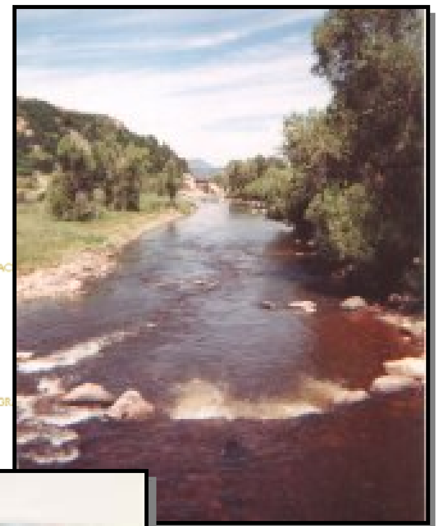
Yampa River Basin
Water Resources Planning Model
User's Manual



July 2016

COLORADO'S DECISION SUPPORT SYSTEMS

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1. Introduction

1.1 Background

The Colorado Decision Support System (CDSS) consists of a database of hydrologic and administrative information related to water use in Colorado, and a variety of tools and models for reviewing, reporting, and analyzing the data. The CDSS water resources planning models, of which the Yampa River Basin Water Resources Planning Model (Yampa 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 Yampa 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 Yampa 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 for such analysis, 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 the user has added features, to determine 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 Yampa River Basin Water Resources Planning Model

The Yampa model was developed in a series of phases that spanned 1994 through the present. The earliest effort, designated Phase II following a Phase I scoping task, accomplished development of a calibrated model that simulated an estimated 75 percent of water use in the basin, leaving the remaining 25 percent of the use “in the gage”. The original model study period was 1975 through 1991, which also served as the model’s calibration period.

One objective of the CDSS endeavor was to represent all potential consumptive use within Colorado, and estimate actual consumptive use under water supply limitations. Thus in Phase

IIIa, the heretofore unmodeled 25 percent use was added to the model as 27 aggregations of numerous small users. With the introduction of this demand, the calibration was reviewed and refined. The objective of Phase IIIb was to extend the model study period, using automated data filling techniques as well as 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 again reviewed, now using through the period 1975 through 1996.

The State continues to refine the Yampa basin model, creating a daily version in 2002, and more recently adding the "variable efficiency" method for determining irrigation consumptive use and return flows to the model. In 2004, the State modified representation of the upper Little Snake River basin in Wyoming, drawing from Wyoming's Green River Basin Plan (GRBP) for irrigated acreage mapping and aggregation, crop demand, irrigation water requirement, efficiencies, and historical municipal depletions. The model was updated in 2009 as part of the Colorado River Water Availability Study. The update included refining the approach to representing irrigation water requirement at high elevation, and incorporated changes in water rights and operations that have occurred since 2004.

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 Acknowledgements

CDSS is a project of the Colorado Water Conservation Board (CWCB), with support from the Colorado Division of Water Resources. The Yampa model has been developed and enhanced at different stages by Riverside Technology, Inc., Leonard Rice Engineers, AECOM, 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 Yampa 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 Yampa River development or management scenario
- Is interested in estimated conditions on the Yampa River under current development, over a range of hydrologic conditions, as simulated by this model; and in understanding assumptions embedded in the modeling estimates.

Presumably, the reader has access to a complete set of data files for the Yampa 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

Specifically, the manual is divided into the following sections:

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

Section 4 Modeling Approach – this is an overview of methods and techniques used in the Yampa 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 Yampa model.

Section 5 Baseline Data Set – the Baseline data set refers to the 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 should understand 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 Baseline simulation. It shows the state of the river as the Yampa 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 – historical technical memoranda specific to the Yampa 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 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 Yampa 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. All documentation listed below is available on the CDSS website (cdss.state.co.us). A user's biggest challenge may be in efficiently finding the information. This list of descriptions is intended to help in selecting the most relevant data source:

Basin Information – is a compendium of 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: Yampa 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.

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 Yampa model user's understanding of results. If the user is modifying input files, consult Section 4 Input Description to determine how to format files. To analyze model results in detail, review Section 5 Output Description, which describes the wide variety of reports available to the user.

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.

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

- Phase IIIb Task Memorandum 10.1 – Data Extension Feasibility
- Phase IIIb Task Memorandum 10.2 – Evaluate Extension of Historical Data
- Phase IIIb Task Memorandum 11.5 – Characterize Streamflow Data
- Phase IIIb Task Memorandum 11.7 – Verify Diversion Estimates
- Phase IIIb Task Memorandum 11.10 - Fill Missing Baseflow data (include Mixed Station Model user instruction)
- Daily Yampa Model Task Memorandum 1 – Equivalent daily return flow factors
- 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"
- SPDSS Task 59.1 Memorandum – Develop Locally Calibrated Blaney-Criddle Crop Coefficients

3. The Yampa River Basin

The Yampa River basin occupies Colorado's northwest corner, rising at the Continental Divide and ending at its confluence with the Green River, within miles of the Utah border. The basin encompasses most of Routt and Moffat counties in Colorado, the upper reaches of the Little Snake River basin in southern Wyoming, and a very small area of eastern Utah. Figure 1.1 is a map of the basin. The Yampa River flows through forested mountains, rural irrigated valleys, and desert canyons within Dinosaur National Monument.

3.1 Physical Geography

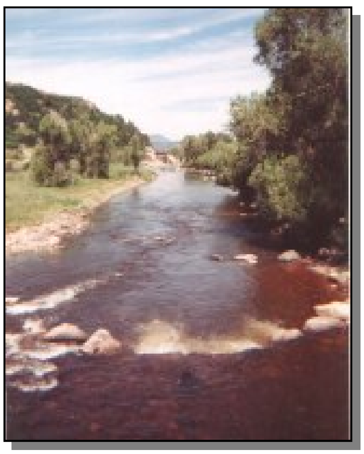

Figure 3.1 - Yampa River near Steamboat Springs

The Yampa River basin within Colorado is approximately 7,660 square miles in size, ranging in elevation from 12,200 feet in the headwaters near the town of Yampa to 5,600 feet in the vicinity of Dinosaur National Monument. Across this expanse, average annual rainfall varies from more than 60 inches near Rabbit Ears Pass, to approximately 10 inches near the State line. Temperatures generally vary inversely with elevation, and variations in the growing season follow a similar trend. Steamboat Springs has an average growing season of 86 days, while the growing season at Craig, Hayden, and Maybell has been estimated at approximately 120 days.

The Yampa River is the primary stream in the basin. It begins at the confluence of the Bear River and Chimney Creek, and other major tributaries include Walton Creek, Fish Creek, Trout Creek, Elk River, Elkhead Creek, Fortification Creek, the Williams Fork River, and the Little Snake River. Most of the water yield in the basin is attributable to snowmelt from the higher elevation areas near the Continental Divide. Average annual streamflow in the upper portions of the drainage (United States Geological Survey [USGS] gage near Stagecoach Reservoir) is approximately 59,000 acre-feet, which increases to an annual average of 1,534,000 acre-feet at the Dinosaur Monument (USGS gage near Deerlodge Park). Over 60 percent of this runoff occurs in April, May and June.

3.2 Human and Economic Factors

The discovery of gold near Hahn's Peak in the 1860's first drew permanent white settlers to the Yampa Valley. The mineral industry remains a key economic sector although coal and related energy activities are of greater importance than gold mining. Farming and ranching, as well as recreation and tourism, are the other primary activities in the basin today.

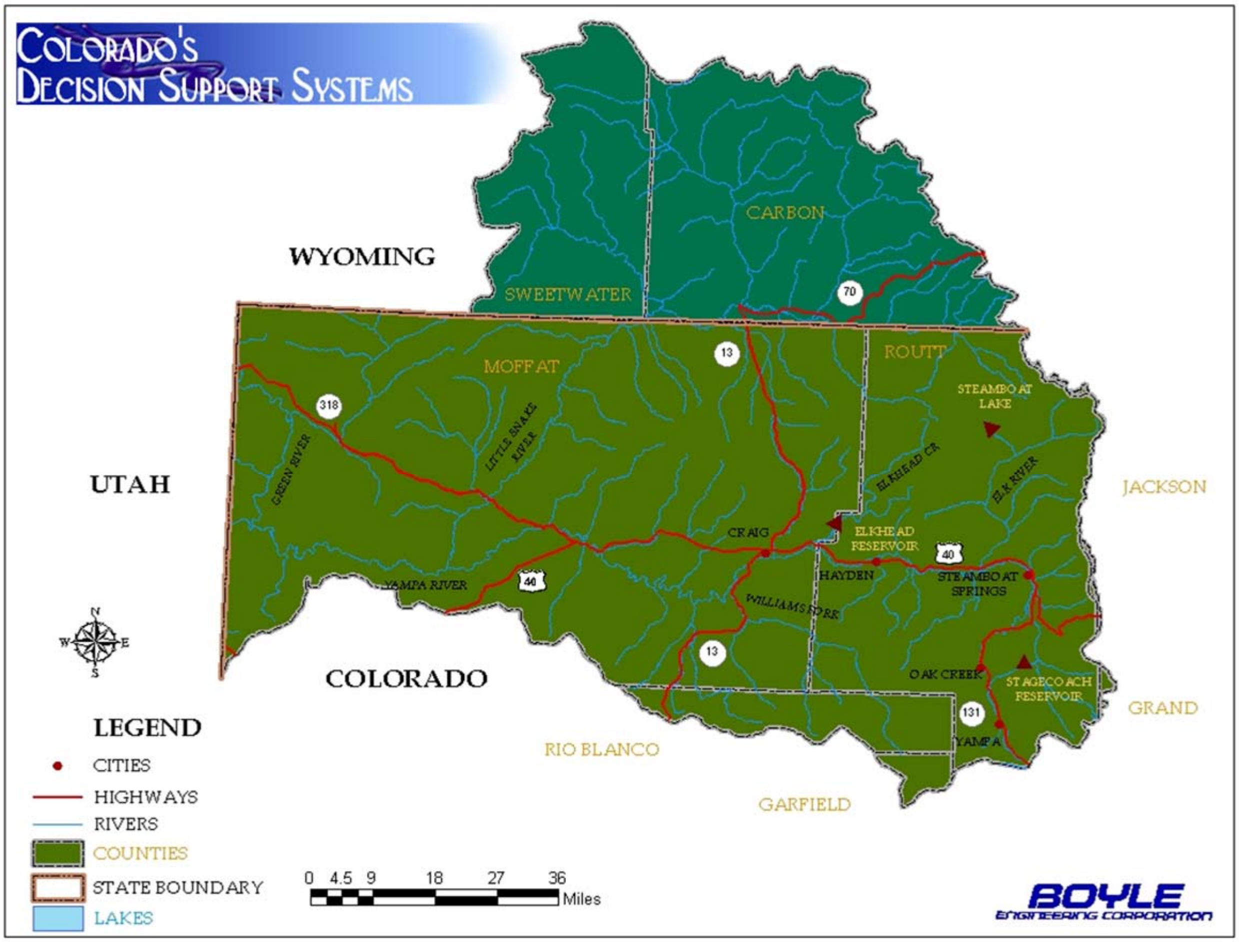

Figure 3.3 - Yampa River Basin Map

The area remains relatively sparsely populated, with the 2010 census placing the combined populations of Routt and Moffat Counties at approximately 47,000. Steamboat Springs and Craig are the major population centers in the basin, with 12,046 and 9,464 residents respectively. Routt County grew by about 65 percent from 1990 to 2009, with growth concentrated in the upper Yampa Valley near Steamboat Springs. This growth attests to the importance of recreation-based activities, as people are drawn to the basin by the ski area and other outdoor recreation opportunities. In recent years, the population has stabilized.

