain_{ungaged,1}$ term.

The baseflow gain distributed to Ungaged Baseflow Node 2 is the baseflow gain between Gage 1, 2, and 3 pro-rated on the A*P terms.

$$Gain_{ungaged,2} = \left(\frac{(A*P)_{ungaged,2}}{(A*P)_{gage,3} - (A*P)_{gage,2} - (A*P)_{gage,1}}\right)\left(BF_{gage,3} - BF_{gage,2} - BF_{gage,1}\right)$$

Total baseflow at Ungaged Node 2 is equal to the $Gain_{ungaged,2}$ term plus the baseflow at Gage 1.

$$BF_{ungaged,2} = Gain_{ungaged,2} + BF_{gage,1}$$

Ungaged Baseflow Node 3 calculations are very similar. The baseflow gain distributed to Ungaged Baseflow Node 3 is the baseflow gain between Gage 1, 2, and 3 pro-rated on the A*P term.

$$Gain_{ungaged,3} = \left(\frac{(A*P)_{ungaged,3}}{(A*P)_{gage,3} - (A*P)_{gage,2} - (A*P)_{gage,1}}\right)\left(BF_{gage,3} - BF_{gage,2} - BF_{gage,1}\right)$$

Total baseflow at Ungaged Node 3 is equal to the $Gain_{ungaged,3}$ term plus baseflow at Gage 1 and Gage 2.

$$BF_{ungaged,3} = Gain_{ungaged,3} + BF_{gage,1} + \ BF_{gage,2}$$

A second option for estimating headwater baseflows can be used if the default "gain approach" method created results that do not seem credible. This method, referred to as the "neighboring gage approach", creates a baseflow time series by multiplying the baseflows at a specified gage by the ratio $(A*P)_{headwater}/(A*P)_{gage}$. This approach is effective when the runoff at an ungaged location does not follow the same pattern as the gains along the main stem. For example, a small ungaged tributary that peaks much earlier or later than the main stem should use the neighboring gage approach with a streamgage in a similar watershed. The user is responsible for ensuring that the overall reach water balance is maintained when using the neighboring gage approach.

Where to find more information

- The **StateDMI** documentation in section 5.10 “Stream Estimate Data” for 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 1950 through 2013 is generated by taking the maximum of crop irrigation water requirement divided by average monthly irrigation efficiency, and historical diversions. The irrigation efficiency may not exceed the defined maximum efficiency. Thus Calculated demand for a perennially shorted diversion 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 1950, calculated demands were filled using the automated time series filling technique described in Section 4.4.2.

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

There are two transbasin diversions which take water out of the Gunnison Basin:

- Redlands Power Canal and irrigation demand (420541 and 420541_I)
- Grand Junction Municipal Export (72_GJMunExp)

For more details on the development of their demand time series, refer to Section 5.4.3.3 *Special Structures*.

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. 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 reservoir operations. 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 *gm2015B.rsp*, describes contents of each file, and shows the subsection of this chapter where the file is described in more detail.

File Name	Description	Reference
gm2015.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 5.2
gm20015.rin	River Network file – lists every model node and specifies connectivity of network	Section 5.3.1
gm2015.ris	River Station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 5.3.2
gm2015.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
gm2015.rih	Historical Streamflow file – Monthly time series of streamflows at modeled gages	Section 5.3.4
gm2015x.xbm	Baseflow Data file – time series of undepleted flows at nodes listed in *gm2015.ris*	Section 5.3.5
gm2015.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
gm2015.dly	Delay Table file – contains several return flow patterns	Section 5.4.2

File Name	Description	Reference
	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	
gm2015.ddh	Historical Diversions file – Monthly time series of historical diversions	Section 5.4.3
gm2015B.ddm	Monthly Demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
gm2015.ddr	Direct Diversion Rights file – lists water rights for direct diversion	Section 5.4.5
gm2015.str	StateCU Structure file – soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
gm2015.ipy	CU Irrigation Parameter Yearly file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
gm2015B.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3
gm2015B.res	Reservoir Station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1
gm2015.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
gm2015.eom	Reservoir End-of-Month Contents file – Monthly time series of historical reservoir contents	Section 5.6.3
gm2015B.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
gm2015B.rer	Reservoir Rights file – lists storage rights for reservoirs	Section 5.6.5
gm2015.ifs	Instream Flow Station file – lists instream flow reaches	Section 5.7.1
gm2015.ifa	Instream Flow Annual Demand file – gives the decreed monthly instream flow demand rates	Section 5.7.2
gm2015.ifm	Instream Flow Monthly Demand file – gives the decreed monthly instream flow demand rates that vary by year	Section 5.7.3
gm2015.ifr	Instream Flow Right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches	Section 5.7.4
gm2015.pln	Plan Data file – contains parameters for plan structures	Section 5.8

File Name	Description	Reference
gm2015B.opr	Operational Rights file – specifies many different kinds of operations that were more complex than a direct diversion or an on-stream storage right. Operational rights could specify, for example, a reservoir release for delivery to a downstream diversion point, a reservoir release to allow diversion by exchange at a point which was not downstream, or a direct diversion to fill a reservoir via a feeder	Section 5.9

5.1.2. For Generating Baseflow

The baseflow file (gm2015.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. In the first step, StateMod estimates baseflows at gaged locations, using the files listed in the response file gm2015.rsp. This response file calls for input files which reflect strictly historical data. When the initial baseflow run is made, the baseflow file (gm2015.xbm) is the output.

The baseflow time series created in the first run are all partial series, because gage data is missing for some of the period of interest for all gages. The Mixed Station Model is used to fill the series, creating a complete series of baseflows at gages in gm2015.xbf. The response file for the third step, in which StateMod distributes baseflow to ungaged points, is named gm2015x.rsp. The only difference between the first-step response file gm2015.rsp and third-step response file gm2015x.rsp is that the file gm2015.xbf replaces the historical gage file gm2015.rih. The output from StateMod is the baseflow file gm2015x.xbm. This contains a complete time series for all gaged and ungaged natural flow locations.

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 StateDMI from the graphical network representation file (gm2015.net). The river network file describes the location and connectivity of each node in the model. Specifically, it is a list of each structure ID and name, along with the ID of the next structure downstream. It is an inherent characteristic of the network that, with the exception of the downstream terminal node, each node had exactly one downstream node.

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. **Error! Reference source not found.** shows how many nodes of each type are in the Gunnison Model.

Table 5.1 River Network Elements

Type	Number
Diversion	513
Stream Gages [1)]	61
Instream Flow	45
Other	41
Plan	1
Reservoir	39
Total	700

1) Includes Leon Tunnel Canal import from the Colorado Basin

Where to find more information

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

5.3.2. River Station File (*.ris)

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

There are 61 gages in the model, 1 basin import, and 60 ungaged baseflow locations, for a total of 121 hydrologic inflows to the Gunnison Model. Ungaged baseflow nodes include all ungaged headwater nodes, reservoir nodes, 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 contains an entry for each ungaged baseflow node in the model, specifying coefficients, or "proration factors", used to calculate the baseflow gain at that point. StateDMI computed proration factors based on the network structure and *area* multiplied by *precipitation* values supplied for both gages and ungaged baseflow nodes. This information is in the network file (gm2015.net), which was input to StateDMI. Under the default "gain approach", described in Section 4.7, 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 structures:

Table 5.2 Baseflow Nodes Using the Neighoring Gage Approach

Tributary Name	Baseflow WDID	Neighboring Gage
Hot Springs Creek	2801077	09118000
Alum Gulch	4000506	09134000
Little Coal Creek	4000554	09128500
Alfalfa Run	4003365	09137050
Iron Creek	4003395	09128500
Willow Creek	5900505	09121500
North Beaver Creek	5900544	09110500
Steuben Creek	5900886	09113300
East Steuben Creek	5900887	09113300
Steuben Creek	5901511	09121500

Tributary Name	Baseflow WDID	Neighboring Gage
Little Cimarron River	6200542	09124500
Big Blue Creek	6201339	09124500
Cow Creek	6800683	09147100

Where to find more information

- 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 1909-2013, 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 HydroBase. Missing values, when the gage was not in operation, are denoted 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, a tributary to the Colorado River. Leon Tunnel Canal (7200758) is included in the historical streamflow file as historical inflow into the basin. **Error! Reference source not found.** lists the USGS gages used, their periods of record, and their average annual flows over the period of record.

Table 5.3 Historical Average Annual Flows for Modeled Gunnison Stream Gages

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09109000	Taylor River Below Taylor Park Reservoir	1938 – 2013	141,112
09110000	Taylor River at Almont	1910 – 2013	237,281
09110500	East River Near Crested Butte	1939 – 1951	100,560
09111500	Slate River Near Crested Butte	1940 – 1951 1994 – 2006	97,425
09112000	Cement Creek Near Crested Butte	1910 – 1914 1940 – 1951	26,435
09112200	East River Below Cement Creek NR Crested Butte	1964 – 1972 1980 – 1981 1994 – 2013	226,715
09112500	East River at Almont	1910 – 1922 1934 – 2013	239,754
09113300	Ohio Creek at Baldwin	1958 – 1970	34,465
09113500	Ohio Creek Near Baldwin	1940 – 1950 1959 – 1971 1980 – 1981	63,874

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09114500	Gunnison River Near Gunnison	1910 – 1928 1945 – 2013	533,963
09115500	Tomichi Creek at Sargents	1916 – 1922 1938 – 1972 1993 – 2013	44,084
09118000	Quartz Creek Near Ohio City	1937 – 1950 1960 – 1970	39,348
09118450	Cochetopa Creek Below Rock Creek Near Parlin	1981 – 2013	28,673
09119000	Tomichi Creek at Gunnison	1937 – 2013	120,070
09121500	Cebolla Creek Near Lake City	1946 – 1954	10,433
09122000	Cebolla Creek at Powderhorn	1937 – 1955	73,826
09124500	Lake Fork at Gateview	1937 – 2013	167,599
09126000	Cimarron River Near Cimarron	1954 – 2013	67,956
09127500	Crystal Creek Near Maher	1945 – 1954 1961 – 1969	20,462
09128000	Gunnison River Below Gunnison Tunnel	1910 – 2013	907,157
09128500	Smith Fork Near Crawford	1935 – 1994	30,978
09130500	East Muddy Creek Near Bardine	1934 – 1953	64,022
09131200	West Muddy Creek Near Somerset	1961 – 1973	22,858
09132500	North Fork Gunnison River Near Somerset	1933 – 2013	327,509
09134000	Minnesota Creek Near Paonia	1936 – 1947 1986 – 2013	15,424
09134500	Leroux Creek Near Cedaredge	1936 – 1956 1961 – 1969	34,500
09135900	Leroux Creek at Hotchkiss	1976 – 1996	20,892
09136200	Gunnison River Near Lazear	1961 – 1985	1,258,434
09137050	Currant Creek Near Read	1976 – 1987	10,560
09137800	Dirty George Creek Near Grand Mesa	1957 – 1969	4,779
09139200	Ward Creek Near Grand Mesa	1957 – 1969	8,780
09141500	Youngs Creek Near Cedaredge	1942 – 1946	1,655
09143000	Surface Creek Near Cedaredge	1939 – 1999 2000 – 2012[1)] 2012 - 2013	30,997
09143500	Surface Creek at Cedaredge	1917 – 1999 2000 - 2012[1)] 2013 - 2013	20,109
09144200	Tongue Creek at Cory	1957 – 1968 1977 – 1987	36,134
09144250	Gunnison River at Delta	1976 – 2013	1,371,050
09146200	Uncompahgre River Near Ridgway	1958 – 2013	119,040
09146400	West Fork Dallas Creek Near Ridgway	1955 – 1970	9,266
09146500	East Fork Dallas Creek Near Ridgway	1948 – 1953 1961 – 1970	18,260

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09146550	Beaver Creek Near Ridgway	1960 – 1968	2,862
09147000	Dallas Creek Near Ridgway	1922 – 1927 1955 – 1971 1980 – 2013	27,273
09147100	Cow Creek Near Ridgway	1954 - 1974	44,900
09147500	Uncompahgre River at Colona	1912 – 2013	190,608
09149420	Spring Creek Near Montrose	1977 – 1981	39,882
09149500	Uncompahgre River at Delta	1938 – 2013	220,004
09150500	Roubideau Creek at Mouth, Near Delta	1938 – 1954 1976 – 1983	89,474
09152000	Kannah Creek Near Whitewater	1917 – 1982	22,359
09152500	Gunnison River Near Grand Junction	1896 – 1899 1902 – 1906 1917 – 2013	1,816,228

1) Irrigation season records only

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.

Error! Reference source not found. compares historical gage flows with simulated baseflows for the 13 gages that operated throughout the calibration period (1975-2013). The difference between the two represents estimated historical consumptive use over this period.

Table 5.4 Baseflow Comparison 1975-2013 Average (af/yr)

Gage ID	Gage Name	Baseflow	Historical	Difference
09109000	Taylor River Below Taylor Park Reservoir	143,193	141,316	1,877
09110000	Taylor River at Almont	232,650	223,968	8,682
09112500	East River at Almont	250,226	231,398	18,829
09114500	Gunnison River Near Gunnison	562,908	504,685	58,222
09119000	Tomichi Creek at Gunnison	173,502	117,418	56,084

09124500	Lake Fork at Gateview	166,986	163,139	3,847
09126000	Cimarron River Near Cimarron	70,257	69,605	652
09128000	Gunnison River Below Gunnison Tunnel	1,349,969	809,376	540,593
09132500	North Fork Gunnison River Near Somerset	357,160	340,329	16,831
09146200	Uncompahgre River Near Ridgway	122,408	120,982	1,427
09147500	Uncompahgre River at Colona	231,533	186,932	44,601
09149500	Uncompahgre River at Delta	317,169	232,099	85,070
09152500	Gunnison River Near Grand Junction	2,354,560	1,794,354	560,206

Where to find more information

- Sections 4.7.1 through 4.7.3 explain how StateMod and the Mixed Station Model were used to create baseflows.
- When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file (**.xbi*) that shows this computation for each gage and each month of the time step.
- When the Mixed Station Model is used to fill baseflows, it creates two reports, gm2015.*sum* and gm2015.*sts*. The first indicates which stations were used to estimate each missing data point, and the second compares statistics of the unfilled time series with statistics of the filled series for each gage.

5.4 Diversion Files

5.4.1. Direct Diversion Station File (*.dds)

StateDMI creates the direct diversion station file. The direct diversion station file describes the physical properties of each diversion simulated in the Gunnison Model. **Error! Reference source not found.** is a summary of the Gunnison River model's diversion station file contents, including each structure's diversion capacity, irrigated acreage served, 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 gm2015.dds also specifies return flow locations, percentages, and delay patterns.

Generally, the diversion station ID and name, diversion capacity, and irrigated acreage are gathered from Hydrobase by **StateDMI**. Return flow locations are specified to **StateDMI** in a hand-edited file gm2015.rtn. The return flow distribution was based on discussions with Division 4 personnel as well as calibration efforts. **StateCU** computes monthly system efficiency from historical diversions and historical crop irrigation requirements for irrigation structures, and **StateDMI** writes the average monthly efficiencies into the *.dds file. For non-irrigation structures, monthly efficiency is specified by the user as input to **StateDMI**. Each of the parameters is described in more detail following **Error! Reference source not found.**.

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

Table 5.5 Direct Flow Diversion Summary Average 1975-2013

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
1	2800500	ADAMS NO 1 DITCH	57	128	31	2444
2	2800501	ADAMS NO 2 DITCH	30	144	35	2084
3	2800503	AGATE NO 2 DITCH	6	140	48	723
4	2800505	ALKALI DITCH	10	17	17	579
5	2800507	ANNA NO 1 DITCH	10	55	41	524
6	2800508	ANNA NO 2 DITCH	6	55	40	467
7	2800510	ARCH IRRIGATING DITCH	150	1761	28	19,955
8	2800513	BENNETT MORTON DITCH	6	174	50	852
9	2800514	BENNETT NO 2 DITCH	10	42	14	1217
10	2800515	BIEBEL DITCHES NOS 1&2	57	246	25	4951
11	2800517	BILLY SANDERSON DITCH	20	84	22	1504
12	2800518	BRIDGE NO 40 DITCH	8	22	23	579
13	2800520	CAIN BORSUM DITCH	25	61	11	2555
14	2800521	CAUFMAN DITCH	9	14	11	596
15	2800526	CHITTENDEN DITCH	35	213	31	3206
16	2800527	CLARK NO 1 DITCH	5	35	33	508
17	2800528	CLARK NO 2 DITCH	10	15	12	745
18	2800529	CLARK NO 3 DITCH	12	61	29	1082
19	2800530	CLOVIS METROZ NO 1 DITCH	14	17	13	881
20	2800532	COATS BROS DITCH	29	226	33	2619
21	2800534	COLE DITCH	10	57	37	581

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
22	2800535	COLE NOS 1 2 & 3 DITCHES	11	76	36	831
23	2800536	COX AND MCCONNELL DITCH	22	100	25	1877
24	2800539	CRARYS LOS PINOS DITCH	11	34	30	593
25	2800542	CUTJO DITCH	23	150	31	2143
26	2800543	D A MCCONNELL DITCH	8	60	32	834
27	2800548	DUBER DITCH	11	27	14	970
28	2800549	DUNCAN DITCH	6	66	42	523
29	2800550	DUNN AND WATTERS DITCH	26	52	30	1100
30	2800551	EAST KRUEGER DITCH	12	30	24	577
31	2800552	EASTSIDE DITCH	9	26	12	903
32	2800553	ELSEN COCHETOPA DITCH	20	77	34	1137
33	2800554	ELSEN VADER DITCH	28	50	16	2307
34	2800555	EVERLY NO 1 DITCH	8	96	45	514
35	2800557	FIELD AND VADER DITCH	14	202	44	1271
36	2800558	FLICK DITCH	28	69	37	762
37	2800559	FLICK DITCH NO 1	9	12	11	652
38	2800560	FLICK DITCH NO 2	8	47	41	437
39	2800564_D	TOMI_GILBERTSON NO 1	20	82	21	1532
40	280566_D	GOODRICH_SYSTEM	43	207	18	3456
41	2800567	GOODWIN AND WRIGHT DITCH	41	188	33	3840
42	2800568_D	LOS _GOVERNMENT DITC	67	728	27	5593
43	2800571_D	TOMI_GRIFFING NO 1 D	50	276	18	4338
44	2800573	GUENTHER NO 1 DITCH	10	52	28	886
45	2800574	GUENTHER NO 2 DITCH	14	11	12	630
46	2800576	GULLETT TOMICHI IRG D	41	128	25	3311
47	2800577	HANNAH J WINTERS NO 2D	21	58	17	1756
48	2800578	HARRIS DITCH	10	46	39	401
49	2800579	HARTMAN WASTE WTR IRG D	28	128	34	1569
50	2800580	HAWES-BERGEN-GILBERTSON	16	189	44	1437
51	2800581	HAZARD DITCH	30	177	37	1728
52	2800582	HEAD AND CORTAY NO 3 D	18	78	32	1287
53	2800583	HEAD AND CORTAY NO 4 D	15	128	42	1010

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
54	2800585	HEAD NO 2 DITCH	8	78	48	477
55	2800586_D	HIRDMAN_SYSTEM	17	282	28	1894
56	2800587	HOME DITCH DITCH NO 81	29	188	43	1436
57	2800588	HOME DITCH DITCH NO 182	24	42	15	1240
58	2800589	HOT SPRINGS NO 1 DITCH	12	14	13	747
59	2800590	HOT SPRINGS NO 2 DITCH	999	11	18	662
60	2800591	HUFF AND DICE DITCH	18	134	32	1714
61	2800593	IRWIN DITCH	16	93	38	883
62	2800595	J M ELLIS NO 1 DITCH	6	48	49	240
63	2800601	JOHN B COATS NO 2 DITCH	12	73	23	1273
64	2800602	JOHN B COATS NO 1 DITCH	12	134	40	1098
65	2800603	JOHN MYERS DITCH	9	33	37	443
66	2800604	KANE DITCH	9	20	22	573
67	2800605	KENDALL NO 1 DITCH	9	100	48	575
68	2800607	KENDALL NO 3 DITCH	36	77	40	853
69	2800608	KENDALL NO 4 DITCH	11	65	38	698
70	2800613	L L BUSH DITCH NO 1	8	4	5	463
71	2800614	L L BUSH DITCH NO 2	9	4	5	458
72	2800615	L L BUSH DITCH NO 3	8	4	7	388
73	2800616	L L BUSH DITCH NO 4	9	4	5	504
74	2800617	L L BUSH DITCH NO 5	8	86	46	565
75	2800618	LEWIS STURGIS AUSTIN D	15	75	38	890
76	2800619	LINDSAY GUENTHER DITCH	7	26	20	644
77	2800622	LOBDELL NO 2 DITCH	12	65	31	903
78	2800624	LOCKWOOD MUNDELL DITCH	57	135	22	3766
79	2800628	LOUIS DITCH	13	61	24	1077
80	2800629	LOUIS SARRASIN DITCH	14	28	13	869
81	2800630	LOWER SWAN DITCH	4	9	20	294
82	2800631	MCCANNE NO 1 DITCH	55	128	28	2677
83	2800632	MCCANNE 2 DITCH	46	140	13	4910
84	2800633	MCCANNE 3 DITCH	41	119	23	2578
85	2800636	MCDONOUGH DITCH	43	430	46	2910

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
86	2800638	MCGOWAN IRRIGATING D	29	91	20	2333
87	2800642	MEANS BROS NO 13 DITCH	15	86	42	804
88	2800645	MEANS BROS NO 4 DITCH	5	98	48	561
89	2800646	MEANS BROS NO 5 DITCH	11	61	30	784
90	2800647	MEANS BROS NO 6 DITCH	8	13	14	444
91	2800648	MEANS BROS NO 7 DITCH	5	23	32	349
92	2800649	MEANS BROS NO 12 DITCH	12	41	34	749
93	2800650	MEANS BROS NO 8 DITCH	20	124	39	1481
94	2800651	MESA DITCH	88	1162	41	8516
95	2800652	MILLER DITCH	12	95	30	1202
96	2800653	MITCHELL DITCH	6	4	4	473
97	2800654	MONSON & MCCONNELL D	24	226	37	2269
98	2800655	MORAN DITCH	10	51	20	992
99	2800658	NEEDLE CREEK DITCH	24	84	34	1126
100	2800659	NESBIT DITCH	7	65	38	622
101	2800660_D	NORMAN_SYSTEM	25	55	15	1449
102	2800661	NORTHSIDE DITCH	19	164	45	1169
103	2800662	OFALLON NO 3 DITCH	20	25	13	1128
104	2800663	OFALLON NO 4 DITCH	14	34	20	962
105	2800664	O'REGAN NO 2 DITCH	8	126	40	856
106	2800665	O'REGAN NO 1 DITCH	8	66	27	737
107	2800666	OWEN NO 2 DITCH	9	50	39	448
108	2800667	OWEN NO 1 DITCH	20	158	41	1438
109	2800668	OWEN REDDEN DITCH	63	457	31	4670
110	2800670	PARLIN NO 2 DITCH	20	99	31	1377
111	2800671	PARLIN QUARTZ CREEK D	42	327	24	4725
112	2800672	PEARCE DITCH	9	60	45	463
113	2800673	PERRY IRRIGATING DITCH	42	270	27	3523
114	2800674	PIONEER DITCH	60	206	31	4966
115	2800676	RAUSIS DITCH	9	27	26	732
116	2800677	RAUSIS NO 2 DITCH	13	77	41	741
117	2800679	ROGERS METROZ DITCH	27	88	26	1800

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
118	2800680	S DAVIDSON&CO FDR D NO 1	73	97	19	4434
119	2800681	SARGENTS NO 1 D	5	21	32	336
120	2800682	SARGENTS NO 2 D	6	15	21	355
121	2800683_D	SHARP_SYSTEM	17	40	14	1198
122	2800684	SHIPMAN LATERALS NO 1&2	15	90	36	957
123	2800685	SLOUGH DITCH	44	60	24	1302
124	2800686	SMITH FORD NO 2 DITCH	66	251	29	4313
125	2800687 [8)]	SNYDER DITCHES NOS 1&2	32	0	21	621
126	2800689 [8)]	SNYDER ROUSER DITCH	6	0	18	324
127	2800690	SORRENSON IRRIGATING D	30	134	26	2753
128	2800691	SOUTH KREUGER DITCH	11	15	19	452
129	2800692	SOUTH SIDE DITCH	28	110	29	2144
130	2800693	STEPHENSON DITCH	36	195	32	2748
131	2800694	STITZER DITCH	14	73	38	707
132	2800697_D	SUTTON_SYSTEM	22	63	12	1486
133	2800703	TARBELL & ALEXANDER D	23	110	33	1123
134	2800704	TARKINGTON DITCH	20	53	11	1907
135	2800707	TORNAY HIGHLINE DITCH	32	76	10	4354
136	2800708	UPPER SWAN DITCH	12	31	17	789
137	2800709	VADER RAUSIS DITCH	23	53	17	1571
138	2800710	VAN BIBBER DITCH	18	33	20	1048
139	2800711	WATERMAN METROZ DITCH	14	30	8	1408
140	2800714	WICKS ROWSER DITCH	5	256	50	1144
141	2800715	WOOD AND GEE DITCH	31	267	43	2218
142	2800716	WOODBRIDGE DITCH	28	205	44	1491
143	2800717	TRAIL CREEK DITCH	5	40	43	314
144	2800718	POLE ROAD DITCH	4	56	50	310
145	2800719	A B COATS DITCH	29	45	23	1169
146	2800726	CAMP BIRD DITCH	5	19	28	234
147	2800777	DUNCAN WASTEWATER DITCH	4	65	46	340
148	2800781	ERNEST VOUGA DITCH	10	55	40	423
149	2800802	JACKSON DITCH	3	46	47	267

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
150	2800803	JAPECK DITCH NO 1	7	5	5	355
151	2800804	JAPECK DITCH NO 2	2	2	25	41
152	2800805	JAPECK DITCH NO 5	6	14	17	351
153	2800806	KENNEDY DITCH NO 1	24	74	38	665
154	2800807	KENNEDY DITCH NO 2	12	134	48	695
155	2800808	KENNEDY DITCH NO 3	4	74	50	317
156	2800809	KENNEDY DITCH NO 4	3	74	48	343
157	2800810	KENNEDY DITCH NO 5	3	60	50	294
158	2800823	MCDONALD BERDEL EX D	4	82	49	406
159	2800849	OWEN NO 3 DITCH	3	50	50	235
160	2800851	PASS CREEK DITCH	14	43	33	603
161	2800869	PISEL CANALS NOS 1&2 D	28	257	31	2984
162	2800872	PITTMAN DITCH NO 1	4	8	12	265
163	2800873	PITTMAN DITCH NO 2	2	8	39	64
164	2800874	PITTMAN DITCH NO 3	5	8	12	341
165	2800875	PITTMAN DITCH NO 4	3	8	25	121
166	2800880	R A PROSSER DITCH	14	154	47	965
167	2800884	RICHARDSON NO1 DITCH	18	78	26	1100
168	2800888	ROCK SLIDE SPRING DITCH	12	39	43	354
169	2800898	STRACHAN DITCH	3	75	50	312
170	2800928	W L PERRY NO 6 DITCH	12	150	45	893
171	2800936	WASTE WATER DITCH	8	120	40	864
172	2800938	WATERMAN MILLER GRIFFIND	6	22	17	572
173	2800943	WESTSIDE DITCH	14	34	12	984
174	2800958	HANNAH WINTERS DITCH	1	58	50	257
175	2800970	MCINTYRE GULCH DITCH	3	14	33	157
176	2801008	GRIFFIN DITCH	2	14	50	36
177	2801055	WATSON DITCH NO 1	4	46	49	226
178	2801068	REINECKE DITCH NO 1	12	30	34	309
179	2801069	REINECKE DITCH NO 2	4	14	22	213
180	2801093	JAPECK DITCH NO 3	5	7	7	298
181	2801094	JAPECK DITCH NO 4	3	1	3	160

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
182	2801146	TOMMIE DITCH	5	9	25	172
183	2801147	JOHN MYERS NO 2 DITCH	5	33	45	236
184	2801148	JOHN MYERS NO 3 DITCH	3	33	43	251
185	2801151	TY WATSON DITCH	999	98	48	515
186	2801152	HOOVER #1	999	10	27	152
187	2801153	HOOVER #2	999	18	45	133
188	2801162	POST TOMICHI DITCH	5	8	11	552
189	2801185	L L BUSH DITCH NO 6	3	4	7	315
190	2801194	PETERSON DITCH	999	60	46	185
191	2801572	S DAVIDSON AND CO DITCH	55	355	29	4722
192	2801581	S DAVIDSON&CO FDR D NO 3	30	197	50	725
193	2801592	MCLAIN DITCH	7	34	28	652
194	28_ADG009	Diversion Aggregate	89	960	36	9271
195	28_ADG010	Diversion Aggregate	45	1005	50	4834
196	28_ADG011	Diversion Aggregate	64	290	23	3707
197	28_ADG012	Diversion Aggregate	123	814	30	11,237
198	28_ADG043	Diversion Aggregate	9	140	41	985
199	28_ADG044	Diversion Aggregate	2	91	50	379
200	4000500	CRAWFORD CLIPPER DITCH	164	3288	40	20,307
201	4000501 [1a)]	NEEDLE ROCK DITCH	60	1663	43	10,324
202	400502	SADDLE MT HIGHLINE D	84	1280	44	7573
203	4000503 [2a)]	GRANDVIEW CANAL	155	2442	45	13,288
204	4000504	CEDAR CANON IRON SPR D	55	1550	41	11,162
205	4000506	ALUM GULCH DITCH	15	144	23	2103
206	4000508 [2b)]	ASPEN DITCH	58	0	46	0
207	4000509 [1b)]	ASPEN CANAL	150	0	50	0
208	4000533	CRYSTAL VALLEY DITCH	16	540	43	2716
209	4000536	DAISY DITCH	29	244	32	2542
210	4000543	DYER FORK DITCH	13	286	46	1497
211	4000549 [3)]	FRUITLAND CANAL	537	0	0	0
212	4000549_I [4)]	Fruitland	183	5891	49	31,080
213	4000554	GOVE DITCH	15	76	38	596

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
214	4000557	HARTMAN MCINTYRE DITCH	16	96	28	1077
215	4000566	LARSON BROTHERS DITCH	13	174	25	1878
216	4000568	LONE ROCK DITCH	10	18	7	947
217	4000576	MEEK DIVERSION TUNNEL	12	403	44	2235
218	4000585 3)	OVERLAND DITCH	999	64	0	0
219	4000586	PILOT ROCK DITCH	20	540	43	3148
220	4000605 3)	SMITH FORK FEEDER CANAL	150	0	0	0
221	4000616	VIRGINIA DITCH	16	283	50	1577
222	4000632	CHILDS DITCH	37	286	26	3974
223	4000661	SURFACE CR D AKA BIG D	117	1958	36	13,487
224	4000675	CEDAR MESA DITCH	52	616	36	4881
225	4000683	HORSESHOE DITCH	11	327	49	1809
226	4000686	LONE PINE DITCH	103	361	36	3920
227	4000692 3)	Sooner Ditch	16	0	0	0
228	4000701_D	CEDAR_PARK_SYSTEM	42	410	14	9621
229	4000703_D	DIRT_EAGLE DITCH	13	118	40	1065
230	4000713	GRANBY DITCH FR WARD CR	11	178	41	1607
231	4000751 3)	ALFALFA DITCH	87	0	0	0
232	4000751_I 4)	ALFALFA_IRR	51	1062	41	7048
233	4000753_D	SURF_BONITA DITCH	15	219	37	1847
234	4000754	BUTTES DITCH	50	394	36	3016
235	4000758	FORREST DITCH	19	553	43	3399
236	4000774	ORCHARD RANCH DITCH	22	361	35	2903
237	4000778	SETTLE DITCH	16	194	43	1319
238	4000797	DURKEE DITCH	25	63	8	2536
239	4000808_D 8)	MORTON_SYSTEM	20	0	31	876
240	4000820_D	ALFA_STELL DITCH	78	1093	24	11,676
241	4000821 3)	TRANSFER DITCH	130	0	0	0
242	4000863	BONA FIDE DITCH	76	1501	14	25,514
243	4000879	HARTLAND DITCH	60	972	12	19,382
244	4000891_D	GUNN_NORTH DELTA CAN	200	1409	0	20,065
245	4000891_I 4)	North Delta Irrigation	103	0	28	0

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
246	4000900	RELIEF DITCH	75	474	5	22,004
247	4000918	COW CREEK DITCH	16	431	43	2481
248	4000919	CURRANT CREEK DITCH	15	202	22	3539
249	4000923	HIGHLINE DITCH	54	880	32	9573
250	4000926	LEROUX CREEK DITCH	198	1779	38	11,850
251	4000929	JESSIE DITCH	26	158	30	1968
252	4000932	MIDKIFF & ARNOLD D	20	120	18	2231
253	4000944_D	LERO_OVERLAND DITCH	172	3743	42	25,277
254	4001012	LONE CABIN DITCH	10	278	50	1511
255	4001020	MINNESOTA CANAL	60	1311	45	8203
256	4001056	TURNER DITCH	12	90	17	2231
257	4001087	BLACK SAGE DITCH	9	37	22	565
258	4001105	COYOTE DITCH	25	233	50	1132
259	4001106	COYOTE DITCH	6	116	50	703
260	4001112	DEER DITCH	6	103	47	673
261	4001114	DITCH NO 2 DITCH	7	44	37	441
262	4001115	DITCH NO 3 DITCH	13	77	21	1166
263	4001116	DITCH NO 4 DITCH	9	181	50	1056
264	4001118	DRIFT CREEK DITCH	9	510	46	2812
265	4001119	DUGOUT DITCH	4	120	49	669
266	4001120	DOWNING DITCH	8	63	25	910
267	4001121	DYKE CREEK DITCH	11	65	50	440
268	4001122	DYKE NO 2 DITCH	5	152	50	881
269	4001126	ELK HORN STOMP DITCH	10	26	25	650
270	4001127	ELKS BEAVER DITCH	7	49	46	407
271	4001132	FILMORE DITCH	20	398	45	2420
272	4001133	FIRE MT CANAL	238	3852	25	52,646
273	4001145	GROUSE CREEK DITCH	5	25	17	531
274	4001166_D	MUDD_LARSON NO 2 DIT	9	105	48	702
275	4001168	LEE CREEK D NO 2	10	343	50	1881
276	4001183	MONITOR DITCH	15	204	30	2568
277	4001185	NORTH FORK FARMERS D	282	961	29	10,290

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
278	4001189	PAONIA DITCH	33	305	13	6872
279	4001195	SHEPHERD & WILMONT DITCH	16	284	18	3516
280	4001196	SHORT DITCH	44	520	23	6406
281	4001197	SMITH AND MCKNIGHT DITCH	12	376	38	2716
282	4001201	SPATAFORE DITCH NO 1	3	68	50	401
283	4001206	STEWART DITCH	77	2706	40	18,080
284	4001207	STREBER DITCH	18	140	24	1940
285	4001212	TWIN SPRUCE DITCH	15	254	46	1418
286	4001213	VANDEFORD DITCH	16	89	10	1992
287	4001214	WADE DITCH	2	38	50	201
288	4001218	WELCH MESA DITCH	21	480	45	2688
289	4001221	WILLIAMS CR DITCH	4	25	46	167
290	4001313	PUG WHITE DITCH	10	14	25	324
291	4001425	ADOBE DITCH	11	25	12	1065
292	4001426	BIG MONITOR NO 1 DITCH	52	122	48	837
293	4001428	DAVIS BROS DITCH	12	20	30	597
294	4001435	EVERLASTING DITCH	22	212	43	1368
295	4001436	HALLEY DITCH	12	55	15	1259
296	4001437_D	ROUB_HAWKINS DITCH	42	14	6	1072
297	40_ADG019	Diversion Aggregate	5	25	31	233
298	40_ADG020	Diversion Aggregate	23	1727	43	10,367
299	40_ADG021	Diversion Aggregate	27	448	33	3988
300	40_ADG022	Diversion Aggregate	103	1321	43	8484
301	40_ADG023	Diversion Aggregate	24	412	43	2588
302	40_ADG024	Diversion Aggregate	50	1196	43	7689
303	40_ADG025	Diversion Aggregate	28	980	41	5762
304	40_ADG026	Diversion Aggregate	544	2275	39	14,783
305	40_ADG027	Diversion Aggregate	42	1497	41	9154
306	40_ADG028	Diversion Aggregate	160	2640	38	20,826
307	40_ADG029	Diversion Aggregate	41	893	35	5453
308	40_ADG030	Diversion Aggregate	117	2527	29	19,926
309	40_ADG039	Diversion Aggregate	85	1500	31	11,477

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
310	40_AMG002 5)	Lower_M&I	2	0	100	1776
311	4100508	BOLES & MANNEY D	20	259	19	4132
312	4100515	CHIPETA BEAUDRY DITCH	32	341	19	4533
313	4100517	PURDY AND VICKERS DITCH	28	102	6	4118
314	4100519	EAGLE DITCH	999	1006	21	8757
315	4100520	EAST CANAL	354	4224	16	58,308
316	4100524	SEEPAGE FEEDER DITCH NO1	19	251	14	3761
317	4100527	GARNET DITCH	156	644	5	23,890
318	4100534_D	UNCO_IRONSTONE CANAL	544	21058	27	133,069
319	4100537	LOUTSENHIZER CANAL	232	3264	14	50,464
320	4100538	LYRA DITCH	16	404	27	3165
321	4100545	MONTROSE & DELTA CANAL	627	19686	19	205,870
322	4100549	OURAY DITCH	36	413	21	5093
323	4100550	RESERVATION DITCH	23	68	6	3986
324	4100554	ROSS BROS DITCH	37	493	29	4710
325	4100559	SELIG CANAL	367	9072	25	79,971
326	4100560	SHAVANO VALLEY DITCH	14	39	23	1471
327	4100566	STARK VOLKMAN DITCH	25	40	2	4658
328	4100568_D	Sunrise DivSys	11	88	10	2013
329	4100577	WEST CANAL	999	5524	21	59,647
330	4100578	SOUTH CANAL	999	3734	20	46,203
331	4100954 8)	SILVER SPRINGS DITCH	14	0	24	629
332	41_ADG035	Diversion Aggregate	10	276	43	1668
333	41_ADG036	Diversion Aggregate	127	2582	40	19,344
334	41_ADG037	Diversion Aggregate	69	1260	31	10,212
335	41_AMG003 5)	Uncomp_M&I	2	0	100	1272
336	41_Proj_7 5)	Project_7	999	0	20	7328
337	4200510	BROWN & CAMPION D	36	164	23	3354
338	4200528	JUNIATA DITCH 1ST ENL	259	629	41	5901
339	4200529	KANNAH CREEK HIGHLINE D	89	217	21	6557
340	4200530	KANNAH CREEK EXT D	14	218	28	2873
341	4200541 5) 6)	REDLANDS POWER CANAL	888	0	0	418,344

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
342	4200541_I [4) 6)]	REDLANDS IRRIGATION	140	1713	18	29,197
343	4200545	SMITH IRR DITCH	23	63	20	1550
344	4200635	COFFMAN & WW MUTUAL D PL	10	22	40	222
345	42_ADG040	Diversion Aggregate	179	1421	37	13,517
346	5900500	A C JARVIS NO 1 DITCH	10	48	16	1034
347	5900501	ACME DITCH	70	425	31	5025
348	5900505	Alfred Ditch	11	56	9	1002
349	5900509	ANDERS BOTTOM D	6	59	46	371
350	5900510	ANNA ROZMAN DITCH	15	30	7	1628
351	5900512	APRIL DITCH	22	118	9	3441
352	5900520	BIEBEL NO 3 DITCH	14	85	42	718
353	5900522	BOCKER DITCH	43	126	7	5414
354	5900524	BOURNE DITCH	14	113	44	740
355	5900527	BUCKEY DITCH	26	99	39	1073
356	5900528	BUCKEY LEHMAN DITCH	16	171	50	830
357	5900529	CARBON DITCH	14	117	38	931
358	5900535	CASTLETON DITCH	17	201	50	998
359	5900537	CEMENT CREEK DITCH	28	82	4	4288
360	5900542	CUNNINGHAM DITCH	24	346	49	1642
361	5900543	DAVID HIGH LINE DITCH	9	99	49	563
362	5900544	DEAN IRRIGATING DITCH	28	60	32	1394
363	5900546	DILLSWORTH DITCH	48	418	10	8321
364	5900549	EAST RIVER NO 1 DITCH	137	584	16	18,480
365	5900550	EAST RIVER NO 2 DITCH	73	208	4	11,346
366	5900554	ELZE WEBBER DITCH	14	87	45	613
367	5900556	FISHER DITCH ENLARGEMENT	42	300	11	5857
368	5900558	FRANK ADAMS NO 1 DITCH	40	394	20	5719
369	5900560	GARDEN DITCH	29	204	24	3640
370	5900563	GLEASON IRRIGATING DITCH	48	407	47	2639
371	5900564	GOODWIN KNOX DITCH	11	118	19	1581
372	5900566	GOOSEBERRY MESA IRG D	28	797	46	4427
373	5900569	GUNNISON & OHIO CR CANAL	169	587	10	16,766

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
374	5900570	GUNNISON R OHIO CR IRG D	999	630	25	17,839
375	5900572	GUNNISON TOWN DITCH	75	226	13	9227
376	5900578	HARRIS BOHM POTATO DITCH	68	630	36	5784
377	5900580	HENRY PURRIER OHIO CR D	31	197	50	713
378	5900581	HENRY PURRIER OHIO CR 2D	9	109	50	561
379	5900584	HIGHLAND DITCH	10	20	10	731
380	5900585	HIGHLINE DITCH	30	35	14	435
381	5900587	HILDEBRAND NO 2 DITCH	37	181	39	2050
382	5900588	HINKLE HAMILTON DITCH	28	171	27	2267
383	5900589	HINKLE IRG DITCH	18	171	48	1075
384	5900591	HOPE RESICH DITCH	33	170	35	1557
385	5900593	HOWE & SHERWOOD IRR D	26	410	32	2794
386	5900594	HYZER DITCH	20	128	28	1758
387	5900595	HYZER KETCHUM DITCH	32	150	6	6261
388	5900596	HYZER VIDAL MILLER D	35	128	36	1868
389	5900597	IMOBERSTEG DITCH	32	80	8	3288
390	5900600	JAMES WATT DITCH	47	52	3	5664
391	5900602	JOHN B OUTCALT NO 2 D	38	204	26	3213
392	5900606	JUDY NORTH HIGH LINE D	22	99	34	1724
393	5900607	KELMEL OWENS NO 1 DITCH	74	221	12	7107
394	5900608	KELMEL OWENS NO 2 DITCH	54	259	21	3770
395	5900609	KUBIACK DITCH	26	81	6	4046
396	5900613	LAFAYETTE DITCH	70	238	6	8129
397	5900615	LEHMAN HARRIS DITCH	15	171	47	1178
398	5900616	LIGHTLEY D & LINTON ENLT	34	118	10	3667
399	5900617	LONE PINE DITCH	72	827	46	5381
400	5900622	MARSHALL NO 1 DITCH	16	266	37	2071
401	5900623	MARSHALL NO 2 DITCH	43	179	22	3422
402	5900624	MARSTON DITCH	18	101	10	2192
403	5900625	MAY BOHM & ENLD M B H P	70	754	45	5296
404	5900627	MCCORMICK DITCH	10	109	39	676
405	5900630	MCGLASHAN N SIDE MILL CR	8	99	50	510