Principal water use in the basin is for irrigation, with hundreds of small irrigation ditches diverting from the main stem and the numerous tributary streams throughout the basin. The ditches irrigate pasture and hay and alfalfa crops primarily. The State's 2010 irrigated acreage assessment estimated 79,436 acres. This excludes irrigated acreage in Wyoming.

Other major water uses include power generation at the Hayden Station and Craig Station plants, which have historically diverted approximately 16,100 acre-feet per year. There are also diversions for municipal use in Steamboat Springs and Craig, as well as in a number of smaller towns. Technically, the largest municipal user is Cheyenne, Wyoming. During the 1990's, Cheyenne's exports out of the headwaters of the Little Snake River in Wyoming averaged 15,400 af/yr. Within Colorado, three transbasin diversions, the Sarvis Ditch, Stillwater Ditch (locally referred to as Five Pines Ditch), and Dome Creek Ditch export water from the Yampa River basin to the Colorado River drainage. There are also a number of smaller transbasin diversions from one tributary drainage to another.

In addition to the direct ditch diversions, there are nine major reservoirs (greater than 4,000 acre-feet in capacity) in the Yampa River basin within Colorado. Three of the reservoirs are used for irrigation (Stillwater Reservoir No. 1, Allen Basin Reservoir, and Yamcolo Reservoir); three are predominantly used for recreational and fishery purposes (Lake Catamount, Pearl Lake, and Steamboat Lake); Fish Creek Reservoir serves municipal use; and the remaining reservoirs are used for multiple uses, including municipal, industrial, irrigation, and recreation (Stagecoach Reservoir, and Elkhead Reservoir). High Savery Reservoir in Wyoming began filling in 2005 and serves irrigators in Wyoming.

3.3 Water Resources Development

The Yampa River basin has seen water resources developments in the form of private irrigation systems, municipal and industrial diversions, and State-sponsored reservoir development. Table 3.1 summarizes key developments within the basin over time. Irrigation has remained relatively constant since the late 1800's, with only small increases in the irrigated acreage as new ditches and storage systems were constructed. The two earliest projects, Allen Basin and Stillwater Reservoirs, were built to relieve late summer irrigation shortages in the headwaters of the Bear River.

Table 3.1 - Key Water Resources Developments

Date	Description	Date	Description
1939	Stillwater Reservoir	c. 1979	Cheyenne Stage II
1956	Fish Creek Reservoir	1981	Yamcolo Reservoir
1963	Craig Station Ditch and Pipeline	1988	Stagecoach Reservoir
1964	Cheyenne Stage I	1996	Fish Creek Reservoir enlargement
1965	Steamboat Lake	2003	High Savery Reservoir
1974	Elkhead Reservoir	2006	Elkhead Reservoir enlargement
1977	Lake Catamount		

Despite a general downturn in growth and economic activity in the Yampa Valley following World War II, the 1950's saw development of the first significant municipal system at Steamboat Springs. This downward trend in growth reversed itself in the mid-1960's, largely due to development of two large electric generating stations at Craig and Hayden, and the related resurgence of the northwest Colorado coal industry. Both the power plants use Yampa River water for cooling.

Figure 3.4 - Echo Park

Later development reflects the rising importance of environmental and recreational uses, as well as the necessity of cooperative efforts and agreements. For example, Steamboat Lake was developed jointly by the Colorado Division of Parks and Wildlife and proponents of the Hayden Station Power Plant. Elkhead Reservoir similarly was a joint project of the Colorado Division Wildlife and the Yampa Project Participants who operate the Craig power plant. Yamcolo Reservoir was developed for irrigation, but its ability to supply water in the upper Bear River was enhanced through an exchange agreement with the multi-use Stagecoach Reservoir.

There are no Federal projects in the Yampa River basin, nor are there any main stem reservoirs below Steamboat Springs. During the 1950's, the Bureau of Reclamation proposed a dam at Echo Park as part of the Colorado River Storage Project, which would have inundated 46 miles of the Yampa and a comparable amount of the Green River. Controversy surrounded the region for more than a decade until a compromise was reached, in which Echo Park was foregone, and Glen Canyon Dam was built.

3.4 Water Rights Administration

Historically, water right calls occur only on internally controlled tributaries where irrigation demands can exceed streamflows, such as Bear River, Fortification Creek, and North, Middle, and South Hunt Creeks. Irrigation shortages on the upper Bear River are typically satisfied by storage releases from Yamcolo and Stillwater reservoirs. On the main stem there has not been administration of water rights calls and water has been available for appropriation.

The Upper Colorado River Basin Compact of 1948 specifies that Colorado may not deplete the flow in the Yampa River below an aggregate of 5 maf over any 10-year period. Average historical consumptive use, per the Colorado Decision Support System (CDSS) Yampa River Water Resources Planning Model, is on the order of 163,000 acre-feet/year on average. Therefore the Compact constraint is not limiting at current levels of development.

Future administration of the Yampa may 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 53,000 acre-feet/year of new consumptive use to be developed.

The US Fish and Wildlife Service (USFWS) released the Programmatic Biological Opinion (PBO) on the *Management Plan for Endangered Fishes in the Yampa River Basin* in 2005. The PBO does not cap the amount of water that can be developed in the Yampa Basin. Rather, it protects the right to develop a certain amount of water within a timeframe, whose impacts can be scientifically analyzed using the best available data. Implementation of the Recovery Program should allow Colorado to fully develop its entitlement to water under the compact.

The Recovery Program determined that 7,000 acre-feet of augmentation would satisfy adopted base flow recommendations for the Yampa River in all but the driest 10% of years. Eleven augmentation water supply alternatives were examined in detail, as described in the *Management Plan*. As part of the PBO, USFWS developed an augmentation protocol to increase the flows at Maybell when the gaged flow drops below 78 cfs from July through October and 109 cfs from November through February. Water will be released from storage at a maximum rate of 50 cfs, or 33 cfs during drought conditions. Storage is provided by the Elkhead Reservoir enlargement. Five thousand acre-feet has been designated for this purpose with an option to lease an additional 2,000 acre-feet.

3.5 Section 3 References

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7. Yampa and White River Basin Facts, Colorado Water Conservation Board, available at http://cwcb.state.co.us

8. The Yampa River Management Plan, Colorado Water Conservation Board, December 2001, available at http://cwcb.state.co.us

9. Yampa Valley Water Demand Study, BBC Research and Consulting, 1998.

4. Modeling Approach

This section describes the approach taken in modeling the Yampa 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 Yampa 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 without and with 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.

Moreover, the model was to estimate the basin's 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 Yampa River model can be viewed in StateDMI. It includes approximately 440 nodes, beginning at the headwaters of Bear River and Elk River and extending to the USGS gage 09260050 - Yampa River at Deerlodge Park.

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 5 cubic feet per second (cfs) cutoff value was selected for the Yampa River basin. Key diversion structures are those with total absolute water rights equal to or greater than 5.0 cfs. The Yampa River model includes 259 key diversion structures. Additionally, three key diversion structures are in Wyoming on the Little Snake River.

Where to find more information

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

4.2.2.2 Aggregation of Irrigation Structures

The use associated with irrigation diversions having total absolute rights less than 5.0 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, or if on the mainstem, gage location, critical administrative reaches, and instream flow reaches. To the extent possible, aggregations were devised so that they represented no more than 1500 irrigated acres. In the Yampa River model within Colorado, 28 aggregated nodes were identified, representing 24,217 acres of irrigated acres. Generally, these nodes were placed in the model at the most downstream position within the aggregated area.

Aggregated irrigation nodes were assigned 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.

Irrigation use in Wyoming was represented primarily with aggregated nodes, of which there are eleven on the Wyoming side of the border. Characteristics of these aggregations were obtained from the GRBP technical memoranda and supporting spreadsheets.

Where to find more information

- Yampa Historical Crop Consumptive Use Analysis: Yampa 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
- Appendix A describes how aggregate structures were created and a complete lists of all structures included in aggregates.

4.2.2.3 Aggregation of Municipal and Industrial Uses

Four nodes in the model represent the combined small diversions for municipal, industrial, and livestock use within Colorado. Total non-irrigation consumptive use in Colorado's portion of the Yampa basin was estimated relatively early in CDSS development, as documented in the memorandum "Consumptive Use Model Non-Irrigation Consumptive Uses and Losses in the Yampa River Basin." (see Appendix B). Consumptive use of the key municipal and industrial 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 44, 55, 57, and 58 in accordance with a general distribution of M&I use identified by BBC Research and Consulting in their 1998 "Yampa Valley Water Demand Study."

The four aggregated M&I nodes represent approximately 2600 af of consumptive use, a small percentage of the basin total use. Their demands are represented as being the same each year, based on annual averages. 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.

One node on the Little Snake River in Wyoming represents the combined diversions of the Towns of Baggs and Dixon, Wyoming. This is the only M&I use identified in the Little Snake basin by the GRBP, other than Cheyenne's transmountain project, which is represented explicitly. Like the Colorado aggregated M&I nodes, this node's demands are modeled as being the same each year, based on annual averages.

Where to find more information

- Appendix B describes how municipal and industrial uses were aggregated.
- "Yampa Valley Water Demand Study", BBC Research and Consulting, June 30, 1998. The study is currently available in .pdf format from the Colorado River Water Conservation District's website, www.crwcd.gov

4.2.3 Reservoirs

4.2.3.1 Key Reservoirs

Reservoirs with decreed capacities equal to or in excess of 4,000 acre-feet are considered key reservoirs, and are explicitly modeled. In addition, the 2,250-af Allen Basin Reservoir is included because it is involved with some trans-tributary diversions that were more readily modeled by including the reservoir operations. Excluding Wyoming reservoirs, there are nine key reservoirs with a combined total capacity of approximately 108,000 af, or 80 to 90 percent of the total absolute storage rights of the basin within Colorado. High Savery Reservoir and several small impoundments are modeled in Wyoming. Physical parameters for the Wyoming structures were provided by the Wyoming Water Development Commission or by the Wyoming State Engineer's office.

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 six aggregated reservoir structures within Colorado and four aggregated structures in Wyoming.

Three of the six Colorado structures were used to represent all the adjudicated, absolute storage rights in the database that are otherwise unaccounted for. Reservoir 44_ARY001, although placed in the network at the top of Water District 44, represents storage rights in districts 57 and 58. Reservoir 44_ARY002 represents District 44 storage, and reservoir

55_ARY003 represents storage in Districts 55 and 56. Table 4.1 below summarizes storage capacity for the three reservoirs. Surface area for the reservoirs was developed assuming they are straight-sided pits with a depth of 25 feet. This depth was selected to be consistent with modeling efforts for the other basins on the Western Slope.

Table 4.1 - Aggregated Reservoirs

ID	WD	Name	Capacity (AF)	%
44_ARY001	57&58	ARY_001_YampaRbelCraig	23,206	69
44_ARY002	44	ARY_002_YampaR@Deerlodge	9,122	27
55_ARY003	54&55	ARY_003_LSnakeRnrLily	1,494	4
		Total	**33,822**	**100**

The three remaining Colorado reservoir aggregates represent stock pond use, as documented in CDSS Task Memo 2.09-12, "Consumptive Use Model Non-Irrigation Consumptive Uses and Losses in the Yampa River Basin". Each represents stockponds within a hydrologic unit, as presented in the task memo and shown below in Table 4.2. The stockponds were modeled as 10-foot deep straight sided pits. Locations, sizes, and total evaporation amount for the aggregated Wyoming reservoirs were provided either by the Wyoming State Engineer's Office or the GRBP and are included in Appendix C.

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

Table 4.2 - Aggregated Stockponds

ID	HUC	Name	Capacity (AF)	%
44_ASY001	14050001	ASY_001_YampaRbelCraig	8,344	52
44_ASY002	14050002	ASY_002_YampaR@Deerlodge	4,441	28
55_ASY003	14050003	ASY_003_LSnakeRnrLily	3,173	20
		Total	**15,958**	**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. It also includes CDSS Task 2.09-12 Memorandum "Consumptive Use Model Non-Irrigation Consumptive Uses and Losses in the Yampa River Basin", November 1996.
- Appendix C contains memos that relate to representation of Wyoming depletions, including those due to reservoir evaporation.

4.2.4 Instream Flow Structures

The model includes 22 instream flow reaches representing instream flow rights held by CWCB. 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. Six additional instream flow reaches are used to represent other operations in StateMod.

The Steamboat Springs Boating Recreational In-Channel Diversion is represented using an instream flow node (5802591).

Two instream flow nodes are used represent the Programmatic Biological Opinion for the Yampa River at Maybell (44_FishTar) and the lower Yampa River (44_FishRch). Two instream flow nodes are used to represent the FERC required minimum flow bypass for Stagecoach Reservoir (5804213_F2 and 5804213_F4) and a potential future bypass requirement for the future Morrison Creek Reservoir (5803913_MF).

4.3 Modeling Period

The Yampa 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, 2002s) and wet cycles (1983-1985).

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

Where to find more information

- The feasibility study for the data extension is documented in two task memos, which are 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. Generally, 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 Yampa River basin model.

4.4.1 Historical Data Extension for Major Structures

4.4.1.1 Historical Diversions

Based primarily on the size of their historical diversions, the Maybell Canal, Walton Creek Ditch, and Gibralter Ditch were identified as warranting additional investigation to find actual diversion records prior to 1975. As it turned out, the database for these structures was already fairly complete, beginning in the mid-1920's or early 1930's. The microfiche records at the Division of Water Resources yielded three additional years of data for the Maybell Canal and four additional years for the Gibralter Ditch. These few additional years were incorporated in the model input data set.

4.4.1.2 Historical Reservoir Contents

The four largest reservoirs in the Yampa River basin are fairly recent developments, as shown by the list of major Yampa basin reservoirs below. Historical information prior to 1975 was sought from Division 6 for Steamboat Lake without success, and therefore had to be filled in using the automated data filling procedure used for less significant structures. Division 6 provided content information on Stagecoach Reservoir from December, 1988 forward. Post-1975 data were in the database for Yamcolo Reservoir, Steamboat Lake, and Elkhead Reservoir, but it was determined that the monthly reservoir content table was sparsely populated. A more complete time series was developed for these three reservoirs by taking reservoir contents from the sporadic observations table, using only observations within 16 days of month's end. Data from 2006 to 2015 for Elkhead reservoir was collected from the Colorado River District. Data from 1998 to 2014 for Yamcolo reservoir was collected from the Upper Yampa Water Conservancy District.

Table 4.3 - Major Reservoirs Structures

WDID	Reservoir Name	Capacity (af)	First Year of Operation	Year of Enlargement
5804240	YAMCOLO	9,621	1981	1998
5804213	STAGECOACH	36,439	1988	2009
4403902	ELKHEAD	24,778	1975	2006
5803787	STEAMBOAT LAKE	26,364	1965	2008

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 Yampa 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 Yampa basin, based on three indicator gages: Little Snake River at Lily (09260000), Yampa River at Maybell (09251000), and Yampa River at Steamboat Springs (09239500). The characterization for the Lily gage is used when filling in time series for any structure in District 55, as well as the two lowest Wyoming aggregates. Similarly, the Maybell gage characterization pertains to District 44 and District 56, and the Steamboat Springs gage characterization pertains to Districts 54, 57, 58, and the upper Little Snake basin.

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

When historical diversion records are filled, a constraint is added to the estimation procedure. The estimated diversion may not exceed the water rights that were available to the diversion at the time. For example, if a ditch was enlarged and a junior right added to it in the 1950s, then a diversion estimate for 1935 cannot exceed the amount of the original right. The date of first use is derived from the administration number of the water right, which reflects the appropriation date.

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.
- Documentation for the Streamflow Characterization Tool, a calculator for categorizing months as Average, Wet, or Dry, is under development.
- 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.

In reality, the further one goes back in time, the fewer gage records exist to create baseflow series that can serve as independent variables. In 1909, were no gages in the Yampa River basin, and there were fewer than three USGS stations in the basin until the mid-1930's. To fill baseflows during these early periods, historical averages are used. Approximately 55 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.
- Documentation for the Mixed Station Model is included in the TSTool documentation, under the "FillMixedStation()" command.

4.5 Consumptive Use and Return Flow Amounts

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 Yampa River model is allowed to vary through time, up to a specified maximum efficiency. Setting aside soil moisture dynamics for the moment, the predetermined crop irrigation water requirement is met out of the simulated headgate diversion, and efficiency (the ratio of consumed water to diverted water) falls where it may – up to the specified maximum efficiency. If the diversion is too small to meet the irrigation requirement at the maximum efficiency, maximum efficiency becomes the controlling parameter. Crop consumption is limited to the diverted amount times maximum efficiency, and the balance of the diversion, less 3 percent loss, returns to the stream. The 3 percent loss represents water lost to the hydrologic system altogether, though, for example, non-crop consumptive use, deep groundwater storage, or evaporation. This value is recommended as an appropriate estimate of incidental use for the Yampa River basin.

The model is supplied with the time series of irrigation water requirements for each structure based on its crop type and irrigated acreage. This information is generated using the CDSS StateCU model. Maximum system efficiency (combined ditch efficiency and application efficiency) is also input to the model. Maximum flood irrigation system efficiencies are estimated to be 54 percent and sprinkler irrigation is estimated at 72 percent throughout the Yampa River basin.

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 full crop irrigation requirement at the maximum efficiency.

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

> Let **DIV** be defined as the river diversion, $\boldsymbol{\eta_{max}}$ be defined as the maximum system efficiency, and let $\mathbf{CU_i}$ be defined as the crop irrigation water requirement.
>
> Then, $SW = DIV * \eta_{max}$; (Max available water to crop)
>
> when $SW \geq CU_i$: (Available water to crop is sufficient to meet crop demand)
>
> $CU_w = CU_i$ (Water supply-limited CU = Crop irrigation water requirement)

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

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

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

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

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

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

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

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

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

CU_w is water supply limited consumptive use;

SS_m is the maximum soil moisture reservoir storage;

SS_i is the initial soil moisture reservoir storage;

SS_f is the final soil moisture reservoir storage;

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

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

For the following example, assume the maximum system efficiency is 54 percent; therefore a maximum of 54 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 54 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 46 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 Yampa model applies an assumed, specified monthly efficiency to a diversion in order to determine consumptive use and return flows. Although the efficiency varies by month, the monthly pattern is the same in each simulation year. This approach is applied to municipal, industrial, and transbasin users, as well as any irrigation diversion for which crop water requirement has not been developed.

The four basin exporters in the Yampa model (Stillwater Ditch, Sarvis Ditch, Dome Creek Ditch, and City of Cheyenne) have been assigned a diversion efficiency in all months of 1.00. During both baseflow estimation and simulation, the entire amount of the diversion is assumed to be removed from the hydrologic system. The two explicitly modeled municipal systems in Colorado (Craig and Steamboat Springs/Mt. Werner) have been given typical monthly efficiencies that reflect indoor use only in the winter, and combined indoor and outdoor use during the irrigation season. Efficiency for the municipal diversion representing the Towns of Baggs and Dixon in Wyoming was based on annual efficiencies available in the GRBP. Snowmaking has been assigned an efficiency of .80, based on industry estimates and recent decrees. Cooling water demand at the Hayden and Craig stations has an efficiency of 1.00 because there are no returns to the river.

Finally, every structure in the model, including irrigation structures operating by variable efficiency, has monthly efficiencies assigned to it in the model input files. For irrigation structures, these are average monthly efficiencies based on historical diversions and historical crop water requirement over the period 1975-2013, but may not exceed 0.60. These are used by DMI components of CDSS to create time series of headgate demands for input to the model, as described in Section 4.9.1.