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
406	5900631	MCGLASHAN S SIDE MILL CR	18	148	50	863
407	5900644	OHIO CREEK NO 2 DITCH	16	72	30	842
408	5900645	OTIS MOORE DITCH	45	364	50	1981
409	5900646	PALISADES DITCH	12	53	15	1288
410	5900649	PASS CREEK DITCH	14	53	22	973
411	5900651	PILONI DITCH	48	177	33	1866
412	5900653	POWER DITCH	28	177	6	5561
413	5900654	PRESSLER POLISIC DITCH	10	53	33	596
414	5900655	PURRIER DITCH	14	109	48	699
415	5900656	REDDEN ELSINORE DITCH	20	144	14	2289
416	5900658	RICHARD BALL DITCH	41	433	21	5015
417	5900667	SCHUPP DITCH	17	89	25	1059
418	5900668	SEVENTY FIVE DITCH	78	91	4	6588
419	5900670	SILKA DITCH	13	73	29	718
420	5900671	SIMINEO DITCH	28	141	48	901
421	5900672	SLIDE DITCH	47	167	8	5636
422	5900674	SMELSER DITCH	9	44	37	455
423	5900679	SPRING CR IRG DITCH	73	147	5	6238
424	5900680	SQUIRREL CREEK NO1 DITCH	10	35	40	433
425	5900684	STRAND DITCH NO 1	24	140	18	2595
426	5900691	TEACHOUT DITCH	48	890	47	5279
427	5900692	TEACHOUT-FAIRCHILD DITCH	94	171	38	1959
428	5900695	TINGLEY DITCH	9	71	42	509
429	5900699	VERZUH DITCH	44	231	7	7472
430	5900700	VERZUH YOUNG BIFANO D	49	112	4	7603
431	5900701	VIDAL BROS NO 1 DITCH	12	128	49	755
432	5900704	WHIPP DITCH	39	177	17	4116
433	5900706	WILLOW DITCH	10	59	31	552
434	5900707	WILLOW RUN DITCH	17	201	49	1087
435	5900709	WILSON DITCH	17	85	37	1047
436	5900711	WILSON OHIO CREEK DITCH	27	89	26	1955
437	5900720	PIONEER DITCH	14	109	46	796

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
438	5900847	CUNNINGHAM WASTEWATER D	29	71	15	2224
439	5900886 3)	Elk Home Ditch	14	0	0	192
440	5900887 3)	Elk Home No. 2 Ditch	7	0	0	156
441	5900912	GEORGE KAPUSHION DITCH	10	29	29	381
442	5900967	JOHN B OUTCALT NO 1 D	20	204	46	1177
443	5901165	THORNTON DITCH NO 2	5	128	48	639
444	5901180	WEINERT-OWENS CR DITCH	9	35	37	274
445	5901361	BURT GUERRIERI DITCH	5	73	47	433
446	5903602_C 3)	Farris Creek Carrier	15	0	0	0
447	5903660_C 3)	MillCarrier to Cunningha	0	0	0	0
448	5903660_MC 3)	MillCarrier to Cunningha	6	0	0	0
449	5903663_C 3)	Meridian Carrier	15	0	0	0
450	59_ADG001	Diversion Aggregate	120	277	11	10,961
451	59_ADG002	Diversion Aggregate	52	288	17	6811
452	59_ADG003	Diversion Aggregate	51	527	43	3120
453	59_ADG004	Diversion Aggregate	58	793	31	7857
454	59_ADG005	Diversion Aggregate	109	892	32	9676
455	59_ADG006	Diversion Aggregate	61	732	45	4146
456	59_ADG007	Diversion Aggregate	99	1664	49	8429
457	59_ADG008	Diversion Aggregate	137	1905	25	20,317
458	6200506	ANDREWS DITCH	13	63	29	918
459	6200528	BIG BLUE DITCH	66	1944	49	9365
460	6200529	BIG DITCH	39	69	18	3641
461	6200533 5)	BLUE MESA POWER PLANT	3500	0	0	1,785,012
462	6200542	BUTTE & BUTTE EX DITCH	26	195	24	2753
463	6200560 3)	CIMARRON CANAL	185	0	0	0
464	6200560_I 4)	Cimmaron_Canal	156	4029	25	28,032
465	6200565	COBB-CEBOLLA CR D	12	22	12	1084
466	6200567	COLLIER DITCH	17	582	50	2682
467	6200569	COOPER NO 2 D	36	99	23	3167
468	6200578 5)	CRYSTAL POWER PLANT	3000	0	0	3,891,633
469	6200602	FOSTER DITCH NO 1	11	58	34	1015

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
470	6200604	FOSTER IRG D NO 4	8	73	46	497
471	6200605	FRANK ADAMS D NO 2	45	132	27	3016
472	6200612	GEORGE ANDREWS NO 1 D	40	132	34	1768
473	6200617 3)	GUNNISON TUNNEL&S CANAL	1228	0	0	0
474	6200641	INDIAN CREEK IRR DITCH	18	72	39	588
475	6200653	LAKE FORK NO 1 DITCH	23	78	19	1444
476	6200661	LONE PINE DITCH	12	10	4	1017
477	6200670	M B & A DITCH	34	150	31	2718
478	6200672	MCKINLEY DITCH	35	942	41	5790
479	6200687	MINNIE B NO 2 DITCH	12	27	27	790
480	6200692 5)	MORROW POINT POWER PLANT	5450	0	0	2,142,003
481	6200732	RUDOLPH IRG DITCH	19	120	30	2042
482	6200734	SAMMONS DITCH NO 2	15	23	29	689
483	6200736_D	CEBO_SAMMONS IRG D N	18	28	10	895
484	6200737	SAMMONS IRG D NO 5	17	19	26	588
485	6200738	SAMMONS IRG D NO 6	12	80	36	1047
486	6200756	SPRING BRANCH DITCH	10	33	23	430
487	6200779	UPPER CEBOLLA DITCH	22	192	35	1853
488	6200783	VEO DITCH	16	410	39	2882
489	6200789	WARRANT DITCH	21	34	25	1217
490	6200792	WEST DITCH	12	37	29	1021
491	6200812_D	YOUMANS NO 4 DITCH	29	26	7	1961
492	62CSUB_I 7)	Subordinate_Crystal_M&I	999	0	25	0
493	62CSUB_M 7)	Subordinate_Crystal_M&I	999	0	20	0
494	62L_MY7)	Lower Market Yield	999	0	25	0
495	62MSUB_I 7)	Subordinate_Morrow_M&I	999	0	25	0
496	62MSUB_M 7)	Subordinate_Morrow_M&I	999	0	20	0
497	62USUB_I 7)	Subordinate Irr Demand	999	0	25	0
498	62USUB_M 7)	Subordinate_Upper_M&I	999	0	20	0
499	62U_MY 7)	Upper_Market_Yield	999	0	100	0
500	62_ADG013	Diversion Aggregate	137	932	30	15,315
501	62_ADG014	Diversion Aggregate	107	1021	37	11,732

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
502	62_ADG015	Diversion Aggregate	170	882	18	14,944
503	62_ADG016	Diversion Aggregate	182	986	24	15,810
504	62_ADG017	Diversion Aggregate	54	287	31	2870
505	62_ADG018	Diversion Aggregate	36	4377	50	19,208
506	62_AMG001 [5)]	Upper_M&I	2	0	100	1536
507	6800501	ALKALI DITCH D NO 80	42	1408	49	7131
508	6800502	ALKALI NO 2 DITCH	37	618	35	5283
509	6800514	BURKHART EDDY DITCH	21	384	40	2799
510	6800526	CHARLEY LOGAN DITCH	31	160	12	3834
511	6800538	CRONENBERG DITCH	12	233	50	1024
512	6800543	DALLAS DITCH	41	989	48	5309
513	6800559	DOC WADE DITCH	21	163	34	2326
514	6800603	HENRY TRENCHARD DITCH	12	143	35	1287
515	6800604	HIELAND DITCH	18	123	7	2775
516	6800607	HOMESTRETCH DITCH	22	174	5	4809
517	6800609	HOSNER BROWNYARD DITCH	20	75	11	2467
518	6800610	HOSNER ROWELL DITCH	18	251	34	2255
519	6800613	HYDE SNEVA DITCH	19	341	41	2621
520	6800636	LEOPARD CREEK DITCH	24	594	50	2754
521	6800647	MARTIN DITCH	13	211	41	1459
522	6800652	MAYOL LATERAL DITCH	15	108	28	1060
523	6800653	MAYOL SISSON DITCH	13	192	46	1115
524	6800657	MCDONALD DITCH NO 145	37	576	17	4841
525	6800668	MOODY DITCH	22	93	11	2660
526	6800669	MOODY NO1 DITCH	26	423	40	2944
527	6800671	MORRISON DITCH	16	48	25	1493
528	6800681	OLD AGENCY DITCH	15	549	28	2744
529	6800683	OWL CREEK DITCH	17	187	35	1629
530	6800685	PARK DITCH	21	261	30	2829
531	6800692	PINION DITCH	24	425	12	5041
532	6800703	REED OVERMAN DITCH	27	176	37	1542
533	6800710	RIDGWAY DITCH	27	67	17	1296

#	Model ID #	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
534	6800720	ROSWELL HOTCHKISS DITCH	26	131	14	1423
535	6800721	RUFFE WADE DITCH	15	163	50	738
536	6800729	SHORTLINE D COW CREEK	14	55	28	657
537	6800738	SNEVA DITCH	36	1346	50	5890
538	6800763	TRENCHARD DITCH	16	54	28	1157
539	6800765	UPPER UNCOMPAHGRE DITCH	20	210	9	3545
540	6800770	VON HAGEN DALLAS DITCH	13	134	37	1252
541	6801064	VON HAGEN LATERAL DITCH	16	134	25	1498
542	68_ADG033	Diversion Aggregate	88	1575	38	11,875
543	68_ADG034	Diversion Aggregate	230	3684	34	28,153
544	72_GJMunExp 6)	Grand_Junction_Demand	21	0	100	6659

1a) Primary Structure of the Grandview canal Multi-structure System
1b) Secondary Structure of the Grandview Canal Multi-structure System
2a) Primary Structure of the Needle Rock Ditch Multi-structure System
2b) Secondary Structure of the Needle Rock Ditch Multi-structure System
3) Reservoir Feeder or Carrier Ditch
4) Irrigation demand node
5) Municipal/Industrial Diversion
6) Basin Export
7) Node for Future Modeling of Aspinall Unit Subordination and Marketable Yield Demands
8) Irrigation nodes with acreage assigned in 2005, but not in 2010

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
4000508	Aspen Ditch	Secondary structure in Multistructure system
4000509	Aspen Canal	Secondary structure in Multistructure system

4000549	Fruitland Canal	Trans-tributary carrier and reservoir feeder
4000585	Overland Ditch	Trans-tributary carrier
4000605	Smith Fork Feeder Canal	Trans-tributary reservoir feeder
4000751	Alfalfa Ditch	Trans-tributary reservoir feeder
4000821	Transfer Ditch	Trans-tributary reservoir feeder
41_Proj_7	Project 7 Demand	Municipal
4200541	Redlands Power Canal	Industrial
5900886	Elk Home Ditch	Trans-tributary reservoir feeder
5900887	Elk Home No. 2 Ditch	Trans-tributary reservoir feeder
6200560	Cimarron Canal	Trans-tributary carrier and reservoir feeder
6200617	Gunnison Tunnel	Trans-tributary carrier and reservoir feeder
72_GJMunExport	Grand Junction 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 given month of the simulation is a function of the amount diverted that month, and the consumptive use, as limited by the water supply.

For municipal, industrial 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, 41_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 was 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 was 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. One 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 **Error! Reference source not found.**.
- 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 046. 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
- Appendix A –describes the Gunnison irrigation structure aggregation.

5.4.1.3 Special Structures

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 4000549_I. Fruitland Canal (4000549) is modeled as a carrier to both Fruitland Reservoir and to the 4000549_I demand. 4000549_I demand can also be satisfied from releases from Fruitland Reservoir.

Cimarron Canal

6200560_I represents the irrigated acreage demand of the Bostwick Park Project. The key components of the Bostwick Park Project are Silver Jack Reservoir (6203548) and the Cimarron Canal (6200560). The Cimarron Canal (6200560) delivers water to supply both 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.

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. 41_Proj_7 represents the municipal demand for the Project 7 Water Authority.

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 4200541 represents transbasin diversion from the Gunnison to the Colorado for power generation. Structure 4200541_I represents transbasin diversion for irrigation.

Grand Junction

72_GJMunExp 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.

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 (41_WQ1, and 41_WQ2). These “other” type nodes are located on Loutsenheizer Arroyo and Cedar Creek, both just upstream of their confluences with the Uncompahgre.

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:

- 62USUB_I, 62USUB_M, 62MSUB_I, 62MSUB_M, 62CSUB_I, and 62CSUB_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.
- 62U_MY and 62L_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 gm2015.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.

Five patterns are available to the model in this file, as shown in **Error! Reference source not found.**. 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 5.6 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 was created by StateDMI, which filled missing records as described in Section 4.4.2. StateMod uses the file for baseflow estimations at stream gage locations, and for comparison output during calibration.

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

5.4.3.1 Key Structures

For most explicitly modeled irrigation and M&I structures, StateDMI accessed HydroBase for historical diversion records. Historical diversions were accumulated by StateDMI for defined diversion systems. For certain structures, the data was assembled from other sources or developed from database data into a time-series file which StateDMI read. These include the diverters in the Uncompahgre Valley who are recipients of Gunnison Tunnel water plus other larger diverters as listed in **Error! Reference source not found.**.

5.4.3.2 Aggregate Structures

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

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

Fruitland Canal Irrigation

Diversion time series for the node representing the historical irrigation demand of the Fruitland Irrigation Company (4000549_I) was by estimating the total irrigation demand from all sources using the average monthly efficiency of the nearby Needle Rock Ditch (4000501). 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.

Cimarron Canal

Diversion time series for the node representing the historical irrigation demand of the Bostwick Project (6200560_I) was created by subtracting the estimated Project 7 Water Authority demand from the historical Cimarron Canal (6200560).

Project 7

Diversion time series for the node representing the Project 7 Water Authority M&I historical diversions (41_Proj_7) was created from information obtained directly from the water authority.

Redlands Canal

Diversion time series for the two nodes that represent the historical irrigation (4200541_I) and power (4200541) demands of the Redlands Canal were created from SEO records.

Grand Junction

Diversion time series for the node representing water exported from Kannah Creek for the City of Grand Junction (72_GJMunExp) was from information obtained directly from the city.

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

  -Evaluate Extension of Historical Data

5.4.4. Direct Diversion Demand File (*.ddm)

Created by StateDMI, this file contains time series of demand for each structure in the model. Demand is the amount of water the structure “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. **Error! Reference source not found.** 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 (1975 through 2013) but capped at 0.50.

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

The Aspinall Unit power plant demands were set to the power plant capacity year round. There are no operating rules to force water to be released from any of the Aspinall Unit storage reservoirs. The power plant diversions pick up water that is released from the reservoir for other downstream uses and return 100 percent of the diversion immediately.

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

The information in this file is used during simulation to allocate water in the right sequence or priority and to limit the allocation by decreed amount. 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.

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

5.4.5.1 Key Structures

Water rights for explicitly modeled structures were taken from Hydrobase and match the State Engineer's official water rights tabulation.

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 (10 x 1 + 4 x 2) / (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

Fruitland Canal Irrigation

Direct diversion water rights for the Fruitland Canal are extracted directly from Hydrobase and assigned to the feeder canal 4000549. The direct diversion rights for the irrigation demand (4000549_I) are set to zero and water is only delivered via the feeder canal or from Fruitland Reservoir. The junior Water 90 cfs right under Fruitland Canal is split and represented as two water rights to reflect that 50 cfs is used directly for irrigation while 40 cfs is used to fill Fruitland Reservoir (aka Gould Reservoir).

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 (6200560) to the Bostwick area as an import to the system. The Cimarron Canal irrigation demand (6200560_I) 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 (6200560_I) using the Cimarron Canal (6200560) direct water right.

Project 7

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

Redlands Canal

Redlands Canal irrigation rights are store in Hydrobase under the Redlands Power Canal (4200541). They are assigned to the Redlands Canal Irrigation Structure (4200541_I) as follows: 60 cfs with an administration number of 22283.20300 and 80 cfs with an administration number of 34419.33414

Grand Junction

A senior water right for 999 cfs, with an administration number of 1.0000, was assigned to the City of Grand Junction (72_GJMunExp) export from Kannah Creek.

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 (6200617) 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.

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.

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.

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. StateCU Structure File (*.str)

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

5.5.2. Irrigation Parameter Yearly (*.ipy)

This file contains conveyance efficiency and maximum application efficiency by irrigation type for each irrigation structure for 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, 98 to 99 percent of the 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 was created by StateDMI.

5.5.3. Irrigation Water Requirement File (*.iwr)

Data for the irrigation water requirement file was generated by StateCU for the period 1950 through 2013, then extended back to 1909 using TSTool. StateCU was executed using the SCS modified Blaney-Criddle monthly evapotranspiration option with TR-21 crop parameters for lands irrigated below elevation 6,500 feet. A standard elevation adjustment was applied to TR-21 crop coefficients. For structures irrigating pasture grass above 6,500 feet, StateCU was executed using the original Blaney-Criddle method with high-altitude crop coefficients, as described in the SPDSS 59.2 Task Memorandum *Develop Locally Calibrated Blaney-Criddle Crop Coefficients*, March 2005. Acreage for each structure was set to the acreage defined in 2010 for the entire study period. The irrigation water requirement file contains the time series of monthly irrigation water requirements for structures whose efficiency varied through the simulation.

5.6 Reservoir Files

5.6.1. Reservoir Station File (*.res)

This file describes physical properties and some administrative characteristics of each reservoir simulated in the Gunnison basin. It was assembled by StateDMI, using considerable amount of information provided in the commands file. Twenty four key reservoirs were modeled explicitly. Fourteen aggregated reservoirs and stock ponds account for evaporation from numerous small storage facilities. Three future reservoirs are included as placeholders, but are not operational in the baseline model. The modeled reservoirs are listed below with their capacity and their number of accounts or pools.

Table 5.7 List of Modeled Reservoirs

ID #	Name	Capacity (af)	# of Accounts
2803590	HOT SPRINGS RES	1,029	1
2803591	MCDONOUGH RES	1,808	1

2803592	MCDONOUGH RES NO 2	1,774	1
2803593	NEEDLE CREEK RES	1,298	1
2803594	UPPER DOME RESERVOIR	1,298	1
2803595	VOUGA RESERVOIR	1,450	1
2803617	LOWER DOME RESERVOIR	60	1
2803652	BOULDER LAKE	104	1
2803674	PETERSON RESERVOIR	190	1
4003365	FRUIT GROWERS RES	4,540	2
4003395	FRUITLAND RESERVOIR	8,100	1
4003399	OVERLAND RES NO 1	6,200	2
4003416	PAONIA RESERVOIR	18,700	4
4003553	CRAWFORD RESERVOIR	14,395	2
41_Cerro	CERRO	650	1
41_Fairview	FAIRVIEW	350	1
5903663	MERIDIAN LAKE	1380	2
5903664	RAINBOW LAKE RESERVOIR	200	1
5903666	TAYLOR PARK RESERVOIR	108,490	3
6203532	BLUE MESA RESERVOIR	940,800	3
6203545	MORROW POINT RESERVOIR	118,764	2
6203548	SILVERJACK RESERVOIR	13,520	2
6203578	CRYSTAL RESERVOIR	25,236	1
6803675	RIDGWAY	84,467	6
28_ARG001	AGG_RES_Tomichi	156	1
40_ARG001	AGG_RES_Surface	23,268	1
40_ARG002	AGG_RES_Ngunn	23,268	1
40_ASG001	AGG_STOCK_Surface	1,727	1
41_ARG001	AGG_RES_Uncomp	3,226	1
41_ASG001	AGG_STOCK_Uncomp	1,727	1
42_ARG001	AGG_RES_Kannah	17,876	1
42_ASG001	AGG_STOCK_Kannah	1,727	1
59_ARG001	AGG_RES_East	9,826	1
62_ARG001	AGG_RES_Lake	6,475	1
62_ARG002	AGG_RES_Main	6,475	1
62_ASG001	AGG_STOCK_Main	1,727	1
68_ARG001	AGG_RES_UpperUncomp	8,359	1
68_ASG001	AGG_STOCK_UpperUncomp	1,727	1

Reservoirs that were investigated under the Gunnison Basin Roundtable's Gunnison Basin Implementation Plan (GBIP) are included in the model network, but are not actively modeled.

Table 5.8 shows the ID used in the model and reservoir site name. Volumes and accounts are not included as that is left to the discretion of the user. The user is also responsible for confirming the water rights and operations related to these potential future reservoirs. In addition to the reservoirs listed in the table, two existing reservoirs were considered for enlargement: Meridian Lake (5903663) and Rainbow Lake (5903664). Meridian Lake is included in the model with current day capacity, water rights and operations. Rainbow Lake is not operated in the model.

Table 5.8 - Future Reservoir Sites

ID #	Name
4003527	FUTURE GORSUCH RESERVOIR
5903602	FUTURE FARRIS CREEK RES
5903660	FUTURE CUNNINGHAM GULCH

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 full.

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 for Key Reservoirs

Hot Springs Reservoir

Hot Springs Reservoir (2803590) is a privately owned reservoir on Hot Springs Creek that provides water to ten downstream ditches from a single irrigation account.

McDonough Reservoir

McDonough Reservoir (2803591) is a privately owned reservoir on Los Pinos Creek that provides water to five downstream ditches from a single irrigation account. It is part of a system with McDonough No. 2 Reservoir.

McDonough No. 2 Reservoir

McDonough No. 2 Reservoir (2803592) is a privately owned reservoir located just off stream of Los Pinos Creek. It provides water to one upstream ditch by exchange and two downstream ditches from a single irrigation account. It is part of a system with McDonough Reservoir

Needle Creek Reservoir

Needle Creek Reservoir (2803593) is a privately owned reservoir located on Needle Creek. It provides water to seven downstream ditches from a single irrigation account.

Upper Dome Reservoir

Upper Dome Reservoir (2803594) is a privately owned reservoir located on Archuleta Creek. It does not provide water to any downstream users directly. It releases to maintain target reservoir contents from a single account. It is part of a system with Lower Dome Reservoir, which is located immediately downstream.

Vouga Reservoir

Vouga Reservoir (2803595) is a privately owned reservoir located on Razor Creek. It provides water to ten downstream ditches from a single irrigation account.

Lower Dome Reservoir

Lower Dome Reservoir (2803617) is a privately owned reservoir located on Archuleta Creek. It does not provide water to any downstream users directly. Its storage content remains constant year round and is modeled with a single account. It is part of a system with Upper Dome Reservoir, which is located immediately upstream.

Boulder Lake

Boulder Lake (2803652) is a privately owned reservoir located on Gold Creek. It does not provide water to any downstream users directly. Its storage content remains constant year round and is modeled with a single account.

Peterson Reservoir

Peterson Reservoir (2803674) is a privately owned reservoir located on Razor Creek. It provides water to three downstream ditches from a single irrigation account.

Fruit Growers Reservoir

Fruit Growers Reservoir (4003365) 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.

Fruitland Reservoir

Fruitland Mesa encompasses Fruitland Reservoir (aka Gould Reservoir, aka Onion Valley Reservoir, 4003395) 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 (4000549) is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir. The model node 4000549_I represents the full irrigation demand, which can be satisfied with water diverted directly for irrigation by Fruitland Canal or releases from Fruitland Reservoir.

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 400549_I.

Overland Reservoir

Overland Reservoir #1 (4003399) is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch (4000585) to Leroux Creek, and then picked up by the Lower Overland Ditch (4000944). A single irrigation account with a capacity of 6,148 and a dead pool account of 52 acre-feet are modeled for Overland Reservoir.

Paonia Reservoir

The Paonia Project provides full and supplemental irrigation water to land near Paonia and Hotchkiss. The Paonia Project consists of Paonia Reservoir (4003416) and Fire Mountain Canal (4001133), 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	4001133	12,650
Ragged Mountain Exchange Account	4001120, 4001121, 4001119, 4001106, 4001105, 4001145, 4001168, 4001112, 4001201, 4001214, 4001166_D, 4001122, 4001087, 4001114, 4001127, 4001118, 4001132, 4001207, 4001218	2,000
Endangered Fish		1,500
Inactive Pool		2,550
TOTAL		18,700

Crawford Reservoir

Crawford Reservoir (4003553) 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 (4000605).

Numerous irrigation diversion structures use Crawford Reservoir water directly or by exchange, including 4000500, 4000501, 4000502, 4000503, 4000509, 4000536, and 4000616. 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.

Cerro and Fairview Reservoirs

41_Cerro and 41_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.

Meridian Lake

Meridian Lake (5903663) is an existing reservoir located on Washington Gulch. It is operated by the Upper Gunnison River Water Conservancy District, primarily as a source of augmentation water for users on Slate, East, and Gunnison rivers. In the model, it has an irrigation account with a 1,100 acre-foot capacity and a Fish and Wildlife account with 280 acre-feet. These accounts are placeholders for a future enlargement of Meridian Lake. The reservoir currently does not release to downstream demands. It is kept at a constant storage of 470 acre-feet.

Rainbow Lake Reservoir

Rainbow Lake (5903664) is an existing reservoir located on Willow Creek. It is privately owned. Most of the inflow to the lake is supplied by Elk Home Ditch and Elk Home No. 2 Ditch, which divert water from the Stuben Creek drainage. The reservoir is not operational in the model.

Taylor Park Reservoir

The U.S. Bureau of Reclamation constructed Taylor Park Reservoir (5903666) as part of the Uncompahgre Project to store and delivers 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. Water that is released for fishery purposes only is accounted for in Blue Mesa Reservoir, see details in Aspinall Unit section below.

Taylor Park Reservoir is modeled 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.

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 (6203545), and Crystal (6203578).

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.

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 (6203548) and the Cimarron Canal (6200560). 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 6200560_I 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 6200560_I demands. There is also a dead-pool account with a capacity of 683 acre-feet.

Ridgway Reservoir

Dallas Creek Project, and its principal component Ridgway Reservoir (6803675), provide supplemental water supplies for municipal, industrial, and irrigation uses in the Uncompahgre Valley. The Project 7 Water Authority, though not a component of the Dallas Creek Project, has an account in Ridgway Reservoir. They provide municipal water to several communities and rural areas. Through an agreement with the UVWUA, Project 7 Water Authority can divert Gunnison Tunnel water to Fairview Reservoir in exchange for stored water in Ridgway. The UVWUA then calls for the exchanged water to be released from Ridgway and picked up from the Uncompahgre River. In addition to this accounting, 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. The exchange account is not filled with storage rights and is emptied back to the other accounts in October.

An account for recreation and the USBR firm yield pool are also included. When there is not enough inflow to satisfy the downstream minimum streamflow requirements, water is released from this account. In drought years, water from this pool can be made available to users at the discretion of USBR.

Ridgway Reservoir hydropower plant became operational in 2014. The reservoir does not actively make releases to hydropower, but produces power passively as water is released for other purposes.

Ridgway Reservoir is also operated under a “No Spill” guideline. Small mouth bass live in the reservoir and are a threat to endangered native fish. To prevent the bass from escaping over the spillway, Ridgway Reservoir is drawn down during the spring in response to inflow forecasts. This draw down impacts all active reservoir accounts.

Accounts and users are listed in the table below.

Structure (Account)	Structure ID	Storage (ac-ft)
Project 7	Water booked over to the Exchange pool	28,100
UVWUA	4100520, 4100527, 4100534_D, 4100537, 4100545, 4100559, 4100577	11,200

Rec_USBR	6803675_M	19,200
Inactive Pool		25,067
Unallocated		900
Exchange	4100520, 4100527, 4100534_D, 4100537, 4100545, 4100559, 4100577	28,100
TOTAL		99,467

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 **Error! Reference source not found.**. These monthly distributions are used by the State Engineer's Office.

Table 5.9 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. Ruedi Reservoir Station (10006) was used t0 calculate evaporation for the following reservoirs: Meridian, Rainbow, 59_ARG001

3. Taylor Park Reservoir Station (10010) was used to calculate evaporation for the following reservoirs: Hot Springs, McDonough, McDonough No. 2, Needle Creek, Upper Dome, Vouga, Lower Dome, Boulder Lake, Peterson, 28_ARG001, Overland, Taylor Park, and 28_ARG001.
4. Blue Mesa Reservoir Station (10011) was used to calculate evaporation for the following reservoirs: Paonia, Blue Mesa, Morrow Point, Crystal, 62_ARG001, 62_ARG002, 68_ARG001, and 68_ARG002.
5. Ridgway Reservoir Station (10012) was used to calculate evaporation for the following reservoirs: 40_ASG001, 41_ARG001, 41_ASG001, 41_Cerro, 41_Fairview, 42_ARG001, 42_ASG001, Silverjack, 62_ASG001, Ridgway, 68_ARG001, 68_ASG001.

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

Table 5.10 Evaporation Estimates

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
10006	0.13	0.02	-0.09	-0.10	-0.02	0.07	0.17	0.32	0.41	0.42	0.29	0.24	1.86
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 was created by TSTool, which reads data from HydroBase and filled missing data with a variety of user-specified algorithms.

5.6.3.1 Key Reservoirs

Data for the 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. **Error! Reference source not found.** 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 5.11 Reservoir On-line Dates and EOM Contents Data Source

WDID	Reservoir Name	On-Line Date	Primary Data Source
2803590	Hot Springs	1956	Hydrobase
2803591	McDonough	1946	Hydrobase
2803592	McDonough No. 2	1956	Hydrobase
2803593	Needle Creek	1960	Hydrobase
2803594	Uppper Dome	1971	Hydrobase
2803595	Vouga	1956	Hydrobase
2803617	Lower Dome	1971	Capacity Used
2803652	Boulder Lake	1977	Capacity Used
2803674	Peterson	2002	Hydrobase
4003365	Fruitgrowers	1959	USBR
4003395	Fruitland	1962	Hydrobase
4003399	Overland No. 1	1962	USBR
4003416	Paonia	1962	USBR
4003553	Crawford	1963	USBR
5903666	Taylor Park	1937	USBR
41_Cerro	Cerro	1932	Capacity Used
41_Fairview	Fairview	1968	Capacity Used
6203532	Blue Mesa	1965	USBR
6203545	Morrow Point	1970	USBR
6203548	Silverjack	1971	USBR
6203578	Crystal	1977	USBR
6803675	Ridgway	1987	USBR

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.) Additionally, Ridgway has a "No Spill" operational target. Small mouth bass in Ridgway Reservoir present a significant threat to native fish and can escape over the spillway. Ridgway reduces storage in the spring in response to forecasted inflows to prevent a spill. Targets allow maximum control of reservoir levels by storage rights and releases to meet demands. The file was created by TSTool.

Future reservoirs included because of their investigation in the Gunnison Basin Implementation Plan are assigned a maximum target of zero. Meridian Lake has a maximum target set to existing capacity. Rainbow Lake has a maximum target of zero.

5.6.5. Reservoir Right File (*.rer)

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

5.6.5.1 Key Reservoirs

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

Ridgway Reservoir

Ridgway Reservoir (6803675) 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 6803679. This right has been re-assigned for modeling purposes to structure 6803675.

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.

Gunnison Basin Implementation Plan Reservoirs

The future reservoirs investigated under the GBIP have their water rights turned off, except for Meridian Reservoir, which is assigned its absolute and conditional water rights.

5.7 Instream Flow Files

5.7.1. Instream Flow Station File (*.ifs)

Thirty-four instream flow reaches are defined in this file, which was created in StateDMI. The file specifies an instream flow station and downstream terminus node for each reach, through which instream flow rights can exert a demand in priority. **Error! Reference source not found.** 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 (5903666_M).
- An instream flow node was added to reflect the National Park Service Black Canyon of the Gunnison filing (62_NPS).
- An instream flow node was added to reflect the U.S. Fish and Wildlife Service recommended flow targets (41_USFS) that have been incorporated into the Aspinall Unit Operations EIS (2012) and Record of Decision (2012).
- The Tri-County Water Conservancy District and the USBR have implemented a minimum flow requirement downstream of Ridgway Reservoir. From May 16 through October 31, the minimum flow is 75 cfs, and from November 1 through May 15, the minimum flow is 45 cfs. When inflows are insufficient to meet the downstream minimum flow, releases are made from the Recreation/USBR account. These operations are represented at node 6803675_M.

5.7.2. Instream Flow Annual 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 except for structures included in the Instream Demand Monthly File (*.ifm), see below.

5.7.3. Instream Flow Monthly Demand File (*.ifm)

There are three instream flow structures with variable demands:

- 62_NPS – National Park Instream Flow varies depending on natural inflows to Blue Mesa Reservoir from April 1 to July 31. The decree has established three hydraulic regimes. For each regime, an equation to calculate the baseflow is defined. Short duration recommended peak flows are not incorporated in the model due to the monthly time step.
- 41_USFWS – USFWS Recommended Flow varies depending on natural inflows to Blue Mesa Reservoir from April 1 to July 31. The flow targets have been simplified into three hydraulic regimes and monthly flow rates.
- 593666_Min – Minimum Bypass from Taylor Park Resevoir's targets are reduced during extremely dry years according to reservoir operators. Twelve monthly

instream flow demands were developed for each of the years in the study period.

5.7.4. Instream Right File (*.ifr)

Water rights for each instream flow reach modeled in the Gunnison Model are contained in the instream flow right file, and shown in **Error! Reference source not found.**. These data were obtained from the CWCB instream flow database with the exception of instream flow reaches listed in following Section 5.7.4.1 *Special Instream Flow Rights*.

Table 5.12 Instream Flow Summary

#	ID	Name	Administration Number	Decree (cfs)
1	2801057	COCHETOPA CREEK	48366.0000	4
2	2801060	GOLD CREEK	47558.0000	7
3	2801067	QUARTZ CREEK	47558.0000	10
4	2801072	TOMICHI CREEK SEG 1	47558.0000	9
5	2801077	HOT SPRINGS CREEK	49067.0000	1.5
6	2801078	COCHETOPA CREEK	49067.0000	8.5
7	2801079	TOMICHI CREEK SEG 2	47558.0000	18
8	2801087	ARCHULETA CREEK	49067.0000	0.5
9	2801097	MARSHALL CREEK	46705.0000	8
10	2801100	QUARTZ CREEK (NO2)	47558.0000	5
11	2801631	RAZOR CREEK	54187.0000	1.5
12	4002344	SMITH FORK GUNNISON RIVE	56978.5664	12.9
13	4002347	NORTH FORK GUNNISON R.	49067.0000	60
14	4003024	CLEAR FORK EAST MUDDY	58101.0000	13
15	42_USFWS	USFWS_Request	99999.0000	14350
16	5901273	Taylor_River_Vader	49673.4590	445
17	5901327	GUNNISON RIVER WHITEWATE	55517.5435	1200
18	5901401	MILL CREEK	47558.0000	5
19	5901402	CARBON CREEK	47558.0000	3
20	5901412	EAST RIVER	48577.4837	25
21	5901485	BRUSH CREEK SEG 1	48366.0000	12
22	5901493	OHIO CREEK SEGMENT 3	47558.0000	12
23	5901495	OHIO CREEK SEGMENT 2	47558.0000	10
24	5901505	SLATE RIVER SEGMENT 3	47558.0000	20
25	5901506	SLATE RIVER SEGMENT 4	47558.0000	23
26	5901511	STEUBEN CREEK	49067.0000	1
27	5901516	EAST RIVER	48577.4837	50
28	5901550	CEMENT CREEK	47558.0000	10
29	5901552	CASTLE CREEK	47558.0000	7
30	5901583	TAYLOR RIVER	45552.0000	55
31	5901610	EAST RIVER	48577.4837	10
32	5901814	BEAVER CREEK	54085.0000	7.25
33	5903666_M	Taylor_Min	30667.1994	400
34	6200579	CEBOLLA CREEK	47734.0000	4
35	6201331	LAKE FORK GUNNISON RIVER	47558.0000	45

36	6201339	BLUE CREEK	49067.0000	7
	6201339	BLUE CREEK	58465.0000	4.5
37	6201340	CIMARRON RIVER	49067.0000	25
38	6201540	Black_Canyon	42347.0000	300
39	6201682	CIMARRON RIVER	49067.0000	16
40	62_NPS	NPS-BlackCanyon	30376.0000	2500
41	6801084	BEAVER CREEK	49673.4907	1.5
42	6801129	OWL CREEK	49673.4907	1.5
43	6801153	WEST FORK DALLAS CREEK	49673.4907	2.5
44	6801447	DALLAS CREEK	54250.0000	20
45	6801456	UNCOMPAHGRE RIVER	54250.0000	65
46	6803675_M	Ridgway Min Flow Req	20269.1476	75

5.7.4.1 Special Instream Flow rights

Several reservoir bypass agreements and other operations are represented as instream flow reaches as follows:

- The Taylor River instream flow right (5901273) above the confluence with East Creek is stored in Hydrobase with a use type of “RECFISSTK”. Only use types of “MIN” are extracted using StateDMI. Therefore, the 445 cfs instream flow right with an administration number of 49673.45896 was set.
- The Gunnison River Whitewater Course (5901327) is a Recreational In-Channel Diversion (RICD). It is set for 1,200 cfs water right with an administration number of 55519.54349. Actual flow requests vary by season.
- The instream flow right used to represent the Taylor minimum bypass requirements at Taylor Park Reservoir (5903666_M) was set to reflect the 400 cfs bypass with an administration number of 30667.19939.
- The CWCB Black Canyon instream flow right (6201540) 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 set.
- The National Park Service instream flow agreement (62_NPS) right was set to 2500 cfs with an administration number of 30376.0000.
- The U.S. Fish and Wildlife Service request for an instream flow upstream of the Redland Power Canal (41_USFWS) was set to 14,350 cfs, which corresponds to the maximum peak flow request, with an administration number of 99999.00000.
- The instream flow right used to represent the minimum downstream flow requirement at Ridgway Reservoir (6803675_M) was set to 75 cfs from May 16 through October 31 and 45 cfs from November 1 through May 15. Under extreme drought conditions, the USBR may set a lower minimum flow requirement, but this aspect is not captured in the model. The administration number is 20269.14761, or just senior to Ridway Reservoir’s most senior storage right.

5.8 Plan Data File (*.pln)

The plan data file can contain information related to operating terms and conditions, well augmentation, water reuse, recharge, and out-of-priority plans. Plan structures are accounting tools used in coordination with operating rights to model complicated systems. In the Gunnison Model, a plan limits the monthly volume released from Blue Mesa Reservoir to help supplement the flows in the river to support the endangered fish recovery at node 42_USFWS. The instream flow node contains the streamflow levels desired by the USFWS at the Redlands Power Canal (4200541). The monthly volumetric limit is equal to the Morrow Point hydropower plant capacity of 5,450 cfs, converted to acre-feet.

5.9 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 remaining capacity.
- **Type 27** – provides a method to release water from a reservoir, reuse plan, accounting plan, or out-of-priority plan to a diversion, reservoir, or instream flow either directly via the river to by a carrier. In the Gunnison Model, the Type 27 operating rule is used to limit the releases from Blue Mesa to the instream flow node 41_USFWS to the Morrow Point power plant capacity of 5450 cfs.
- **Type 47 –** Accounting plan limit. This rule imposes monthly and annual limits on other operating rules. In the Gunnison Model, it is used to limit the releases from Blue Mesa to the instream flow node 41_USFWS to the Morrow Point power plant capacity of 5450 cfs.

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	Tomichi Creek Area

5.8.13 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.

5.9.1. Taylor Park Reservoir

Taylor Park Reservoir (5903666) 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		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 (6200617) from the UVWUA account. The senior administration number, which is junior to the Tunnel's direct flow decree, forces this rule to operate and release water 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 (5903666_M) demand located downstream of the reservoir. The demand reflects 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. As noted below, when these releases occur, they trigger a book over in Blue Mesa Reservoir that re-colors the water for subsequent UVWUS or UGRWCD use.

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

Operating rules 5 through 12 provide supplemental water to the 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" as 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.

5.9.2. Overland Reservoir and Ditch

Overland Reservoir (4003399) is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch (4000585) to Leroux Creek, then picked up by the Lower Overland Ditch (4000944). Overland Reservoir is operated with two accounts.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	6148

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

Four 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	Opr Overland to Target		99999.99999	9	Release to river by target
3	Lower Overland Ditch	Overland Ditch	21263.15919	11	Carrier to diversion
4	Lower Overland Ditch	Overland Ditch	21263.15919	11	Carrier to diversion

Operating rule 1 allows Lower Overland Ditch diversion system (4000944_D) to get reservoir releases by using Overland Ditch (4000585) 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 ditch.

Operating rule 2 releases water to meet storage target values. The junior administration number makes this the last operating rule to fire. This rule is 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, the rule is turned off.

Operating rule 3 allows Lower Overland Ditch (4000944_D) river water to be carried by the Overland Ditch (4000585) 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 4 allows Lower Overland Ditch (4000944_D) water to be carried by the Upper Overland Ditch (4000585) 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.

5.9.3. 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 (4003416) and the Fire Mountain Canal (4001133), 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:

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

Twenty-one 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	Drift Creek Ditch	2	43829.43799	4	Exchange to direct diversion
18	Filmore Ditch	2	43829.43799	4	Exchange to direct diversion
19	Streber Ditch	2	43829.43799	4	Exchange to direct diversion
20	Welch Mesa Ditch	2	43829.43799	4	Exchange to direct diversion
21	Opr Paonia to Target		99999.99999	9	Release to river by target

Operating rule 1 releases Paonia Reservoir water directly to Fire Mountain Canal (4001133). 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 20 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 the exchange potential as measured by the available water in Muddy Creek between the destination ditch and Paonia Reservoir.

Operating rule 21 releases water to meet operational targets per USBR operations. The junior administration number makes this the last operating rule to fire.

5.9.4. 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 (6203532), Morrow Point (6203545), and Crystal (6203578).

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 0:

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

Nineteen operating rules are used to simulate Aspinall Unit operations:

Right #	Destination	Acct #	Admin #	Right Type	Description
1	Power Plant Capacity Limit Accounting Plan		1.00000	47	Accounting Plan to limit releases
2	Opr Blue Mesa Bookover	1 to 3	1.00000	6	Reservoir account bookover
3	Opr Blue Mesa Bookover	1 to 3	1.00000	6	Reservoir account bookover
4	Opr Blue Mesa to Target		99999.99997	9	Release to river by target
5	Gunnison Tunnel	1	20393.18780	2	Release to direct diversion
6	Fairview Reservoir	1	20393.18780	2	Release to river to carrier
7	Black Canyon Instream Flow	1	56156.00000	1	Release to instream flow demand
8	South Canal	1	20393.18780	2	Release to river to carrier
9	West Canal	1	20393.18780	2	Release to river to carrier
10	Montrose and Delta Canal	1	20393.18780	2	Release to river to carrier
11	Loutsenhizer Canal	1	20393.18780	2	Release to river to carrier
12	Selig Canal	1	20393.18780	2	Release to river to carrier
13	Ironstone Canal	1	20393.18780	2	Release to river to carrier
14	East Canal	1	20393.18780	2	Release to river to carrier
15	Garnet Canal	1	20393.18780	2	Release to river to carrier
16	NPS Black Canyon Instream Flow	1	99999.99998	1	Release to instream flow demand
17	USFWS Instream Flow	1	99999.99999	27	Release to instream flow demand, limited accounting plan “Power Plant Capacity”
18	Opr Morrow Point Target		99999.99997	9	Release to river by target
19	Opr Crystal to Target		99999.99997	9	Release to river by target

Operating rule 1 is an accounting plan that tracks the amount of water released by operating rule 17 – USFWS Instream Flow. Because the USFS Instream Flow does not have a Colorado water right, the accounting plan limits the releases to Morrow Point power plant capacity of 5,450 cfs, converted to acre-feet.

Operating rules 2 and 3 book water over 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 (Taylor Park rule 2), or from the UGRWCD’s refill account (Taylor Park rule 3) to meet minimum flows.

Operating rule 4 releases water to meet operational targets per USBR operations. The rule fires after releases to consumptive use demands, but before any releases are made to non-consumptive demands with the exception of the CWCB instream flow right. This allows water released for operational targets to first be used to meet the National Park Service (62_NPS) and the USFWS (42_USFWS) instream flow targets before additional water is released.

Operating rule 5 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.

Operating rule 6 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 7 provides Blue Mesa Reservoir storage water to the CWCB Black Canyon instream flow water right (6201540). The administration number is set just junior to the administration number of the instream flow right. 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.

Operating rules 8 through 15 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 calibration when the UVWUA demands is at the Gunnison Tunnel.

Operating rule 16 provides Blue Mesa Reservoir storage water from the USA account to a NPS Black Canyon instream flow node. The administration number is set to just junior of the release to target rule. Therefore, this rule will only release water if there is not enough in the instream flow reach after almost all other reservoir operations. The amount of water releases is restricted by the amount of water available in the USA account and the flow through the instream flow reach.