Where to find more information

- StateCU documentation describes different methods for estimating irrigation water requirement for structures, for input to the StateMod model.
- Section 7 of the StateMod documentation has subsections that describe "Variable Efficiency Considerations" and "Soil Moisture Accounting"
- Section 5 of this manual describes the input files where the parameters for computing consumptive use and return flow amounts are specified:
    - Irrigation water requirement in the Irrigation Water Requirement file (Section 5.5.3)
    - Headgate demand in the Direct Diversion Demand file (Section 5.4.4)
    - Historical efficiency in the Direct Diversion Station file (Section 5.4.1)
    - Maximum efficiency in the CU Time Series file (Section 5.5.2)
    - Soil moisture capacity in the StateCU Structure 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 by specifying what percentage of the return flow accruing from a diversion reaches the stream in the same month as the diversion, and in each month following the diversion month. Four different return flow patterns are used in the Yampa River 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 subject to 3 percent loss for one pattern, and 10 percent loss for the other. The basic return pattern was 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, distance from the stream to the alluvial boundary as 3,500 ft. The Glover analysis was then executed for both a distance of 600 feet from the recharge center to the stream, and 1500 feet from the recharge center to the stream. (Currently, the pattern resulting from the shorter distance is used in the model.)

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.). It was also assumed that incidental losses occur due to processes such as evaporation and non-beneficial consumptive use. In the one case, losses of 3 percent occur in the first return month. In the second case, 10 percent loss is spread over the first two return months, with 7 percent occurring in the first month, and 3 percent occurring in the second month. The patterns listed in Table 4.3, and graphed in Figure 4.2, show the net result for these assumptions imposed on the Glover analysis, that is, that the irrigation return patterns supplied to the model reflect combined surface and groundwater returns, and that non-beneficial loss occurs at a specified level. Month 1 is the month in which the diversion takes place.

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*	With 3 percent Incidental Loss	With 10 percent Incidental Loss
1	75.6	71.6
2	11.3	8.3
3	3.2	3.2
4	2.2	2.2
5	1.6	1.6
6	1.2	1.2
7	0.8	0.8
8	0.6	0.6
9	0.5	0.5

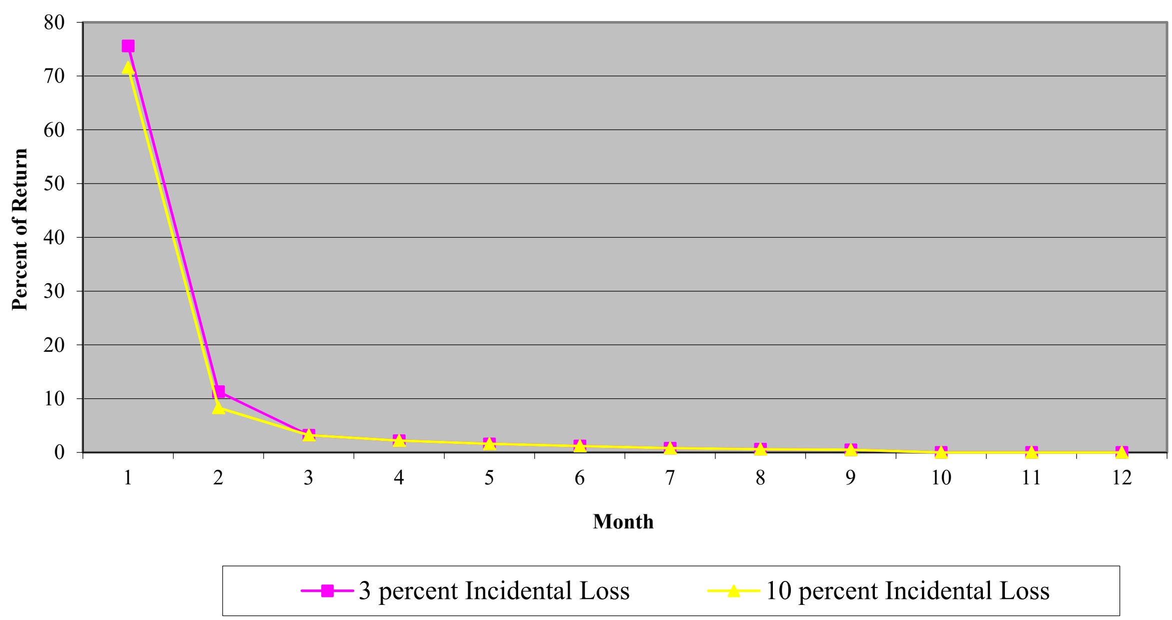


Figure 4.1 - Percent of Return in Months After Diversion

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

4.7.1 Baseflow Computations at Gages

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

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

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 similarly computed based on diversions, crop water requirements, and/or efficiencies as described in Section 4.5, and return flow parameters as described in Section 4.6.

Where to find more information

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

4.7.2 Baseflow Filling

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

4.7.3 Distribution of Baseflow To Ungaged Points

In order for StateMod to have 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.

Figure 4.2 illustrates a hypothetical basin and the areas associated with three gages and three ungaged baseflow nodes.

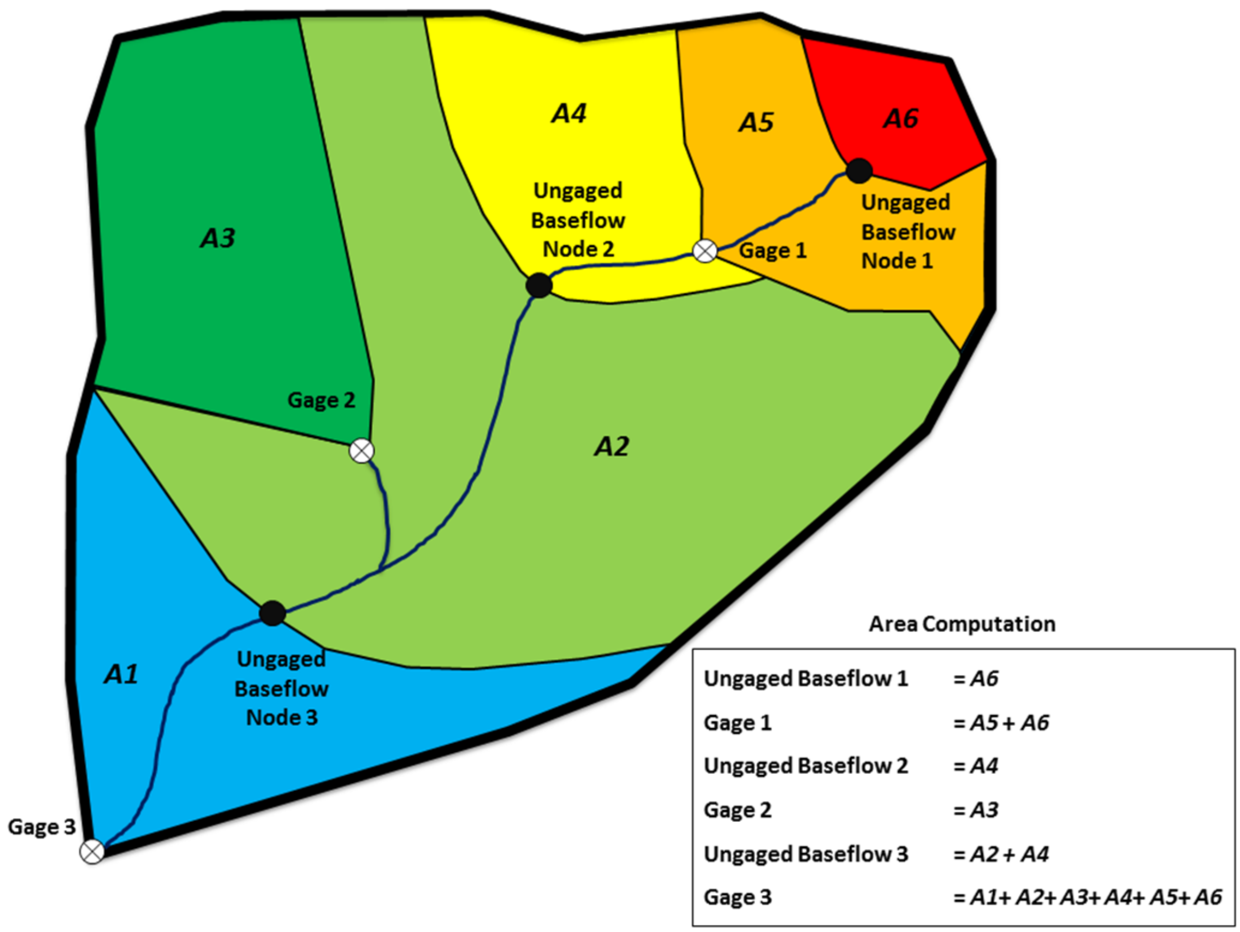


Figure 4.2 - Hypothetical Basin Illustration

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 (diagonal stripes) includes the upstream area between the Ungaged Baseflow Node 3 and Gage 2 and Gage 1.

In Figure 4.2, 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.

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

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.

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

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.

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

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 Yampa River model was calibrated in a two-step process described below. The issues encountered and results obtained are described in Section 7.

4.8.1 First Step Calibration

In the first calibration run, the model was executed with relatively little freedom with respect to operating rules. Headgate demand was simulated by historical diversions, and historical reservoir contents served as operational targets. The reservoirs would not fill beyond the historical content even if water was legally and physically available. Operating rules caused the reservoir to release to satisfy beneficiaries' demands, but if simulated reservoir content was higher than historical after all demand was satisfied, the reservoir released water to the river to achieve the historical end-of-month content. Had there been any multiple-headgated collection systems in the Yampa basin, the first calibration run 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 the three multi-structures in the Yampa basin, a centralized demand is placed at the final destination node, 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. At Elkhead Reservoir, for example, considerable effort was devoted to capture releases to support instream flows at the Maybell and the lower Yampa River instream flow reaches. 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 Yampa River model.

4.9 Baseline Data Set

The Baseline data set is intended as a generic representation of current conditions on the Yampa River, to be used for "what if" analyses. It represents one interpretation of current use, operating, and administrative conditions, as though they prevailed throughout the modeling period. All existing water resources systems are on-line and operational in the model from 1909 forward, as are junior rights and modern levels of demand. The data set is a starting point, which the user may choose to add to or adapt for a given application or interpretation of probable demands and near-term conditions.

4.9.1 Calculated Irrigation Demand

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

Calculated demands must account for both crop needs and irrigation practices. Monthly calculated demand for 1975 through 2013 is generated directly, by taking the maximum of crop irrigation water requirement divided by average monthly irrigation efficiency, and historic diversions. The system irrigation efficiency may not exceed the defined maximum efficiency. Thus calculated demand for a perennially shorted diversion can 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.

4.9.2 Municipal and Industrial Demand

Municipal and industrial demands were set to recent values or averages of recent records, as recommended by the Yampa Hydrology Subcommittee of the Yampa Management Plan effort.

4.9.3 Transbasin Demand

Transbasin diversion demands were set to average monthly diversions over the period 1989-2013.

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

- Section 5.9 describes the operating rights file, which specifies 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 *ym2015B.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
ym2015.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 5.2
ym2015.rin	River network file – lists every model node and specifies connectivity of network	Section 5.3.1
ym2015B.res	Reservoir station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1
ym2015.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
ym2015.ris	River station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 5.3.2
ym2015.ifs	Instream flow station file – lists instream flow reaches	Section 5.7.1
ym2015.ifr	Instream flow right file – gives decreed amount and administration number of instream flow rights associated with instream flow	Section 5.7.3

	reaches	
ym2015B.rer	Reservoir rights file – lists storage rights for all reservoirs	Section 5.6.5
ym2015.ddr	Direct diversion rights file – lists water rights for direct diversion	Section 5.4.5
ym2015B.opr	Operational rights file – specifies operations that are more complex than a direct diversion or on channel storage. Operational rights can specify, for example, a reservoir release for delivery to a downstream diversion point, a reservoir release to allow diversion by exchange at a point which is not downstream, or a direct diversion to fill a reservoir via a feeder	Section 5.8
ym2015.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
ym2015x_mod.xbm	Baseflow data file – time series of undepleted flows at all nodes listed in *ym2015.ris*	Section 5.3.5
ym2015B.ddm	Monthly demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
ym2015.ifa	Instream flow demand file – gives the decreed monthly instream flow rates	Section 5.7.2
ym2015.dly	Delay Table – contains several return flow patterns that express how much of the return flow accruing from diversions in one month reach the stream in each of the subsequent months, until the return is extinguished	Section 5.4.2
ym2015B.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
ym2015B.ipy	Irrigation practice yearly file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
ym2015B.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3
ym2015.str	StateCU Structure file – location, assigned climate station(s), and soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
ym2015.eom	Reservoir End of month contents file – Monthly time series of historical reservoir contents	Section 5.6.3
ym2015.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
ym2015.rih	Historical streamflow file – Monthly time series of streamflows at modeled gages	Section 5.3.4
ym2015.ddh	Historical Diversions – Monthly time series of historical diversions	Section 5.4.3
ym2015.pln	Plan Data file – contains parameters for plan structures	Section 5.8

5.1.2 For Generating Baseflow

The baseflow file (ym2015x_mod.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 Section 4.7 and one additional step performed in TSTool specific to the Yampa. In the first step, StateMod estimates baseflows at gaged locations, using the files listed in the response file ym2015.rsp. This response file calls for input files which reflect strictly historical data. When the initial baseflow run is made, the baseflow file (ym2015.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. In the second step, the Mixed Station Model is used to fill the time series, creating a complete time series of baseflows at gages. The output from the Mixed Station Model is the ym2015.xbf file.

In the third step, StateMod distributes baseflow to ungaged points. The response file is named ym2015x.rsp. The only difference between the first-step response file ym2015.rsp and third-step response file ym2015x.rsp is that the ym2015.xbf file replaces the historical gage file ym2015.rih. The output from StateMod is the baseflow file ym2015x.xbm. This contains a complete time series for all gaged and ungaged natural flow locations.

The fourth step is specific to the Yampa basin. Trout Creek is an ungaged tributary to the Yampa River. Peabody Energy studied the feasibility of constructing a reservoir on Trout Creek upstream of the Fish Creek confluence. As part of this study, the hydrology on Trout Creek was carefully reviewed (ERC 2015). It was determined that the previously modeled inflows to Trout Creek were being under-simulated in the month of April and over-simulated in the month of May. It was recommended that 14 percent of the flow in May be shifted to April (ERC 2015). This step is accomplished in TSTool and the output is written to the final baseflow input file ym2015x_mod.xbm.

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 Yampa model. Control file switches are all specifically described in the StateMod documentation. The simulation period parameters (starting and ending year) are the ones that users most typically adjust.

5.3 River System Files

5.3.1 River Network File (*.rin)

The river network file is created by the StateDMI. It describes the location and connectivity of each node in the model. Specifically, it is simply a list of each structure ID and name, along with the ID of the next structure downstream. It is an inherent characteristic of the network that, with the exception of the downstream terminal node, each node has exactly one downstream node.

The Yampa River actually ends at its confluence with the Green River within Colorado. The network includes the confluence, one aggregated node on the Green River representing Colorado's consumptive use of mainstem Green River water, and tributaries to Green River. Additionally, three nodes are used to explicitly represent diversions on Beaver Creek, a tributary to the Green River.

River gage nodes are labeled with United States Geological Survey (USGS) stream gaging station numbers (i.e., 09000000). Diversion and reservoir structure identification numbers are composed of Water District number followed by the State Engineer's four-digit structure ID. Table 5.1 shows how many nodes of each type are in the Yampa model.

Table 5.1 - River Network Elements

Type	Count
Diversion	338
Instream Flow	38
Reservoirs	30
Stream Gages	22
Plan Structures	1
Total	429

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 is also 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 22 gages in the model and 72 ungaged baseflow locations, for a total of 94 hydrologic inflows to the Yampa River model. Ungaged baseflow nodes include ungaged headwater nodes, most key reservoir nodes, many of the aggregated diversion nodes, and any other nodes where calibration indicated a need for it. In the last case, water that was simulated as entering the system further down (e.g., at the next gage) was moved up the system to the ungaged point.

5.3.3 Baseflow Parameter File (*.rib)

The baseflow parameter file has an entry for each ungaged baseflow node in the model, specifying coefficients, or “proration factors”, used to calculate the baseflow gains at that point. StateDMI computes proration factors based on the network structure, area, and precipitation values supplied for both gages and ungaged baseflow nodes. Upstream area and precipitation is entered in the network file (ym2015.net), which is 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 area and local average precipitation for the gage-to-gage reach.

At some locations, the hydrograph developed using the gain approached showed an attenuated shape that was not representative of a “natural” hydrograph. This occurred in headwater areas where the runoff occurs earlier and quicker than on lower tributaries. In these situations, baseflow was determined as a function of baseflow at a nearby stream gage, specified by the user. Ideally, this “neighboring gage” was from a drainage with similar physiographic characteristics. Baseflow at the ungaged site was assumed to be in the same proportion to baseflow at the nearby gage as the product of area and average precipitation at the two locations. This procedure, referred to as the “neighboring gage approach”, was applied to these tributaries shown in Table 5.2.

Table 5.2 - Baseflow Node Using the Neighboring Gage Approach

Tributary Name	Baseflow WDID	Neighboring Gage
Walton Creek	5800687	09238900
Soda Creek	5802311	09238900
Sand Creek	5802304	09236000
Hot Springs Creek	5802254	09236000
Trout Creek	5701009	09241000
W. Fish Creek	5700544	09241000
Fish Creek	5700612	09241000
Anderson Ditch	4400533	09245500
Little Bear Creek	4400573	09245000
Dry Fork Little Bear Creek	4400785	09245000
Little Cottonwood Creek	4400998	09245000
Milk Creek	4400692	09249750
Stinking Gulch	4400518	09236000
Good Spring Creek	4400524	09249750
Pine Creek	4401454	09249750
Morapos Creek	4400726	09249750
Deer Creek	4400716	09249750
Waddle Creek	4400644	09249750

Muddy Creek	WYD_009	09255500
Beaver Creek	5600621	09241000
Green River	56_ADY027	09241000

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 through 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 the database. Missing values, when the gage was not in operation, are denoted using the value "-999."

Table 5.3 lists the 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 Yampa Stream Gages

Gage ID	Gage Name	Period of Record	Historical Flow (af/yr)
09236000	Bear River Near Toponas	1953-1965, 1967-1986	29,403
09237500	Yampa River Below Stagecoach Reservoir	1940-1944. 1957-1972, 1985-2014	59,017
09238900	Fish Creek At Upper Station	1967-1972, 1973-1979[1], 1983-2014	47,536
09239500	Yampa River At Steamboat Springs	1910-2014	333,863
09242500	Elk River near Milner	1905,1906,1910-1927, 1990-2014	40,4468
09241000	Elk River At Clark	1911-1916, 1918, 1920, 1932-1991, 1998-2003[1]	237,766
09244410	Yampa River Below Diversion nr Hayden	1966-1986	809,415
09245000	Elkhead Creek Near Elkhead	1953-1996	40,199
09245500	North Fork Elkhead Creek	1959-1973	12,514
09246920	Fortification Creek near Fortification	1985-1991, 2003-2005	7,588
09247600	Yampa River Below Craig	1985-2014	918,139
09249000	East Fork of Williams Fork	1954-1971	81,571
09249200	South Fork of Williams Fork	1966-1979	30,635
09249750	Williams Fork at Mouth	1985-2001	157,476
09251000	Yampa River near Maybell	1916-2014	1,126,160

09253000	Little Snake River Near Slater	1944-1947, 1951-1999,2002-2014	167,282
09255000	Slater Fork Near Slater	1932-2014	57,008
09255500	Savery Creek at Upper Station near Savery	1941,1953-1998	36,470
09256000	Savery Creek near Savery	1942-1946,1948-1998	80,651
09257000	Little Snake River near Dixon	1911-1923,1939-1998	376,476
09258000	Willow Creek Near Dixon	1954-1992	7,380
09260000	Little Snake River Near Lily	1922-2014	411,763
09260050	Yampa River At Deerlodge Park	1983-1994, 1997-2014	1,514,208

[1] Summer 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.

Table 5.4 compares historical gage flows with simulated baseflows for the four gages that operated throughout the calibration period (1975-2013). The difference between the two represents an estimate of historical consumption over this period.

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

Gage ID	Gage Name	Baseflow	Historical	Difference
09239500	Yampa River at Steamboat Springs	362,562	319,743	42,819
09251000	Yampa River near Maybell	1,266,860	1,120,083	146,777
09255000	Slater Fork near Slater	65,479	61,113	4,366
09260000	Little Snake River near Lily	470,946	405,988	64,958

Where to find more information

- Sections 4.7 explains how StateMod and the Mixed Station Model are used to create baseflows.
- When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file *(*.xbi)* that shows this computation for each gage and each month of the time step.
- When the Mixed Station Model is used to fill baseflows, it creates two reports, *ym2015.sum* and *ym2015.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 Yampa Model. Table 5.5 is a summary of the Yampa 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 also specifies return flow nodes and average monthly efficiencies.

Generally, the diversion station ID and name, diversion capacity, and irrigated acreage are gathered from Hydrobase by **StateDMI**. Return flow locations are specified to **StateDMI** in a hand-edited file ym2015.rtn. The return flow distribution was based on discussions with Division 6 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

Table 5.5.