Operating rule 17 provides Blue Mesa Reservoir storage water from the USA account to the USFWS instream flow node. The administration number is set to the most junior reservoir operation. Therefore, the rule will only release water after all other reservoir operations. The amount of water releases is restricted by the accounting plan established in operating rule 1: Power Plant Capacity.

Operating rule 18 releases water to meet the storage target values for Morrow Point Reservoir. The administration number is junior to all reservoir operations, except for releases to the NPS Black Canyon and USFWS instream flow nodes.

Operating rule 19 releases water to meet the storage target values for Crystal Reservoir. The administration number is junior to all reservoir operations, except for releases to the NPS Black Canyon and USFWS instream flow nodes.

5.9.5. 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 (6200617), storage in Taylor Park, Blue Mesa and Ridgway reservoirs.

The operating rules associated with the storage for the Uncompahgre Project are detailed in the Aspinall Unit section. 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 the Gunnison Tunnel priority is junior to the Uncompahgre diversion structures direct flow rights on the Uncompahgre River. 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.

5.9.6. Dallas Creek Project

The Dallas Creek Project and its principal component, Ridgway Reservoir (6803675), provide supplemental water supplies for municipal, industrial and irrigation uses in the Uncompahgre valley. Ridgway Reservoir is modeled with six accounts, which are listed below and described in more detail in Section 0.

Acct	Owner	Capacity (acre-feet)
1	Project 7	28,100
2	UVWUA	11,200
3	Rec_USBR	19,200
4	Inactive Pool	25,067
5	Unallocated	900
6	Exchange	28,100

Twenty-one operating rules are used to simulate Ridgway operations:

Right #	Destination	Acct #	Admin #	Right Type	Description
1	Bookover Blue Mesa	1 to 6	1.00000	6	Reservoir account bookover
2	Bookover Gunn Tunn	1 to 6	1.00000	6	Reservoir account bookover
3	Montrose and Delta Canal	6	20393.18780	2	Release to direct diversion
4	Loutsenhizer Canal	6	20393.18780	2	Release to direct diversion
5	Selig Canal	6	20393.18780	2	Release to direct diversion
6	Ironstone Canal	6	20393.18780	2	Release to direct diversion
7	East Canal	6	20393.18780	2	Release to direct diversion
8	Garnet Canal	6	20393.18780	2	Release to direct diversion
9	West Canal	6	20393.18780	2	Release to direct diversion
10	Montrose and Delta Canal	2	20393.18781	2	Release to direct diversion
11	Loutsenhizer Canal	2	20393.18781	2	Release to direct diversion
12	Selig Canal	2	20393.18781	2	Release to direct diversion
13	Ironstone Canal	2	20393.18781	2	Release to direct diversion
14	East Canal	2	20393.18781	2	Release to direct diversion

15	Garnet Canal	2	20393.18781	2	Release to direct diversion
16	West Canal	2	20393.18781	2	Release to direct diversion
17	Ridgway to Target		99999.99999	9	Release to river by target
18	Bookover Exchange	6 to 2	1.00000	6	Reservoir account bookover
19	Bookover Exchange	6 to 1	1.00000	6	Reservoir account bookover
20	Bookover Exchange	6 to 3	1.00000	6	Reservoir account bookover
21	Min Flow	3	99999.99999	1	Release to instream flow

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 6. Water stored in this exchange account 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 the Uncompahgre Project 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 delivery system.

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 makes this operating rule fire after all releases to downstream users. For the historical calibration, end-of-month targets are set to historical storage values because the “No Spill” guidelines are highly flexible and depend heavily on the both the short term and long term inflow forecasts. For the Baseline data set, end-of-month targets for Ridgway Reservoir are set to the "No Spill" guideline targets.

The Exchange account cannot be carried over after the end of the irrigation season. Operating rules 18 through 20 allow any remaining water in the Exchange account to be re-distributed back to the Project 7, UVWUA, and the Recreation/USBR accounts in October.

Operating rule 21 releases water from the Recreation/USBR account to the instream flow node (683675_MIN). This node represents the required streamflow downstream of the reservoir. It can be met from any other releases or by-pass from the reservoir. When it is not met through other releases, the junior administration number makes this the last rule to fire.

5.9.7. 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 (4003553). 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.

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

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

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Crawford Reservoir	Smith Fork Feeder Canal	38064.35309	11	Carrier to reservoir
2	Crawford Reservoir	Smith Fork Feeder Canal	47847.47095	11	Carrier to reservoir
3	Grandview Ditch	Aspen Ditch	21263.18487	11	Carrier to diversion
4	Grandview Ditch	Aspen Ditch	25807.23557	11	Carrier to diversion
5	Grandview Ditch	Aspen Ditch	31924.18487	11	Carrier to diversion
6	Needle Rock Ditch	Aspen Canal	38064.35309	11	Carrier to diversion

7	Clipper Ditch	1	31924.12152	3	Release to carrier
8	Daisy Ditch	1	31924.13697	4	Exchange to diversion
9	Virginia Ditch	1	31924.13868	4	Exchange to diversion
10	Grandview Ditch	1	31924.18488	2	Release to diversion with carrier
11	Needle Rock Ditch	1	31924.29261	4	Exchange to diversion
12	Saddle Mountain Ditch	1	31924.29276	4	Exchange to diversion
13	Needle Rock Ditch	1	38064.35308	2	Release to diversion with carrier
14	Opr Crawford to Target		99999.99999	9	Release to river by target

Operating rules 1 and 2 deliver Smith Fork Feeder (4000605) water to Crawford Reservoir (4003553). 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.

Operating rules 3 through 5 deliver water carried through Aspen Ditch (4000508) to Grandview Ditch (4000503). 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 Grandview Ditch (4000503). Note that these rules are not active during the historic simulation.

Operating rule 6 delivers water carried through Aspen Canal (4000509) to Needle Rock Ditch (4000501). 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 Needle Rock Ditch. Note that this rule is not active during the historic simulation.

Operating rule 7 provides Crawford Reservoir storage water from the irrigation account to the Clipper Ditch (4000500) 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 rules 8, 9, 11, and 12 provide Crawford Reservoir storage water from the irrigation account to Daisy Ditch (4000536), Virginia Ditch (4000616), Needle Rock Ditch (4000501), and Saddle Mountain Ditch (4000502) 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 10 provides Crawford Reservoir storage water from the irrigation account to the Grandview Canal (4000503) via the carrier structure Aspen Ditch (4000508). 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 Grandview ditch.

Operating rule 13 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 14 releases water to meet storage target values for Crawford Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.8. Fruitland Mesa

Fruitland Mesa includes Fruitland Reservoir (aka Gould Reservoir, 4003395) and a transbasin diversion from Crystal Creek, which irrigates 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 (4000549) is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir. The model node 4000549_I was included in the model network to simulate the irrigation demand for Fruitland Canal (4000549).

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

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	4000549_I	Fruitland Canal	21263.18764	11	Carrier to diversion
2	Fruitland Reservoir	Fruitland Canal	25807.18764	11	Carrier to reservoir
3	4000549_I	Fruitland Canal	25807.23557	11	Carrier to diversion
4	4000549_I	Fruitland Canal	31924.18764	11	Carrier to reservoir
5	Fruitland Reservoir	Fruitland Canal	31924.18764	11	Carrier to diversion

6	4000549_I	1	31924.18766	2	Release to direct diversion
7	Opr Fruitland to Target		99999.99999	9	Release to river by target

Operating rules 1, 3, and 5 divert water from Crystal Creek to Fruitland irrigation demand (4000549_I) using Fruitland Canal's (4000549) three irrigation rights. Operating rules 2 and 4 divert water from Crystal Creek to Fruitland Reservoir using the two water rights with storage use. 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 4000549_I or storage capacity in Fruitland Reservoir.

Operating rule 6 releases water from Fruitland Reservoir to 4000549_I 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 4000549_I.

Operating rule 7 releases water to meet storage target values for Fruitland Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.9. 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 (6203548) and the Cimarron Canal (6200560). 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 6200560_I represents the irrigation demand only.

Operating rules allow Cimarron Canal to divert direct flow rights for irrigation (6200560_I) and storage in Cerro Reservoir (41_Cerro.) 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	6200560_I	Cimarron Canal	19810.19448	11	Carrier to diversion
2	Cerro Reservoir	Cimarron Canal	19810.19448	11	Carrier to reservoir
3	6200560_I	Cimarron Canal	20393.20175	11	Carrier to diversion
4	Cerro Reservoir	Cimarron Canal	20393.20175	11	Carrier to reservoir
5	6200560_I	Cimarron Canal	27585.27545	11	Carrier to diversion
6	Cerro Reservoir	Cimarron Canal	27585.27545	11	Carrier to reservoir
7	6200560_I	1	38532.00001	2	Reservoir to river to carrier
8	Opr Silverjack to Target		99999.99999	9	Release to river by target

Operating rules 1 through 6 allow both the irrigation (6200560_I) and municipal demands (Cerro Reservoir) to be served by the Cimarron Canal's three water 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 6200560_I or storage capacity in Cerro Reservoir.

Operating rule 7 releases water from Silverjack Reservoir to the irrigation component (6200560_I) 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 8 releases water to meet storage target values for Silverjack Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.10. Project 7 Water Authority

Project 7 (41_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 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 provides water, by agreement, from UVWUA sources via the Gunnison Tunnel to Fairview Reservoir, in exchange for storage in Ridgway Reservoir.

Fairview Reservoir is operated to meet demands of Project 7 water users. There is no modeled inflow to Fairview Reservoir – all water is from Blue Mesa storage and delivered by the Gunnison Tunnel or from UVWUA Gunnison Tunnel water in exchange for storage in Ridgway Reservoir.

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

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	27585.27548	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 Operating rule 1. The amount of water released is limited by the available capacity in Fairview Reservoir, and the unsatisfied Project 7 demand.

5.9.11. 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 is primarily return flows to Alfalfa Run Tongue and Surface Creeks irrigation diversions. 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

Eleven operating rules are used to simulate Fruitgrowers operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Alfalfa D Irrigation	Alfalfa Ditch	11674.00000	11	Carrier to diversion
2	Alfalfa D Irrigation	Alfalfa Ditch	22370.00000	11	Carrier to diversion
3	Alfalfa D Irrigation	Alfalfa Ditch	29260.23550	11	Carrier to diversion
4	Alfalfa D Irrigation	Alfalfa Ditch	56978.11674	11	Carrier to diversion
5	Fruitgrowers Reservoir	Alfalfa Ditch	20501.17820	11	Carrier to reservoir
6	Fruitgrowers Reservoir	Alfalfa Ditch	38064.17820	11	Carrier to reservoir
7	Fruitgrowers Reservoir	Transfer Ditch	27528.00000	11	Carrier to reservoir
8	Fruitgrowers Reservoir	Transfer Ditch	29261.00000	11	Carrier to reservoir
9	Alfalfa Irrigation	1	56978.11675	7	Exchange to Carrier
10	Stell Enlargement Ditch	1	38064.31951	2	Release to direct diversion
11	Opr Fruitgrowers to Target		99999.99999	9	Release to river by target

O p O p O p e

Operating rules 1 through 4 allow water to be carried from Surface Creek to the Alfalfa Ditch Irrigation (4000751_I) demand via Alfalfa Ditch (4000751). The administration numbers for these operating rules correspond to Alfalfa Ditch's irrigation water rights. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Alfalfa ditch) rights, and irrigation demand.

Operating rules 5 and 6 allow Fruitgrowers Reservoir to fill through the Alfalfa Ditch (4000751). The administration numbers for these two operating rules correspond to the Alfalfa Ditch diversion rights that include storage as a use. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Alfalfa Ditch) rights, and storage capacity in Fruitgrowers Reservoir.

Operating rules 7 and 8 allow Fruitgrowers Reservoir to fill through the Transfer Ditch (4000821) on Currant Creek. 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 9 provides releases from Fruitgrowers Reservoir irrigation account to meet the supplemental needs of Alfalfa Ditch Irrigation demands (4000751_I). The administration number is just junior to Alfalfa Ditch's direct diversion rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied irrigation demand.

Operating rule 10 allows releases from Fruitgrowers Reservoir irrigation account to meet the supplemental needs of Stell Enlargement Ditch diversion system (4000820_D). 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 11 releases water to meet storage target values for Fruitgrowers Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.12. Operations in the Tomichi Creek Area

5.9.12.1 Needle Creek Reservoir

Eight operating rules are used to model releases from the single irrigation account:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Needle Creek Ditch	1	28311.11110	2	Release to diversion
2	Owen No. 2 Ditch	1	16192.12054	2	Release to diversion
3	Shipman Laterals No. 1&2	1	28311.19604	2	Release to diversion
4	Owen No. 3 Ditch	1	16192.11841	2	Release to diversion
5	Ty Watson Ditch	1	16192.11838	2	Release to diversion
6	Hoover #1	1	16192.11839	2	Release to diversion
7	Hoover #2	1	16192.11840	2	Release to diversion
8	Opr Needle to Target		99999.99999	9	Release to river by target

Operating rules 1 through 4 release from Needle Creek Reservoir (2803593) irrigation account to meet the supplemental needs of Needle Creek Ditch (2800658), Owen No. 2 Ditch (2800666), Shipman Laterals No. 1&2 (2800684), and Owen No. 3 Ditch (2800849). The administration numbers are just junior to the ditch's direct flow rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demand.

Operating rules 5 through 7 release from Needle Creek Reservoir irrigation account to meet the full irrigation needs of Ty Watson Ditch (2801151), Hoover #1 Ditch (2801152), and Hoover #2 Ditch (2801153). The administration numbers are just senior to releases to supplemental irrigation demands from Needle Creek Reservoir. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demand.

Operating rule 8 releases water to meet storage target values for Needle Creek Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.12.2 Vouga Reservoir

Eleven operating rules are used to model releases from the single irrigation account:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Anna No. 1	1	28311.12541	2	Release to diversion
2	Anna No. 2	1	28311.12541	2	Release to diversion
3	Hirdman Ditch DivSys	1	28311.10744	2	Release to diversion
4	Snyder Ditches No.s 1&2	1	28311.11110	2	Release to diversion
5	Snyder Rouser Ditch	1	28311.23862	2	Release to diversion
6	A B Coats Ditch	1	28311.10333	2	Release to diversion
7	Ernest Vouga Ditch	1	35168.25000	2	Release to diversion
8	Kennedy Ditch No. 1	1	28311.10302	2	Release to diversion
9	Kennedy Ditch No. 2	1	10301.00001	2	Release to diversion
10	Watson Ditch No. 1	1	47847.40634	2	Release to diversion
11	Opr Vouga to Target		99999.99999	9	Release to river by target

Operating rules 1 through 10 releases from Vouga Reservoir (2803595) irrigation account to meet the supplemental needs of Anna No. 1 Ditch (2800507), Anna No. 2 Ditch (2800508), Hirdman Ditch (2800586_D), Snyder Ditches Nos 1&2 (2800687), Snyder Rouser Ditch (2800689), A B Coats Ditch (2800719), Ernest Vouga Ditch (2800781), Kennedy Ditch No. 1 (2800806), Kennedy Ditch No. 2 (2800807), and Watson Ditch No. 1 (2801055). The administration numbers are just junior to the each ditches direct flow rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demands.

Operating rule 11 releases water to meet storage target values for Vouga Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.12.3 Hot Springs Reservoir

Eleven operating rules are used to model releases from the single irrigation account:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Bennet Morton	1	16192.13660	2	Release to diversion
2	Hot Springs No. 1	1	16192.14215	2	Release to diversion
3	L L Bush Ditch No. 1	1	35168.27911	2	Release to diversion
4	L L Bush Ditch No. 2	1	35168.27912	2	Release to diversion
5	L L Bush Ditch No. 3	1	35168.27913	2	Release to diversion
6	L L Bush Ditch No. 4	1	35168.27914	2	Release to diversion
7	L L Bush Ditch No. 5	1	35168.27915	2	Release to diversion
8	Wicks Rowser	1	16192.11607	2	Release to diversion
9	McDonald Berdel Ex. D	1	19066.00001	2	Release to diversion
10	L L Bush Ditch No. 6	1	51134.40268	2	Release to diversion
11	Opr Hot Springs to Target	1	99999.99999	9	Release to river by target

Operating rules 1 through 10 release from Hot Springs Reservoir (2803590) irrigation account to meet the supplemental needs of Bennett Morton Ditch (2800513), Hot Springs No. 1 Ditch (2800589), L L Bush No. 1 Ditch (2800613), L L Bush No. 2 Ditch (2800614), L L Bush No. 3 Ditch (2800615), L L Bush No. 4 Ditch (2800616), L L Bush No. 5 Ditch (2800617), Wicks Rowser Ditch (2800714), McDonald Ditch (2800823), and L L Bush No. 6 Ditch (2801185). The administration numbers are just junior to the each ditches direct flow rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demands.

Operating rule 11 releases water to meet storage target values for Hot Springs Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.12.4 McDonough Reservoir

Six operating rules are used to model releases from the single irrigation account:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Billy Sanderson	1	16192.13660	2	Release to diversion
2	Government	1	16192.14215	2	Release to diversion
3	McDonough	1	35168.27911	2	Release to diversion
4	Miller	1	35168.27912	2	Release to diversion
5	Northside	1	35168.27913	2	Release to diversion
6	Opr McDonough to Target	1	99999.99999	9	Release to river by target

Operating rules 1 through 5 release from McDonough Reservoir (2803591) irrigation account to meet the supplemental needs of Billy Sanderson Ditch (2800517), Government Ditch (2800568_D), McDonough Ditch (2800636), Miller Ditch (2800652), and Northside Ditch (2800661). The administration numbers are just junior to the each ditches direct flow rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demands.

Operating rule 6 releases water to meet storage target values for McDonough Reservoir. The junior administration number makes this 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, the rule is turned off.

5.9.13. Gunnison Basin Implementation Plan Reservoirs

The future reservoirs considered under the Gunnison Basin Implementation Plan are included in the model, but with no operations. Suggested operating rules are included in the gm2015B.opr file, but are turned off. The user is responsible turning on the reservoirs and checking that the operations are working as intended.

5.9.14. 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 (*.str).

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

Error! Reference source not found. shows, for each gage, the average annual flow from the Baseline simulation, based on the entire simulation period (1909 through 2013). 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 or the same as 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.

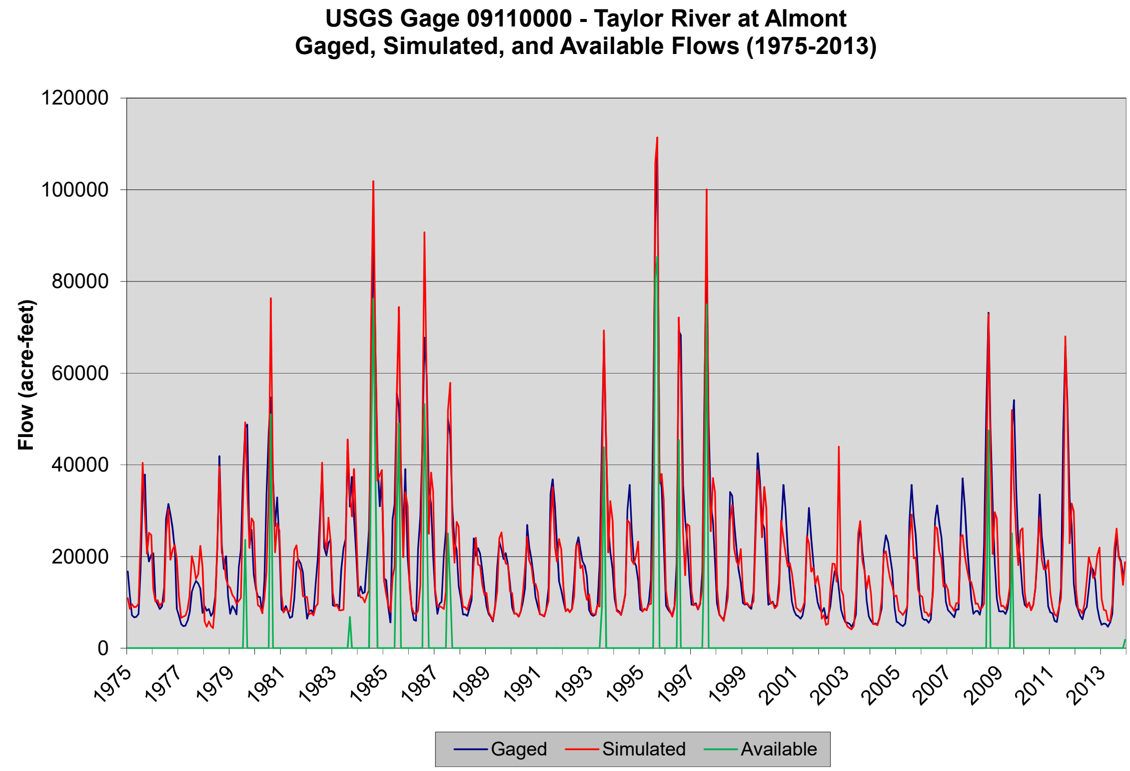
Temporal variability of the historical and Baseline simulated flows is illustrated in **Error! Reference source not found.** through **Error! Reference source not found.** for selected gages. Each figure shows two graphs: overlain hydrographs of historical gage flow, simulated gage flow, and simulated available flow for 1975 through 2013; 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 2013.

Baseline simulated flows are higher than historical flows during the irrigation season on the Gunnison River below Blue Mesa. This is, in part, due to increased reservoir releases required to meet the higher Baseline demands, but primarily due to changes in Aspinall operations to meet NPS and USFWS demands.

Table 6.1 Simulated and Available Baseline Average Annual Flows for Gunnison Model Gages 1909-2013

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
9109000	Taylor River Below Taylor Park Reservoir	148,997	16,850
9110000	Taylor River at Almont	238,264	22,490
9110500	East River Near Crested Butte	104,529	24,117
9111500	Slate River Near Crested Butte	99,426	24,698
9112000	Cement Creek Near Crested Butte	25,741	5,480
9112200	East River Below Cement Creek NR Crested Butte	239,499	47,367
9112500	East River at Almont	240,870	48,644
9113300	Ohio Creek at Baldwin	39,524	9,717
9113500	Ohio Creek Near Baldwin	63,059	13,247
9114500	Gunnison River Near Gunnison	521,745	67,285
9115500	Tomichi Creek at Sargents	44,011	7,418
9118000	Quartz Creek Near Ohio City	40,530	6,843
9118450	Cochetopa Creek Below Rock Creek Near Parlin	28,200	2,719
9119000	Tomichi Creek at Gunnison	123,973	27,366
9121500	Cebolla Creek Near Lake City	11,274	2,049
9122000	Cebolla Creek at Powderhorn	71,949	13,570
9124500	Lake Fork at Gateview	172,939	36,264
9126000	Cimarron River Near Cimarron	70,388	15,147
9127500	Crystal Creek Near Maher	23,857	1,985
9128000	Gunnison River Below Gunnison Tunnel	831,120	352,966
9128500	Smith Fork Near Crawford	32,847	6,789
9130500	East Muddy Creek Near Bardine	61,477	40,657
9131200	West Muddy Creek Near Somerset	20,687	14,141
9132500	North Fork Gunnison River Near Somerset	338,109	162,477
9134000	Minnesota Creek Near Paonia	16,908	5,811
9134500	Leroux Creek Near Cedaredge	37,042	8,206
9135900	Leroux Creek at Hotchkiss	21,371	16,423
9136200	Gunnison River Near Lazear	1,215,107	561,819
9137050	Currant Creek Near Read	6,757	5,330

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
9137800	Dirty George Creek Near Grand Mesa	5,513	344
9139200	Ward Creek Near Grand Mesa	9,629	2,715
9141500	Youngs Creek Near Cedaredge	2,610	1,049
9143000	Surface Creek Near Cedaredge	31,996	3,860
9143500	Surface Creek at Cedaredge	22,201	3,877
9144200	Tongue Creek at Cory	37,153	30,811
9144250	Gunnison River at Delta	1,390,783	595,321
9146200	East Fork Dallas Creek Near Ridgway	123,588	42,522
9146400	Dallas Creek Near Ridgway	9,017	1,309
9146500	Beaver Creek Near Ridgway	19,190	4,344
9146550	West Fork Dallas Creek Near Ridgway	2,916	725
9147000	Uncompahgre River Near Ridgway	24,241	8,414
9147100	Cow Creek Near Ridgway	45,163	23,549
9147500	Uncompahgre River at Colona	187,228	74,623
9149420	Spring Creek Near Montrose	41,633	27,932
9149500	Uncompahgre River at Delta	224,890	175,656
9150500	Roubideau Creek at Mouth, Near Delta	93,975	70,556
9152000	Kannah Creek Near Whitewater	21,150	7,150
9152500	Gunnison River Near Grand Junction	1,856,714	604,489



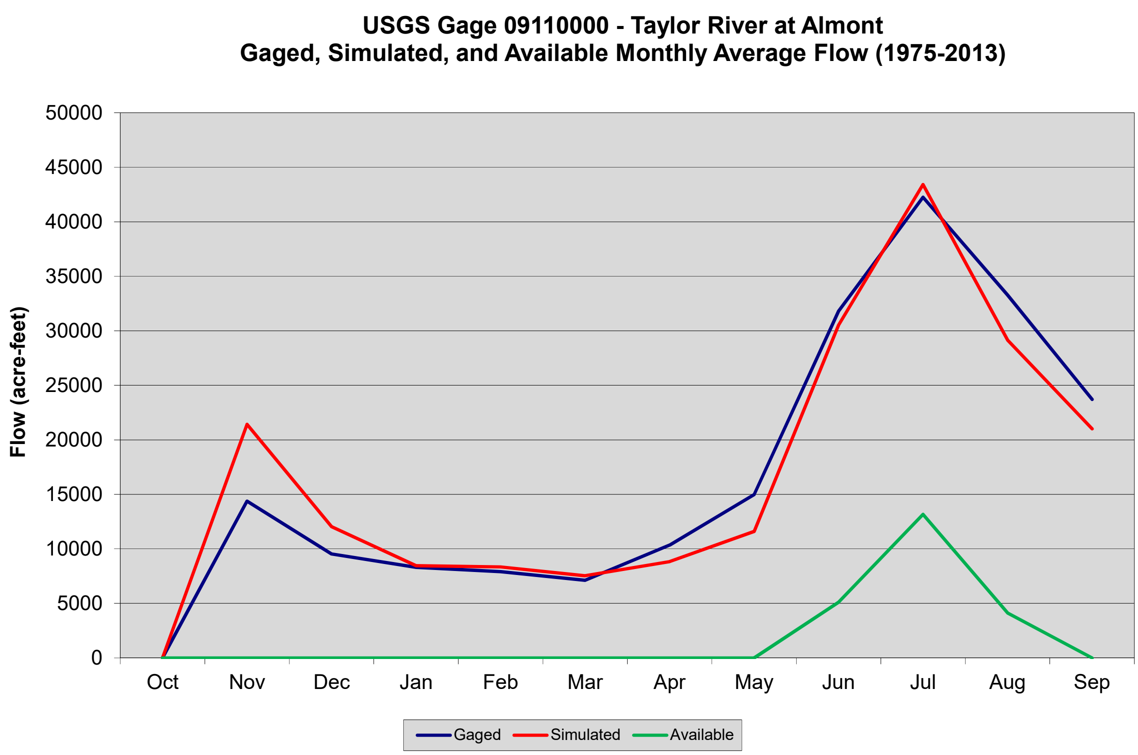
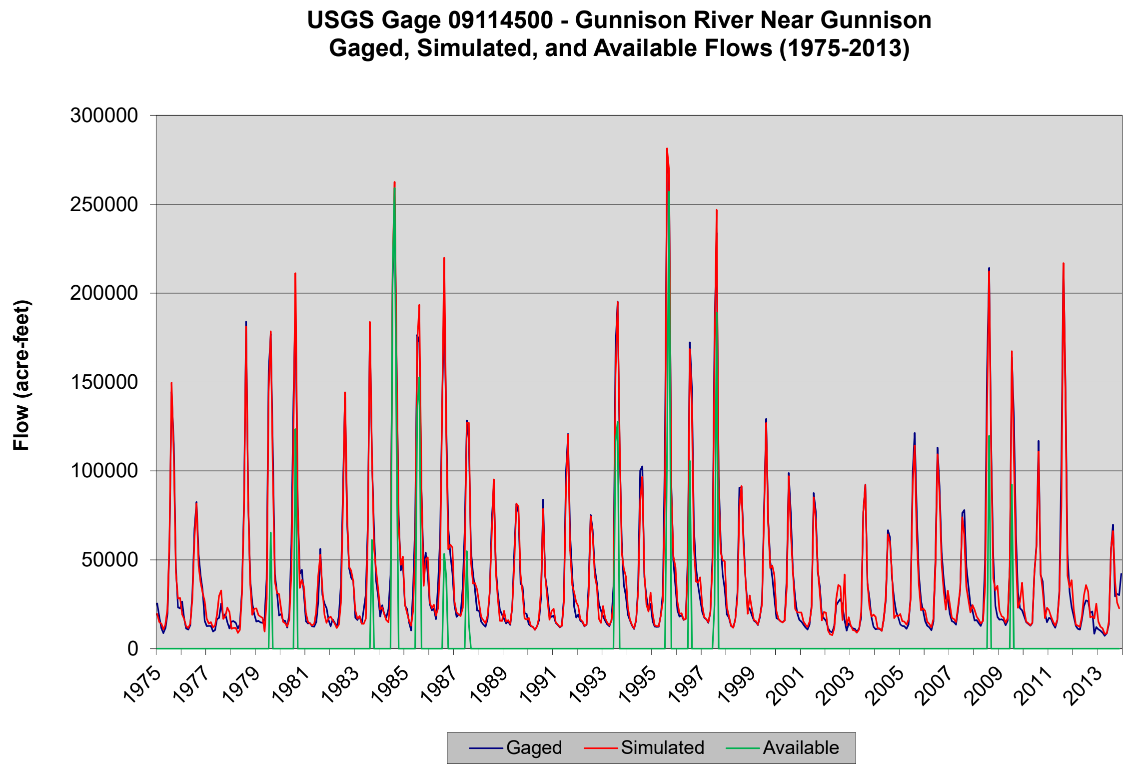


Figure 6.1 Baseline Results – Taylor River at Almont



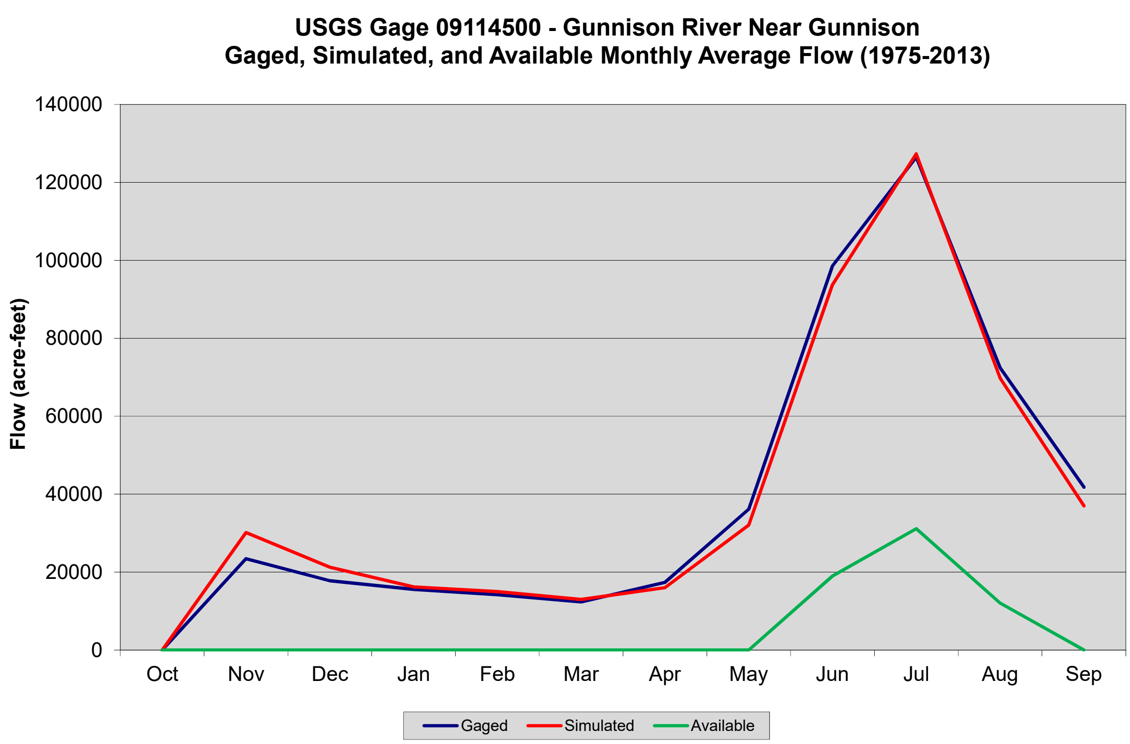
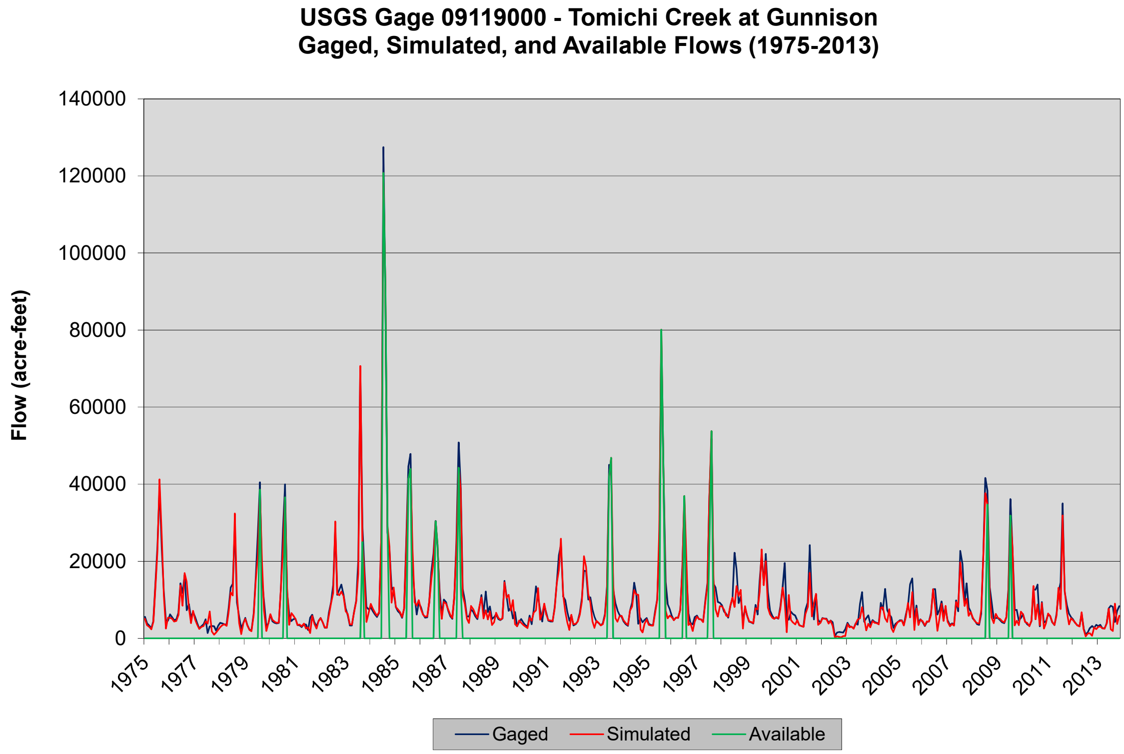


Figure 6.2 Gunnison River near Gunnison



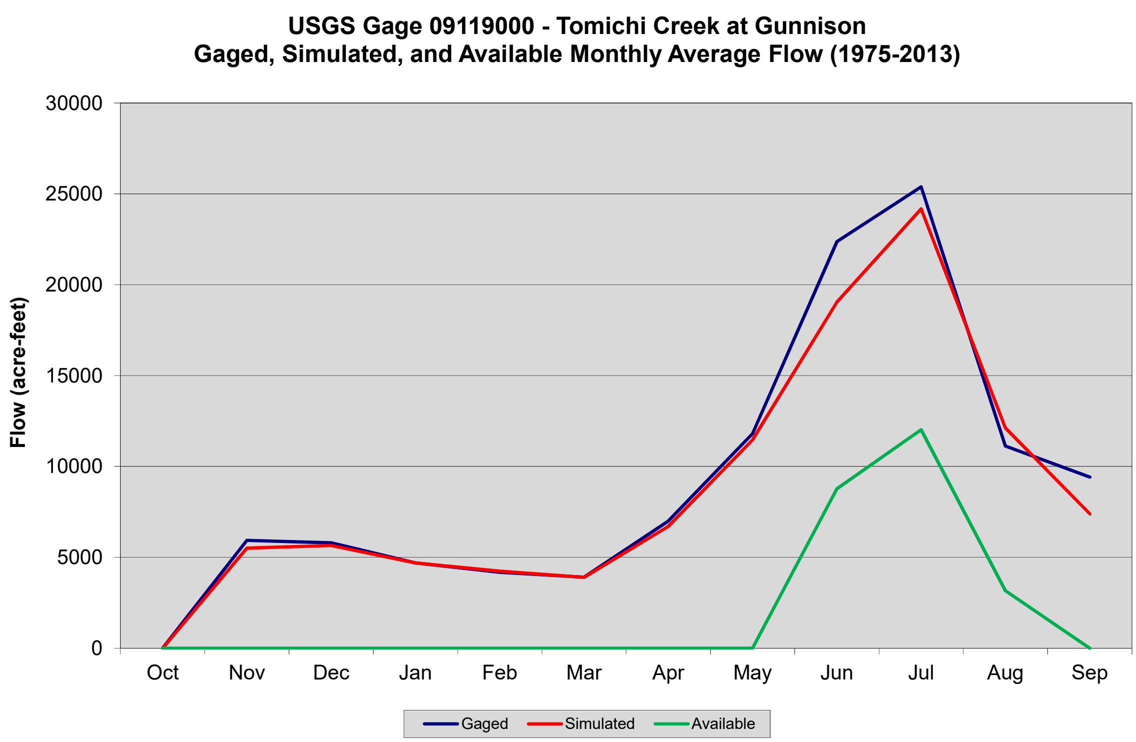
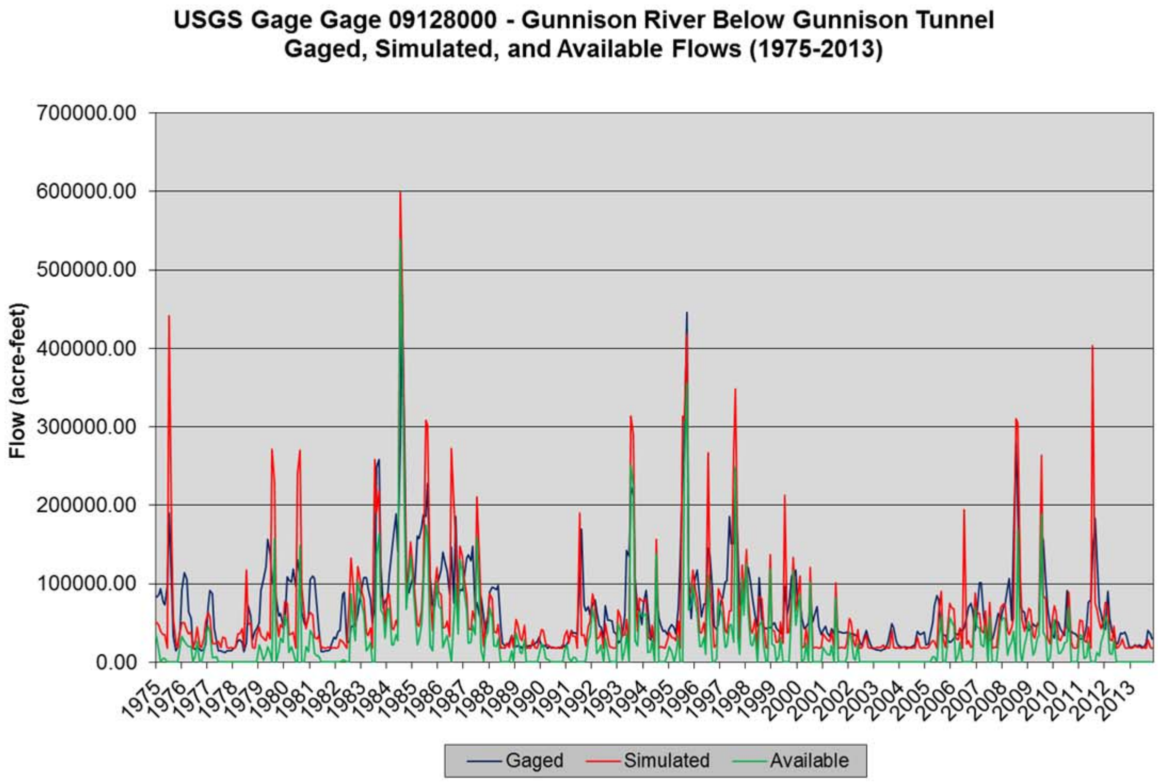


Figure 6.3 Baseline Results Tomichi Creek at Gunnison



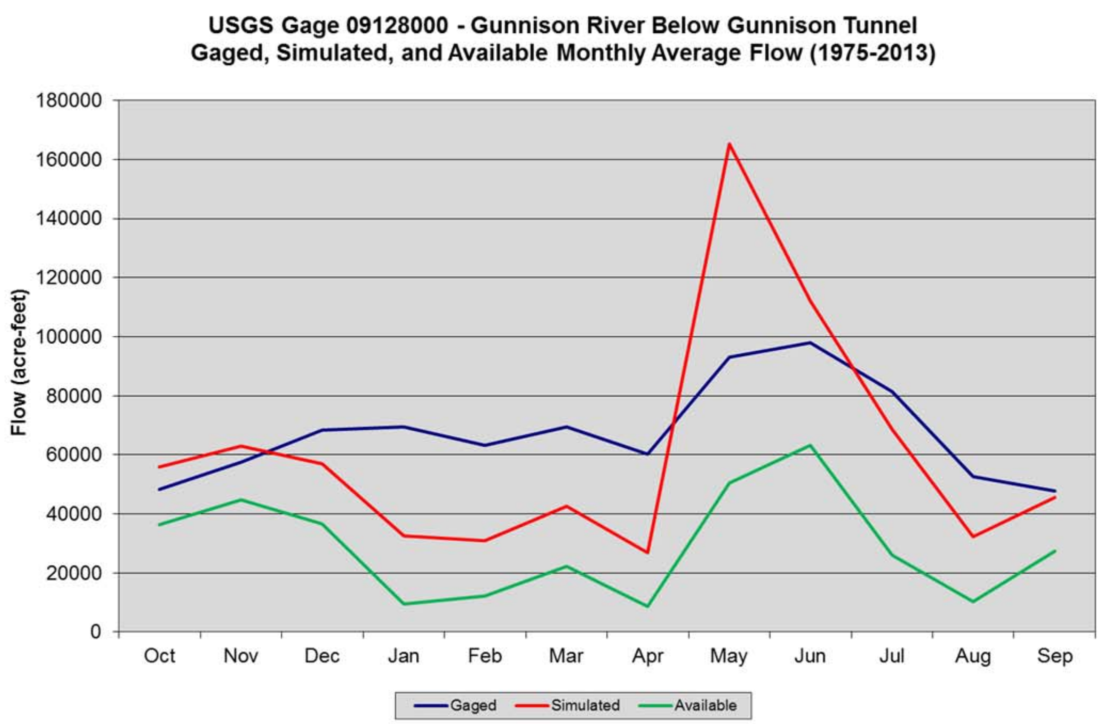
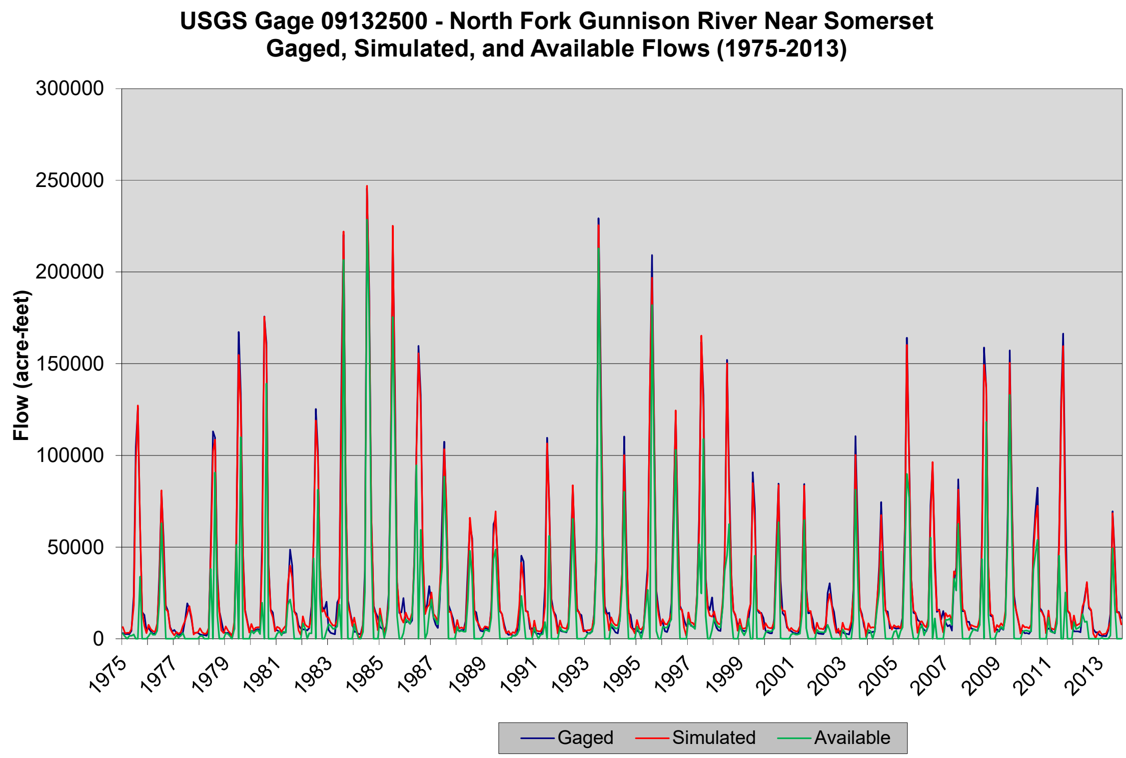