Table 5.5 - Direct Flow Diversion Summary (1975-2013)

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
1	4400501	W R DEAKINS DITCH	11	54	22	907
2	4400506_D [1]	Wideman Ditch DivSys	43	316	49	1544

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
3	4400509	WILSON DITCH	17	280	55	1538
4	4400511	WISCONSIN DITCH	32	612	41	3680
5	4400514	WOOLEY & JOHNSON D	9	114	53	575
6	4400516	YAMPA DITCH	12	48	31	514
7	4400517	YAMPA VAL STOCK BR CO D	19	555	56	2079
8	4400518	YELLOW JACKET DITCH NO 1	21	202	56	822
9	4400519 [9]	YELLOW JACKET DITCH NO 2	7	0	0	159
10	4400522 [2]	CRAIG STATION D & PL #1	45	0	100	12483
11	4400524	A Q DITCH 1	5	7	30	236
12	4400527	AIR LINE IRR D	999	123	58	504
13	4400529	BEHRMAN DITCH 1	9	37	14	720
14	4400533	ANDERSON DITCH	5	64	55	301
15	4400541	BAILEY DITCH	16	106	34	1047
16	4400570	CARD DITCH	18	102	24	1769
17	4400572	CARRIGAN-AVERILL D	11	47	50	197
18	4400573	CATARACT DITCH	21	578	60	2260
19	4400581 [2]	CRAIG WATER SUPPLY PL	16	800	36	2169
20	4400583	CROSS MTN PUMP - GROUNDS	26	576	26	3504
21	4400584	CROSS MTN PUMP NO 1	25	684	36	3545
22	4400585	CRYSTAL CK DITCH	6	30	24	501
23	4400586	D D & E DITCH	51	484	39	3738
24	4400587	D D FERGUSON D NO 2	30	364	51	2308
25	4400589	DEEP CUT IRR D	69	514	13	7657
26	4400590	DEER CK & MORAPOS D	27	217	37	1896
27	4400593	DENNISON & MARTIN D	11	220	54	1000
28	4400601	DUNSTON DITCH	10	21	7	969
29	4400607_D [1]	Egry Mesa Ditch DivSys	48	497	17	6296
30	4400611	ELK TRAIL DITCH	19	246	49	1344
31	4400612	ELKHORN IRR DITCH	20	376	60	1393
32	4400613	ELLGEN DITCH	8	137	53	448
33	4400614	ELLIS & KITCHENS D	8	20	13	471
34	4400628	GIBBONS WILSON JORDAN D	10	263	56	810
35	4400635	GRIESER DITCH	8	95	51	611
36	4400638	HADDEN BASE DITCH	15	237	60	999
37	4400644	HARPER DITCH 1	8	139	60	624
38	4400645	HARPER DITCH 2	8	55	48	375
39	4400647	HAUGHEY IRR DITCH	14	291	54	1388
40	4400650	HIGHLINE MESA BAKER D	11	148	60	384
41	4400651	HIGHLAND DITCH	16	500	49	2720
42	4400652	HIGHLAND AKA HIGHLINE D	14	131	44	1181

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
43	4400660	J A MARTIN DITCH	12	108	46	742
44	4400661	J P MORIN DITCH	16	120	49	834
45	4400670	J W KELLOGG D 2	6	84	48	443
46	4400674 [9]	JUNIPER DITCH	8	0	0	137
47	4400675	JUNIPER MTN TUNNEL	67	198	22	4317
48	4400677	K DIAMOND DITCH	21	239	26	2106
49	4400681	LAMB IRR DITCH	9	64	50	530
50	4400687	LILY PARK D PUMP STA NO	999	147	10	2990
51	4400688	LITTLE BEAR DITCH	22	685	60	2781
52	4400691	M DITCH	15	53	10	1418
53	4400692	MARTIN CK DITCH	62	448	45	3404
54	4400694	MAYBELL CANAL	129	1306	12	19183
55	4400695 [2]	MAYBELL MILL PIPELINE	2	0	100	350
56	4400698	MCDONALD DITCH	12	100	46	623
57	4400699	MCKINLAY DITCH NO 1	27	213	56	1124
58	4400700	MCKINLAY DITCH NO 2	30	373	54	1990
59	4400702	MCINTYRE DITCH	20	133	18	2315
60	4400706	MILK CK DITCH	28	29	6	792
61	4400711 [9]	MOCK DITCH	12	0	0	824
62	4400716	MULLEN DITCH	6	146	54	464
63	4400720	MYERS DITCH NO 1	8	38	16	717
64	4400723	NICHOLS DITCH NO 1	8	101	27	1150
65	4400724	NORVELL DITCH	30	388	43	2508
66	4400726	OWEN CARRIGAN DITCH	16	77	60	248
67	4400729	PATRICK SWEENEY D	18	448	47	2323
68	4400731	PECK IRRIG D	20	159	26	1721
69	4400735	PINE CK DITCH	12	166	35	895
70	4400740	RATCLIFF DITCH	11	67	38	950
71	4400747	ROBY D AKA ROBY D NO 1	8	92	54	415
72	4400748	ROBY DITCH NO 2	14	18	35	273
73	4400749	ROUND BOTTOM D NO 1	7	42	55	174
74	4400750	ROUND BOTTOM D NO 2	9	83	46	456
75	4400751	ROUND BOTTOM DITCH	12	174	60	499
76	4400763	SMITH DITCH	21	339	37	1813
77	4400765	SOUTH SIDE DITCH	11	22	11	1186
78	4400770	STARR IRRIG DITCH	9	8	8	334
79	4400776	SULLIVAN SEEPAGE D	7	25	26	522
80	4400778	SUNBEAM DITCH	10	136	13	1837
81	4400785	TIPTON IRR DITCH	20	415	59	1821
82	4400786	TISDEL D NO 2	15	286	25	1993

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
83	4400790	UTLEY DITCH	13	51	8	1595
84	4400801	CROSS MOUNTAIN PUMP DITC	9	99	16	1442
85	4400806	ELLGEN NO 2 DITCH	10	67	44	356
86	4400808_D [1]	Five Pines Pump DivSys	2	14	11	257
87	4400812	HART DITCH	16	170	60	558
88	4400814	HIGHLINE DITCH	12	106	41	768
89	4400820	LOWRY SEELEY PUMP	12	149	22	1585
90	4400821	MACK DITCH	8	38	27	403
91	4400830	OLD SWEENEY DITCH	14	148	22	1717
92	4400834	ROWLEY PUMP STATION	6	60	34	471
93	4400851 [9]	MORGAN DITCH	12	0	0	360
94	4400863_D [1]	Henry Sweeney Ditch	21	383	31	2787
95	4400998	DRY COTTONWOOD DITCH 1	9	104	45	644
96	4401122 [9]	VAUGHN PUMP	25	0	0	1819
97	4402001	ASHBAUGH PUMP NO 1	6	90	60	275
98	4402029 [3]	Fut. Yampa R Milk Crk	400	0	0	0
99	4402207	BROCK D VANTASSEL TRANS	6	36	35	332
100	4402214	WISE DITCH ALT PT	999	150	59	495
101	4404325_D [3]	Fut Oxbow Rampart Res	999	0	51	0
102	44_ADY012	Diversion Aggregate	17	346	58	1680
103	44_ADY013	Diversion Aggregate	83	1078	44	4577
104	44_ADY014	Diversion Aggregate	48	1144	57	5604
105	44_ADY015	Diversion Aggregate	56	562	49	4012
106	44_ADY016	Diversion Aggregate	64	885	47	5231
107	44_ADY017	Diversion Aggregate	20	189	50	1087
108	44_ADY018	Diversion Aggregate	27	552	44	2582
109	44_ADY019	Diversion Aggregate	30	1123	50	4018
110	44_ADY025	Diversion Aggregate	40	491	17	5529
111	44_AMY001 [2]	44_AMY001_YampaRbelCraig	999	0	36	742
112	44_FDP001 [3]	44_FDP_WD_44	999	0	36	0
113	44_WSA [3]	44_WSA_EDFdemand	999	0	0	0
114	5400500	ANDERSON DITCH	8	52	36	526
115	5400507	BEELER DITCH	16	113	30	1533
116	5400513	CLARK BUTLER WESTFALL D	15	174	47	1445
117	5400531	HEELEY DITCH	35	178	17	3081
118	5400532	HOME SUPPLY DITCH	15	135	34	1715
119	5400543	LUCHINGER DITCH	12	108	40	1263
120	5400548	MORGAN & BEELER D	18	250	31	1669
121	5400549	MORGAN SLATER DITCH	10	104	45	956

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
122	5400554	PERKINS FOX DITCH	10	156	60	721
123	5400555	PERKINS IRR DITCH	19	384	56	1982
124	5400564	SALISBURY DITCH	7	102	47	837
125	5400568	SLATER FORK DITCH	24	101	41	1158
126	5400570	SLATER PARK DITCH NO 1	12	422	60	1750
127	5400571	SLATER PARK DITCH NO 2	5	96	60	483
128	5400574_D [1]	Slater Park Ditch DivSys	19	242	35	1320
129	5400583	TROWEL DITCH	72	1269	39	7083
130	5400590	WEST SIDE CANAL	203	283	5	21251
131	5400591	WILLOW CK DITCH	24	699	57	3174
132	5400592	WILSON DITCH	6	41	30	478
133	5400594	WOODBURY DITCH	23	86	32	890
134	5401070_D [1]	Anderson D Grieve DivSys	10	62	22	731
135	5402068	STATE LINE WW DITCH	20	97	36	889
136	5402075	WILLOW CK SEEP & WASTE D	8	53	32	610
137	54_ADY020	Diversion Aggregate	75	1520	52	8491
138	54_ADY021	Diversion Aggregate	34	354	41	2724
139	54_ADY022	Diversion Aggregate	88	1636	55	8025
140	54_ADY023	Diversion Aggregate	203	3250	39	24627
141	5500504	ESCALANTA PUMP 2	999	157	27	1458
142	5500506	MAJORS PUMP NO 2	19	233	19	2665
143	5500507	NINE MILE IRR DITCH	13	62	15	1166
144	5500508	NINE MILE IRR PL	6	80	29	962
145	5500509	ONECO PUMP NO 2	15	120	13	1999
146	5500513	VISINTAINER DITCH	5	40	11	775
147	5500519	RINKER PUMP D	12	26	11	1058
148	5500537	LEFEVRE NO 1 PUMP	11	127	14	1993
149	5500538	DUNN PUMP & PL	6	67	52	322
150	5501011	DEWEY SHERIDAN D	10	46	15	1092
151	5501081	RAFTOPOULOS LSR PUMP	13	336	22	2437
152	5502034	HAYSTACK PUMP	7	5	5	200
153	55_ADY024	Diversion Aggregate	12	114	22	1432
154	55_ADY026	Diversion Aggregate	9	9	4	520
155	55_AMY003 [2]	55_AMY003_LSnakeRnrLily	999	0	36	13
156	55_FDP001 [3]	Fu_Dev_55	999	0	16	0
157	5600536	THOMAS DOUDLE DITCH	7	34	24	662
158	5600562	MCKNIGHT NO 1	5	24	40	208
159	5600621	GOODMAN DITCH	5	12	12	395
160	56_ADY027	Diversion Aggregate	91	1185	27	8445