Figure 6.4 Baseline Results – Gunnison River below Gunnison Tunnel



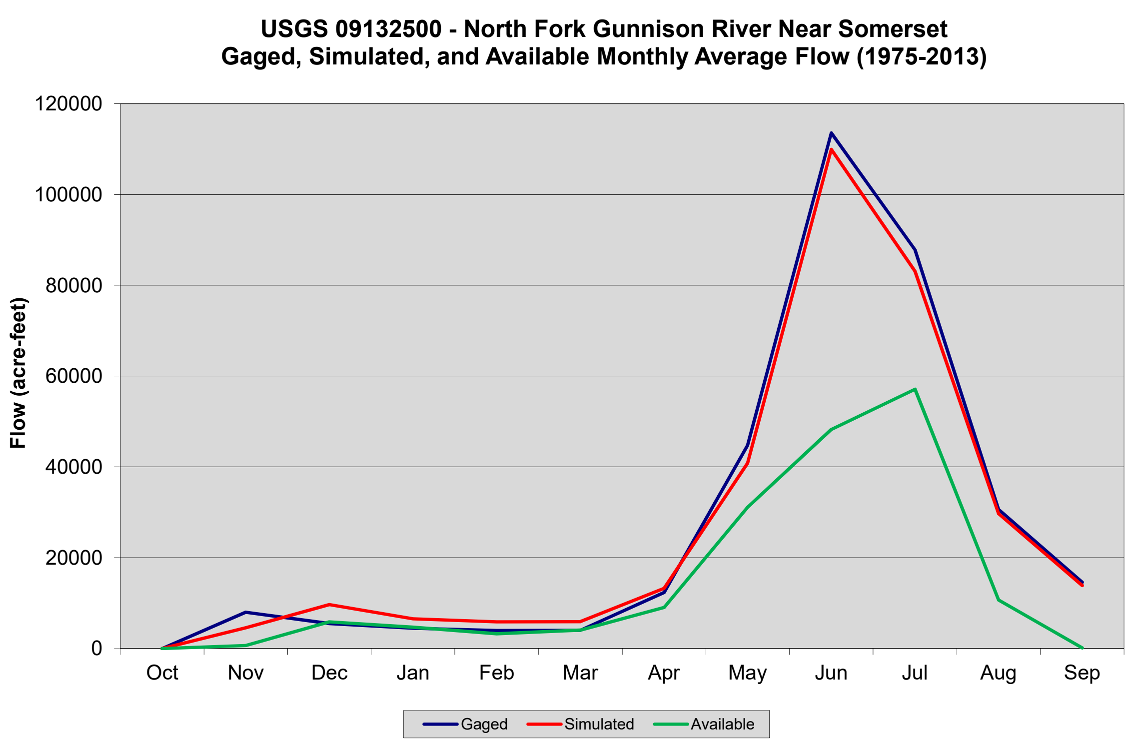
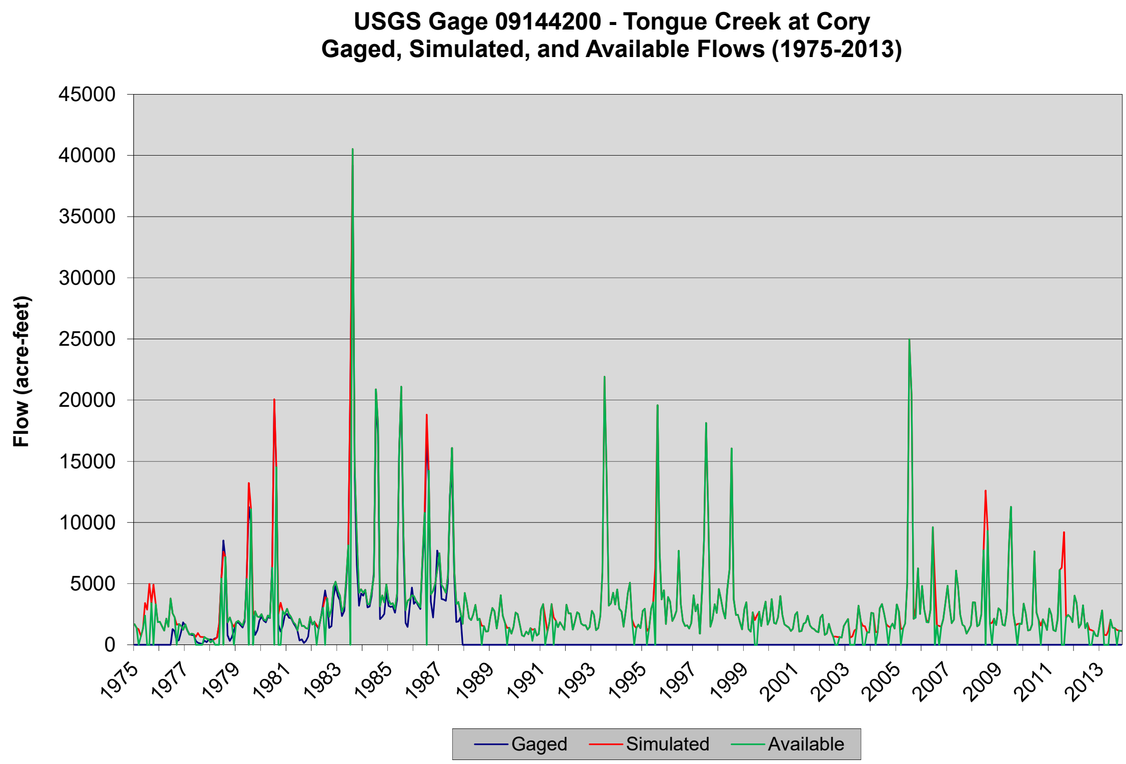


Figure 6.5 Baseline Results – North Fork Gunnison River near Somerset



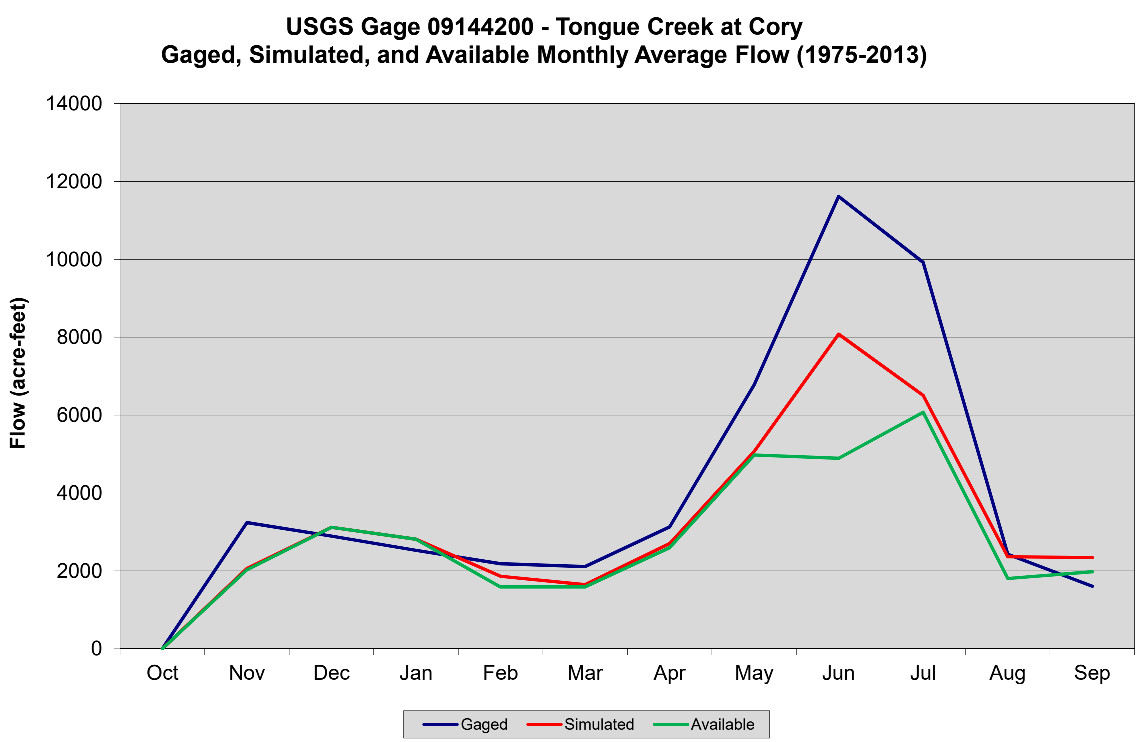
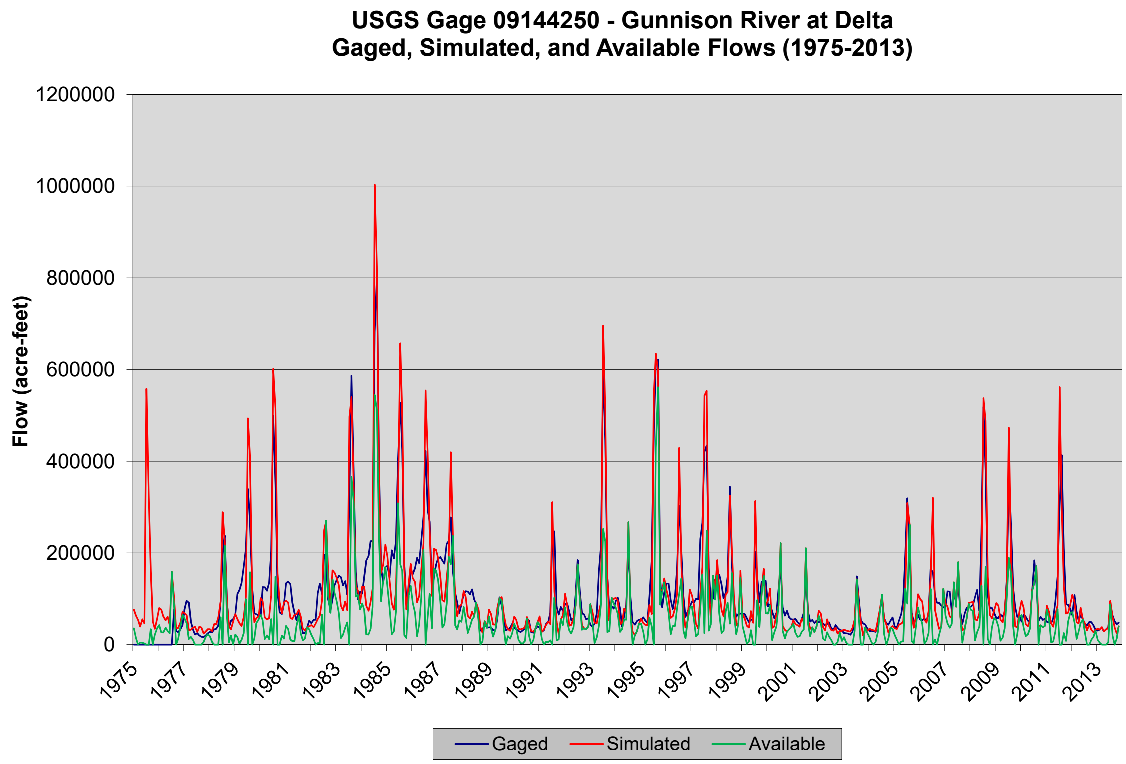


Figure 6.6 Baseline Results – Tongue Creek at Cory



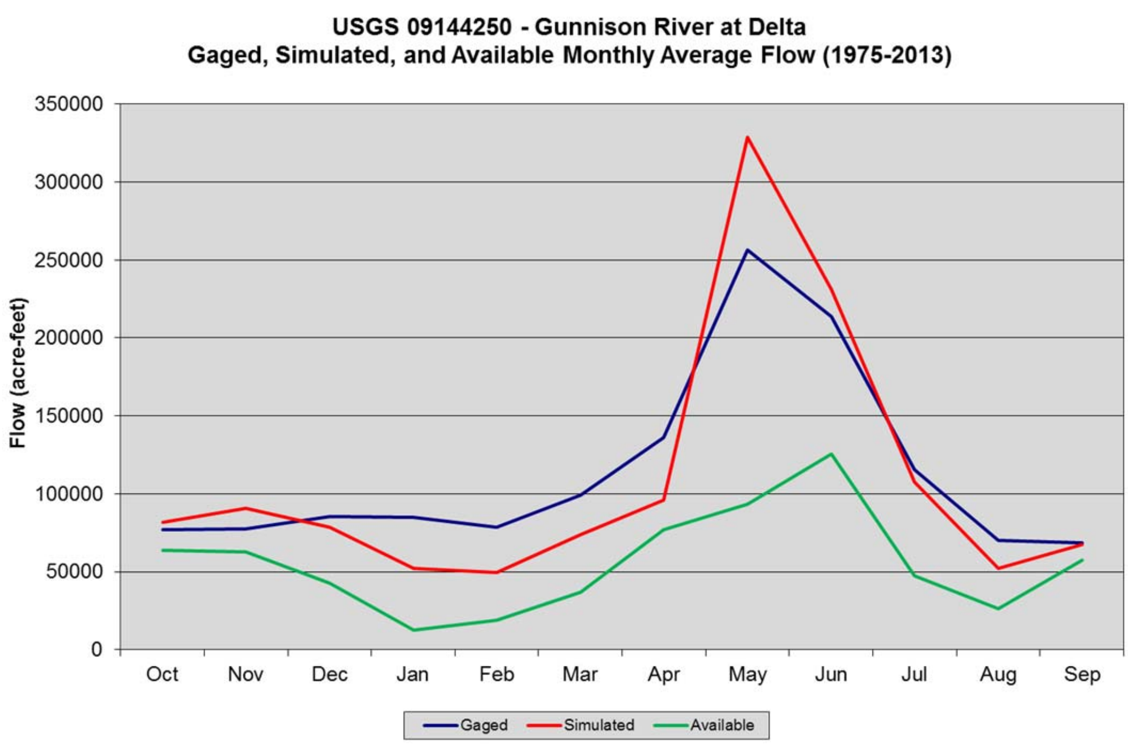
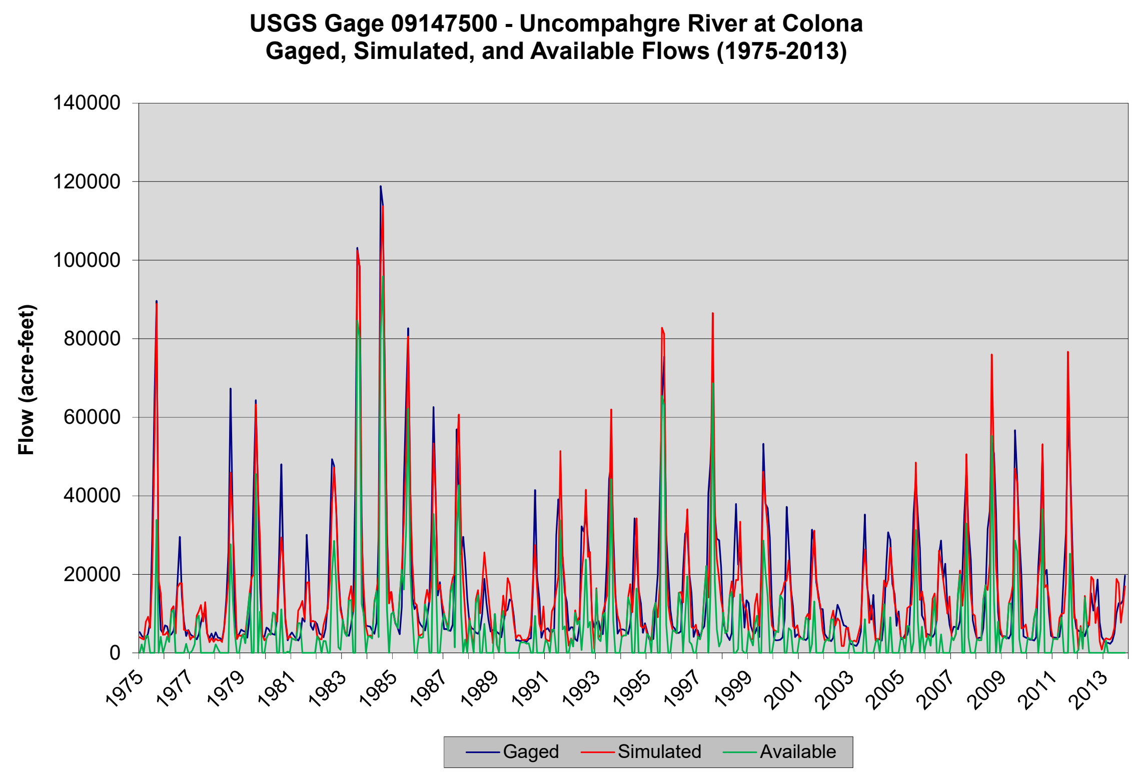


Figure 6.7 Baseline Results – Gunnison River at Delta



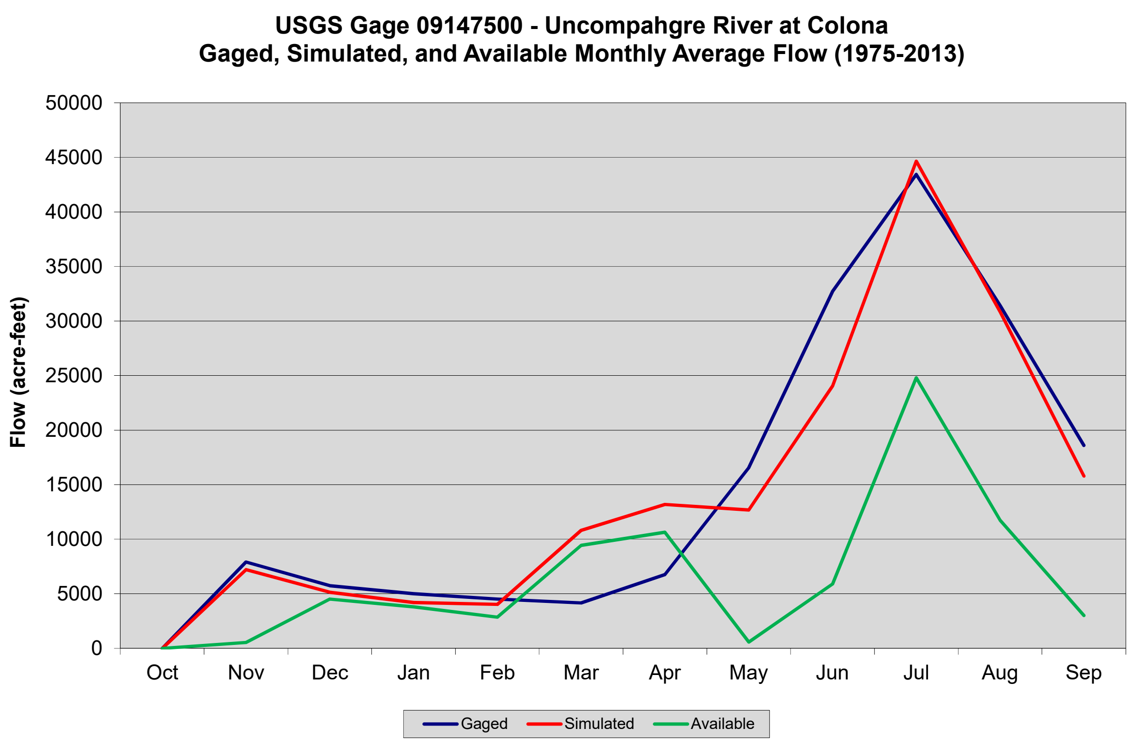
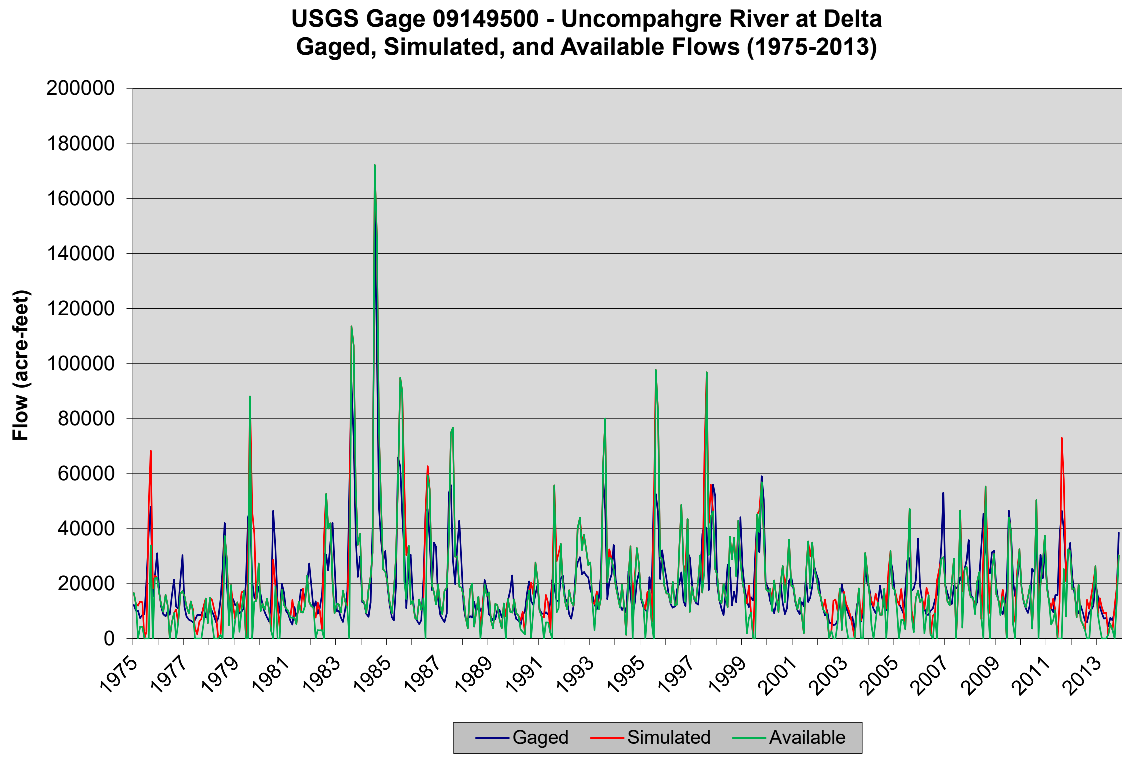


Figure 6.8 Baseline Results – Uncompahgre River at Colona



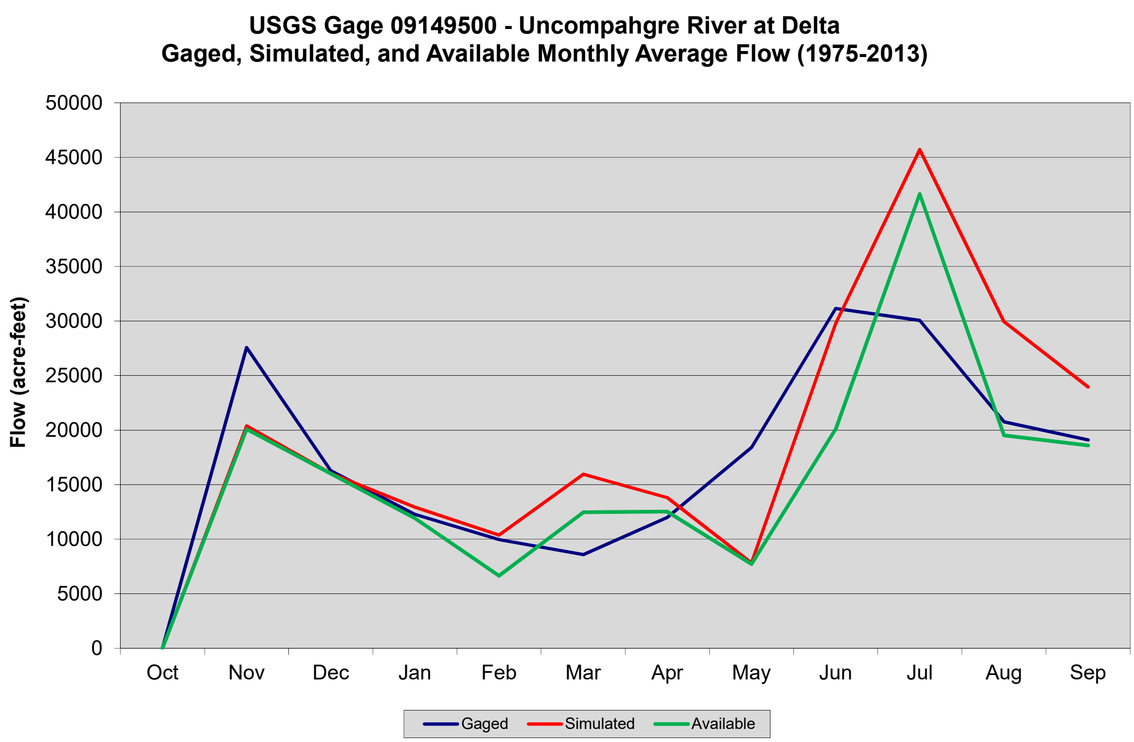
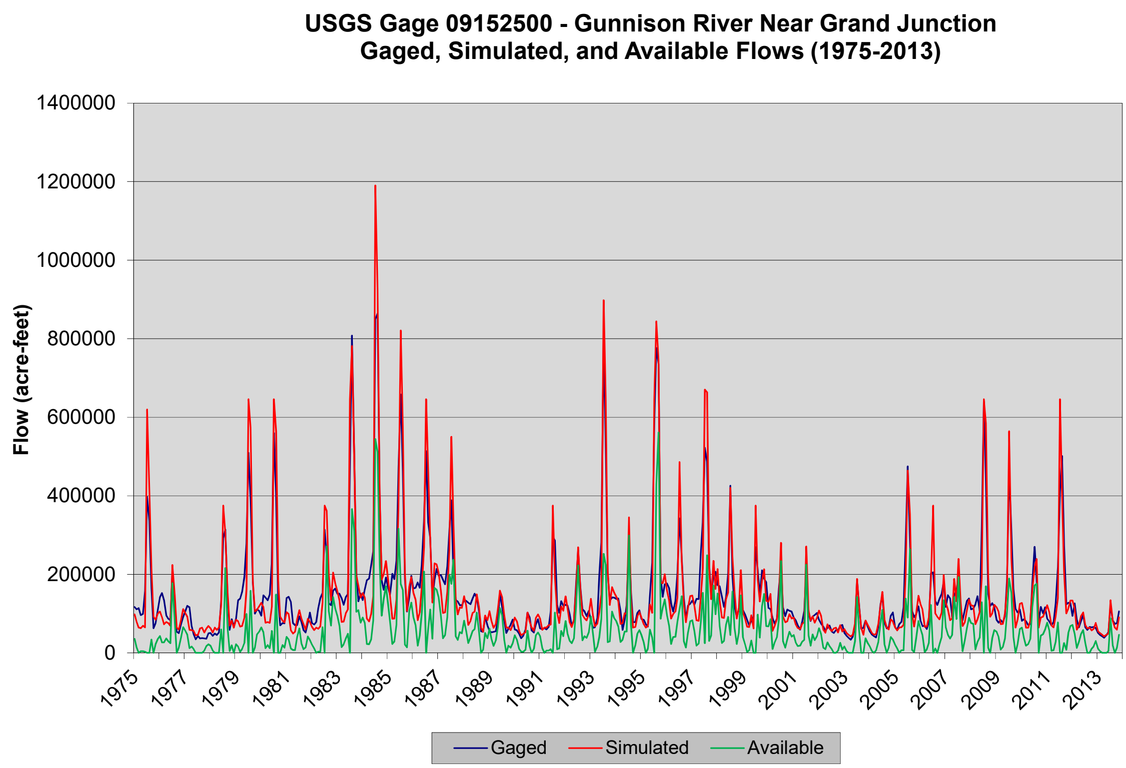


Figure 6.9 Baseline Results – Uncompahgre River at Delta



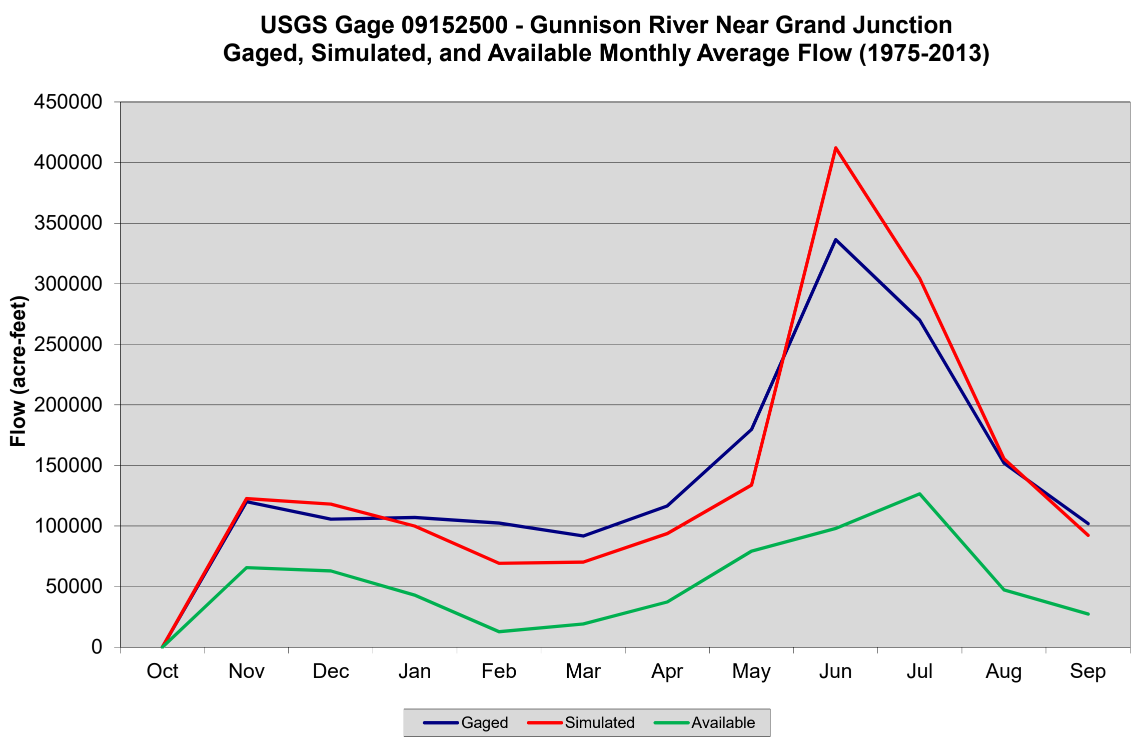


Figure 6.10 Baseline Results – Gunnison River near Grand Junction

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 2013 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 2013. 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 occurred. 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 reviewed, this time focusing on the operations. For example, operating criteria in the form of monthly targets might be added for reservoirs that operate for 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 may be 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 (6200617), the Cimarron Canal (6200560), the multi-structure system of Aspen Canal (4000509) and Needle Rock Ditch (4000501), and the multi-structure system of Aspen Ditch (4000508) and Grandview Canal (4000503). 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. West Canal is physically located on the Uncompahgre River while the headgate for South Canal is located on the Gunnison Tunnel. For simplicity in the model, South Canal is included in the model network as a diversion on the Uncompahgre River. For the historical calibration simulation, water is delivered from the Gunnison Tunnel (6200617) to the Uncompahgre River as an import to the system. To enable the 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 (20393.18780). 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.

As noted above, for the historical calibration simulation, water is delivered from the Gunnison Tunnel (6200617) 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, regulating reservoirs, or other operational targets. This includes Taylor Park, Blue Mesa, and Paonia reservoirs. Targets were developed to express the operations. Targets were set to historical end-of-month contents for Ridgway, Morrow Point and Crystal Reservoirs. Ridgway operates based on short-term and long-term inflow forecasts to prevent a spill. Morrow Point and Crystal operate as regulating reservoirs for Aspinall Unit power generation.

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 are turned off for most reservoirs. The exceptions are noted above in Section 7.2.3. Section 5.9 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 the destination; carrier structures demands are set to zero	▪ Historical diversions ▪ Historical diversions for multi-structures and carrier structures are set to historical diversions at each individual structure
Direct Rights (*.ddr)	▪ Uncompahgre Valley Water Users Association most Junior Rights are turned off to better represent the UVWUA good neighbor policy, as discussed in Section 5.4.5.3	▪ 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 = capacity.
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, Ridgway, Morrow Point, and Crystal 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. For this update, irrigated acreage assessments representing 2005 and 2010 were used as the basis for identifying structures that needed to be represented in the model. Aggregated structures were revised to include 100 percent of the irrigated acreage based on both the 2005 and 2010 assessments. The update also included the development of "no diversion" aggregates—groups of structures that have been assigned acreage but do not have current diversion records. "No diversion" aggregates are included in StateCU in order to capture 100 percent of irrigated acreage. However, they were not included in the StateMod modeling effort. Because the individual structures included in these aggregates do not have current diversion records, their effect on the stream cannot be accounted for in the development of natural flows. Therefore, it is appropriate that their diversions also not be included in simulation. The individual structures in the "no diversion" aggregates generally irrigate minimal acreage, often with spring water as a source. There is an assumption that the use will not change in future "what-if" modeling scenarios.

In addition, several structures were combined into diversion systems to represent lands served by more than one ditch on the same tributary. These efforts helped to reduce shortages to aggregate structures and to structures with overlapping acreage

7.3.2. Tomichi Creek Basin

A significant number of new key structures were added to the Tomichi Creek Basin and most of the existing storage reservoirs are now represented explicitly. This work was done for a different project and has been incorporated into this update of the Gunnison Basin model. The calibration results from the streamflow at the USGS gage 09119000 Tomichi Creek at Gunnison are greatly improved. There are still some shortages in the basin, especially on Cochetopa Creek, but they are improved over the last calibration effort.

7.3.3. 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 Transfer Ditch on Currant Creek. This area was a problem during the last calibration effort. Some minor improvements have been made by modifying the operations slightly. The USGS gages in the area all have very short period of records. The large amount of filled data makes historical calibration difficult to accurately verify.

Remaining shortages may be attributable to diverters in the Tongue and Surface Creek basins using small reservoirs on the south end of the Grand Mesa that are not included in the model and a neighborly trade-and-share approach to water management. Facilities apparently exist to move water around, and diversion records may not reflect actual operations.

7.3.4. Uncompahgre River

A significant amount of effort was spent in the last calibration update to improve the Uncompahgre River. For this calibration effort, the return flow locations and timing were not modified for structures that were explicitly represented in the previous modeling effort. Based on the new aggregate structures, some return flow locations were modified for aggregate structures and new key structures. The calibration quality has remained the same.

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 used for supplemental irrigation or municipal supply do not release to targets.

Reservoirs that operate for provide flood control (storage capacity for spring runoff); for hydropower generation; or other operational targets are operated using StateMod's forecast feature, based on rules provided by the USBR. These reservoirs include Paonia, Taylor Park, 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. Note the release schedule used by USBR is often not strictly adhered to; as USBR can adjust their schedule within certain criteria to reflect actual (non-forecasted) conditions. The forecasting curves provided do not appear to ever have been strictly adhered to.

Blue Mesa and Taylor Park targets have recently been updated in response to a new Aspinall Unit Operations Record of Decision (ROD) signed in 2010. The new targets do not reflect historical operations. Therefore, the historical targets are set to the targets that were used at the time. The most recent period reflects the 2010 ROD.

As determined in the previous modeling effort, Morrow Point and Crystal Reservoir targets are set to historical end-of-month content. This approach is reasonable for regulating reservoirs. Additionally, Upper Dome Reservoir only releases to end of month targets. It does not have any identified downstream demands.

Ridgway Reservoir targets are set to historical end of month contents. The reservoir operates under a No Spill policy, which is highly dependent on short-term and long-term inflow forecasts. Additionally, hydropower has been installed and recent releases are optimized for hydropower production.

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

7.3.6. Calibration Operating Rules

The releases from Blue Mesa to the National Park Service instream flow right for the Black Canyon of the Gunnison and the instream flow right representing the USFWS recommended flows are turned off for the historical calibration because these operations are new and there is no example of them in the historical record.

7.4 Calibration Results

Calibration of the Gunnison River model is considered 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 2 percent on an annual basis, and the basinwide shortage is about 4 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 (1975-2013). Following are observations based on the summary table:

- Stream water inflow to the basin averages 2.35 million acre-feet per year, and stream water outflow averages 1.80 million acre-feet per year.
- Annual diversions amount to approximately 2.34 million acre-feet on average, indicating that there is extensive re-diversion of return flows in the basin.
- Approximately 519,000 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 1975-2013 (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	91,773	148,615	1,293	241,681	154,155	1,915	125,862	-41,544	4,109	-2,816	241,681	0	17,348
NOV	67,142	70,674	214	138,031	44,508	726	130,848	-38,265	1,212	-997	138,031	0	1,880
DEC	60,644	62,691	0	123,335	48,181	268	112,310	-37,424	946	-946	123,335	0	1,186
JAN	57,107	55,205	0	112,312	45,230	349	77,137	-10,405	786	-786	112,312	0	1,235
FEB	55,555	49,094	0	104,649	42,648	687	73,254	-11,939	591	-591	104,649	0	1,467
MAR	88,719	49,275	681	138,674	46,905	1,496	91,540	-1,948	625	55	138,675	0	3,421
APR	221,220	102,328	2,501	326,048	135,030	3,306	129,487	55,724	4,432	-1,931	326,048	0	18,445
MAY	601,960	235,144	4,789	841,892	358,134	5,494	361,140	112,336	9,579	-4,791	841,892	0	75,676
JUN	603,534	330,320	5,645	939,499	506,474	7,267	300,394	119,720	6,547	-902	939,500	0	129,903
JUL	275,487	299,157	10,580	585,225	433,722	6,250	155,569	-20,897	1,792	8,788	585,225	0	130,354
AUG	131,752	229,173	6,364	367,288	304,089	5,161	116,860	-65,184	2,482	3,881	367,288	0	88,064
SEP	99,668	186,196	4,625	290,489	222,320	4,119	117,950	-58,524	3,520	1,104	290,489	0	50,300
AVG	2,354,558	1,817,873	36,691	4,209,123	2,341,396	37,038	1,792,350	1,649	36,622	69	4,209,122	0	519,279

Note: Consumptive Use (CU) = Diversion (Divert) * Efficiency + Reservoir Evaporation (Evap)

7.4.2. Streamflow Calibration Results

Error! Reference source not found. summarizes the annual average streamflow for water years 1975 through 2013, 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. **Error! Reference source not found.** through **Error! Reference source not found.** (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 on the scatter plot by the equation for the "best fit" regression line relating simulated to gage values. A perfect fit would be indicated by an equation y = 1.000x.

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 and flood control operations. However, this rule curve has just been updated in response to the 2012 ROD. Previous modeling efforts also showed 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 historical reservoir operations result in large deviations in downstream flow. Therefore, the Step 1 and Step 2 calibration constrained Blue Mesa to release to targets of historical end-of-month contents. Results from both are shown on **Error! Reference source not found.**, Gunnison River below Gunnison Tunnel.

For tributaries to the Gunnison, most of the stimulated streamflow aligns well with the observed gage flow. Exceptions are Leroux Creek and Uncompahgre River at Delta. Leroux Creek is strongly influenced by Overland Ditch operations. Overland Ditch delivers trans-tributary water from West Muddy Creek stored in Overland Reservoir to Leroux Creek, where it is re-diverted by the Lower Overland Ditch diversion system. The total amount of water that arrives in Leroux Creek appears to vary in a way that is not captured by the model.

Uncompahgre River at Delta is generally simulated with more flow than historically observed, despite significant effort to understand operations and improve calibration. There is likely more return flows captured and used by down-stream ditches without being measured in the river headgate than simulated in the model.

Table 7.3 Historical and Simulated Average Annual Streamflow Volumes (1975-2013) Calibration Run (acre-feet/year)

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9109000	141,316	142,067	-752	-1%	Taylor River Below Taylor Park Reservoir
9110000	223,968	224,846	-878	0%	Taylor River at Almont
9110500	*No gage during calibration period*				East River Near Crested Butte
9111500	95,490	95,499	-9	0%	Slate River Near Crested Butte
9112000	*No gage during calibration period*				Cement Creek Near Crested Butte
9112200	223,188	224,001	-813	0%	East River Below Cement Creek NR Crested Butte
9112500	231,398	231,562	-165	0%	East River at Almont
9113300	*No gage during calibration period*				Ohio Creek at Baldwin
9113500	64,851	64,939	-88	0%	Ohio Creek Near Baldwin
9114500	504,685	505,863	-1,177	0%	Gunnison River Near Gunnison
9115500	42,291	42,408	-118	0%	Tomichi Creek at Sargents
9118000	*No gage during calibration period*				Quartz Creek Near Ohio City
9118450	28,673	28,868	-195	-1%	Cochetopa Creek Below Rock Creek Near Parlin
9119000	117,418	118,574	-1,156	-1%	Tomichi Creek at Gunnison
9121500	*No gage during calibration period*				Cebolla Creek Near Lake City
9122000	*No gage during calibration period*				Cebolla Creek at Powderhorn
9124500	163,139	163,140	-1	0%	Lake Fork at Gateview
9126000	69,605	69,558	48	0%	Cimarron River Near Cimarron
9127500	*No gage during calibration period*				Crystal Creek Near Maher
9128000	809,376	808,083	1,292	0%	Gunnison River Below Gunnison Tunnel
9128500	33,416	35,005	-1,589	-5%	Smith Fork Near Crawford
9130500	*No gage during calibration period*				East Muddy Creek Near Bardine
9131200	*No gage during calibration period*				West Muddy Creek Near Somerset
9132500	340,329	338,506	1,823	1%	North Fork Gunnison River Near Somerset
9134000	14,573	14,883	-310	-2%	Minnesota Creek Near Paonia
9134500	*No gage during calibration period*				Leroux Creek Near Cedaredge
9135900	20,892	24,705	-3,813	-18%	Leroux Creek at Hotchkiss
9136200	1,446,348	1,462,147	-15,799	-1%	Gunnison River Near Lazear
9137050	10,559	9,240	1,319	12%	Currant Creek Near Read
9137800	*No gage during calibration period*				Dirty George Creek Near Grand Mesa

9139200	*No gage during calibration period*				Ward Creek Near Grand Mesa
9141500	*No gage during calibration period*				Youngs Creek Near Cedaredge
9143000	32,210	32,763	-553	-2%	Surface Creek Near Cedaredge
9143500	22,165	23,403	-1,238	-6%	Surface Creek at Cedaredge
9144200	52,621	55,458	-2,837	-5%	Tongue Creek at Cory
9144250	1,371,050	1,373,202	-2,153	0%	Gunnison River at Delta
9146200	120,982	120,868	113	0%	Uncompahgre River Near Ridgway
9146400	*No gage during calibration period*				West Fork Dallas Creek nr Ridgway
9146500	*No gage during calibration period*				East Fork Dallas Creek nr Ridgway
9146550	*No gage during calibration period*				Beaver Creek nr Ridgway
9147000	27,474	27,905	-432	-2%	Dallas Creek nr Ridgway
9147100	*No gage during calibration period*				Cow Creek Near Ridgway
9147500	186,932	188,521	-1,590	-1%	Uncompahgre River at Colona
9149420	39,881	39,881	0	0%	Spring Creek Near Montrose
9149500	232,099	231,890	209	0%	Uncompahgre River at Delta
9150500	88,629	88,697	-68	0%	Roubideau Creek at Mouth, Near Delta
9152000	17,378	17,487	-109	-1%	Kannah Creek Near Whitewater
9152500	1,794,354	1,800,845	-6,491	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 2013, by Water District/tributary. Table 7.6 (at the end of this section) shows the average annual shortages for water years 1975 through 2013 by structure. On a basin-wide basis, average annual diversions differ from historical diversions by 4 percent in the calibration run.

Table 7.4 - Historical and Simulated Average Annual Diversions by Sub-basin (1975-2013) Calibration Run (acre-feet/year)

Water District/Tributary	Historical	Simulated	Historical minus Simulated	
			Volume	Percent
WD 28 – Tomichi Creek	212,729	204,283	8,446	4%
WD 40 – North Fork Gunnison/Tribs	493,894	471,514	22,345	5%
WD 41 – Lower Uncompahgre River	656,328	655,636	692	0%
WD 42 – Lower Gunnison River	528,284	531,807	-3,523	-1%
WD 59 – East River	304,813	295,935	8,878	3%

WD 62 – Upper Gunnison River	472,631	493,480	-20,849	-4%
WD 68 – Upper Uncompahgre River	106,433	102,304	4,129	4%

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

- In the Tomichi Creek area, representing more structures explicitly reduced the overall basin error from 5% to 4%. However, there are some small structures on small tributaries to Tomichi Creek that are shorted. Effort was spent trying to accurately estimate return flow locations and distribute gains. Marginal improvement may still be possible.
- The Tongue Creek drainage (WD 40) is experiencing shortages for small diversions high up in the watershed. There are several USGS gages that have been discontinued and are being filled with the Mixed Station Model. The discontinued gages all have short periods of record, which makes it difficult to find a reliable filling technique. In future modeling efforts, the overall calibration may be improved if these gages are removed and baseflow are distributed to the headwater tributaries using either the gains approach or the neighboring gage approach.
- Shortages on Currant Creek and Surface Creek (WD 40) are fairly uniform throughout. 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 fully understood; therefore, not as accurately modeled as other areas in the basin. Additional calibration efforts were not conducted as part of this modeling phase.
- The Kannah Creek (WD 42) is experiencing shortages throughout the calibration period, with shortages getting worse in the more recent period. The USGS gage on Kannah Creek was discontinued in 1982. The filling procedure may not be producing reliable results.

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:

- Until the late 2000's, 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. In 2007, the irrigation demand for Fruitland Irrigation starts to taper off, which results in less demand for reservoir water.

- Paonia Reservoir appears to be under-simulating storage values in the summer time. However, the historical storage values are larger than the reservoir capacity.
- Silverjack Reservoir is under-simulated in the historical model. The irrigation demand is not large enough to draw the reservoir down.

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 slightly consistent less than the overall basin diversion shortages simulated by the model.

Table 7.5 - Average Annual Crop Consumptive Use Comparison (1975-2013)

Comparison	StateCU Results (af/yr)	Calibration Run Results (af/yr)	% Difference
Explicit Structures	389,359	370,146	5%
Aggregate Structures	93,566	91,706	2%
Basin Total	482,925	461,852	4%

Table 7.6 - Historical and Simulated Average Annual Diversions (1975-2013) Calibration Run (acre-feet/year)

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
2800500	1,848	1,837	12	1	ADAMS NO 1 DITCH
2800501	1,582	1,575	7	0	ADAMS NO 2 DITCH
2800503	461	377	84	18	AGATE NO 2 DITCH
2800505	402	400	1	0	ALKALI DITCH
2800507	312	307	5	2	ANNA NO 1 DITCH
2800508	323	292	32	10	ANNA NO 2 DITCH
2800510	15,073	14,917	155	1	ARCH IRRIGATING DITCH
2800513	460	453	8	2	BENNETT MORTON DITCH
2800514	905	874	31	3	BENNETT NO 2 DITCH
2800515	3,706	3,706	0	0	BIEBEL DITCHES NOS 1&2
2800517	1,000	906	94	9	BILLY SANDERSON DITCH
2800518	400	344	56	14	BRIDGE NO 40 DITCH
2800520	1,904	1,874	30	2	CAIN BORSUM DITCH
2800521	418	415	3	1	CAUFMAN DITCH
2800526	2,426	2,378	48	2	CHITTENDEN DITCH
2800527	378	365	13	3	CLARK NO 1 DITCH
2800528	533	518	15	3	CLARK NO 2 DITCH
2800529	805	793	12	1	CLARK NO 3 DITCH
2800530	612	583	29	5	CLOVIS METROZ NO 1 DITCH
2800532	1,955	1,939	17	1	COATS BROS DITCH
2800534	403	392	11	3	COLE DITCH
2800535	589	533	56	10	COLE NOS 1 2 & 3 DITCHES
2800536	1,387	1,349	38	3	COX AND MCCONNELL DITCH
2800539	400	345	55	14	CRARYS LOS PINOS DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
2800542	1,629	1,595	34	2	CUTJO DITCH
2800543	614	602	12	2	D A MCCONNELL DITCH
2800548	721	711	10	1	DUBER DITCH
2800549	354	342	11	3	DUNCAN DITCH
2800550	723	716	7	1	DUNN AND WATTERS DITCH
2800551	424	326	98	23	EAST KRUEGER DITCH
2800552	695	656	39	6	EASTSIDE DITCH
2800553	802	755	47	6	ELSEN COCHETOPA DITCH
2800554	1,822	1,805	17	1	ELSEN VADER DITCH
2800555	266	245	21	8	EVERLY NO 1 DITCH
2800557	828	766	62	7	FIELD AND VADER DITCH
2800558	549	467	82	15	FLICK DITCH
2800559	500	455	45	9	FLICK DITCH NO 1
2800560	315	285	30	10	FLICK DITCH NO 2
2800564_D	1,060	1,019	42	4	TOMI_GILBERTSON NO 1
2800566_D	2,702	2,646	56	2	GOODRICH_SYSTEM
2800567	2,963	2,773	190	6	GOODWIN AND WRIGHT DITCH
2800568_D	4,092	3,922	170	4	LOS _GOVERNMENT DITC
2800571_D	3,152	3,103	49	2	TOMI_GRIFFING NO 1 D
2800573	643	639	4	1	GUENTHER NO 1 DITCH
2800574	460	410	50	11	GUENTHER NO 2 DITCH
2800576	2,391	2,383	8	0	GULLETT TOMICHI IRG D
2800577	1,317	1,307	10	1	HANNAH J WINTERS NO 2D
2800578	273	203	70	26	HARRIS DITCH
2800579	1,118	911	207	18	HARTMAN WASTE WTR IRG D
2800580	934	915	19	2	HAWES-BERGEN-GILBERTSON
2800581	1,169	1,120	48	4	HAZARD DITCH
2800582	902	869	33	4	HEAD AND CORTAY NO 3 D
2800583	635	634	1	0	HEAD AND CORTAY NO 4 D
2800585	298	295	3	1	HEAD NO 2 DITCH
2800586_D	1,333	1,319	14	1	HIRDMAN_SYSTEM
2800587	956	915	41	4	HOME DITCH DITCH NO 81
2800588	896	769	127	14	HOME DITCH DITCH NO 182
2800589	583	577	6	1	HOT SPRINGS NO 1 DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
2800590	494	493	1	0	HOT SPRINGS NO 2 DITCH
2800591	1,316	1,289	27	2	HUFF AND DICE DITCH
2800593	589	502	87	15	IRWIN DITCH
2800595	150	143	7	4	J M ELLIS NO 1 DITCH
2800601	951	946	5	1	JOHN B COATS NO 2 DITCH
2800602	739	726	14	2	JOHN B COATS NO 1 DITCH
2800603	306	298	8	3	JOHN MYERS DITCH
2800604	421	367	54	13	KANE DITCH
2800605	335	305	30	9	KENDALL NO 1 DITCH
2800607	570	502	68	12	KENDALL NO 3 DITCH
2800608	485	432	53	11	KENDALL NO 4 DITCH
2800613	326	283	43	13	L L BUSH DITCH NO 1
2800614	309	251	58	19	L L BUSH DITCH NO 2
2800615	284	241	43	15	L L BUSH DITCH NO 3
2800616	384	328	56	15	L L BUSH DITCH NO 4
2800617	309	233	76	25	L L BUSH DITCH NO 5
2800618	643	624	19	3	LEWIS STURGIS AUSTIN D
2800619	452	431	21	5	LINDSAY GUENTHER DITCH
2800622	647	600	47	7	LOBDELL NO 2 DITCH
2800624	2,784	2,763	21	1	LOCKWOOD MUNDELL DITCH
2800628	767	753	14	2	LOUIS DITCH
2800629	634	629	5	1	LOUIS SARRASIN DITCH
2800630	224	204	20	9	LOWER SWAN DITCH
2800631	2,053	2,029	24	1	MCCANNE NO 1 DITCH
2800632	3,642	3,613	28	1	MCCANNE 2 DITCH
2800633	1,910	1,881	29	2	MCCANNE 3 DITCH
2800636	1,849	1,688	162	9	MCDONOUGH DITCH
2800638	1,711	1,695	16	1	MCGOWAN IRRIGATING D
2800642	547	501	46	8	MEANS BROS NO 13 DITCH
2800645	367	351	16	4	MEANS BROS NO 4 DITCH
2800646	553	552	1	0	MEANS BROS NO 5 DITCH
2800647	290	250	40	14	MEANS BROS NO 6 DITCH
2800648	240	222	18	7	MEANS BROS NO 7 DITCH
2800649	542	488	54	10	MEANS BROS NO 12 DITCH
2800650	1,023	1,016	7	1	MEANS BROS NO 8 DITCH
2800651	6,394	5,743	650	10	MESA DITCH
2800652	875	867	8	1	MILLER DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
2800653	313	272	41	13	MITCHELL DITCH
2800654	1,573	1,557	16	1	MONSON & MCCONNELL D
2800655	725	697	28	4	MORAN DITCH
2800658	779	735	44	6	NEEDLE CREEK DITCH
2800659	437	395	42	10	NESBIT DITCH
2800660_D	1,117	934	183	16	NORMAN_SYSTEM
2800661	765	708	56	7	NORTHSIDE DITCH
2800662	806	793	13	2	OFALLON NO 3 DITCH
2800663	707	667	40	6	OFALLON NO 4 DITCH
2800664	629	627	3	0	O'REGAN NO 2 DITCH
2800665	553	550	3	0	O'REGAN NO 1 DITCH
2800666	297	288	10	3	OWEN NO 2 DITCH
2800667	945	924	22	2	OWEN NO 1 DITCH
2800668	3,453	3,416	37	1	OWEN REDDEN DITCH
2800670	982	972	9	1	PARLIN NO 2 DITCH
2800671	3,777	3,755	22	1	PARLIN QUARTZ CREEK D
2800672	252	252	0	0	PEARCE DITCH
2800673	2,687	2,579	108	4	PERRY IRRIGATING DITCH
2800674	3,769	3,764	5	0	PIONEER DITCH
2800676	551	549	2	0	RAUSIS DITCH
2800677	494	439	54	11	RAUSIS NO 2 DITCH
2800679	1,319	1,194	125	9	ROGERS METROZ DITCH
2800680	3,365	2,954	412	12	S DAVIDSON&CO FDR D NO 1
2800681	233	201	31	13	SARGENTS NO 1 D
2800682	247	223	23	9	SARGENTS NO 2 D
2800683_D	912	791	121	13	SHARP_SYSTEM
2800684	624	619	5	1	SHIPMAN LATERALS NO 1&2
2800685	951	920	31	3	SLOUGH DITCH
2800686	3,290	3,151	139	4	SMITH FORD NO 2 DITCH
2800687	621	609	12	2	SNYDER DITCHES NOS 1&2
2800689	324	308	15	5	SNYDER ROUSER DITCH
2800690	2,069	2,037	32	2	SORRENSON IRRIGATING D
2800691	319	272	47	15	SOUTH KREUGER DITCH
2800692	1,697	1,696	2	0	SOUTH SIDE DITCH
2800693	2,003	1,982	21	1	STEPHENSON DITCH
2800694	514	447	67	13	STITZER DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
2800697_D	1,145	1,088	57	5	SUTTON_SYSTEM
2800703	773	647	126	16	TARBELL & ALEXANDER D
2800704	1,465	1,363	102	7	TARKINGTON DITCH
2800707	3,483	3,346	138	4	TORNAY HIGHLINE DITCH
2800708	582	492	90	15	UPPER SWAN DITCH
2800709	1,193	1,181	12	1	VADER RAUSIS DITCH
2800710	793	770	23	3	VAN BIBBER DITCH
2800711	1,014	989	26	3	WATERMAN METROZ DITCH
2800714	275	274	1	1	WICKS ROWSER DITCH
2800715	1,481	1,459	23	2	WOOD AND GEE DITCH
2800716	1,016	972	45	4	WOODBRIDGE DITCH
2800717	215	193	22	10	TRAIL CREEK DITCH
2800718	177	170	7	4	POLE ROAD DITCH
2800719	833	813	20	2	A B COATS DITCH
2800726	187	129	58	31	CAMP BIRD DITCH
2800777	209	196	13	6	DUNCAN WASTEWATER DITCH
2800781	293	275	18	6	ERNEST VOUGA DITCH
2800802	180	150	30	17	JACKSON DITCH
2800803	237	214	22	9	JAPECK DITCH NO 1
2800804	27	19	8	29	JAPECK DITCH NO 2
2800805	267	228	39	15	JAPECK DITCH NO 5
2800806	462	461	2	0	KENNEDY DITCH NO 1
2800807	400	390	9	2	KENNEDY DITCH NO 2
2800808	73	71	1	2	KENNEDY DITCH NO 3
2800809	109	105	4	4	KENNEDY DITCH NO 4
2800810	188	187	2	1	KENNEDY DITCH NO 5
2800823	260	258	3	1	MCDONALD BERDEL EX D
2800849	97	97	0	0	OWEN NO 3 DITCH
2800851	442	411	32	7	PASS CREEK DITCH
2800869	2,279	2,273	5	0	PISEL CANALS NOS 1&2 D
2800872	182	168	14	8	PITTMAN DITCH NO 1
2800873	35	27	8	22	PITTMAN DITCH NO 2
2800874	256	236	20	8	PITTMAN DITCH NO 3
2800875	94	85	9	9	PITTMAN DITCH NO 4
2800880	599	558	41	7	R A PROSSER DITCH
2800884	913	793	120	13	RICHARDSON NO1 DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
2800888	212	211	1	0	ROCK SLIDE SPRING DITCH
2800898	73	73	0	0	STRACHAN DITCH
2800928	626	589	36	6	W L PERRY NO 6 DITCH
2800936	697	650	47	7	WASTE WATER DITCH
2800938	456	385	71	16	WATERMAN MILLER GRIFFIND
2800943	775	517	258	33	WESTSIDE DITCH
2800958	69	53	16	23	HANNAH WINTERS DITCH
2800970	100	98	3	3	MCINTYRE GULCH DITCH
2801008	16	7	8	54	GRIFFIN DITCH
2801055	118	113	5	4	WATSON DITCH NO 1
2801068	224	184	39	18	REINECKE DITCH NO 1
2801069	166	140	26	16	REINECKE DITCH NO 2
2801093	225	188	38	17	JAPECK DITCH NO 3
2801094	123	96	27	22	JAPECK DITCH NO 4
2801146	117	68	49	42	TOMMIE DITCH
2801147	138	138	0	0	JOHN MYERS NO 2 DITCH
2801148	148	145	3	2	JOHN MYERS NO 3 DITCH
2801151	287	264	24	8	TY WATSON DITCH
2801152	99	82	17	18	HOOVER #1
2801153	73	53	20	27	HOOVER #2
2801162	427	320	107	25	POST TOMICHI DITCH
2801185	243	211	32	13	L L BUSH DITCH NO 6
2801194	88	18	70	79	PETERSON DITCH
2801572	3,707	3,702	5	0	S DAVIDSON AND CO DITCH
2801581	195	188	6	3	S DAVIDSON&CO FDR D NO 3
2801592	497	447	50	10	MCLAIN DITCH
28_ADG009	7,783	7,659	124	2	Diversion Aggregate
28_ADG010	2,931	2,914	17	1	Diversion Aggregate
28_ADG011	2,910	2,885	26	1	Diversion Aggregate
28_ADG012	9,481	9,481	0	0	Diversion Aggregate
28_ADG043	810	801	9	1	Diversion Aggregate
28_ADG044	68	61	7	10	Diversion Aggregate
4000500	15,876	15,805	71	0	CRAWFORD CLIPPER DITCH
4000501	6,375	6,329	46	1	NEEDLE ROCK DITCH
4000502	3,383	2,078	1,306	39	SADDLE MT HIGHLINE D
4000503	6,822	6,784	38	1	GRANDVIEW CANAL

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
4000504	7,626	7,383	243	3	CEDAR CANON IRON SPR D
4000506	1,676	1,662	15	1	ALUM GULCH DITCH
4000508	6,503	2,698	3,805	59	ASPEN DITCH
4000509	1,173	2,000	-827	-70	ASPEN CANAL
4000533	1,027	962	66	6	CRYSTAL VALLEY DITCH
4000536	2,124	1,678	446	21	DAISY DITCH
4000543	942	856	86	9	DYER FORK DITCH
4000549	9,383	9,335	48	1	FRUITLAND CANAL
4000549_I	12,749	12,466	284	2	Fruitland
4000554	468	373	95	20	GOVE DITCH
4000557	834	765	69	8	HARTMAN MCINTYRE DITCH
4000566	1,512	1,508	4	0	LARSON BROTHERS DITCH
4000568	802	614	188	23	LONE ROCK DITCH
4000576	540	129	412	76	MEEK DIVERSION TUNNEL
4000585	8,288	10,421	-2,133	-26	OVERLAND DITCH
4000586	1,289	1,191	98	8	PILOT ROCK DITCH
4000605	4,147	5,256	-1,108	-27	SMITH FORK FEEDER CANAL
4000616	1,158	739	419	36	VIRGINIA DITCH
4000632	3,441	2,901	540	16	CHILDS DITCH
4000661	9,862	9,227	635	6	SURFACE CR D AKA BIG D (
4000675	3,677	3,244	433	12	CEDAR MESA DITCH
4000683	1,077	1,053	25	2	HORSESHOE DITCH
4000686	2,811	2,453	359	13	LONE PINE DITCH
4000692	648	152	497	77	Sooner Ditch
4000701_D	8,358	4,486	3,872	46	CEDAR_PARK_SYSTEM
4000703_D	742	450	292	39	DIRT_EAGLE DITCH
4000713	1,276	965	311	24	GRANBY DITCH FR WARD CR
4000751	8,260	6,967	1,293	16	ALFALFA DITCH
4000751_I	5,402	5,360	43	1	ALFALFA_IRR
4000753_D	1,526	1,514	12	1	SURF_BONITA DITCH
4000754	2,164	2,123	42	2	BUTTES DITCH
4000758	2,759	2,447	312	11	FORREST DITCH
4000774	2,365	2,346	19	1	ORCHARD RANCH DITCH
4000778	950	946	4	0	SETTLE DITCH
4000797	2,157	1,041	1,116	52	DURKEE DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
4000808_D	876	772	104	12	MORTON_SYSTEM
4000820_D	9,486	9,398	88	1	ALFA_STELL DITCH
4000821	1,529	3,612	-2,083	-136	TRANSFER DITCH
4000863	22,473	22,459	14	0	BONA FIDE DITCH
4000879	17,215	17,211	4	0	HARTLAND DITCH
4000891_D	20,065	20,051	14	0	GUNN_NORTH DELTA CAN
4000891_I	0	0	0	0	North Delta Irrigation
4000900	19,025	19,023	2	0	RELIEF DITCH
4000918	976	968	8	1	COW CREEK DITCH
4000919	3,115	3,031	84	3	CURRANT CREEK DITCH
4000923	8,448	7,381	1,068	13	HIGHLINE DITCH
4000926	5,886	5,856	30	1	LEROUX CREEK DITCH
4000929	1,400	1,281	119	8	JESSIE DITCH
4000932	1,767	1,341	426	24	MIDKIFF & ARNOLD D
4000944_D	18,532	17,491	1,041	6	LERO_OVERLAND DITCH
4001012	624	345	279	45	LONE CABIN DITCH
4001020	6,135	5,357	778	13	MINNESOTA CANAL
4001056	1,972	1,657	315	16	TURNER DITCH
4001087	436	424	11	3	BLACK SAGE DITCH
4001105	351	351	0	0	COYOTE DITCH
4001106	389	380	9	2	COYOTE DITCH
4001112	410	396	13	3	DEER DITCH
4001114	322	320	2	1	DITCH NO 2 DITCH
4001115	941	859	82	9	DITCH NO 3 DITCH
4001116	520	409	111	21	DITCH NO 4 DITCH
4001118	633	625	8	1	DRIFT CREEK DITCH
4001119	256	235	20	8	DUGOUT DITCH
4001120	686	673	13	2	DOWNING DITCH
4001121	214	100	114	53	DYKE CREEK DITCH
4001122	242	88	154	64	DYKE NO 2 DITCH
4001126	460	420	40	9	ELK HORN STOMP DITCH
4001127	263	233	30	11	ELKS BEAVER DITCH
4001132	1,665	1,585	80	5	FILMORE DITCH
4001133	46,658	45,626	1,032	2	FIRE MT CANAL
4001145	407	404	2	1	GROUSE CREEK DITCH
4001166_D	429	201	228	53	MUDD_LARSON NO 2 DIT
4001168	455	450	5	1	LEE CREEK D NO 2
4001183	2,238	2,233	4	0	MONITOR DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
4001185	9,021	8,924	97	1	NORTH FORK FARMERS D
4001189	6,123	5,814	309	5	PAONIA DITCH
4001195	3,078	3,073	5	0	SHEPHERD & WILMONT DITCH
4001196	5,591	5,583	8	0	SHORT DITCH
4001197	2,079	2,073	6	0	SMITH AND MCKNIGHT DITCH
4001201	153	152	1	0	SPATAFORE DITCH NO 1
4001206	15,736	15,373	363	2	STEWART DITCH
4001207	1,546	1,261	285	18	STREBER DITCH
4001212	308	164	144	47	TWIN SPRUCE DITCH
4001213	1,652	1,652	0	0	VANDEFORD DITCH
4001214	61	61	0	0	WADE DITCH
4001218	887	849	38	4	WELCH MESA DITCH
4001221	94	94	0	0	WILLIAMS CR DITCH
4001313	228	222	6	3	PUG WHITE DITCH
4001425	838	749	89	11	ADOBE DITCH
4001426	363	349	14	4	BIG MONITOR NO 1 DITCH
4001428	431	415	17	4	DAVIS BROS DITCH
4001435	502	466	36	7	EVERLASTING DITCH
4001436	982	958	25	3	HALLEY DITCH
4001437_D	839	837	3	0	ROUB_HAWKINS DITCH
40_ADG019	143	141	1	1	Diversion Aggregate
40_ADG020	3,141	2,578	562	18	Diversion Aggregate
40_ADG021	3,375	3,112	262	8	Diversion Aggregate
40_ADG022	5,795	5,751	44	1	Diversion Aggregate
40_ADG023	1,760	1,577	183	10	Diversion Aggregate
40_ADG024	6,024	6,024	0	0	Diversion Aggregate
40_ADG025	3,441	3,239	201	6	Diversion Aggregate
40_ADG026	12,638	12,638	0	0	Diversion Aggregate
40_ADG027	6,943	5,634	1,309	19	Diversion Aggregate
40_ADG028	17,535	17,214	321	2	Diversion Aggregate
40_ADG029	3,368	3,271	98	3	Diversion Aggregate
40_ADG030	17,760	17,574	185	1	Diversion Aggregate
40_ADG039	10,010	10,010	0	0	Diversion Aggregate
40_AMG002	1,776	1,731	45	3	Lower_M&I
4100508	3,327	3,322	4	0	BOLES & MANNEY D
4100515	3,820	3,814	6	0	CHIPETA BEAUDRY DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
4100517	3,218	3,218	0	0	PURDY AND VICKERS DITCH
4100519	7,384	7,366	18	0	EAGLE DITCH
4100520	50,687	50,602	85	0	EAST CANAL
4100524	2,929	2,878	50	2	SEEPAGE FEEDER DITCH NO1
4100527	20,996	20,996	0	0	GARNET DITCH
4100534_D	112,920	112,840	80	0	UNCO_IRONSTONE CANAL
4100537	44,158	44,158	0	0	LOUTSENHIZER CANAL
4100538	2,501	2,495	6	0	LYRA DITCH
4100545	186,552	186,552	0	0	MONTROSE & DELTA CANAL
4100549	4,310	4,234	76	2	OURAY DITCH
4100550	3,019	2,906	113	4	RESERVATION DITCH
4100554	3,734	3,675	59	2	ROSS BROS DITCH
4100559	70,983	70,983	0	0	SELIG CANAL
4100560	1,115	1,113	3	0	SHAVANO VALLEY DITCH
4100566	3,487	3,444	42	1	STARK VOLKMAN DITCH
4100568_D	1,631	1,631	0	0	Sunrise DivSys
4100577	53,286	53,286	0	0	WEST CANAL
4100578	41,881	41,881	0	0	SOUTH CANAL
4100954	629	629	0	0	SILVER SPRINGS DITCH
41_ADG035	529	527	2	0	Diversion Aggregate
41_ADG036	16,010	15,915	95	1	Diversion Aggregate
41_ADG037	8,680	8,680	0	0	Diversion Aggregate
41_AMG003	1,272	1,272	0	0	Uncomp_M&I
41_Proj_7	7,270	7,219	52	1	Project_7
4200510	2,728	2,642	86	3	BROWN & CAMPION D
4200528	3,105	2,645	460	15	JUNIATA DITCH 1ST ENL
4200529	4,855	4,051	804	17	KANNAH CREEK HIGHLINE D
4200530	2,415	2,198	217	9	KANNAH CREEK EXT D
4200541	474,826	473,802	1,024	0	REDLANDS POWER CANAL
4200541_I	27,224	26,979	245	1	REDLANDS IRRIGATION
4200545	1,258	1,079	179	14	SMITH IRR DITCH
4200635	162	148	14	9	COFFMAN & WW MUTUAL D PL
42_ADG040	11,710	11,710	0	0	Diversion Aggregate
5900500	769	714	55	7	A C JARVIS NO 1 DITCH
5900501	3,884	3,881	3	0	ACME DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
5900505	744	711	32	4	Alfred Ditch
5900509	237	218	19	8	ANDERS BOTTOM D
5900510	1,275	1,077	198	16	ANNA ROZMAN DITCH
5900512	2,840	2,714	127	4	APRIL DITCH
5900520	459	459	0	0	BIEBEL NO 3 DITCH
5900522	4,262	4,029	233	5	BOCKER DITCH
5900524	541	535	7	1	BOURNE DITCH
5900527	787	783	4	0	BUCKEY DITCH
5900528	271	271	0	0	BUCKEY LEHMAN DITCH
5900529	660	656	4	1	CARBON DITCH
5900535	472	472	0	0	CASTLETON DITCH
5900537	3,728	3,515	213	6	CEMENT CREEK DITCH
5900542	667	646	21	3	CUNNINGHAM DITCH
5900543	334	331	3	1	DAVID HIGH LINE DITCH
5900544	1,061	1,016	44	4	DEAN IRRIGATING DITCH
5900546	6,959	6,316	643	9	DILLSWORTH DITCH
5900549	15,680	15,038	642	4	EAST RIVER NO 1 DITCH
5900550	9,142	8,817	325	4	EAST RIVER NO 2 DITCH
5900554	379	367	12	3	ELZE WEBBER DITCH
5900556	4,606	4,450	156	3	FISHER DITCH ENLARGEMENT
5900558	4,363	4,310	54	1	FRANK ADAMS NO 1 DITCH
5900560	2,916	2,702	214	7	GARDEN DITCH
5900563	1,779	1,761	18	1	GLEASON IRRIGATING DITCH
5900564	1,302	1,167	136	10	GOODWIN KNOX DITCH
5900566	3,059	3,054	5	0	GOOSEBERRY MESA IRG D
5900569	14,299	14,299	0	0	GUNNISON & OHIO CR CANAL
5900570	17,415	16,835	580	3	GUNNISON R OHIO CR IRG D
5900572	7,715	7,715	0	0	GUNNISON TOWN DITCH
5900578	4,155	4,078	77	2	HARRIS BOHM POTATO DITCH
5900580	45	45	0	0	HENRY PURRIER OHIO CR D
5900581	256	256	0	0	HENRY PURRIER OHIO CR 2D
5900584	486	451	35	7	HIGHLAND DITCH
5900585	411	355	56	14	HIGHLINE DITCH

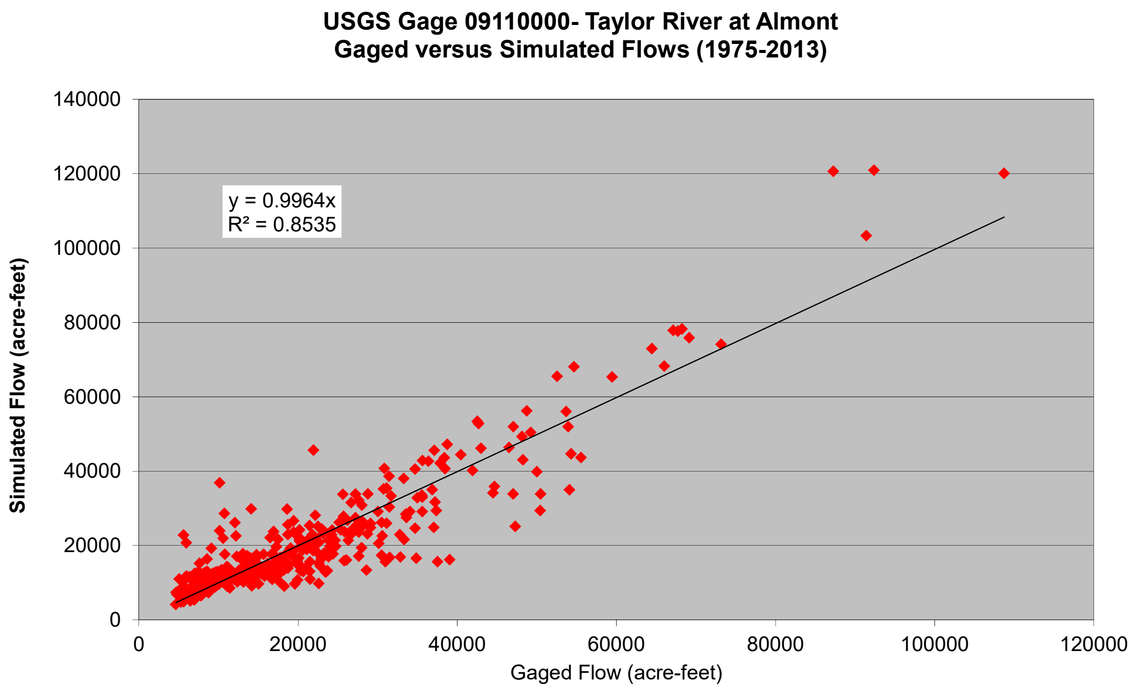
WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
5900587	1,349	1,332	17	1	HILDEBRAND NO 2 DITCH
5900588	1,608	1,599	9	1	HINKLE HAMILTON DITCH
5900589	717	716	1	0	HINKLE IRG DITCH
5900591	1,214	1,211	3	0	HOPE RESICH DITCH
5900593	2,154	2,143	11	1	HOWE & SHERWOOD IRR D
5900594	1,259	1,220	38	3	HYZER DITCH
5900595	5,318	5,206	111	2	HYZER KETCHUM DITCH
5900596	1,307	1,307	0	0	HYZER VIDAL MILLER D
5900597	2,503	2,367	136	5	IMOBERSTEG DITCH
5900600	4,639	4,506	132	3	JAMES WATT DITCH
5900602	2,371	2,312	59	2	JOHN B OUTCALT NO 2 D
5900606	1,309	1,303	6	0	JUDY NORTH HIGH LINE D
5900607	5,868	5,858	10	0	KELMEL OWENS NO 1 DITCH
5900608	3,120	3,087	32	1	KELMEL OWENS NO 2 DITCH
5900609	3,190	2,990	200	6	KUBIACK DITCH
5900613	6,445	5,992	453	7	LAFAYETTE DITCH
5900615	750	729	22	3	LEHMAN HARRIS DITCH
5900616	3,040	3,018	23	1	LIGHTLEY D & LINTON ENLT
5900617	3,658	3,588	70	2	LONE PINE DITCH
5900622	1,668	1,656	12	1	MARSHALL NO 1 DITCH
5900623	2,714	2,674	40	1	MARSHALL NO 2 DITCH
5900624	1,672	1,552	119	7	MARSTON DITCH
5900625	3,564	3,564	0	0	MAY BOHM & ENLD M B H P
5900627	465	448	17	4	MCCORMICK DITCH
5900630	268	268	0	0	MCGLASHAN N SIDE MILL CR
5900631	534	506	29	5	MCGLASHAN S SIDE MILL CR
5900644	618	615	2	0	OHIO CREEK NO 2 DITCH
5900645	858	858	0	0	OTIS MOORE DITCH
5900646	968	952	16	2	PALISADES DITCH
5900649	720	688	32	4	PASS CREEK DITCH
5900651	1,322	1,310	12	1	PILONI DITCH
5900653	4,751	4,575	177	4	POWER DITCH
5900654	444	404	40	9	PRESSLER POLISIC DITCH
5900655	421	415	7	2	PURRIER DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
5900656	1,651	1,409	243	15	REDDEN ELSINORE DITCH
5900658	4,058	3,979	79	2	RICHARD BALL DITCH
5900667	738	713	26	3	SCHUPP DITCH
5900668	5,324	5,269	55	1	SEVENTY FIVE DITCH
5900670	520	457	62	12	SILKA DITCH
5900671	516	516	0	0	SIMINEO DITCH
5900672	4,464	4,184	280	6	SLIDE DITCH
5900674	318	316	2	1	SMELSER DITCH
5900679	4,903	4,809	93	2	SPRING CR IRG DITCH
5900680	304	304	0	0	SQUIRREL CREEK NO1 DITCH
5900684	2,031	1,937	94	5	STRAND DITCH NO 1
5900691	3,587	3,556	31	1	TEACHOUT DITCH
5900692	1,406	1,277	129	9	TEACHOUT-FAIRCHILD DITCH
5900695	345	345	0	0	TINGLEY DITCH
5900699	6,135	5,760	374	6	VERZUH DITCH
5900700	6,191	5,499	691	11	VERZUH YOUNG BIFANO D
5900701	406	395	11	3	VIDAL BROS NO 1 DITCH
5900704	3,380	3,257	124	4	WHIPP DITCH
5900706	427	394	33	8	WILLOW DITCH
5900707	572	572	0	0	WILLOW RUN DITCH
5900709	763	734	29	4	WILSON DITCH
5900711	1,457	1,423	34	2	WILSON OHIO CREEK DITCH
5900720	491	462	29	6	PIONEER DITCH
5900847	1,777	1,624	153	9	CUNNINGHAM WASTEWATER D
5900886	192	164	28	15	Elk Home Ditch
5900887	156	143	13	8	Elk Home No. 2 Ditch
5900912	247	227	20	8	GEORGE KAPUSHION DITCH
5900967	821	813	8	1	JOHN B OUTCALT NO 1 D
5901165	420	388	32	8	THORNTON DITCH NO 2
5901180	197	167	30	15	WEINERT-OWENS CR DITCH
5901361	299	279	21	7	BURT GUERRIERI DITCH
5903602_C	0	0	0	0	Farris Creek Carrier
5903660_C	0	0	0	0	MillCarrier to Cunningha
5903660_MC	0	0	0	0	MillCarrier to Cunningha
5903663_C	0	0	0	0	Meridian Carrier

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
59_ADG001	9,095	8,719	375	4	Diversion Aggregate
59_ADG002	5,753	5,736	17	0	Diversion Aggregate
59_ADG003	2,286	2,284	2	0	Diversion Aggregate
59_ADG004	6,799	6,797	2	0	Diversion Aggregate
59_ADG005	8,330	8,330	0	0	Diversion Aggregate
59_ADG006	3,117	3,117	0	0	Diversion Aggregate
59_ADG007	6,457	6,457	0	0	Diversion Aggregate
59_ADG008	18,118	18,089	29	0	Diversion Aggregate
6200506	682	646	36	5	ANDREWS DITCH
6200528	6,059	5,894	165	3	BIG BLUE DITCH
6200529	2,816	2,709	107	4	BIG DITCH
6200542	2,023	1,849	174	9	BUTTE & BUTTE EX DITCH
6200560	28,414	25,874	2,540	9	CIMARRON CANAL
6200560_I	24,476	24,384	93	0	Cimmaron_Canal
6200565	880	812	68	8	COBB-CEBOLLA CR D
6200567	1,491	1,462	29	2	COLLIER DITCH
6200569	2,308	2,299	9	0	COOPER NO 2 D
6200602	749	701	48	6	FOSTER DITCH NO 1
6200604	305	278	27	9	FOSTER IRG D NO 4
6200605	2,307	2,280	27	1	FRANK ADAMS D NO 2
6200612	1,284	1,158	126	10	GEORGE ANDREWS NO 1 D
6200617	347,357	347,366	-8	0	GUNNISON TUNNEL&S CANAL
6200641	394	393	0	0	INDIAN CREEK IRR DITCH
6200653	1,076	1,070	6	1	LAKE FORK NO 1 DITCH
6200661	785	729	56	7	LONE PINE DITCH
6200670	2,116	2,028	88	4	M B & A DITCH
6200672	4,680	4,589	91	2	MCKINLEY DITCH
6200687	639	531	108	17	MINNIE B NO 2 DITCH
6200732	1,588	1,520	68	4	RUDOLPH IRG DITCH
6200734	529	493	36	7	SAMMONS DITCH NO 2
6200736_D	684	641	43	6	CEBO_SAMMONS IRG D N
6200737	404	372	32	8	SAMMONS IRG D NO 5
6200738	749	693	56	7	SAMMONS IRG D NO 6
6200756	355	355	0	0	SPRING BRANCH DITCH
6200779	1,310	1,164	146	11	UPPER CEBOLLA DITCH
6200783	2,126	1,965	162	8	VEO DITCH
6200789	941	731	211	22	WARRANT DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
6200792	764	729	35	5	WEST DITCH
6200812_D	1,337	1,079	257	19	YOUMANS NO 4 DITCH
62CSUB_I	0	0	0	0	
62CSUB_M	0	0	0	0	Subordinate_Crystal_M&I
62L_MY	0	0	0	0	
62MSUB_I	0	0	0	0	
62MSUB_M	0	0	0	0	Subordinate_Morrow_M&I
62USUB_I	0	0	0	0	Upper_Market_Yield
62USUB_M	0	0	0	0	
62U_MY	0	0	0	0	Subordinate_Upper_M&I
62_ADG013	13,472	12,911	561	4	Diversion Aggregate
62_ADG014	9,839	9,822	17	0	Diversion Aggregate
62_ADG015	13,399	13,399	0	0	Diversion Aggregate
62_ADG016	13,835	13,678	157	1	Diversion Aggregate
62_ADG017	2,340	2,340	0	0	Diversion Aggregate
62_ADG018	3,079	3,036	43	1	Diversion Aggregate
62_AMG001	1,536	1,501	35	2	Upper_M&I
6800501	5,072	4,806	267	5	ALKALI DITCH D NO 80
6800502	4,368	4,087	281	6	ALKALI NO 2 DITCH
6800514	2,184	2,038	146	7	BURKHART EDDY DITCH
6800526	3,229	3,122	107	3	CHARLEY LOGAN DITCH
6800538	348	255	92	27	CRONENBERG DITCH
6800543	3,848	3,271	577	15	DALLAS DITCH
6800559	1,861	1,712	148	8	DOC WADE DITCH
6800603	1,037	976	61	6	HENRY TRENCHARD DITCH
6800604	2,271	2,256	15	1	HIELAND DITCH
6800607	4,058	3,894	163	4	HOMESTRETCH DITCH
6800609	2,042	1,999	43	2	HOSNER BROWNYARD DITCH
6800610	1,854	1,827	27	1	HOSNER ROWELL DITCH
6800613	1,971	1,834	137	7	HYDE SNEVA DITCH
6800636	1,186	1,186	0	0	LEOPARD CREEK DITCH
6800647	1,107	1,032	75	7	MARTIN DITCH
6800652	843	760	84	10	MAYOL LATERAL DITCH
6800653	864	814	50	6	MAYOL SISSON DITCH
6800657	4,103	3,944	159	4	MCDONALD DITCH NO 145
6800668	2,195	2,137	58	3	MOODY DITCH
6800669	2,358	2,342	16	1	MOODY NO1 DITCH

WDID	Historical	Simulation	Historical Minus Simulated		Structure Name
			Volume	Percent	
6800671	1,133	1,039	94	8	MORRISON DITCH
6800681	2,355	2,339	16	1	OLD AGENCY DITCH
6800683	1,295	1,262	33	3	OWL CREEK DITCH
6800685	2,290	2,187	103	4	PARK DITCH
6800692	4,181	3,877	304	7	PINION DITCH
6800703	1,196	1,181	15	1	REED OVERMAN DITCH
6800710	1,089	924	165	15	RIDGWAY DITCH
6800720	1,200	1,177	23	2	ROSWELL HOTCHKISS DITCH
6800721	188	134	53	28	RUFFE WADE DITCH
6800729	454	448	6	1	SHORTLINE D COW CREEK
6800738	3,262	3,253	9	0	SNEVA DITCH
6800763	911	872	38	4	TRENCHARD DITCH
6800765	3,077	3,053	23	1	UPPER UNCOMPAHGRE DITCH
6800770	912	764	148	16	VON HAGEN DALLAS DITCH
6801064	1,210	1,206	4	0	VON HAGEN LATERAL DITCH
68_ADG033	10,245	9,984	261	3	Diversion Aggregate
68_ADG034	24,638	24,311	328	1	Diversion Aggregate
72_GJMunExp	6,603	6,553	50	1	Grand_Junction_Demand
Basin Total	**2,808,213**	**2,754,924**	**65,609**	**2**	