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
161	56_FDP001 [3]	Fu_Dev_56	999	0	16	0
162	5700508_D [1]	Brock Ditch DivSys	38	426	16	4169
163	5700510	CARY DITCH CO DITCH	44	586	23	5074
164	5700512 [2]	COLO UTILITIES D & PL	30	0	100	5414
165	5700517	DAVID M CHAPMAN DITCH	8	106	41	880
166	5700519	DENNIS & BLEWITT D	15	166	34	1187
167	5700524	EAST SIDE DITCH	10	80	48	638
168	5700525	EAST SIDE DITCH 2	11	149	55	789
169	5700535	ERWIN IRRIGATION DITCH	6	52	19	551
170	5700539	GIBRALTAR DITCH	80	1116	40	7805
171	5700544 [5A]	HIGHLAND DITCH	17	411	60	1578
172	5700545	HOMESTEAD DITCH	16	222	52	1371
173	5700555_D [1]	Last Chance Ditch DivSys	20	251	44	1368
174	5700561	MALE MOORE CO DITCH	13	42	25	625
175	5700563	MARSHALL ROBERTS DITCH	38	697	25	4429
176	5700576_D [1]	Orno Ditch DivSys	16	123	26	1089
177	5700579_D [1]	R E Clark Ditch DivSys	15	179	36	1227
178	5700584	SADDLE MOUNTAIN DITCH	12	87	41	799
179	5700592	SHELTON DITCH	56	718	12	8767
180	5700608	TROUT CREEK DITCH 3	19	180	53	1105
181	5700609	TROUT CREEK DITCH 2	9	34	43	344
182	5700611 [6A]	WALKER IRRIG DITCH	48	1305	28	7178
183	5700612 [5B]	WEST SIDE DITCH	15	0	54	0
184	5700622	WILLIAMS IRRIG DITCH	22	121	6	3335
185	5700623_D [1]	Williams Park Ditch DivS	30	155	33	1042
186	5700635	KOLL DITCH	15	178	47	1371
187	5700675	UTTERBACK ENL COLO UTE D	6	49	40	243
188	5702083 [6B]	DRY CREEK DIVERSION	5	0	42	0
189	5704204_D [3]	Fut Peabody Trout Res	999	0	100	0
190	5704629 [7]	RICH DITCH	19	0	0	1403
191	57_ADY009	Diversion Aggregate	32	303	58	1302
192	57_ADY010	Diversion Aggregate	101	267	33	1935
193	57_ADY011	Diversion Aggregate	67	744	51	3075
194	57_ADY012	Diversion Aggregate	26	321	32	2050
195	57_AMY001 [2]	57_AMY001_YampaRabCraig	999	0	36	484
196	57_FDP001 [3]	Fu_Dev_57	999	0	33	0
197	57_NAG01 [3]	Nu_Ag_Dev	999	0	19	0
198	57_NMID01 [3]	Nu_Fu_M&I	999	0	36	0
199	57_NPWR01 [3]	Nu_Fu_Pwr	999	0	100	0

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
200	5800500	ACTON D	19	382	53	1974
201	5800506 [4]	ALLEN BASIN SUPPLY D	15	0	0	0
202	5800508	ALPHA DITCH	18	270	48	1374
203	5800530	BAXTER DITCH	50	544	53	3183
204	5800532	BEAVER CREEK D	8	102	54	466
205	5800539	BIG MESA DITCH	39	780	50	5345
206	5800540	BIJOU DITCH	8	56	55	319
207	5800541	BIRD DITCH	17	344	53	1932
208	5800556	BRINKER CREEK DITCH	6	35	21	538
209	5800559	BROOKS DITCH	12	142	51	824
210	5800561	BRUMBACK DITCH	11	83	56	444
211	5800564 [8A]	BUCKINGHAM MANDALL D	24	775	58	3336
212	5800568	BURNETT DITCH	20	292	53	1747
213	5800569	BURNT MESA D	14	132	60	496
214	5800574	C R BROWN MOFFAT COAL D	7	94	55	436
215	5800577	CAMPBELL DITCH	17	270	50	1461
216	5800582	CHARLES & A LEIGHTON D	6	30	17	609
217	5800583_D [1]	Charles H Kemmer Ditch D	8	20	14	437
218	5800588	CLARK & BURKE DITCH	10	158	48	959
219	5800590	COLEMAN DITCH	8	54	60	245
220	5800591	COLLINS DITCH	9	223	57	1000
221	5800599	CULLEN DITCH 2	10	96	37	863
222	5800604	DAY DITCH	10	80	60	313
223	5800612	DEVER DITCH	10	194	58	821
224	5800618	DUQUETTE DITCH	20	152	26	2010
225	5800622	EGERIA DITCH	23	299	51	1885
226	5800623	EKHART DITCH	16	193	50	1368
227	5800626	ELK VALLEY DITCH CO. D.	50	434	40	3492
228	5800627	ENTERPRISE DITCH	30	845	53	3456
229	5800628	EXCELSIOR DITCH	12	81	53	479
230	5800634	FERGUSON DITCH	16	174	49	1148
231	5800640	FIRST CHANCE DITCH	10	35	24	534
232	5800642 [2]	FISH CR MUN WATER INTAKE	19	0	36	2884
233	5800643	FIX DITCH	19	542	56	2124
234	5800649_D [1]	Franz Ditch DivSys	26	516	41	2378
235	5800662	GRAHAM & BENNETT D	20	340	43	2419
236	5800663	GREER DITCH	8	180	55	815
237	5800665	GUIDO DITCH	5	119	51	431
238	5800684	HERNAGE & KOLBE DITCH	9	121	39	1104
239	5800685	HIGH MESA IRR D	7	160	59	619

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
240	5800687	HIGHLINE BEAVER DITCH	13	34	35	468
241	5800694	HOOVER JACQUES DITCH	26	226	27	2645
242	5800695	HOT SPGS CR HIGHLINE D	12	52	15	942
243	5800710 [8B]	JUST DITCH	6	0	52	0
244	5800714	KELLER DITCH	32	562	53	2851
245	5800717	KINNEY DITCH	10	111	28	1409
246	5800721	L L WILSON D	8	71	33	703
247	5800722	LAFON DITCH	7	157	59	644
248	5800728	LARSEN DITCH	31	151	54	889
249	5800730	LATERAL A DITCH	12	270	56	1035
250	5800731	LAUGHLIN DITCH	7	59	43	450
251	5800738	LINDSEY DITCH	13	282	51	1643
252	5800749	LOWER PLEASANT VALLEY D	17	68	48	588
253	5800756	LYON DITCH 2	13	80	52	548
254	5800763	MANDALL DITCH	50	541	33	4989
255	5800767	MAYFLOWER DITCH	6	76	52	460
256	5800777	MILL DITCH 1	10	111	50	553
257	5800782	MOODY DITCH	8	109	60	429
258	5800783	MORIN DITCH	24	432	34	3812
259	5800798	NICKELL DITCH	12	385	59	1465
260	5800801	NORTH HUNT CREEK DITCH	9	119	59	491
261	5800805	OAK CREEK DITCH	12	164	52	895
262	5800807	OAK DALE DITCH	10	103	49	723
263	5800808	OAKTON DITCH	20	145	45	1353
264	5800809	OLD CABIN DITCH	6	85	58	360
265	5800811	OLIGARCHY DITCH	5	112	60	456
266	5800813	PALISADE DITCH	6	72	46	588
267	5800821	PENNSYLVANIA DITCH	13	209	34	1808
268	5800826 [8B]	PONY CREEK D	8	0	52	0
269	5800830	PRIEST DITCH	10	28	47	247
270	5800844	SAGE HEN DITCH	6	48	40	437
271	5800847_D [1]	Sand Creek Ditch DivSys	11	72	40	512
272	5800850	SANDHOFER DITCH	6	49	46	515
273	5800863	SIMON DITCH	16	588	57	2324
274	5800866	SNOW BANK DITCH	10	176	49	967
275	5800868	SODA CREEK DITCH	28	445	49	2336
276	5800872	SOUTH SIDE DITCH	10	93	38	717
277	5800879	STAFFORD DITCH	28	304	43	3197
278	5800895_D [1]	Sunnyside Ditch 1 DivSys	16	131	15	1487
279	5800897	SUTTLE DITCH	52	602	55	3337

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
280	5800908	TRULL MORIN DITCH	8	93	29	992
281	5800914	UNION DITCH	999	44	6	1774
282	5800915_D [1]	Upper Elk River D Co Div	15	67	13	1251
283	5800916	UPPER PLEASANT VALLEY D	17	253	52	1549
284	5800917	VAIL SAVAGE DITCH	9	171	58	727
285	5800920	WALTON CREEK DITCH	76	1674	41	11733
286	5800922	WEISKOPF DITCH	8	110	50	720
287	5800924	WELCH & MONSON D	7	25	39	253
288	5800928	WHEELER BROS DITCH	10	117	54	637
289	5800933	WHIPPLE DITCH	12	120	46	758
290	5800939	WINDSOR DITCH	7	85	51	507
291	5800940	WITHER DITCH	15	154	52	858
292	5800943_D [1]	Woodchuck Ditch DivSys	22	371	55	955
293	5800944	WOOLERY DITCH	37	416	47	2954
294	5800945	WOOLEY DITCH	17	268	49	1453
295	5800980	GABIOUD DITCH	5	99	47	726
296	5801021	LEE IRRIGATION D	12	139	40	1156
297	5801035	NORTH SIDE DITCH	6	56	30	655
298	5801074	ROSSI HIGHLINE DITCH	8	103	52	638
299	5801084	ROSSI DITCH 1	6	8	20	243
300	5801085	MILL CREEK DITCH	17	146	56	700
301	5801428	THOMPSON SEEP WASTE D	8	32	9	621
302	5801583 [2]	STAGECOACH HYDROELECTRIC	123	0	0	50579
303	5801869 [3,4]	Fut Morrison Crk 04CW10	999	0	0	0
304	5801919 [2,3]	Fut STEAMBOAT ELK RIVER	999	0	100	0
305	5802374 [2]	STEAMBOAT SKI CORPORATIO	9	0	80	355
306	5804213_A [3]	Stagecoach Aug Plan	999	0	100	0
307	5804630 [7]	Dome_Creek_Ditch	6	0	100	159
308	5804684 [7]	Sarvis Ditch	43	0	100	812
309	5804685_D [1]	Stillwater Ditch DivSys	54	1309	44	5980
310	5804686 [7]	Stillwater to Colorado	17	0	100	1871
311	5805055 [3]	STEAMBOAT MUN WELL A	7	0	60	111
312	5805059_D [3]	Mt Werner Wells G and H	5	0	60	169
313	5805066 [3]	MT WERNER YAMPA DIV	3	0	60	1168
314	58_ADY001	Diversion Aggregate	24	250	44	2440
315	58_ADY002	Diversion Aggregate	47	742	42	4656
316	58_ADY003	Diversion Aggregate	66	1004	50	5467
317	58_ADY004	Diversion Aggregate	38	601	51	3494
318	58_ADY005	Diversion Aggregate	77	1342	52	6156
319	58_ADY006	Diversion Aggregate	48	848	60	3202