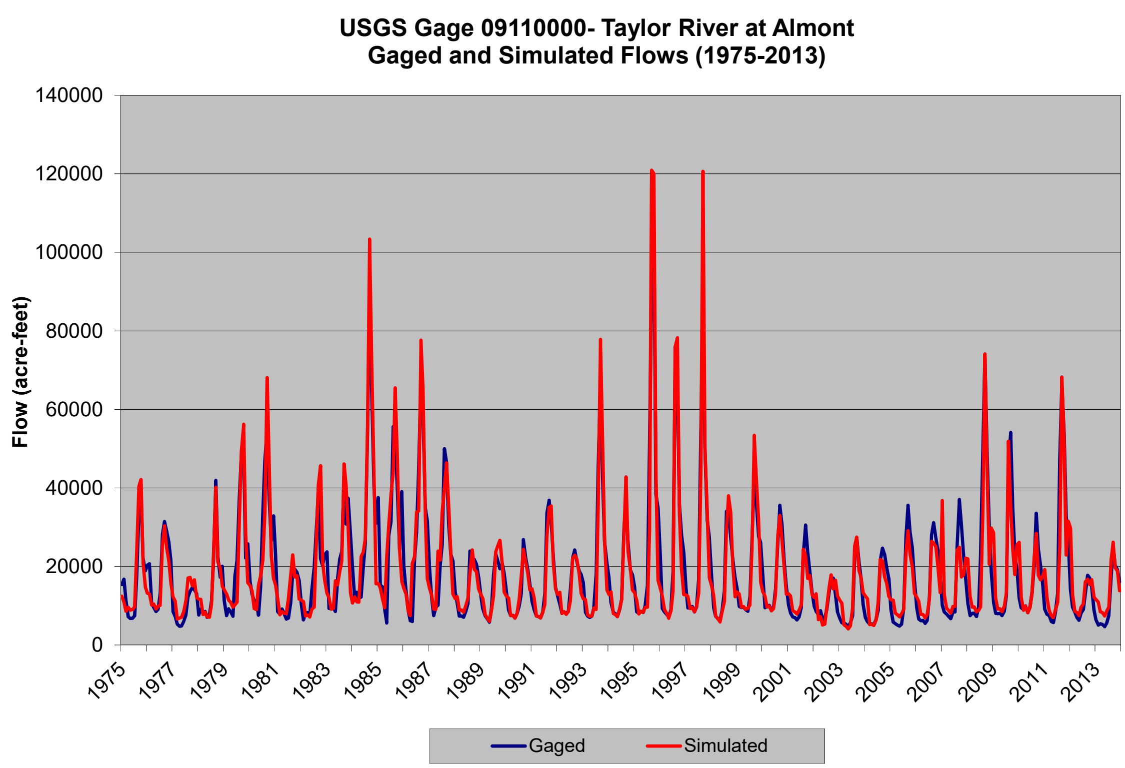
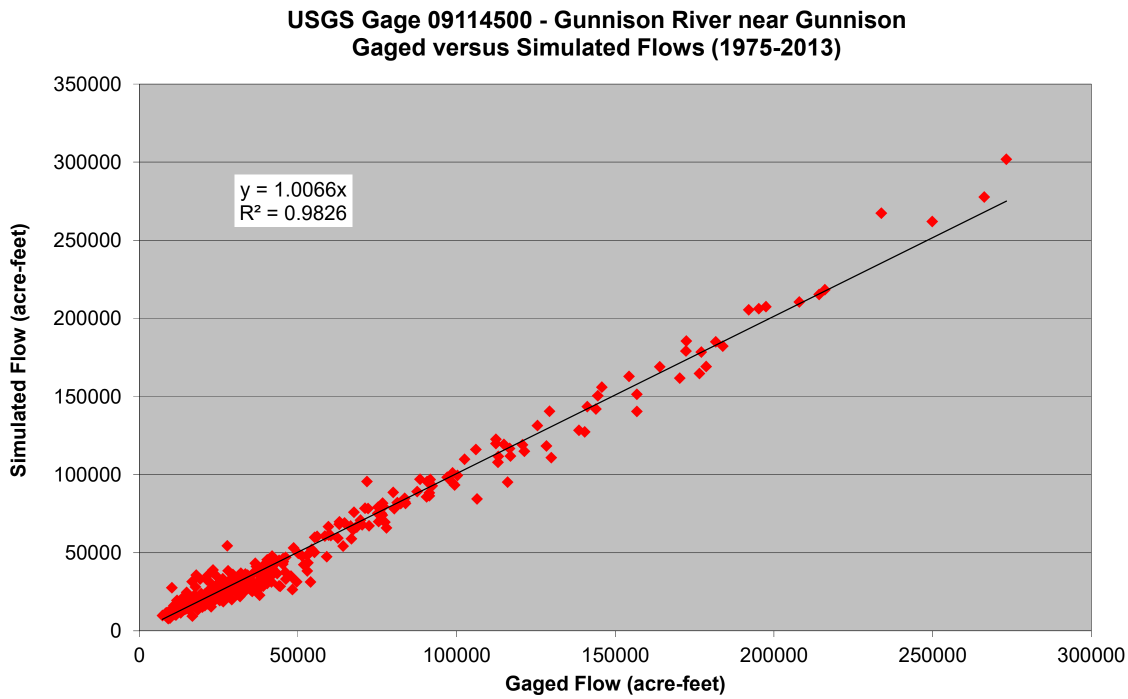


Figure 7.1 Streamflow Calibration – 09110000 Taylor River at Almont



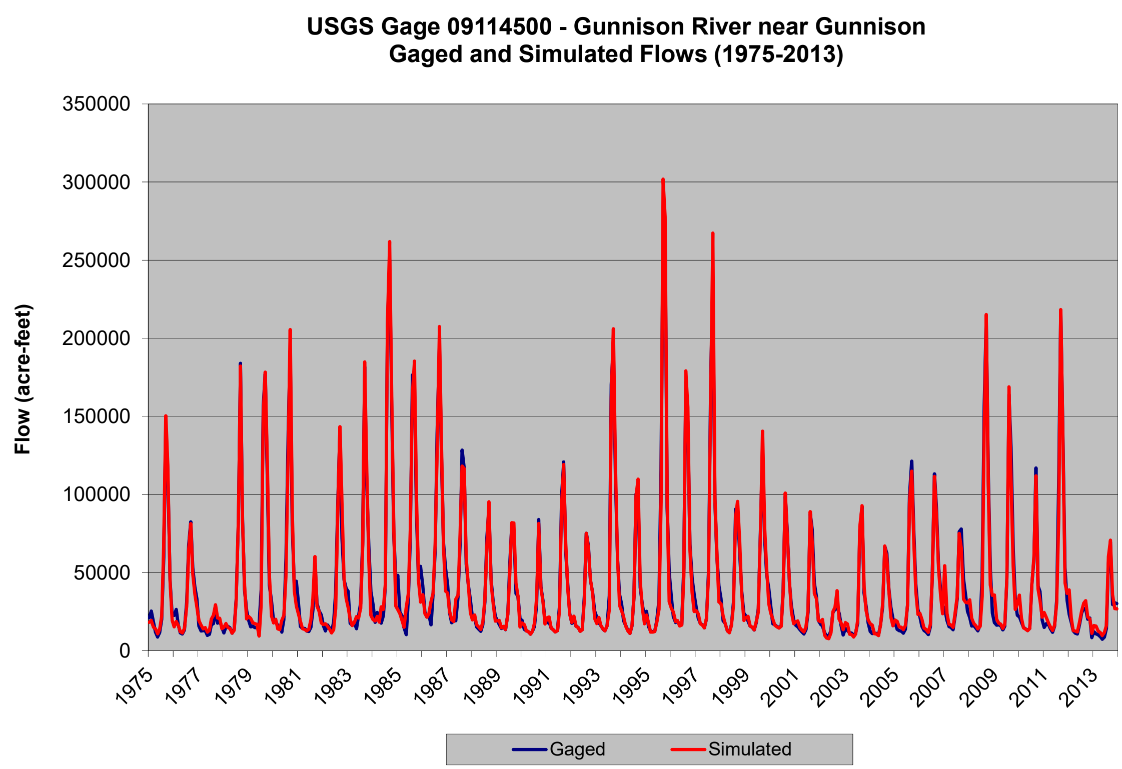
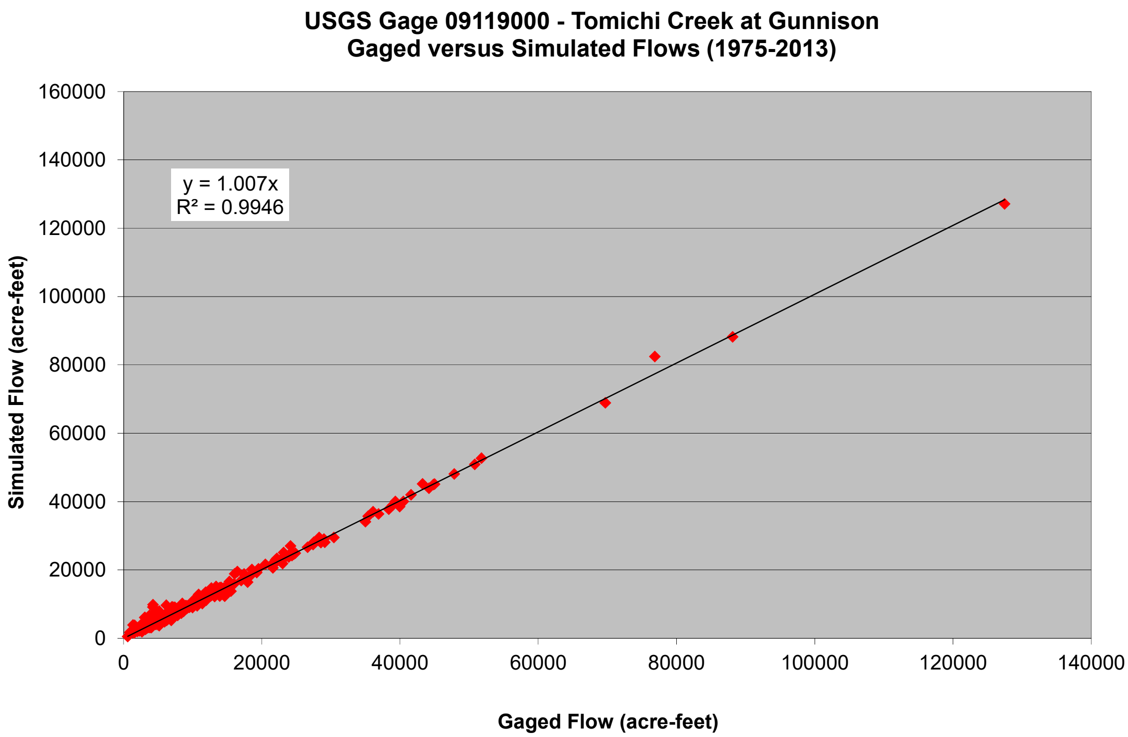


Figure 7.2 Streamflow Calibration – 09114500 Gunnison River near Gunnison



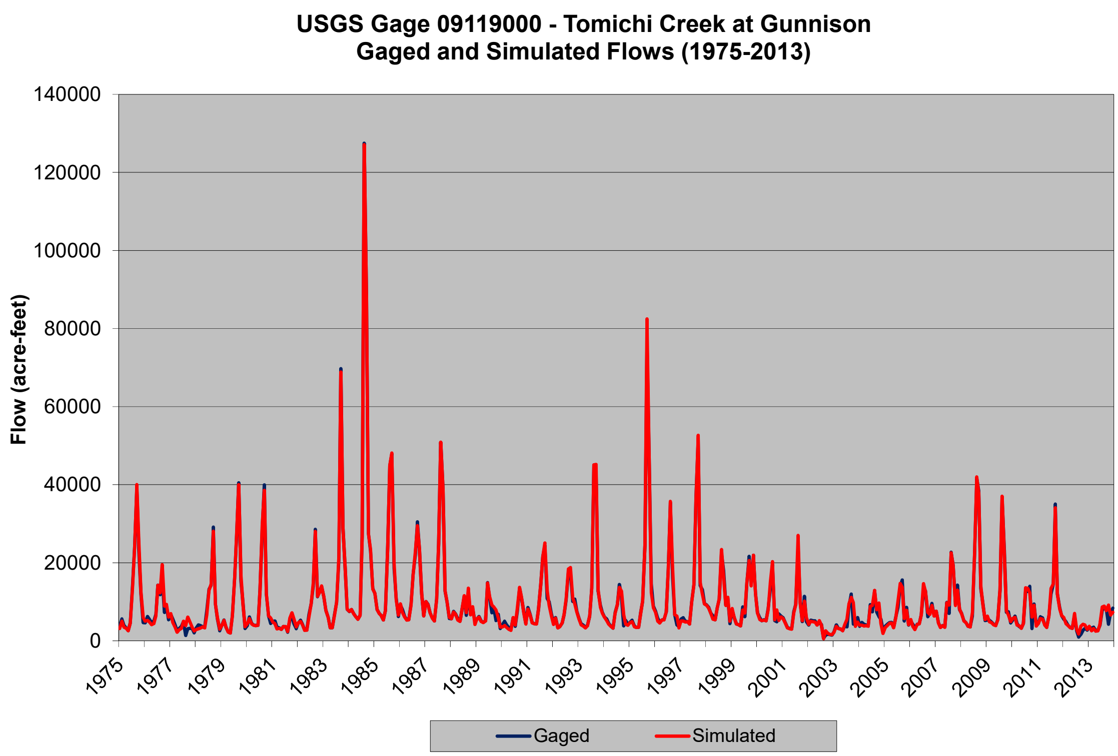
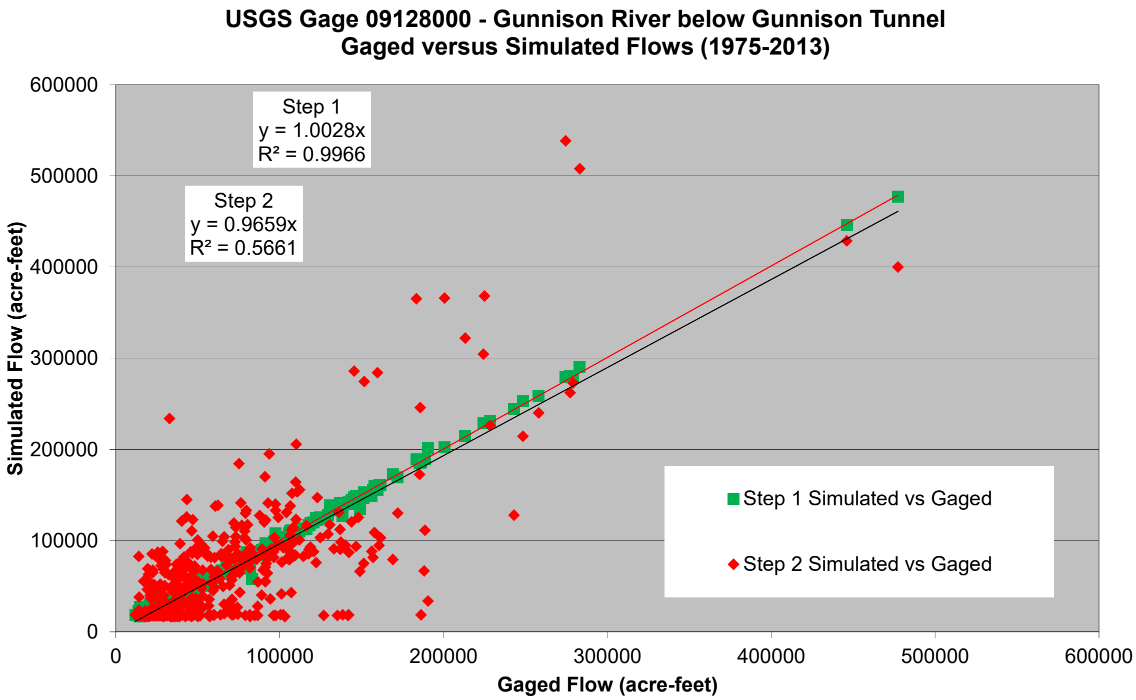


Figure 7.3 Streamflow Calibration – 09119000 Tomichi Creek at Gunnison



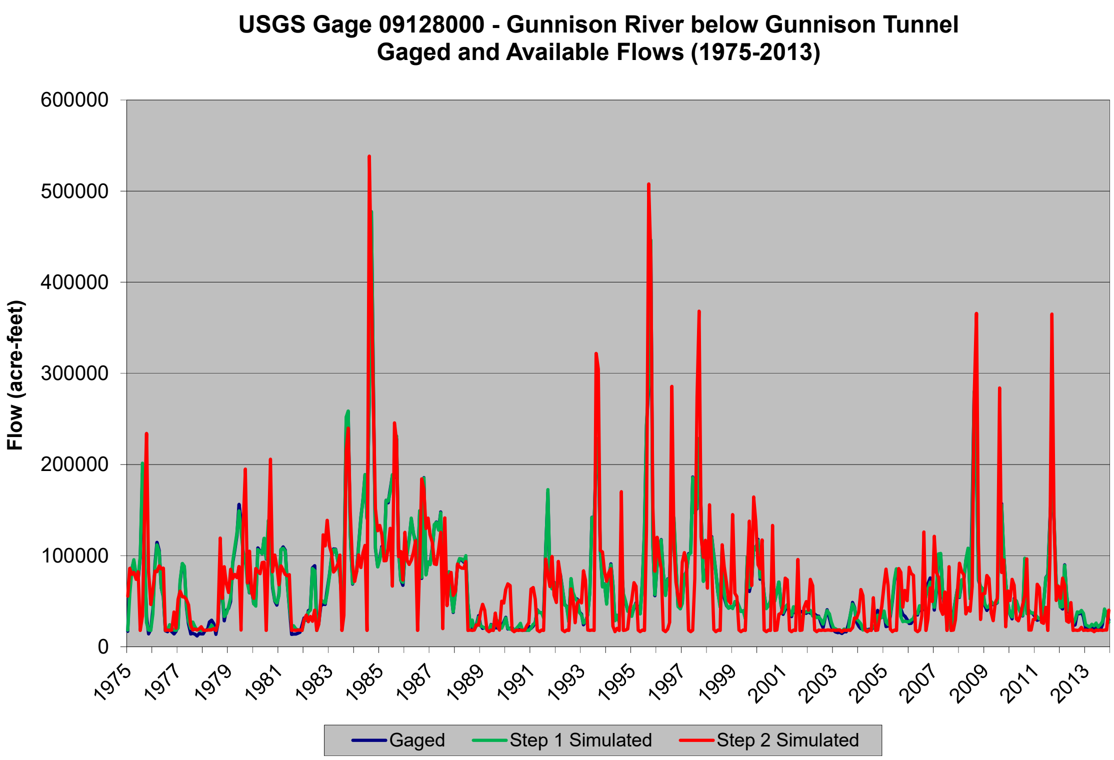
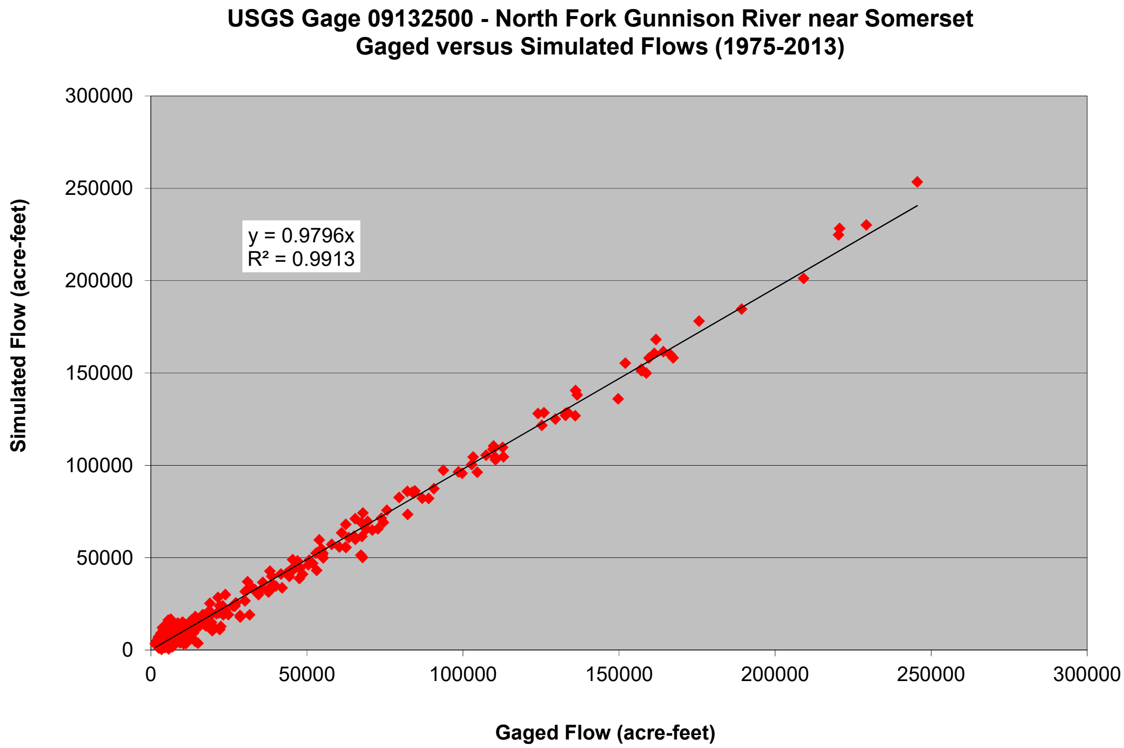


Figure 7.4 Streamflow Calibration – 09128000 Gunnison River below Gunnison Tunnel



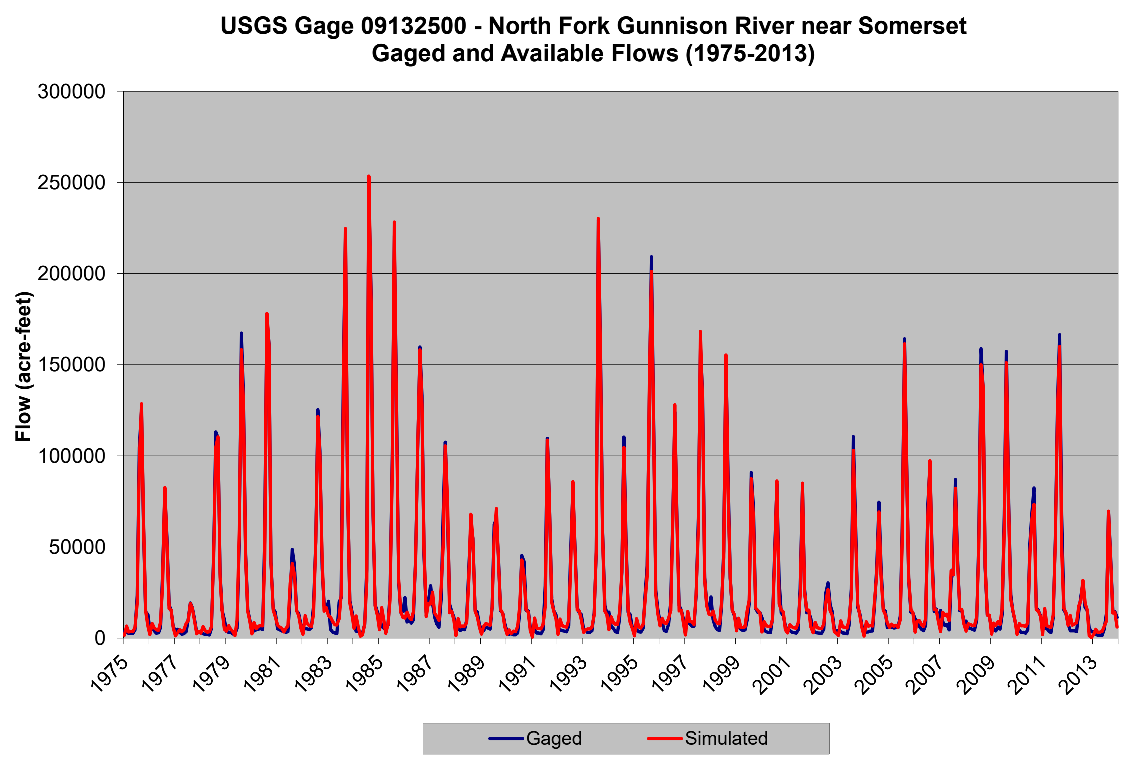
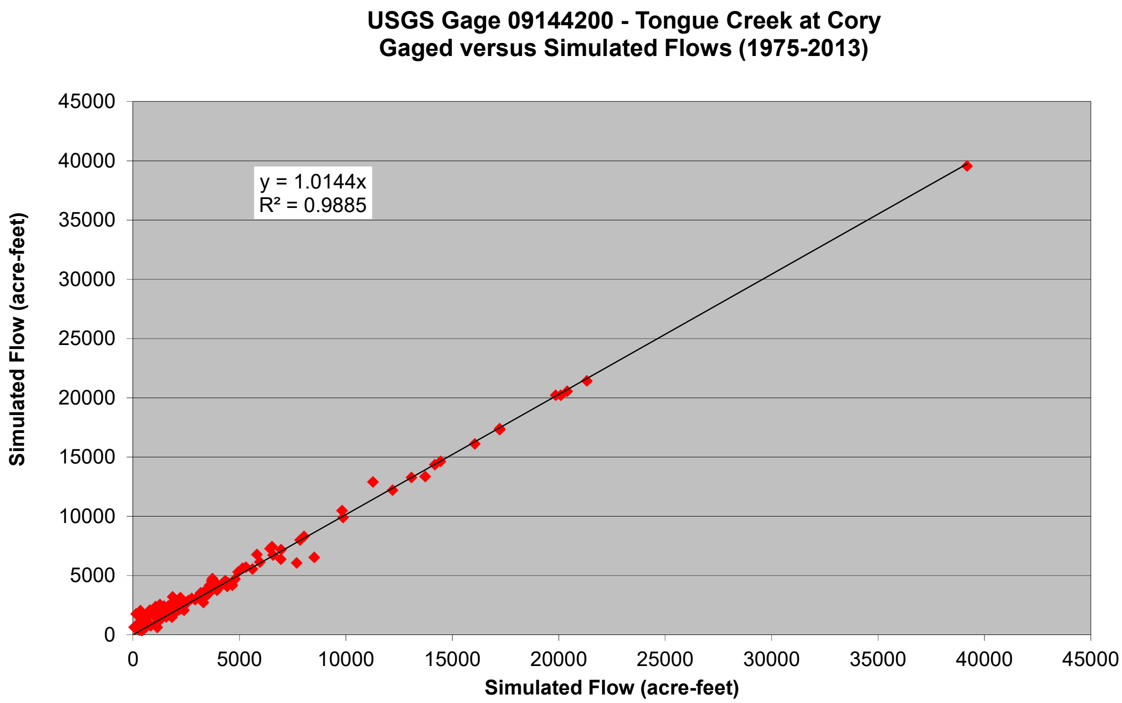


Figure 7.5 Streamflow Calibration – 09132500 North Fork Gunnison River near Somerset



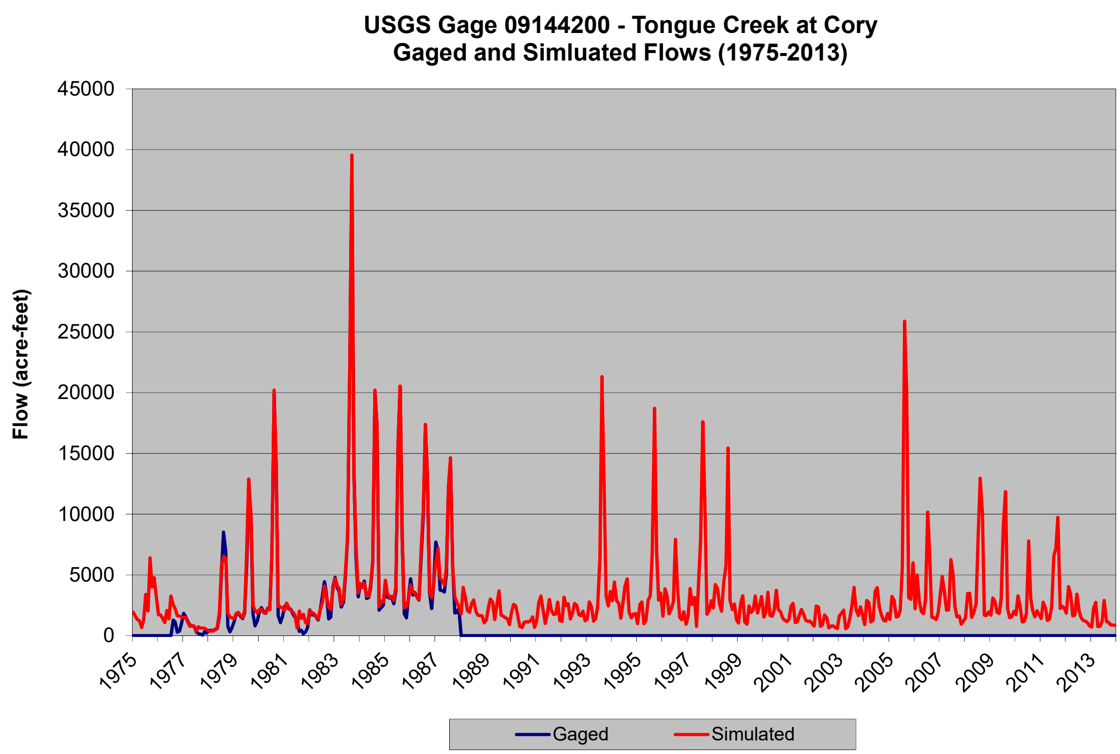
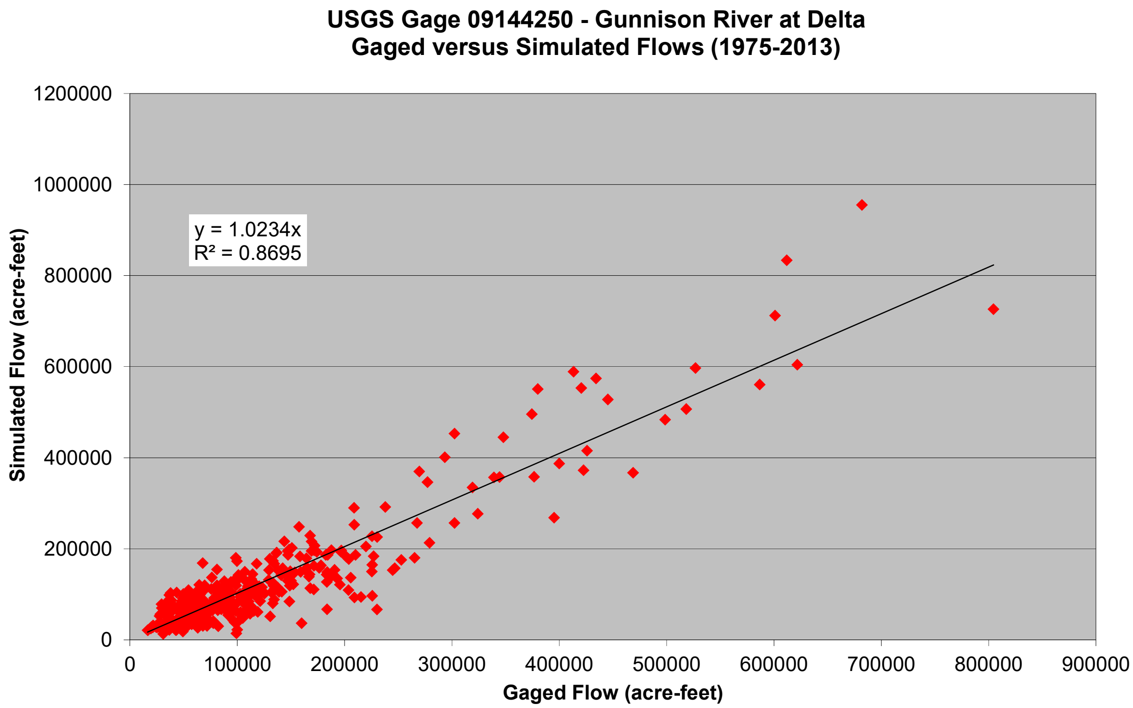


Figure 7.6 Streamflow Calibration – 09144200 Tongue Creek at Cory



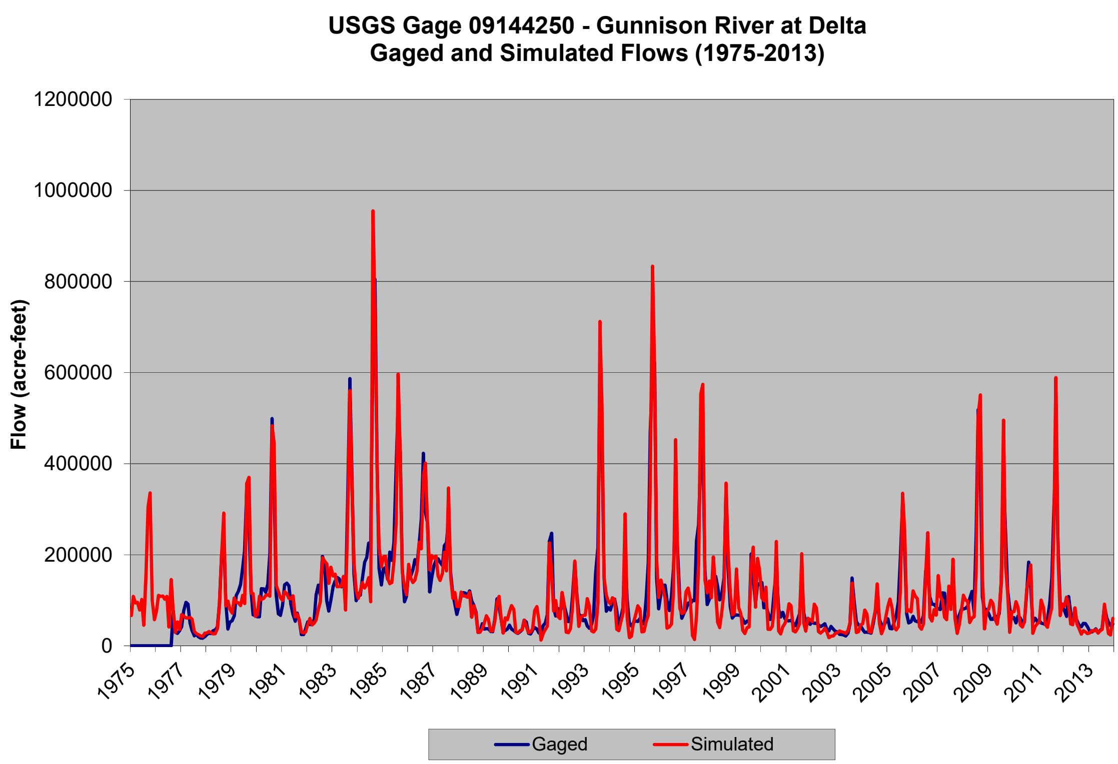
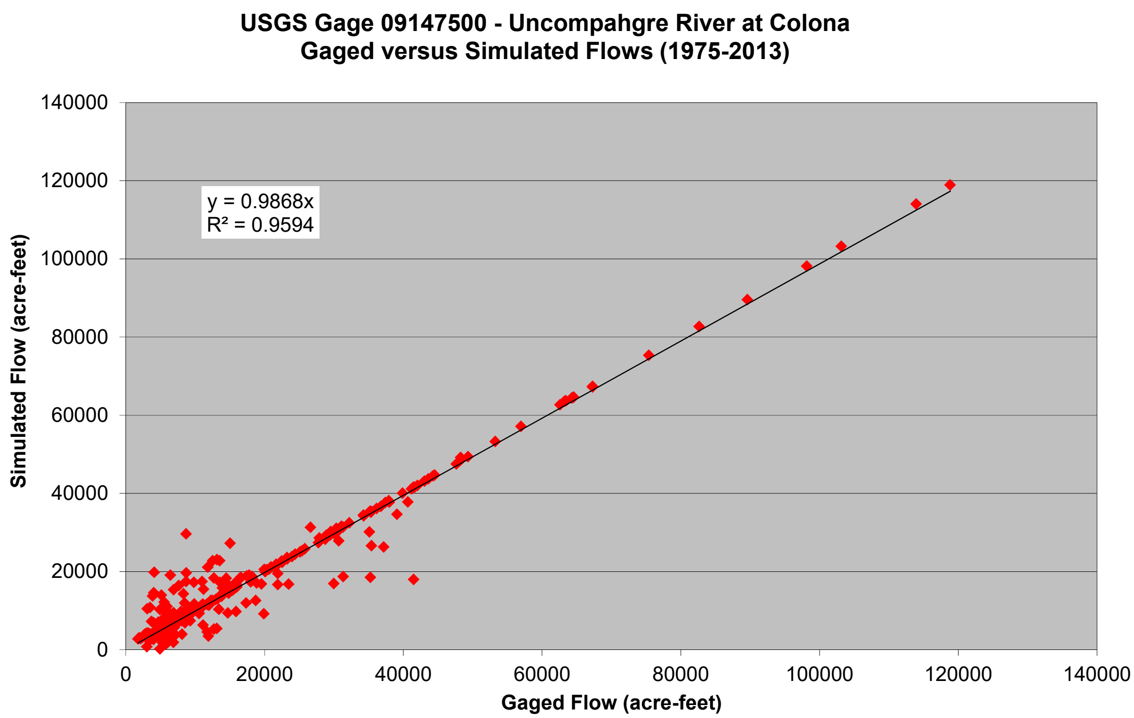


Figure 7.7 Streamflow Calibration – 09144250 Gunnison River at Delta



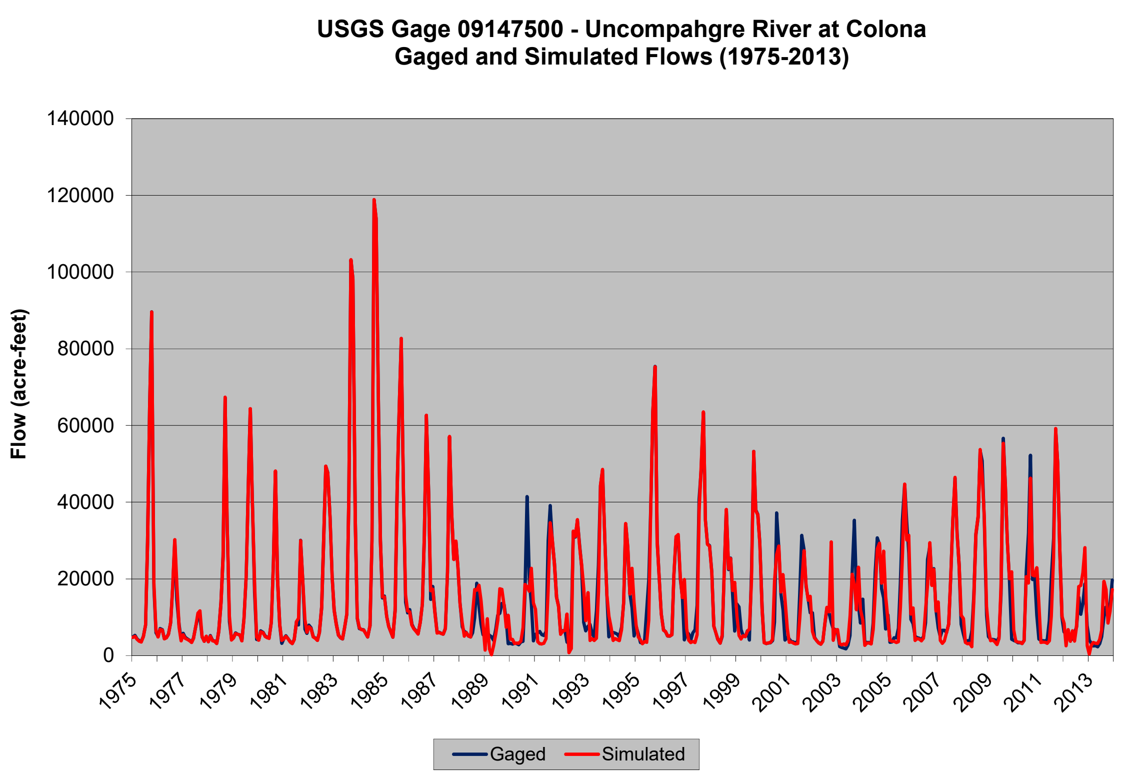
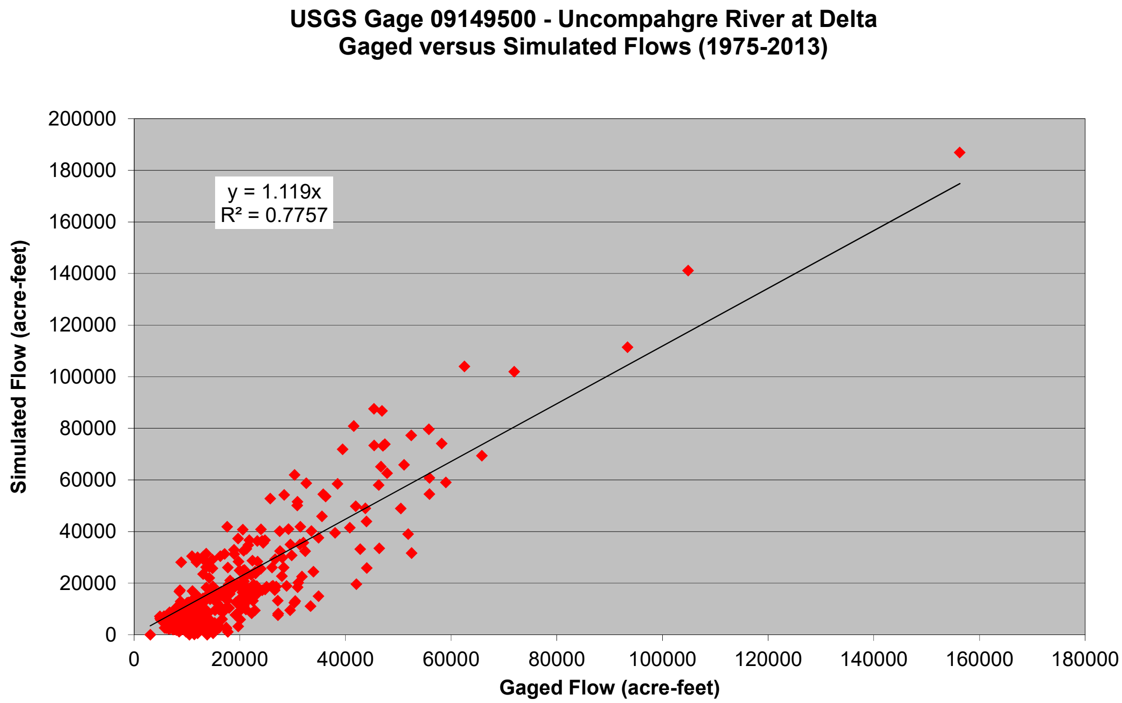


Figure 7.8 Streamflow Calibration – 09147500 Uncompahgre River at Colona



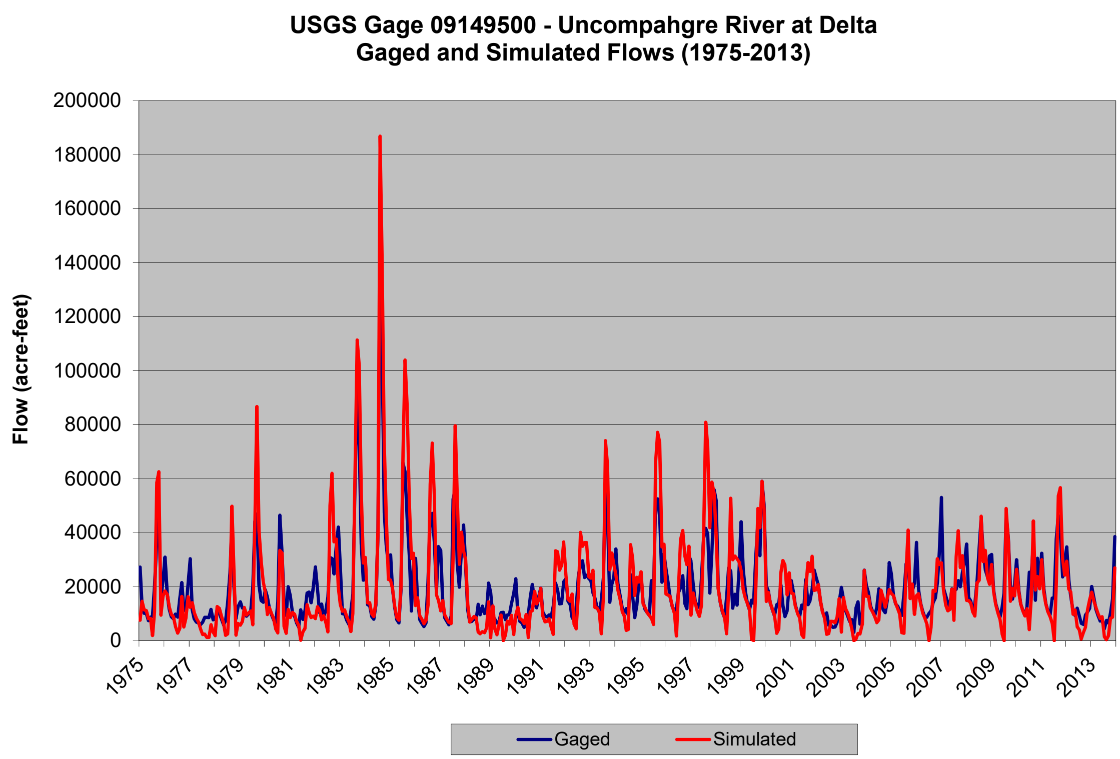
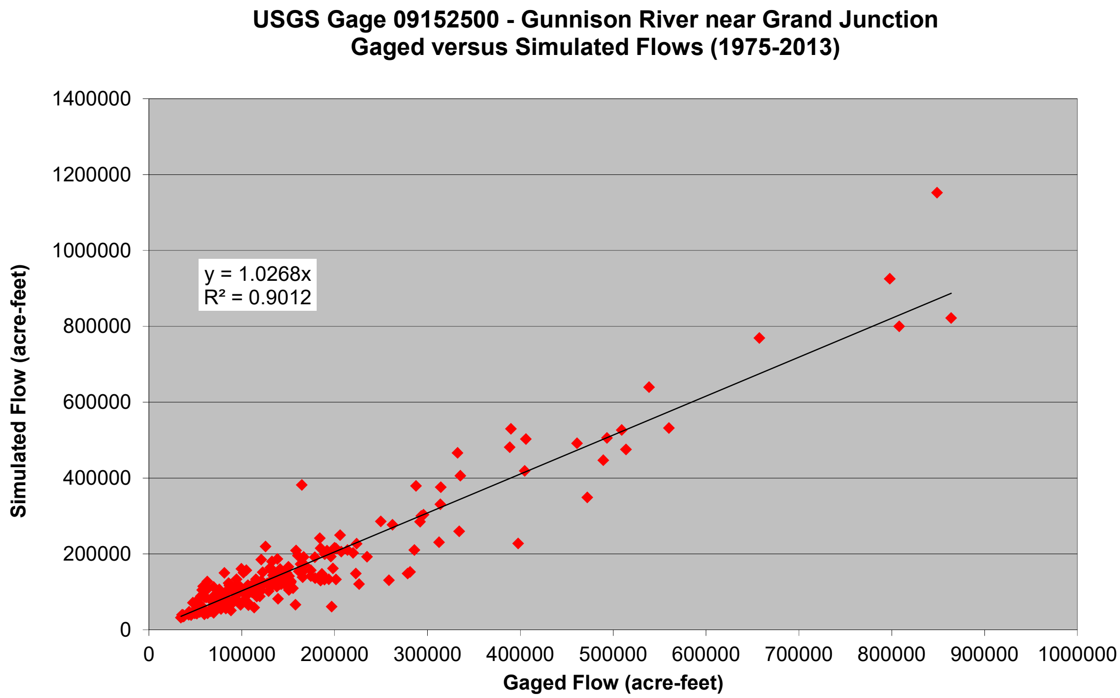


Figure 7.9 Streamflow Calibration – 09149500 Uncompahgre River at Delta



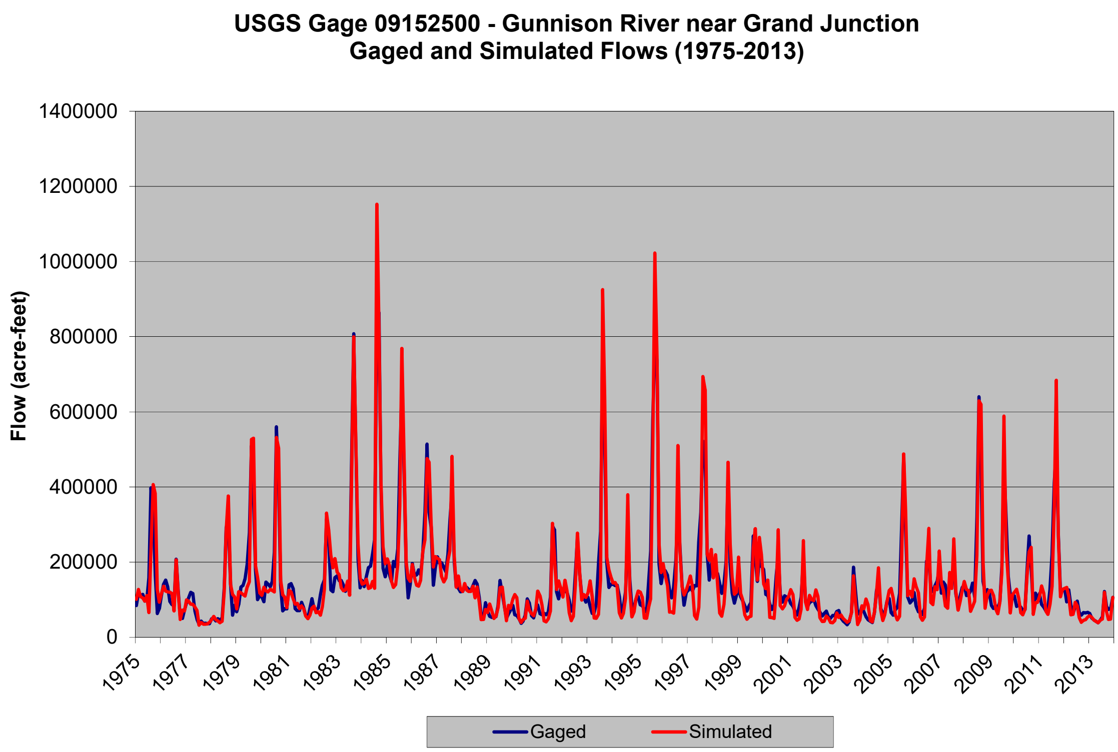


Figure 7.10 Streamflow Calibration – 09152500 Gunnison River near Grand Junction

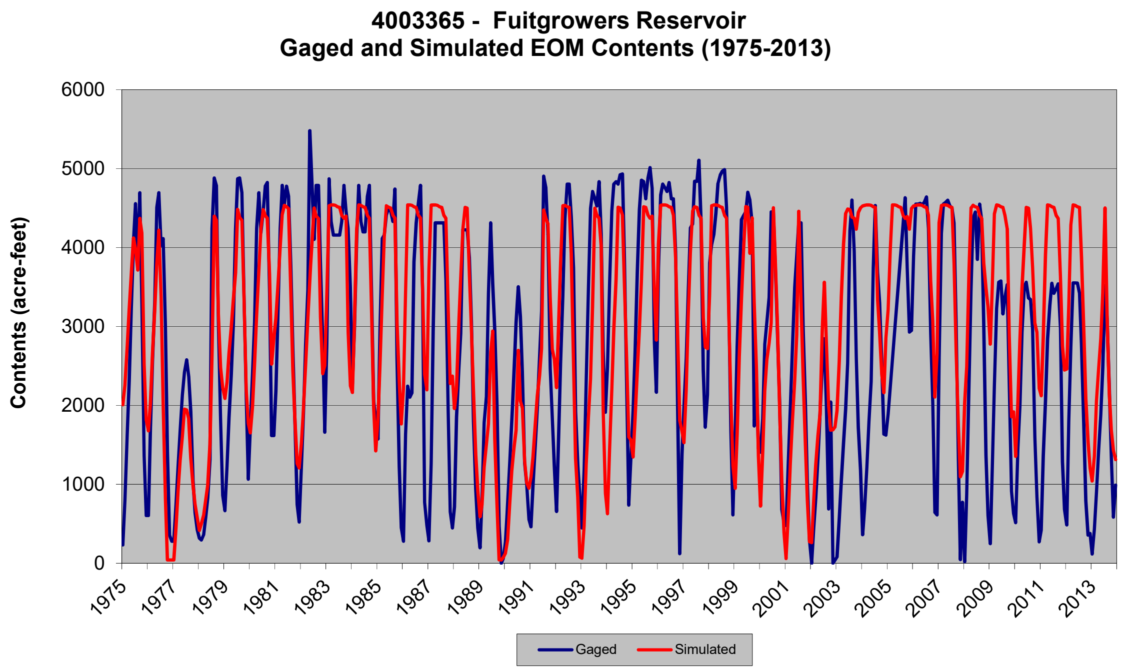


Figure 7.11 Reservoir Calibration – Fruitgrowers Reservoir

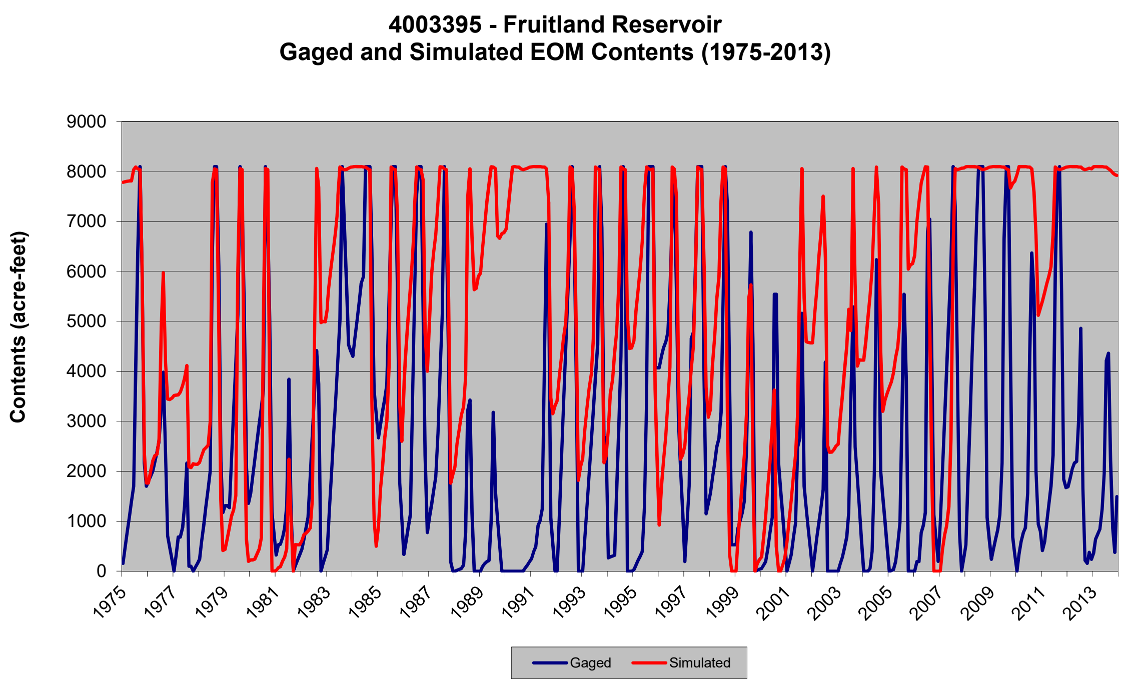


Figure 7.12 Reservoir Calibration – Fruitland Reservoir

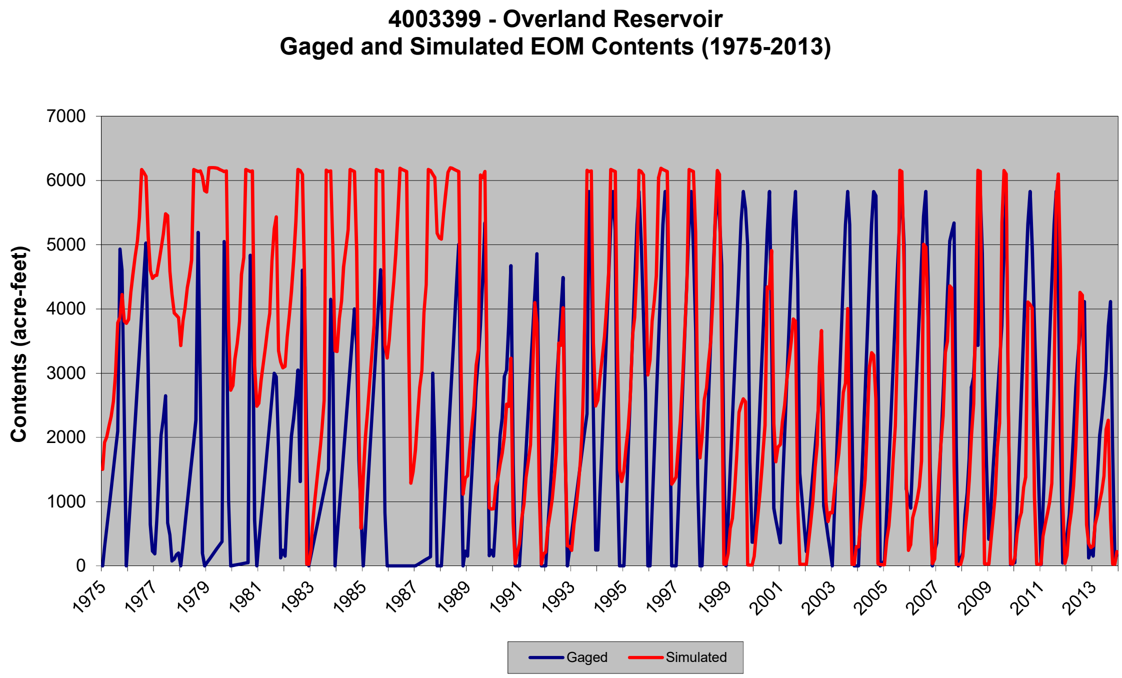


Figure 7.13 Reservoir Calibration – Overland Reservoir

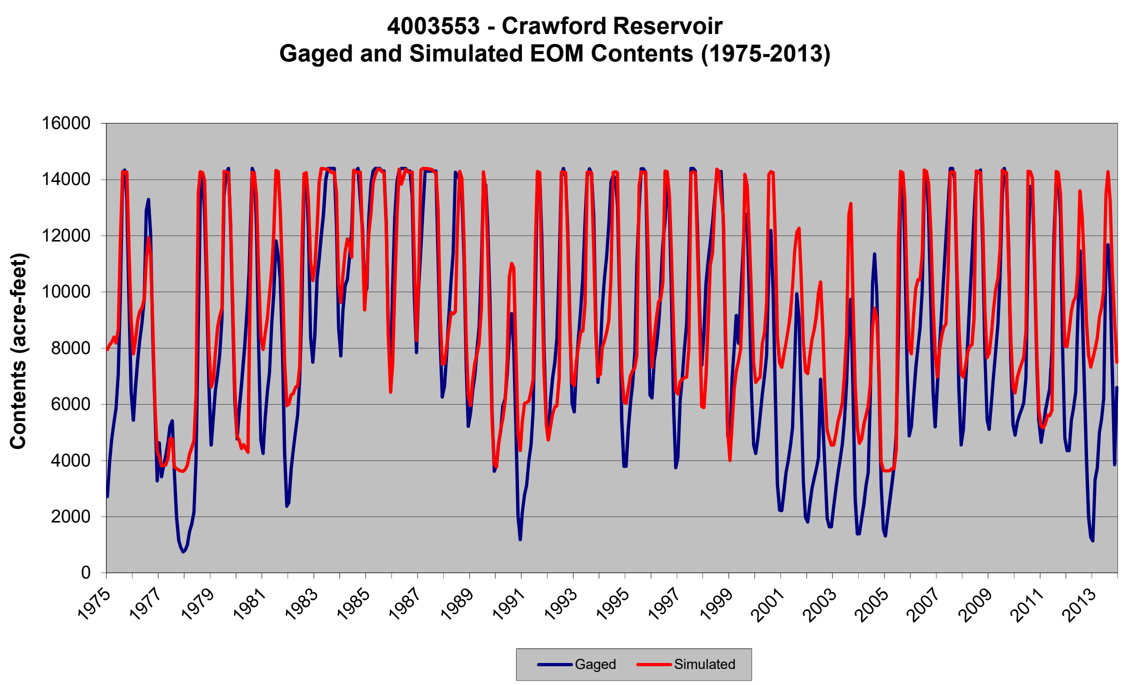


Figure 7.14 Reservoir Calibration – Crawford Reservoir

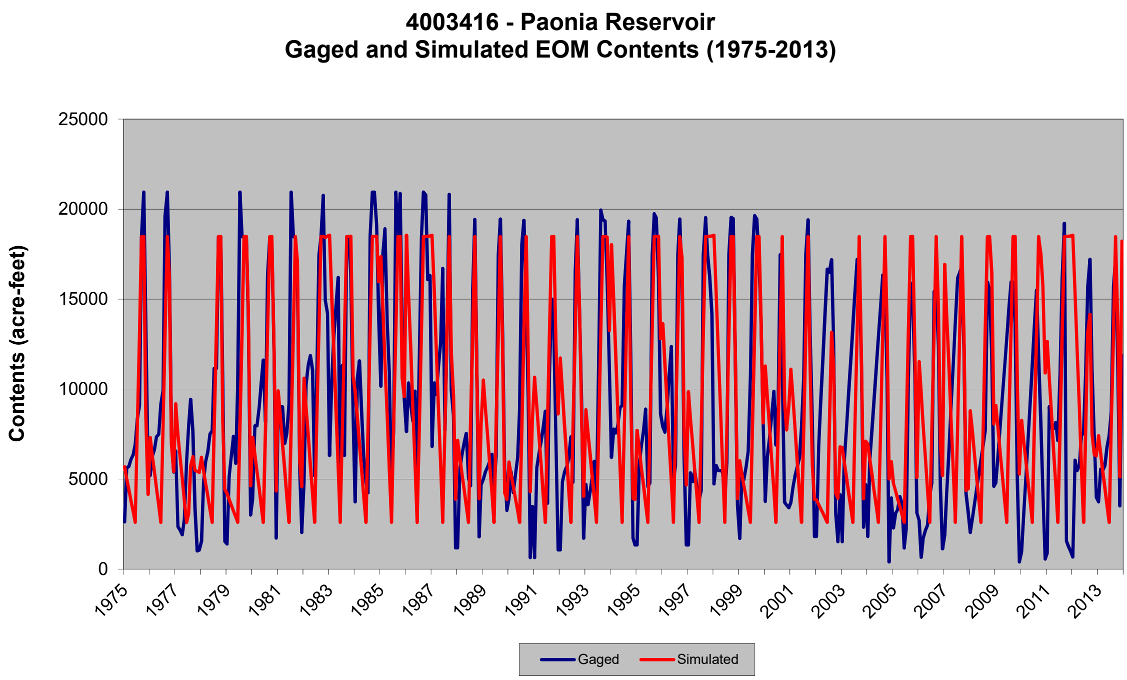


Figure 7.15 Reservoir Calibration – Paonia Reservoir

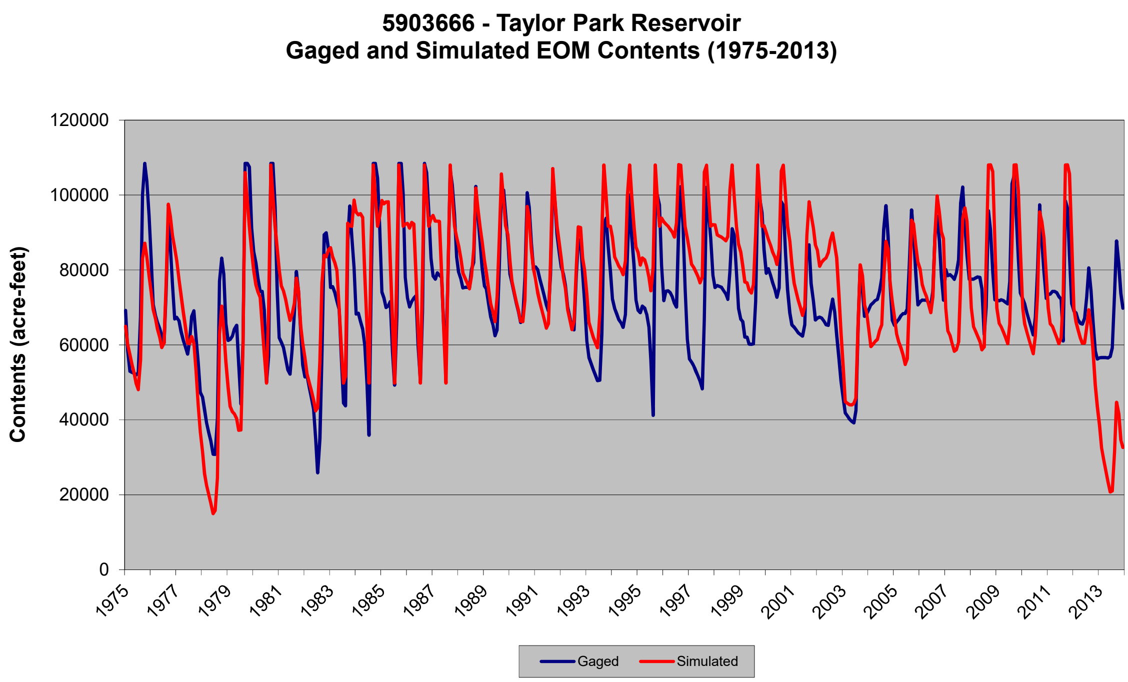


Figure 7.16 - Reservoir Calibration – Taylor Park Reservoir

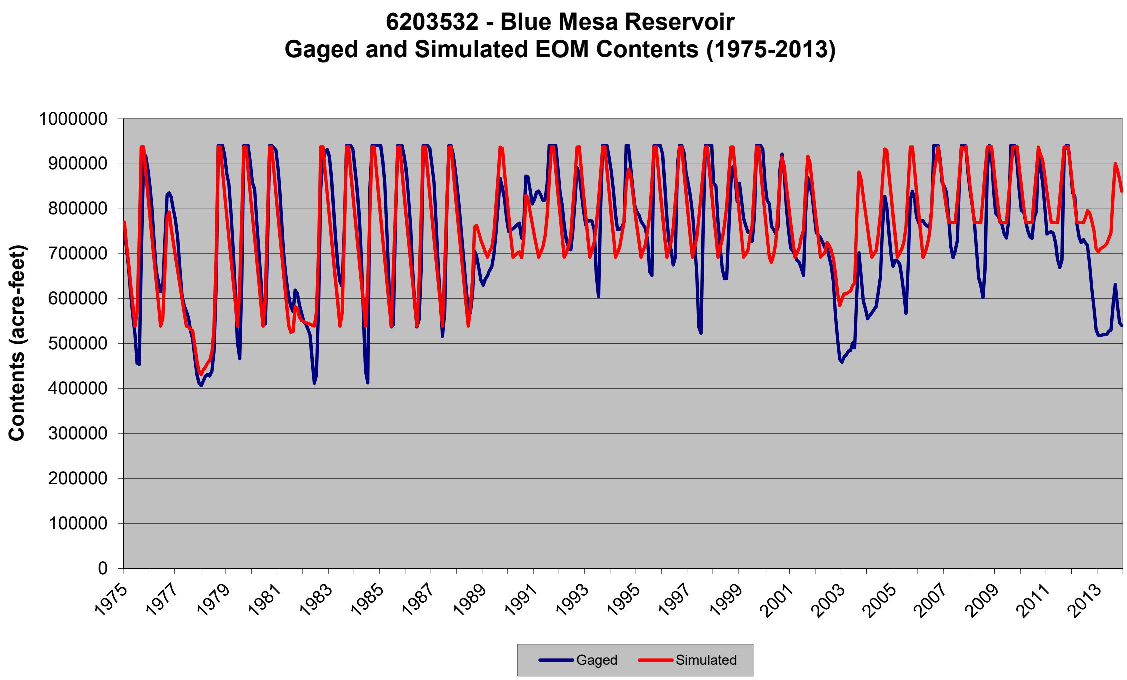


Figure 7.17 - Reservoir Calibration – Blue Mesa Reservoir

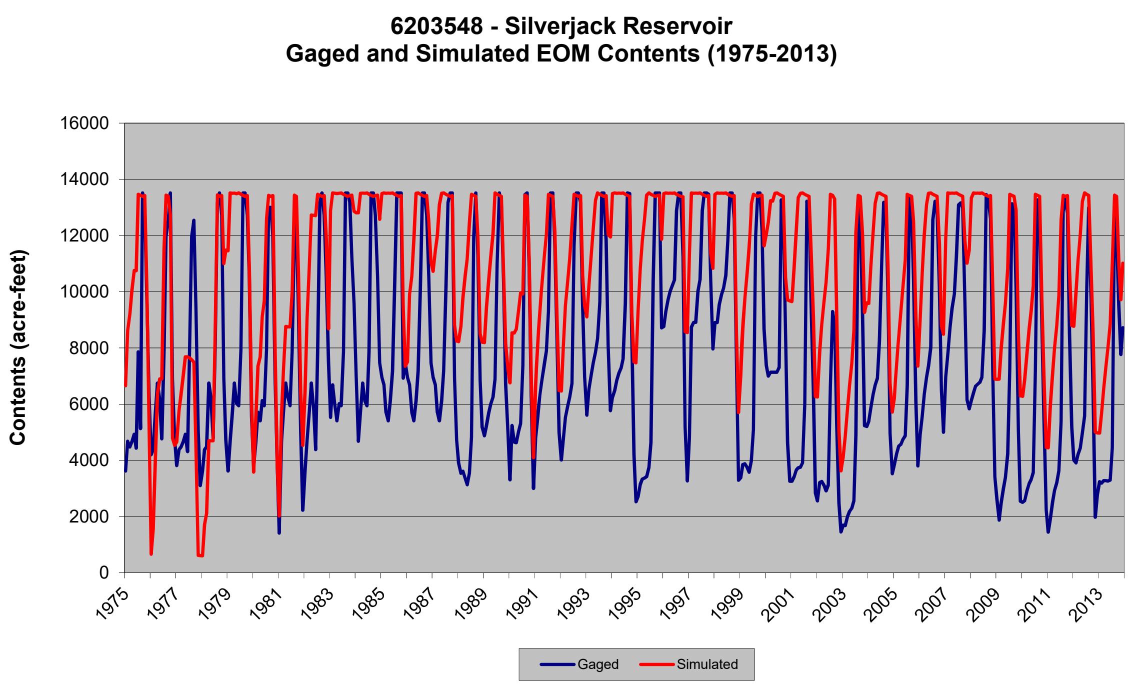


Figure 7.18 - Reservoir Calibration – Silverjack Reservoir

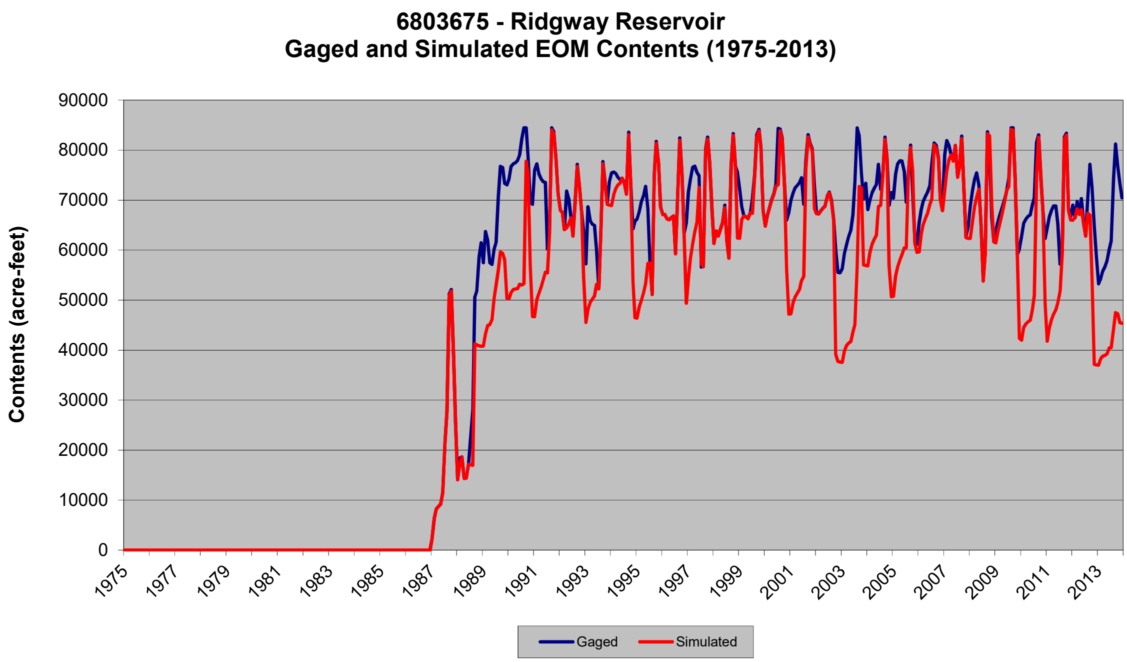


Figure 7.19 - Reservoir Calibration – Ridgway Reservoir

Appendix A

Aggregation of Irrigation Diversion Structures

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

A1. Gunnison River Basin Aggregated Irrigation structures

Introduction

The original CDSS StateMod and StateCU modeling efforts were based on the 1993 irrigated acreage coverage developed during initial CRDSS efforts. Irrigated acreage assessments representing 2005 and 2010 have now been completed for the western slope basins. A portion of the 2005 and 2010 acreage was tied to structures that did not have identified acreage in the 1993 coverage, and, consequently, are not currently represented in the CDSS models. As part of this task, aggregate and diversion system structure lists for the western slope basins were revised to include 100 percent of the irrigated acreage based on both the 2005 and 2010 assessments. The update also included identification of associated structures and the development of "no diversion" aggregates—groups of structures that have been assigned acreage but do not have current diversion records.

The methodology for identifying associated structures is described more in-depth in Section A-2 of this appendix. In general, associated structures—which divert to irrigate a common parcel of land—were updated to more accurately model combined acreage, diversions, and demands. These updates include the integration of the 2005 irrigated acreage, the 2010 irrigated acreage, as well as verification based on diversion comments and water right transaction comments. In StateCU, the modeling focus is on the irrigated parcels of land. Therefore, all associated structures are handled in the same way. The acreage is assigned to a single primary node, which can be supplied by diversions from any of the associated structures. In StateMod, there are two types of associated structures. Diversion systems represent structures located on the same tributary that irrigate common land. Diversions systems combine acreage, headgate demands, and water rights; StateMod treats them as a single structure. In contrast, multi-structure systems represent structures located on different tributaries that irrigate common land. Multi-structure systems have the combined acreage and demand assigned to a primary structure; however, the water rights are represented at each individual structure, and the model meets the demand from each structure when their water right is in priority.

"No diversion" aggregates are included in StateCU in order to capture 100 percent of irrigated acreage. However, they were not included in the StateMod modeling effort. Because the individual structures included in these aggregates do not have current diversion records, their effect on the stream cannot be accounted for in the development of natural flows. Therefore, it is appropriate that their diversions also not be included in simulation. The individual structures in the "no diversion" aggregates generally irrigate minimal acreage, often with spring water as a source. There is an assumption that the use will not change in future "what-if" modeling scenarios.

Approach

The following approach was used to update the aggregated structures in the Gunnison River Basin.

1. Identify structures assigned irrigated acreage in either the 2005 or 2010 CDSS acreage coverages.

2. Identify Key structures represented explicitly in the model. The process for determining key structures is outlined in Section 4 of the report.
3. Identify Key structures that should be represented as diversion systems or multi-structures, based on their association with other structures as outlined in Section A-2 of this appendix.
4. Aggregate remaining irrigation structures identified in either the 2005 or 2010 irrigated acreage coverages based on the aggregate spatial boundaries shown in Figure A-1. The boundaries were developed during previous Gunnison River Basin modeling effort to general group structures by tributaries with combined acreage less than 2,200.
5. Further split the aggregations based on structures with and without current diversions during the period 2000 through 2012.

Results

Table A-1 indicates the number of structures in the aggregation and the total the 2005 and 2010 aggregated acreage. All of the individual structures in the aggregates have recent diversion records.

Table A-1: Gunnison River Basin Aggregation Summary

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
28_ADG009	Upper Tomichi	19	954	960
28_ADG010	Tomichi 1	11	846	1,005
28_ADG011	Cochetopa	7	343	290
28_ADG012	Tomichi 2	21	791	814
28_ADG043	West Pass	3	148	140
28_ADG044	Razor	2	91	91
40_ADG019	Gunnison below Tunnel	2	25	25
40_ADG020	Iron	6	1,684	1,727
40_ADG021	Smith Fork	10	616	448
40_ADG022	North Fork Gunn	20	1,319	1,321
40_ADG023	Minnesota	8	362	412
40_ADG024	North Fork Gunn 2	17	1,183	1,196
40_ADG025	Leroux	12	972	980
40_ADG026	Gunnison near Lazear	32	2,405	2,275
40_ADG027	Currant	14	1,534	1,497
40_ADG028	Upper Tongue	67	2,848	2,640
40_ADG029	Surface	16	922	893
40_ADG030	Tongue	31	2,884	2,527
40_ADG039	Gunnison below Delta	27	1,663	1,500
41_ADG035	Uncompahgre 3	1	295	276
41_ADG036	Uncompahgre 4	29	3,198	2,582

41_ADG037	Uncompahgre 5	12	1,347	1,259
42_ADG040	Gunnison near Grand Junction	34	1,568	1,421
59_ADG001	Taylor	13	518	277
59_ADG002	East 1	6	288	288
59_ADG003	Slate	8	527	527
59_ADG004	East 2	13	793	793
59_ADG005	East 3	12	930	892
59_ADG006	Ohio 1	15	732	732
59_ADG007	Ohio 2	29	1,788	1,664
59_ADG008	Gunnison near Gunnison	18	1,910	1,905
62_ADG013	Cebolla 1	33	942	932
62_ADG014	Cebolla 2	18	1,021	1,021
62_ADG015	Lake	33	1,090	882
62_ADG016	Gunnison Blue Mesa	29	992	986
62_ADG017	Gunnison Morrow Point	5	2,141	287
62_ADG018	Cimarron	6	4,568	4,377
68_ADG033	Dallas	20	1,580	1,575
68_ADG034	Uncompahgre 2	55	3,787	3,684

Table A-2 indicates the structures in the diversion systems and multi-structures.

Table A-2: Diversion System and Multi-Structure Summary

Diversion System ID	Diversion System Name	WDID
2800564_D, TOMI_GILBERTSON NO 1	GILBERTSON NO 1 DITCH	2800564
	GILBERTSON NO 2 DITCH	2800565
2800568_D, LOS _GOVERNMENT DITCH	GOVERNMENT DITCH	2800568
	MCDOWELL VAN TUYL NO 1 D	2800637
2800571_D, TOMI_GRIFFING NO 1 D	GRIFFING NO 1 DITCH	2800571
	GRIFFING NO 2 DITCH	2800572
2800586_D, HIRDMAN_SYSTEM	HIRDMAN DITCH NO 3	2800586
	HIRDMAN DITCH NO 1	2801272
	HIRDMAN DITCH NO 2	2801273
2800660_D, NORMAN_SYSTEM	NORMAN DITCH	2800660
	NORMAN DITCH AP	2800780
2800683_D, SHARP_SYSTEM	SHARP DITCH	2800683
	SHARP DITCH AP	2801585
2800697_D, SUTTON_SYSTEM	SUTTON NO 1 AMENDED D	2800695
	SUTTON NO 2 AMENDED D	2800696
	SUTTON NO 3 AMENDED D	2800697
	SUTTON NO 5 DITCH	2800699
2800566_D, GOODRICH_SYSTEM	GOODRICH DITCH	2800566
	GOODRICH DITCH ALT PT	2800953

4000701_D, CEDAR_PARK_SYSTEM	CEDAR PARK DITCH	4000701
	CEDAR PARK EXT A ENL D	4001230
4000703_D, DIRT_EAGLE DITCH	EAGLE DITCH	4000703
	EAGLE NO1 DITCH	4001239
4000753_D, SURF_BONITA DITCH	BONITA DITCH	4000753
	OLD RELIABLE DITCH	4000772
4000808_D, MORTON_SYSTEM	MORTON DITCH	4000808
	MORTON DITCH NO 2	4000809
4000820_D, ALFA_STELL DITCH	STELL BUTTES ENLG DITCH	4000820
	FOGG DITCH	4000759
	STELL DITCH	4000819
	CIRCLE DITCH	4000791
4000891_D, GUNN_NORTH DELTA CAN	NORTH DELTA CANAL	4000891
	NORTH DELTA CANAL	4000730
4001166_D, MUDD_LARSON NO 2 DIT	LARSON NO 2 DITCH	4001166
	LARSON DITCH	4001165
4001437_D, ROUB_HAWKINS DITCH	HAWKINS DITCH	4001437
	ENTERPRISE DITCH	4001434
4100534_D, UNCO_IRONSTONE CANAL	IRONSTONE CANAL	4100534
	SATISFACTION DITCH	4100558
4100568_D, Sunrise DivSys	SUNRISE DITCH(HAPPY CYN)	4100568
	SUNRISE DITCH	4101680
6200736_D, CEBO_SAMMONS IRG D N	SAMMONS IRG D NO 4	6200736
	SAMMONS DITCH	6200733
6200812_D, YOUMANS NO 4 DITCH	YOUMANS IRG D NO 1	6200809
	YOUMANS NO 4 DITCH	6200812
4000944_D, LERO_OVERLAND DITCH	OVERLAND DITCH	4000944
	STULL DITCH	4000942
	OVERLAND DITCH	4000585
4000503, GRANDVIEW CANAL Multistructure	GRANDVIEW CANAL	4000503
	ASPEN DITCH	4000508
4000501, NEEDLE ROCK DITCH Multistructure	NEEDLE ROCK DITCH	4000501
	ASPEN CANAL	4000509

Figure A-1 shows the spatial boundaries of each aggregation. **Exhibit A**, attached, lists the diversion structures represented in each aggregate and provides a comparison of the 2005 and 2010 irrigated acreage assigned to each structure.

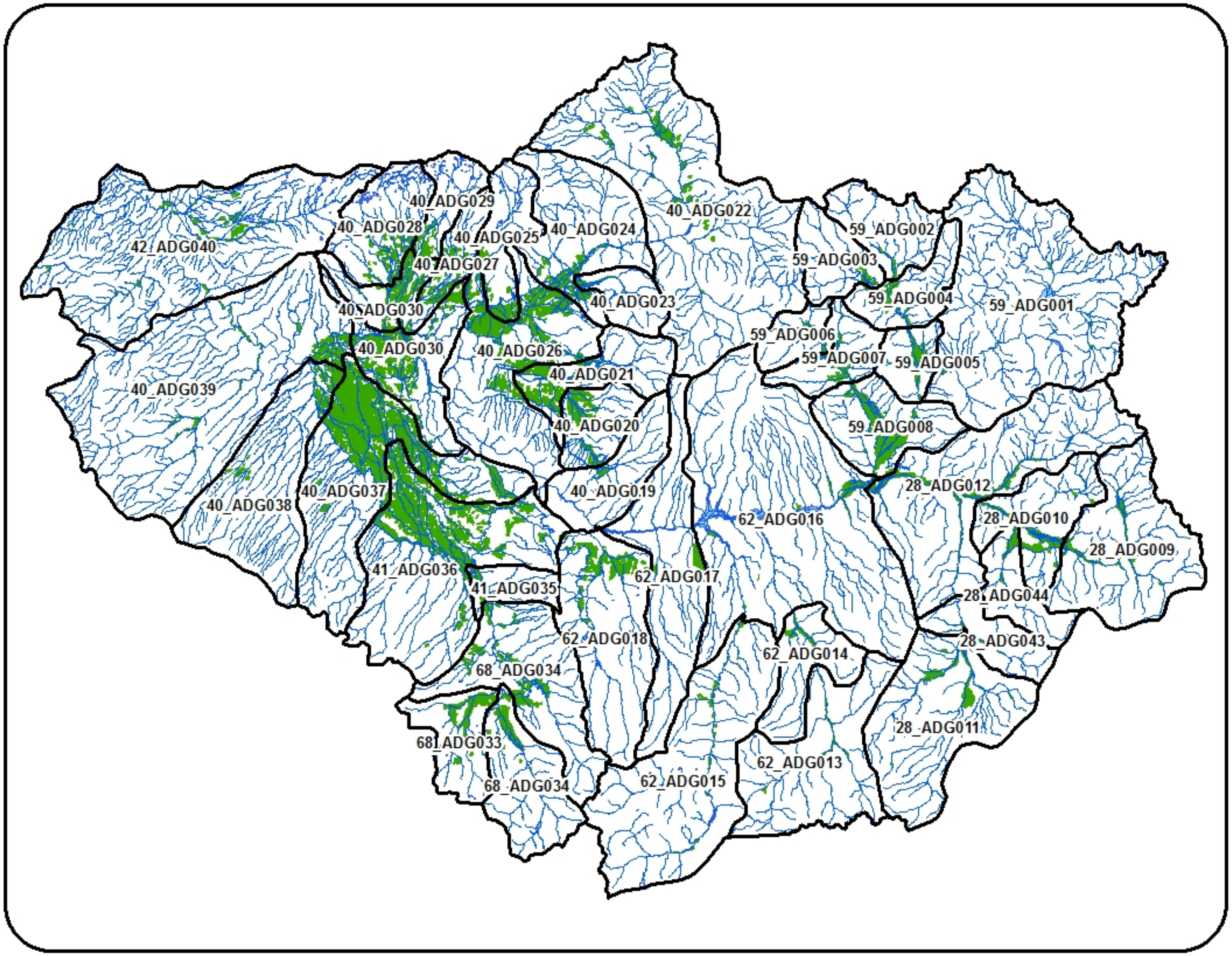


Figure A-1: Aggregate Structure Boundaries

Recommendations

As part of this modeling update, various lists have been developed for review and reconciliation by the Water Commissioner. The lists include:

- Structures tied to irrigated acreage that do not have current diversion records
- Structures tied to irrigated acreage that do not have water rights for irrigation
- Structures that have current diversion records coded as irrigation use, but do not have irrigated acreage in either 2005 or 2010
- Structures that have irrigation water rights, but do not have irrigated acreage in either 2005 or 2010
- More than one structure is assigned to the same irrigated parcel, however there was no indication that the structures serve the same acreage in either diversion comments or water rights transaction comments.

EXHIBIT A: Diversion Structures in Aggregates

Aggregation ID	Structure Name	WDID	2005 Acres	2010 Acres
28_ADG009, Upper Tomichi	Gee Canal	2800563	147	147
	J T Horn Ditch	2800598	69	69
	Long Branch Ditch	2800625	21	21
	Long Branch Rgr Sta Dno1	2800626	20	20
	Long Branch Rgr Sta Dno2	2800627	4	0
	Means Bros No 1 Ditch	2800639	22	21
	Means Bros No 10 Ditch	2800640	75	75
	Means Bros No 11 Ditch	2800641	75	75
	Templeton Ditch	2800705	41	41
	Weddle Ditch	2800713	46	46
	Cole D Cole Clark De & E	2800746	206	189
	Hellmuth D Nos 1&2	2800962	22	48
	Hicks Creek Ditch	2800965	22	22
	Dawson Creek Ditch	2800969	36	36
	Tank 7 Ditch No 1	2800996	24	24
	Tank 7 Ditch No 2	2800997	24	24
	Big Bend Ditch	2801118	46	46
	Mccalister Ditch	2801129	36	36
	Long Brnch/Weddle Hgt1-4	2801184	21	21
28_ADG010, Tomichi 1	Gratehouse Ditch	2800570	25	25
	Gulch No 1 No 2 Ditches	2800575	80	80
	Knowles Barrett Ditch	2800611	33	211
	Knowles Ditch	2800612	383	383
	Munson Creek Ditch	2800656	109	100
	Munson Ditch	2800657	9	0
	Spruce Creek Ditch	2800893	39	39
	Willard Ditch	2800948	33	33
	Willard No 2 Ditch	2800949	33	33
	Mcgowan Irrigating D Alt	2801630	61	61
	D A Mcconnell D Alt Pt	2801649	40	40
28_ADG011, Cochetopa	Cochetopa Meadows Ditch	2800533	7	7
	Curtis Ditch No 1	2800540	8	8
	Curtis Ditch No 2	2800541	23	23
	Leahy Ditch	2800813	25	25
	Stevens Ditch	2800897	113	78
	Crarys Los Pinos No2 Ditch	2800968	43	77
	Willow Creek Ditch	2801012	123	72
	Alder Ditch	2800504	7	7

28_ADG012, Tomichi 2	Cabin Creek Ditch	2800519	21	28
	Cheeney No 1 Ditch	2800524	21	58
	Clovis Metroz No 2 Ditch	2800531	34	36
	Graham Ditch	2800569	52	44
	Jennings Elsen Ditch	2800599	53	53
	Lobdell Alder Creek	2800620	23	23
	Lockwood Ditch	2800623	65	65
	Bever Ditch	2800720	42	26
	Deering Spring Ditch	2800773	50	50
	Dipping Vat Ditch	2800774	56	56
	Marthas Spring Ditch	2800819	44	44
	Piloni Homestead Ditch	2800862	56	56
	Mclain Spring	2800885	65	65
	Waterman Ditch	2800937	4	4
	Hartman Ditch No 1	2800959	20	18
	Mcdowell Van Tuyl No 2 D	2801565	78	78
	Clovis Metroz No1 Alt 1	2801634	17	17
	Clovis Metroz No1 Alt 2	2801635	51	53
	Clovis Metroz No1 Alt 3	2801636	17	17
	Clovis Metroz No1 Alt 4	2801637	17	17
28_ADG043, West Pass	Funk Ditch No 77	2800792	64	64
	Spring Ditch	2800892	64	64
	Gwendolyn K Hack Ditch	2800957	19	11
28_ADG044, Razor	Aurora Ditch	2800724	45	45
	Willis Ditch	2800733	45	45
40_ADG019, Gunnison Below Tunnel	Don Meek No 1 Ditch	4000540	18	18
	Don Meek No 2 Ditch	4000541	7	7
40_ADG020, Iron	Cathedral Ditch	4000519	97	97
	Clear Fork Ditch	4000528	294	331
	Fluke Ditch	4000544	484	489
	Georgia Ditch	4000550	38	38
	Maher Ditch	4000569	594	594
	Mcmillan Ditch	4000573	178	178
40_ADG021, Smith Fork	Anderson Ditch	4000507	30	30
	Barnard Ditch	4000512	57	57
	Bean Ditch	4000514	11	11
	Buck Canon Ditch	4000518	29	29
	Diamond Joe Ditch	4000537	47	47
	Jersey Ditch	4000561	32	31

	Reeder Ditch 1 And 2	4000594	23	23
	Reeder Ditch No 3	4000595	23	23
	Shadeland Ditch	4000604	334	168
	Upper Mcleod Ditch	4000614	28	28
40_ADG022, North Fork Gunnison	Ault Ditch	4001071	68	68
	Beuten Ditch	4001082	193	193
	Bever Hide Ditch	4001085	22	22
	Big Rock Ditch	4001086	11	13
	Buzzard Ditch No 1	4001090	45	45
	Buzzard Ditch No 2	4001091	45	45
	Elk Ditch	4001125	33	33
	Frey Ditch	4001137	19	19
	Galpin No 2 Ditch	4001139	50	50
	Homestead Ditch	4001148	42	42
	Hutchins Ditch	4001151	86	86
	J F Toland Ditch	4001157	77	77
	Layton And Cloone Ditch	4001167	20	20
	Lost Cabin Ditch	4001172	61	61
	Mcmillan Ditch No 1	4001179	38	38
	Norris Ditch	4001184	106	106
	Sperry Ditch	4001203	124	124
	Spring Gulch Ditch	4001204	38	38
	Oak Leaf Ditch	4001279	119	119
	Ridge Ditch	4001756	119	119
40_ADG023, Minnesota	Clough Ditch	4000964	15	14
	East Fork Ditch No 1	4000977	37	88
	Emmons Harding Ditch	4000981	23	23
	Harding Kerns Ditch	4000993	34	34
	Lane Ditch	4001009	60	60
	Sweezy Turner Ditch	4001051	77	77
	Clark & Wade D	4001232	78	78
	Layton Ditch	4001250	38	38
40_ADG024, North Fork Gunnison 2	Ballard Ditch	4000951	43	43
	Bruce Ditch	4000960	28	28
	Gopher Ditch	4000989	11	11
	Hadley Ditch No 2	4000991	86	86
	Miller Ditch	4001018	23	23
	Oak Mesa Ditch	4001027	103	103
	Paonia Fruit Ditch	4001028	13	13
	Reynolds Ditch	4001033	387	379

	Vogel Ditch	4001057	26	34
	Deer Trail Ditch	4001113	78	84
	Fawcett Ditch	4001130	9	9
	Feldman Ditch	4001131	0	5
	Holybee Ditch	4001155	10	10
	Lennox Ditch	4001169	49	49
	Majnik Ditch	4001173	12	12
	Terror Ditch	4001208	295	295
	Hadley Ditch	4001276	10	12
40_ADG025, Leroux	Enos T Hotchkiss Ditch	4000921	17	17
	Orchard Ditch	4000934	52	52
	Richie Ditch	4000938	94	94
	Ross Ditch	4000939	34	34
	Shindledecker Ditch	4000940	40	45
	Smith Ditch	4000941	114	114
	Wilcox Ditch	4000943	47	52
	H S Johnson Ditch	4001001	298	322
	Miller Waste Ditch	4001019	56	29
	Riddle Stephens Ditch	4001034	82	82
	W F Duke Ditch	4001059	52	52
	Duke Ditch	4001847	86	86
40_ADG026, Gunnison Near Lazear	Freeman Ditch No 2	4000547	8	8
	Scrub Oak Ditch No 1	4000602	11	11
	Scrub Oak Ditch No 2	4000603	33	33
	Smiths Fork Cr Canon D	4000606	49	49
	Oasis No 1 Ditch	4000811	136	136
	Big Gulch Ditch	4000915	186	186
	Fleming Ditch	4000922	150	153
	Isom Ditch	4000925	34	36
	Little Mary Ditch	4000927	439	437
	Clements Ditch	4000963	41	41
	Crane Ebersol Ditch	4000968	35	38
	Davenport Ditch	4000971	53	61
	Estes Ditch	4000982	27	21
	Hotchkiss No 1 Ditch	4000998	48	48
	Hotchkiss No 2 Ditch	4000999	42	42
	Hotchkiss No 3 Ditch	4001000	42	42
	Kelley Ditch No 2	4001006	120	120
	Kelley No 1 Ditch	4001007	12	18
	Langford Caddick Ltl D	4001010	15	15

	North Fork Orchard Co D	4001025	183	39
	Runyon Ditch	4001039	114	114
	Whipple Gulch Ditch	4001066	44	44
	Woods No 2 Ditch	4001068	27	27
	Kascak Seepage Ditch	4001233	13	13
	Watson Ditch No 2	4001247	40	40
	White Waste Ditch	4001257	43	45
	Larson Bro Ditch No 2	4001299	69	69
	Frank Allen Ditch	4001614	16	16
	J M Beal Seep Ditch	4001678	19	18
	Needle Rock D Hgt No 5	4001733	139	139
	Hall S Ditch Enlargement	4002482	64	64
	West Reservoir	4003411	153	151
40_ADG027, Currant	Alfalfa Run Seep Ditch	4000788	9	9
	Chandler Ditch	4000790	0	22
	Currant Creek No 1 Ditch	4000793	35	0
	Dry Creek Ditch	4000796	290	290
	Evergreen Ditch	4000799	155	150
	Fuller Ditch No 2	4000802	69	51
	Gallant Ditch	4000803	147	135
	Mcneil Ditch	4000806	31	38
	Mineral Springs Ditch	4000807	11	11
	Oak Park Ditch	4000813	254	254
	Rimrock Ditch	4000817	99	99
	Welch Ditch	4000823	101	101
	Whiting Ditch	4000826	205	208
	Burt And Thompson Ditch	4001272	128	128
40_ADG028, Upper Tongue	Billys Cross Ditch	4000629	8	8
	Broncho Ditch	4000630	53	47
	Cherokee Ditch	4000631	59	46
	Church Ditch	4000633	8	8
	Cottonwood Ditch	4000634	7	7
	Horse Park Ditch	4000638	42	42
	I E Baker Ditch	4000640	28	28
	Kiser Ditch	4000643	44	44
	Oak Leaf Ditch	4000652	3	3
	Red Bluff Ditch	4000654	114	113
	Roseberry Ditch	4000655	126	126
	Roosevelt Ditch	4000657	19	19
	States Ditch	4000660	20	20

	Sweitzer Ditch	4000663	12	12
	Texas Ditch	4000664	58	58
	Tipple Ditch	4000665	8	8
	Wonders Ditch	4000667	56	53
	Adobe Ditch	4000696	27	27
	Blake Ditch	4000697	49	49
	B And M Ditch	4000698	12	12
	Bryson Ditch	4000699	17	17
	Carbon Ditch	4000700	59	79
	Eckert Ditch	4000704	11	11
	Edgar Ditch	4000705	8	8
	Gabriel Ditch	4000707	6	6
	Gallagher Ditch	4000708	35	35
	Gard Ditch	4000710	23	23
	Genes Ditch	4000711	8	8
	Gilger Ditch	4000712	15	15
	Hansen Ditch	4000714	10	9
	Happy Hollow Ditch	4000715	74	56
	H J Neighbors Ditch	4000716	15	15
	Humper Ditch	4000717	64	64
	Kile Ditch	4000721	8	8
	Lone Friday Ditch	4000724	29	29
	Morris Ditch	4000729	12	12
	Obert Ditch	4000731	89	86
	Orchard Ditch	4000732	10	10
	Parker Ditch	4000734	29	29
	Perkins Ditch	4000735	57	57
	Pratt Ditch	4000737	7	7
	Red Haw Ditch	4000738	41	42
	R And K Ditch	4000739	8	8
	Sandstone Bluff Ditch	4000741	265	266
	Sessions Ditch	4000742	14	14
	Shoup Ditch	4000743	43	42
	Stillwagon Ditch	4000744	48	48
	Sunrise Ditch	4000745	42	31
	Todd Ditch	4000746	44	43
	West Ditch	4000747	122	122
	Williams Ditch No 2	4000749	31	30
	Cook Ditch	4000755	55	112
	Hoosier Ditch	4000841	183	144
	Loucks Ditch	4000843	70	70

	Mt View Mesa No 1 Ditch	4000845	100	0
	Oak Creek No 2 Ditch	4000847	77	52
	Pumpkin Swag Seep Ditch	4000850	23	23
	Right Hand Ditch	4000851	31	31
	Sanburg Ditch	4000852	55	21
	Short Cut Ditch	4001231	13	3
	Valley View Ditch	4001235	114	114
	Perkins Ditch	4001240	39	35
	Bourn Ditch	4001266	50	50
	Stillwagon No 2 Ditch	4001295	6	6
	Stillwagon No 3 Ditch	4001296	10	10
	Roy J Tompson Ditch	4001496	7	7
	Clark-Wetterick Mesa D	4002256	18	0
40_ADG029, Surface	Lookout Ditch	4000648	69	83
	Beeson Ditch	4000671	37	24
	C And D Ditch	4000672	67	62
	Cold Water Ditch	4000677	57	57
	Gregg Ditch	4000679	56	27
	Gurney Ditch	4000680	114	139
	Hard Labor Ditch	4000681	32	6
	Harris Ditch	4000682	11	8
	Jackson Ditch	4000684	20	13
	Klondyke Ditch	4000685	68	68
	Metzger Ditch	4000687	22	22
	Paradise Ditch	4000688	118	118
	Reed Ditch	4000689	41	41
	Rose Ditch	4000690	0	13
	Trickle Ditch	4000693	200	202
	Wild Cherry Ditch	4000694	11	11
40_ADG030, Tongue	Shamrock Ditch	4000646	91	91
	Daisy Ditch	4000702	36	26
	Forked Tongue Ditch	4000706	178	178
	Kennicott & Mower D	4000720	139	100
	Lucky Ditch No 1	4000726	26	26
	Park Ditch	4000733	185	192
	Pioneer Ditch	4000736	66	66
	Big Fall Ditch	4000752	35	33
	Eric Johnson Ditch	4000757	33	33
	Hal Ditch	4000763	61	14
	Kohler Waste Water D	4000767	59	49

	Omega Ditch	4000773	217	216
	Shepherd Ditch	4000779	139	194
	Stillwater Ditch	4000780	105	58
	Sunflower Ditch	4000782	6	0
	Weir And Johnson Ditch	4000786	29	29
	Zanola And Pelazini D	4000787	84	84
	Desert Ditch	4000795	79	79
	Fuller Ditch	4000801	9	0
	Hillside Ditch	4000804	8	3
	Oasis Ditch 1St Enlt	4000812	218	33
	Peterson Ditch	4000815	11	24
	Hixon Ditch No 1	4000839	10	10
	Hixon Ditch No 2	4000840	29	29
	Mcmurray Ditch	4000844	134	124
	Pumpkin Swag Ditch	4000849	160	160
	Shoemaker Ditch	4000903	11	13
	Baker Ditch No 1	4001292	59	63
	Broad Ax Ditch	4001341	20	4
	Sunflower Ditch	4001385	559	545
	Maud S Ditch	4001473	87	49
40_ADG039, Gunnison below Delta	Alkali Ditch	4000854	193	193
	Bass Ditch	4000857	8	8
	Bever Ditch Pipeline	4000858	86	86
	Blumberg Ditch	4000859	50	50
	Blumberg No 2 Ditch	4000860	50	50
	Boise Ditch	4000862	4	3
	Campbell Ditch	4000866	74	74
	Capt H A Smith Ditch	4000867	19	19
	Cowger Ditch	4000872	41	31
	Elk Horn Ditch	4000875	39	39
	Granite Rock Ditch	4000876	40	40
	Harry Walker Ditch	4000878	66	36
	John W Musser Ditch	4000882	106	106
	Mccarthy Ditch	4000887	56	56
	Mccarthy Ditch No 2	4000888	17	17
	Mow Ditch	4000890	8	8
	Obergfell Baldwin Ditch	4000892	283	282
	Palmer Ditch	4000894	203	86
	Peeples Pump&Pipe	4000896	80	80
	Poverty Ditch	4000898	22	22

	Red Squirrel Ditch	4000899	45	45
	Schafer Ditch	4000901	21	21
	Tatum Burton Ditch	4000910	48	44
	Wilbur Ditch	4000911	39	39
	Independent Ditch	4001304	18	18
	North Fork Ditch	4001325	14	13
	Rio Dominguez Ditch	4200542	35	35
41_ADG035, Uncompahgre 3	Buckhorn Ditch	4100509	295	276
41_ADG036, Uncompahgre 4	Albush Ditch	4100500	107	107
	Bancroft D	4100503	0	103
	C A Palmer Ditch	4100511	6	6
	Cedar Park Ditch	4100512	234	250
	Enlt Of Garrett Ditch	4100521	500	0
	Fansher Horsefly No 2 D	4100522	188	187
	J. C. Frees Private Ditch	4100526	50	50
	Glendening Ditch	4100529	30	30
	Heath Ditch	4100533	31	31
	J H Anderson D No 1	4100535	253	253
	Keller Brothers Ditch	4100536	24	24
	Menke Mc Collum Ditch	4100541	16	43
	Miles Ditch	4100543	72	72
	Mock Ditch	4100544	56	56
	Neugart Ditch	4100546	24	22
	Rice Ditch	4100551	67	58
	S E Dillon Ditch	4100555	50	50
	Sampson Frasier Ditch	4100556	68	68
	Sampson Frasier Cont	4100557	10	10
	Supply Ditch	4100569	34	29
	Woodgate Callaway Ditch	4100572	262	439
	Kearny Ditch	4100579	45	45
	Spring Valley Ditch	4100842	21	21
	Cross 7 Ranch Ditch	4101006	31	31
	J H Anderson D No 2	4101133	61	61
	Loutsenhizer Ditch	4101744	35	35
	Tierra Colo Ditch	6800759	722	462
	Williams D Nos 1,2&3	6800784	38	38
	Thrasher Ditch	6800935	164	0
41_ADG037, Uncompahgre 5	Baldy Ditch	4100501	0	0
	Beach No 1 D	4100504	17	17

	Beach No 2 D	4100505	19	19
	Chaparral D No 2	4100513	54	54
	Darter & Haugsted Ditch	4100516	197	192
	Garren Lewis Ditch	4100528	66	39
	Grays Creek Ditch	4100530	0	0
	Mccollum Ditch	4100539	29	29
	Spring Ditch	4100565	126	149
	Angel Dry Cr D System	4100731	47	47
	Short Ditch	4100772	29	29
	Oscar Richards Ditch	6200703	251	203
42_ADG040, Gunnison near Grand Junction	Anderson Ditch	4200501	37	41
	Bales Williams Morrison	4200503	38	36
	Bauer Ditch	4200504	369	250
	Black Ditch	4200505	6	6
	Bowen Private Ditch	4200507	98	82
	Brandon Ditch	4200509	52	141
	East Creek Ditch	4200515	8	0
	F B Grant Ditch	4200516	7	7
	Florence H Berry Ditch	4200517	4	0
	Gunnison Pumping Plant	4200521	75	75
	Helmke Ditch	4200522	47	46
	Ira Vincent Ditch	4200523	32	32
	Johnson Cr Ditch Hdgt No 1	4200526	27	27
	Johnson Cr Ditch Hdgt No2	4200527	14	14
	Lurvey Ditch #1	4200531	105	48
	M J Woodring Ditch	4200534	12	12
	Northwestern Ditch	4200536	102	100
	Raber Coal Cr Supply D	4200538	5	26
	Shropshire Ditch	4200544	27	27
	Snyder Creek Supply Ditch	4200546	21	21
	Unaweep Ditch	4200547	27	27
	Wadlow Pumping Plant	4200548	8	0
	Washburn & Downing Ditch	4200549	48	48
	William J Ponsford D	4200551	4	4
	Wm H Williams Ditch	4200552	25	29
	Laurent Ditch	4200554	178	178
	Anderson Ditch 4	4200556	17	17
	Ladder Gulch Ditch	4200609	45	0
	Vanpelt Cox Seepage D	4200630	1	1
	F B Grant Ext	4200639	20	20

	Johnson Creek Ditch No2	4200650	41	41
	Brandon D City Of Gj	4200822	27	27
	Brandon D Lockhart Draw	4200823	27	27
	M J Woodring Res	4203621	11	11
59_ADG001, Taylor	Axtell Ditch	5900513	47	10
	Elmer Ditch	5900552	39	35
	Lowline Ditch	5900618	33	30
	Summerville Ditch	5900685	5	5
	Elmer No 2 Ditch	5900714	16	14
	Churchill Ditch	5900718	84	84
	Summerville Ditch No 2	5900726	5	5
	Doctor Ditch	5900861	4	4
	Doctor No 2 Ditch	5900862	0	4
	Korn Ditch	5900959	84	84
	Murdie Mesa Irg D	5901026	28	0
	Pieplant Ditch	5901063	135	0
	Tincup Town Ditch	5901168	37	0
59_ADG002, East 1	Beitler Ditch No 1	5900517	48	48
	F E And A C Jarvis Ditch	5900555	53	53
	Jarvis Ditch	5900601	48	48
	Meads Ditch No 1	5900635	68	68
	Beitler Ditch No 2	5900751	48	48
	Panion Ditch	5901055	23	23
59_ADG003, Slate	Breem Ditch	5900525	256	256
	Coal Cr Ditch	5900539	5	5
	Meridian Ditch	5900638	65	65
	Rozich Ditch	5900661	84	83
	Spann Nettick Ditch	5900678	51	51
	Willson Ditch	5900708	24	24
	Kapushion Ditch	5900968	5	5
	Renas Ditch	5901209	38	38
59_ADG004, East 2	Adams Cement Creek Ditch	5900502	2	2
	Baxter Ditch	5900515	111	111
	Cement Cr Ranger Sta	5900536	30	30
	Jones Highline Ditch	5900605	30	30
	Mcclenathan Ditch	5900626	145	145
	Meads No 3 Ditch	5900637	229	229
	Rozman No 1 Ditch	5900662	30	30
	Rozman No 2 Ditch	5900663	55	55
	Yarnell Ditch	5900712	27	27

	Tim & Helen Morgan Ditch	5900727	8	8
	Granite Ditch	5900921	82	82
	Maxson Ditch	5901250	14	14
	Obaid Ditch	5901736	30	30
59_ADG005, East 3	Ahrens Ditch	5900503	140	140
	Alkali Ditch	5900507	37	0
	Bear Gulch Ditch	5900516	249	248
	Dennis Alkali Cr Ditch	5900545	44	44
	Happy Hollow Highline D	5900576	21	21
	John Lorr Ditch	5900603	57	57
	L R Spann Ditch	5900611	59	59
	Mcdonald Ditch	5900628	89	89
	Shackleford Ditch	5900669	52	52
	Watt No 2 Ditch	5900703	57	57
	Danni Ditch	5900716	21	21
	Red Mt Highline Ditch	5901076	104	104
59_ADG006, Ohio 1	Allison Ditch	5900508	141	141
	Castle Creek No 1 Ditch	5900532	29	29
	Castle Creek No 2 Ditch	5900533	29	29
	Gafney Ditch	5900559	37	37
	Kunze Ditch	5900610	43	43
	Polisic No 1 Ditch	5900652	53	53
	Sunki No 1 Ditch	5900687	29	29
	Sunki No 3 Ditch	5900688	150	150
	Valentines Ditch	5900698	67	67
	William Elze Ditch	5900705	29	29
	Buffington Ditch	5900717	6	6
	Keever Ditch	5900974	49	49
	Spring Branch Ditch	5901139	30	30
	Sunki No 2 And Sunki-Res	5901469	30	30
	Sawmill Ditch	5901766	12	12
59_ADG007, Ohio 2	Carmine Ditch	5900530	94	94
	East Wilson Ditch	5900551	25	25
	Mcglashan E Side Irr D	5900629	114	114
	Mcglashan W Side Ohio Cr	5900632	100	99
	Mckee Desert Land No 2D	5900633	74	74
	Mckee No 1 Ditch	5900634	49	49
	Milton White Ditch	5900639	89	89
	N Willow Run Ditch	5900642	4	4
	Ohio Creek No 1 Ditch	5900643	65	65

	Park Ditch	5900648	34	34
	Smith Ditch	5900676	39	39
	Squirrel Creek No3 Ditch	5900681	43	43
	Squirrel Creek No6 Ditch	5900682	82	82
	Price Creek Ditch	5900721	29	29
	Price Creek Ditch No 3	5900723	33	33
	Price Creek Ditch No 4	5900724	33	33
	Squirrel Creek No2 Ditch	5900725	16	16
	Black Diamond Springs D	5900776	8	8
	Campbell Ditch E Branch	5900792	152	176
	Campbell Ditch W Branch	5900793	151	5
	Dollard Desert Land D	5900863	130	130
	Howard Eilbrecht Ditch	5900954	9	9
	Mckee Ditch	5901006	57	57
	Mckee No 2 Ditch	5901007	25	25
	South Willow Run D	5901135	88	88
	Squirrel Cr Highline D	5901141	82	82
	Mount Carbon Ditch	5901200	113	113
	Kubler Ditch	5901792	25	25
	Cabin Ditch	5901794	25	25
59_ADG008, Gunnison near Gunnison	Biebel No 1 Ditch	5900519	85	85
	Channel Ditch	5900538	79	79
	Dooley Antelope Irg D	5900547	16	16
	Elmer Marshall No1 Ditch	5900553	204	204
	Geo Smith No 1 Ditch	5900561	5	5
	Geo Smith No 2 Ditch	5900562	44	44
	Gunnison And Tomichi Valley Ditch Association Ditc	5900571	338	338
	Hamor Ditch	5900577	5	5
	Home Ditch	5900590	233	233
	Palisades Ditch No 2	5900647	24	24
	Peter Purrier East Ditch	5900650	109	109
	Slough Ditch	5900673	177	177
	Smith And Wilson Ditch	5900675	31	31
	Sunshine Irg Ditch	5900690	23	23
	Thornton No 1 Ditch	5900694	71	71
	Wilson No 2 Ditch	5900710	204	204
	Elmer Marshall No2 Ditch	5900713	204	204
	Dos Rios Ditch	5900864	58	53
	A Doering Spg Cr D	6200501	39	39

62_ADG013, Cebolla 1	Bandit Ditch	6200545	25	25
	Cathedral Branch Irr D	6200552	40	40
	Cliff Irr Ditch	6200562	38	38
	Cliff Irr Ditch No 2	6200563	14	14
	Creede Trail Irr Ditch	6200575	35	35
	Ferris Ditch	6200596	8	8
	Hatcher Ditch	6200619	57	57
	Johnson E Side Ditch	6200645	16	16
	Johnson W Side Ditch	6200646	11	11
	Lower Spring Cr Irr D	6200664	28	28
	Maybell Ditch No 1	6200669	63	63
	Mendenhall Ditch	6200677	27	27
	Mineral Creek No 1 D	6200684	49	49
	Mineral Creek No 2 D	6200685	54	54
	Mineral Creek No 3 D	6200686	17	17
	O R Bowers No 1 D	6200696	22	21
	Orin Bowers No 4 D	6200697	18	18
	Orin Bowers No 6 D	6200699	18	18
	Rock Creek Ditch	6200730	10	10
	Rock Creek Irr Ditch	6200731	27	18
	Stavely Ditch	6200762	17	17
	W S Thompson Ditch	6200805	4	4
	Youmans Irg D No 2	6200810	26	26
	Youmans Ditch No 3	6200811	29	28
	Youmans No 1 Ditch	6200825	28	28
	Bear Creek Ditch	6200841	6	6
	Cadwell Ditch	6200894	6	7
	Pasture Creek Ditch	6201080	18	18
	Wrights Cathedral Ditch	6201180	45	45
	Youmans House Gulch D	6201187	3	3
	Holman Ditch No 1	6201334	74	74
	Holman Ditch No 2	6201513	74	74
62_ADG014, Cebolla 2	Bailey R & Rs Wilson D	6200520	35	35
	Dry Powderhorn Ditch	6200582	102	102
	Foster Ditch No 2	6200603	69	69
	Hot Springs Ditch	6200637	19	19
	John W Andrews Ditch	6200643	25	25
	Mcgregor Ditch	6200671	49	49
	Nichols Powderhorn Ditch	6200693	36	36
	Powderhorn Ditch	6200712	36	36

	Powderhorn Irg Ditch	6200713	201	201
	Radeka Ditch	6200719	28	28
	Sammons Ditch No 3	6200735	60	60
	Sammons Powderhorn D	6200739	47	47
	Schecker Ditch	6200741	53	53
	Schnepf Highline Ditch	6200743	70	70
	Wegener-Knoll Ditch	6200791	24	24
	Youmans Waste Water D	6200813	88	88
	R B Wilson D No 1 2 3	6201089	34	34
	Barrett Ditch	6201519	46	46
62_ADG015, Lake	Addington No 1 D	6200500	61	61
	Antonio Ferraro D No 1	6200508	57	31
	B And B Ditch	6200519	28	28
	Baker No 2 Ditch	6200524	28	28
	Carr Irrigating Ditch	6200548	20	40
	Carris Thompson Ditch	6200549	22	7
	Carson Creek No 2 D	6200551	6	4
	Childs Park Ditch	6200559	3	3
	Copeland Elk Cr D	6200570	113	0
	D C Baker No 1 D	6200580	24	17
	Freeman Ditch	6200606	10	10
	French Ditch No 1	6200607	7	7
	French Ditch No 2	6200608	31	31
	French Ditch No 3	6200609	31	31
	F S William D No 1	6200611	11	11
	Hunter Elk Creek Ditch	6200639	57	57
	Johnson Ditch	6200644	23	23
	Lake Fork Irr Ditch	6200652	11	11
	Reece Richart No 1 D	6200722	24	24
	Reece Richart No 2 D	6200723	24	24
	Reece Richart No 3 D	6200724	24	24
	Seeley Ditch No 3	6200746	41	41
	Steele Ditch	6200763	33	0
	Sunnyside Ditch	6200766	48	48
	Thompson Irr Ditch	6200776	81	81
	Trout Creek No 1 Ditch	6200777	17	17
	Vickers Bros No 2 Ditch	6200786	10	10
	Wilson Ditch	6200802	47	47
	Youmans Irg Ditch	6200808	41	39
	Vickers Ditch No 1	6200822	39	39

	Norsworthy Pump	6201459	5	5
	Thomas Roach Ditch #2	6201493	84	54
	Water Gulch Ditch	6201794	26	26
62_ADG016, Gunnison Blue Mesa	Airport Ditch	5900504	93	91
	Brunton No 1 Ditch	5900526	30	30
	Carron Ditch	5900531	14	14
	Greegh Ditch	5900568	60	60
	Jones Brunton Ditch	5900604	60	60
	Lawrence Ditch	5900614	31	31
	Sun Creek Ditch	5900686	31	31
	Teed Ditch	5900693	26	26
	Ute Trail Ditch	5900697	93	91
	Bagg Ditch	5900715	5	5
	Steenbergen Ditch	5901473	5	5
	Alder Ditch	6200502	20	20
	Austin Ditch	6200510	92	92
	Beaver Creek Ditch	6200525	66	67
	Big Willow Springs D	6200530	21	0
	Browning Ditch	6200536	33	33
	Carr Ditch	6200547	12	12
	Cottonwood Ditch	6200572	14	14
	Lake Fork Ditch	6200651	8	8
	Moore Ditch No 1	6200689	21	21
	Moore Ditch No 2	6200690	21	21
	Soderquist D No 1	6200752	34	34
	Soderquist D No 2	6200753	34	34
	South Beaver Creek Ditch	6200754	45	46
	Indian Creek North Ditch	6201000	31	31
	Johnson Gulch Ditch	6201008	12	0
	Lower Lake Ditch	6201047	5	5
	Beaver Creek Ditch East	6201249	61	78
	Beaver Creek Ditch West	6201250	17	29
62_ADG017, Gunnison Morrow Point	Beaver Ditch	6200527	159	153
	Hazel Ditch	6200620	61	61
	Pine Creek Ditch	6200708	1,848	0
	Squirrel No 1 Ditch	6200760	47	47
	Squirrel Ditch No 2	6200761	25	25
62_ADG018, Cimarron	Mcminn Ditch	6200673	87	86
	Peterson & Riley Ditch	6200707	24	0
	Schildt-Brown Ditch	6200742	87	86

	Stumpy Ditch	6200765	157	146
	Vanderburg D	6200782	49	49
	Cimarron Cnl Coal Cr	6200815	4,164	4,010
68_ADG033, Dallas	Barker Ditch	6800506	18	18
	Burger Ditch	6800513	36	36
	Dallas Placer Ditch	6800545	109	109
	Evans Ditch	6800573	225	225
	Harrison No 1 Ditch	6800597	19	19
	Horn Ditch	6800608	29	29
	James Stewart Ditch	6800619	9	9
	Lischke Ditch	6800640	28	0
	Lischke No. 2 Ditch	6800641	9	37
	Lower Pleasant Valley	6800643	200	200
	Mike Cuddigan Ditch	6800663	35	35
	Oakes Jerome Ditch	6800679	268	263
	Oakes Woodruff Eggleston	6800680	181	181
	P J Nash Ditch	6800684	9	9
	Reynolds Ditch	6800708	11	11
	Scott Mcneil Ditch	6800724	54	54
	Sherbino Ditch	6800727	94	94
	Sibert Ditch	6800731	52	52
	Switzerland Ditch	6800752	59	59
	Wood Perry Ditch	6800781	135	135
68_ADG034, Uncompahgre 2	Babb Ditch	6800505	95	95
	Bigbee Ditch	6800509	74	74
	Brooke Ditch	6800510	77	77
	Brown Ditch	6800511	69	69
	Cannon Ditch	6800516	64	64
	Cassidy Ditch	6800520	2	2
	Cedar Creek Ditch	6800522	96	96
	Chaffee Ditch	6800523	91	91
	Chipeta Cutler Ditch	6800527	8	8
	Climax Ditch	6800531	43	43
	Coal Creek Ditch	6800532	51	51
	Daine Ditch	6800542	21	21
	East Side Ditch	6800565	56	62
	Flora Ditch	6800579	11	11
	Gibson Ditch	6800587	160	160
	Haney Coal Creek Ditch	6800590	28	0
	Hayes Teague Ditch	6800601	14	15

	Heath Ditch	6800602	0	23
	Hyde Ditch	6800612	32	32
	Johnson Ditch	6800621	167	167
	Jolly Ditch	6800624	82	82
	Mcdonald Cuddigan Ditch	6800655	85	85
	Mcdonald Ditch	6800656	33	33
	Middle Miller Ditch	6800660	28	0
	Miller Branch Ditch	6800664	28	139
	Nate Creek No 1 Ditch	6800673	125	125
	Nate Creek No 2 Ditch	6800674	37	37
	Nate Creek No 3 Ditch	6800675	66	66
	Nate Creek No 4 Ditch	6800676	37	82
	Phillips Ditch	6800690	45	45
	Plummer D Nos 1 & 2	6800694	72	72
	Portland Ditch	6800697	16	16
	Private Ditch Shaven	6800700	16	16
	Private Ditch Stealey	6800701	33	33
	Reservoir Ditch	6800704	64	35
	Rhoades Ditch	6800709	1	1
	Rocky No 1 Ditch	6800715	10	10
	Rocky No 2 Ditch	6800716	23	23
	Rocky No 3 Ditch	6800717	43	43
	Sharen No 1 Ditch	6800725	15	15
	Springfield Corrie Ditch	6800744	97	108
	Stanton Ditch	6800747	104	104
	Stealey Owl Creek Ditch	6800749	51	51
	Stough Ditch	6800750	27	27
	Strayer Ditch	6800751	324	324
	Taylor Ditch	6800755	101	101
	Thomas Cow Trail Ditch	6800756	408	222
	Vance Ditch	6800767	263	263
	Ward Ditch	6800771	13	13
	West Miller Ditch	6800774	28	0
	White Ditch	6800778	53	53
	Adam Thomas Ditch	6800793	170	170
	Orvis Ditch	6800907	67	67
	Smith-Brown Ditch	6801263	13	13
	Collin Ditch	6801386	49	48

A-2: Identification of Associated Structures (Diversion Systems and Multi-structures)

Background

The previous CDSS Western Slope models include associated structures which divert to irrigate common parcels of land. These associations were primarily based on information provided directly during meetings with Water Commissioners, and were not based on information from the original 1993 irrigated acreage assessment. The original CDSS 1993 irrigated acreage assessment was based on the USBR identification of irrigated land enhanced with a water source (ditch identifier) that served that land. Many of the irrigated acreage parcels covered more than one ditch service area and, in lieu of spending significant time splitting the parcels by ditch service area, more than one ditch was assigned. For CDSS modeling purposes, the acreage was simply "split" and partially assigned to each ditch.

Introduction

For the recent 2005 and 2010 acreage assessments, there was significant effort spent trying to refine irrigated parcels based on the legal and physical ditch boundaries so, where possible, there was only one ditch assigned to each irrigated parcel in Divisions 5, 6, and 7. Division 4 efforts concentrated on a few areas, but not the entire basin. To model these ditches as accurately as possible, it is important to understand if the acreage that is still assigned to more than one ditch is actually irrigated by all assigned ditches in a comingled fashion or, alternatively, if the acreage should be "split" and the structures should be modeled as having no association. Ditches combined for modeling because the supplies are believed to be comingled are termed "associated structures" for the CDSS modeling effort.

Some associated structures can be identified based on the HydroBase water rights transaction table because they are decreed alternate points or exchange points, while others can be identified based on Water Commissioner accounting procedures, generally documented in their comments accessible through Hydrobase. In the models, associated structures are represented as diversion systems if the structures are located on the same tributary or multi-structure systems if they are located on different tributaries. As part of Task 3, the associated structures were updated to more accurately model the combined acreage, diversions, and demands. These updates include the integration of the 2005 irrigated acreage, the 2010 irrigated acreage, as well as verification of associated structures based on diversion comments and water right transaction comments.

Approach

The following steps were used to identify associated structures in Divisions 5, 6, and 7. Because the Division 4 parcels have not yet been refined to the ditch service level, no effort was made to determine additional associated structures. Note, however, the parcels that require additional refinement have been identified and provided to Division 4. These updates should be included with the next acreage assessment.

Updating the associated structures was a multi-step process that involved 1) identifying potential associated structures by integrating the 2005 and 2010 CDSS irrigated acreage, 2) verifying the associated structures using the diversion and water right transaction comments, and 3) making recommendations on how to best represent the associated structures in the CDSS Western Slope models.

1) *Develop an Associated Structure List Based on Revised 2005and 2010 CDSS Irrigated Acreage*

   An initial associated structure list was developed by combining the CDSS revised 2005 and 2010 irrigated acreage. During this process the overlapping similarities between the two irrigated acreage coverages were integrated, resulting in a list of associated structures containing unique IDs. An illustrative example is presented below. In this example, the 2005 irrigated acreage coverage contains parcel A assigned to structures 1, 2, and 3; while the 2010 irrigate acreage coverage contains parcel B assigned to structures 2 and 4. Parcel A and B are integrated, resulting in an association comprised of structures 1, 2, 3, and 4.

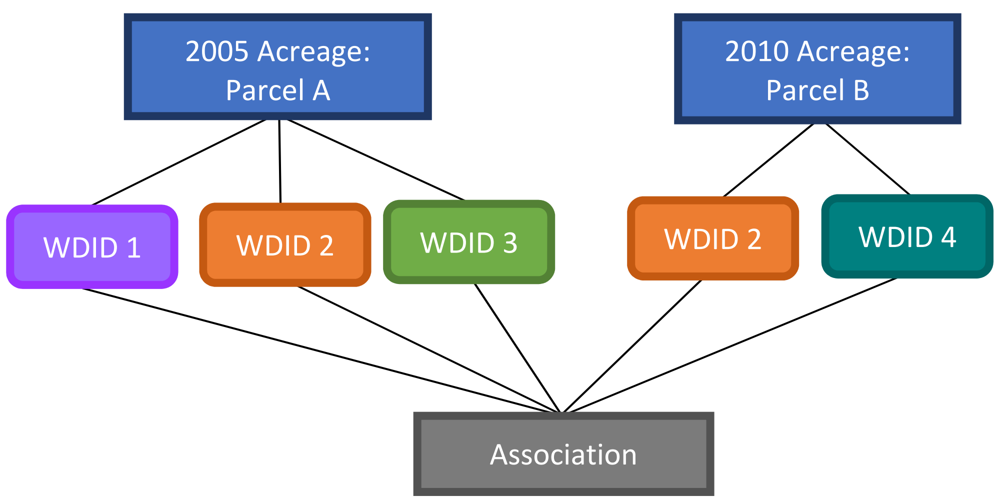


Figure A-2. Example of integrating the CDSS irrigated acreage coverage to identify associated structures.

2) *Verify the Associations Using Diversion and/or Water Right Transaction Comments*

   Once a unique list of associated structures was developed, each association was verified using diversion comments and/or water right transaction comments. If the diversion comments and/or water right transaction comments could not verify structure associations, then unverified structures were removed from the list of associated structures (i.e., their diversions will not be treated as commingled). Types of verification included comments identifying structures as alternate points of diversion, points of exchange, acreage reported under alternative structure, same points of diversion, and water right transfers.

Below is an example of the verification methodology using the diversion and/or transaction comments for the association shown in step 1.

Table A-4. Example of Integrating the Diversion and Water Right Transaction Comments for Verification.

WDID	Verification Comment	Source	Verified?
1	Irrigates Y Ranch	Diversion Comment	N
2	Water right transferred to WDID 4	Transaction Comments	Y
3	Acreage is recorded under WDID 2	Diversion comments	Y
4	-	-	Y

Given this example, WDID 1 was not verified by the comments and, thus, not included in the final list of associated structures.

3) *Recommend a Modeling Approach for Representing Associated Structures in the CDSS Western Slope Models*

Using the refined associated structure list developed in step 2, recommendations on how to best represent the associated structures in the CDSS models were provided. These recommendations were based on the following criteria:

- If located on non-modeled tributaries, the associated structures were added to appropriate aggregates.
- Associated structures were explicitly modeled—either in diversion systems or multi-structure systems—if the net water rights for at least one structure in the association exceeded a specific threshold identified in previous modeling efforts. In general, the thresholds represent 75% of the net water rights and are listed in **Table A-5**.

Table A-5. Water Right Thresholds for Explicit Modeling

CDSS Model	Water Right Threshold (CFS)
Yampa	5
White	4.8
Upper Colorado	11
San Juan/Dolores	5/6.5

Structures located on the same tributary were modeled as diversion systems, while structures located on different tributaries were modeled as a multi-structure system.

Note, diversions systems combine acreage, headgate demands, and water rights; and the model treats them as a single structure. Contrastingly, multi-structure systems have the combined acreage and demand assigned to a primary structure; however, the water rights are represented at each individual structure, and StateMod meets the demand from each structure when their water right is in priority. **Figure A-3** illustrates how a diversion system is modeled, while **Figure A-4** illustrates how a multi-structure system is modeled.

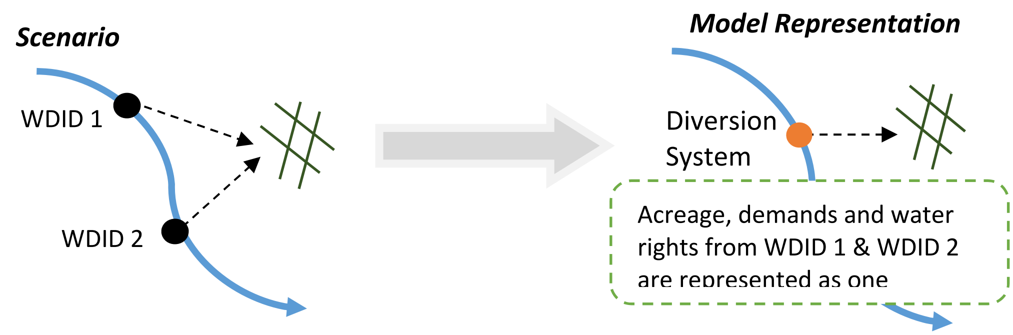


Figure A-3. Model Representation of a Diversion System.

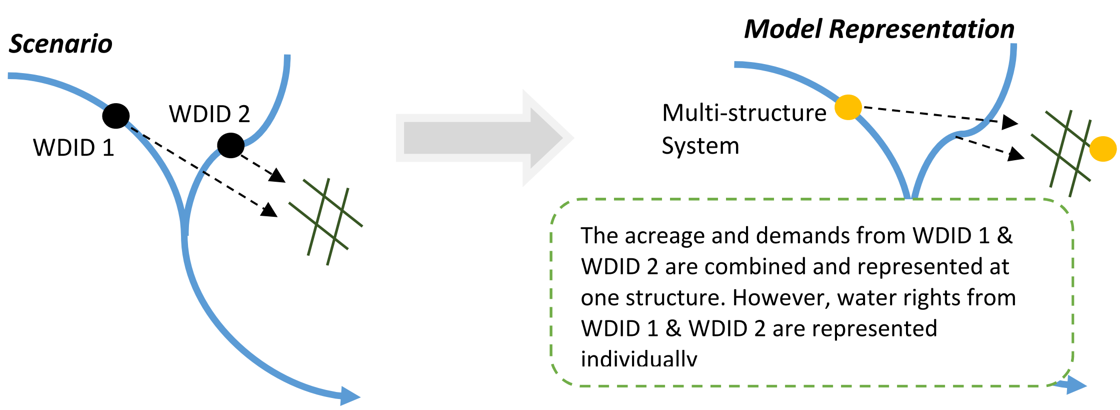


Figure A-4. Model Representation of a Multi-structure System.

- The structure with the most irrigated acreage—based on the 2005 and 2010 CDSS coverages—was selected as the modeled structure for each diversion system.
- The structure with the greatest net water rights was selected as the primary structure for multi-structure systems.
- If none of the structures in an association exceeded the water right threshold identified in Table 2 and have contemporary diversion records, the structures were modeled in an aggregate.
- If all structures in an associated did not have diversion records, the structures were placed in a “no diversion” aggregate.

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

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**

Appendix B

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)	Percen t
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 aggregated stock ponds were assigned an administration number equal to 1.00000.