#	Model ID#	Name	Cap (cfs)	2010 Area (acres)	Average System Efficiency (percent)	Average Annual Demand (af)
320	58_ADY007	Diversion Aggregate	97	1561	60	5867
321	58_ADY008	Diversion Aggregate	81	1018	49	5426
322	58_AMY001[2]	58_AMY001_AMY001_Yampa@S	999	0	36	1342
323	58_FDP001 [3]	Fu_Dev_58	999	0	23	0
324	9900528 [2,7]	Cheyenne_City	999	0	100	11038
325	9900538 [3]	New_Wyo_Ag	999	0	25	0
326	9900539	WY_First_Mesa_Canal	999	2519	28	15397
327	9900540	WY_Westside_Canal	999	3491	28	23417
328	WYD_001	WY_Divs_blw_Slater_Creek	999	272	38	1132
329	WYD_002	WY_Divs_abv_High_Savery	999	160	38	666
330	WYD_003	WY_Divs_blw_High_Savery	999	313	38	1299
331	WYD_004	WY_Divs_btwn_gages_Svery	999	332	38	1385
332	WYD_005	WY_Divs_lower_SaveryCrk	999	1364	38	5678
333	WYD_006	WY_Divs_blw_SaveryCreek	999	297	38	1237
334	WYD_007	WY_Divs_blw_WillowCreek	999	2288	38	9526
335	WYD_008 [9]	WY_Baggs&Dixon	999	0	74	115
336	WYD_009	WY_Divs_Muddy_Creek	999	538	38	2547
337	WYD_010	WY_Divs_blw_Muddy_Creek	999	306	38	1449
338	WYD_011	WY_Divs_abv_StateLine	999	950	38	4500

[1] Primary structure in a diversion system. For more information, see section 5.4.1.2
[2] Municipal/industrial diversion
[3] Future project or future demand
[4] Transbasin Diversion
[5A] Highland Ditch Multistructure, primary structure is 5700544
[5B] Highland Ditch Multistructure, secondary structure is 5700612
[6A] Walker Irrigation Ditch Multistructure, primary structure is 5700611
[6B] Walker Irrigation Ditch Multistructure, secondary structure is 5702083
[7] Reservoir Feeder or Carrier Ditch
[8A] Buckingham Mandall Multistructure, primary structure is 5800564
[8B] Buckingham Mandall Multistructure, secondary structures are 5800826 and 5800710
[9] No acreage assigned 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 Yampa basin, diversion structures with water rights totaling 5 cfs or more were designated key structures. They are identified by a seven-digit number which is a combination of water district number and structure ID from the State Engineer’s structure and water rights tabulations. Structures in Wyoming were assigned ID’s beginning with “99”, with the following four digits being arbitrary.

The majority of diversion structures in the Yampa basin are for irrigation; Table 5.6 lists the structures that divert to non-irrigation use.

Table 5.6 - Diversions to Non-Irrigation Uses

WDID	Name	Diversion Type
4400522	Craig Station Ditch & Pipeline	Industrial
4400581	Craig Water Supply Pipeline	Municipal
4400695	Maybell Mill Pipeline	Industrial
5700512	Colorado Utilities Ditch and Pipeline	Industrial
5704629	Rich Ditch	Trans-tributary carrier
5800506	Allen Basin Supply Ditch	Trans-tributary reservoir feeder
5800642	Fish Creek Municipal Water Intake	Municipal
5801583	Stagecoach Hydroelectric	Industrial
5802374	Steamboat Ski Snowmaking Pipeline	Industrial
5804630	Dome Creek Ditch	Transbasin diverter
5804684	Sarvis Ditch	Transbasin diverter
5804686	Stillwater Colorado	Transbasin diverter
5805055	Steamboat Muni Well A	Municipal
5805059_D	Mt. Werner Well G and H Diversion System	Municipal
5805066	Mt. Werner Yampa Diversion	Municipal
9900528	Cheyenne_City	Municipal, transbasin diverter
WYD_008	Baggs & Dixon	Municipal

Average historical monthly efficiencies for each irrigation structure appear in the diversion station file; however, when StateMod operates in the "variable efficiency" mode the values are not used during simulation.

For municipal, industrial, and transbasin diverters, StateMod uses the efficiencies in the diversion station file directly during simulation to compute consumption 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, the Steamboat snowmaking diversion is assigned an efficiency of 80 percent, a value accepted in decrees and supported by industry research. Municipal diversions are assigned efficiencies that vary by month, reflecting indoor use in winter and a blend of indoor and outdoor use in the summer. Diversions for cooling water (Craig Station Ditch and Pipeline and Colorado Utilities Ditch and Pipeline) were assigned an efficiency of 100 percent, as there are no returns. This is also the case for the Maybell Mill and pipeline, as confirmed in basin meetings early in the CDSS project. The two carrier ditches, the Allen Basin Supply Ditch and Rich Ditch, are zero percent efficient, meaning their diversions are delivered without loss. All transbasin diversions are modeled as 100 percent efficient because there are no return flows to the basin.

Diversion capacity is stored in Hydrobase for most structures and is generally taken directly from the database. In preparing this file, however, the DMI's determine whether historical records of diversion indicate diversions greater than the database capacity. If so, the diversion capacity is modified to reflect the recorded diversion. Diversion capacities for Wyoming structures were not available, and were therefore set to a high, non-limiting value of 999 cfs.

Return flow parameters in the diversion station file specify the nodes at which return flows will re-enter the stream system, and divide the returns among several locations as appropriate. The locations were determined primarily on a case-by-case basis from topography and from conversations with water commissioners and users. For example, the Rich Ditch (5704629), which takes water from Trout Creek and delivers it to the Oak Creek basin for general use by several diverters, has been assigned a return flow location of Alpha Ditch, on Oak Creek (5800508).

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 gives the return flow locations and percent of return flow to each location, for every diversion structure in the model.
- 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-basins were combined and represented at aggregated nodes. Aggregated irrigation structures in Colorado were given the identifiers "wd_ADYxxx", where "wd" is the Water District number, and "ADY" stands for Aggregated Diversion Yampa; the "xxx" ranged from 001 to 028. Similarly, aggregated municipal and industrial structures were named "WD_AMYxxx" for Aggregated Municipal Yampa. Wyoming aggregated structures are designated 'WYD_xxx."

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

Diversion systems are a group of diversion structures on the same tributary that divert in a similar fashion to satisfy a common demand. Similar to aggregated structures, their demands and water rights are grouped under a single structure. In Table 5.5, they are designated as “WDID _D” where WDID represents the model node designation. Multistructure systems are diversion structures on different tributaries that satisfy a common irrigation demand. Each structure in a multistructure system is included as a model node; the irrigation demand is represented at the “primary” structure in the multistructure system, as indicated in the Table 5.5 footnotes. The model has eighteen diversion systems and three multistructure systems.

Where to find more information

- Section 4.2.2 describes how small irrigation structures were aggregated into larger structures
- Appendix A – Yampa River Aggregated Irrigation Structures describes the aggregation of irrigated lands into aggregate structures, diversion systems, and multistructures.

5.4.1.3 Special Structures

Stillwater Ditch (aka Five Pines Ditch)

Stillwater Ditch is represented with two separate diversion structures, 5804685 and 5804686, because it irrigates lands in the Yampa basin as well as lands within the Colorado basin. Based on diversion coding, 72 percent of the total diversions are assigned to Yampa irrigation node 5804685, locally known as Five Pines Ditch, with return flows accruing within the Yampa basin. Structure 5804686 is represented as a transbasin diversion 100 percent consumptive within the Yampa basin.

Wyoming Historical Diversion Structures

Historical use in Wyoming was represented by fourteen nodes: one for the City of Cheyenne’s diversions from the headwaters of the North Fork of the Little Snake River, ten aggregate irrigation structures, each representing a known amount of irrigated acreage served by several ditches, one diversion representing M&I use of Baggs and Dixon combined, and two explicitly modeled irrigation structures, the Westside Canal and First Mesa Canal. This representation was adopted from the Green River Basin Plan (GRBP) spreadsheet model, which is the source of most of the data in the diversion station file for these structures. Irrigated acreage, monthly efficiency for explicitly modeled irrigation structures, and return flow locations for explicitly modeled structures were taken from the GRBP.

Under the GRBP modeling effort, aggregates diverted only their depletive amounts, and it was assumed that they were perennially water short in July, August, and September. These assumptions had to be made because there were no diversion records for most ditches. Therefore, for the CDSS model, average monthly irrigation efficiencies for District 54 in Colorado were adopted for May, June, and July. August, September, and October efficiencies were set to 55 percent, the maximum efficiency cited in the GRBP.

Monthly efficiencies for the municipal use node were based on average monthly depletions by Baggs and Dixon, which were estimated as part of the Basin Use Profile section of the GRBP. It was stated that Baggs returned 41.8 percent of its municipal diversions on an annual basis, and Dixon returned none of its diversions. The monthly efficiencies assumed in the CDSS model are simply weighted by the depletion amount for each municipality and do not necessarily reflect seasonal, indoor and outdoor use.

Diversion capacities were not available from the GRBP, and were therefore set to a large, non-limiting value of 999 cfs.

Future Use Diversion Structures

Several diversion stations in the network are "placeholders" for modeling the Yampa Management Plan under current and future conditions. Strictly speaking, they are not part of the Baseline data set, and are disabled in this data set. Demands are set to zero or rights are either absent or turned off. The diversion structure that fall into this category, and their potential configurations, are:

- 44_WSA – a nonconsumptive diversion that drives releases from Steamboat Lake and Elkhead Reservoir when the minimum flow requirement per the Yampa Management Plan is not being met.
- 44_FDP001, 55_FDP001, 56_FDP001, 57_FDP001, and 58_FDP001 – future depletions in Water Districts 44, 55, 56, 57, and 58, per the Yampa Valley Water Demand Study (BBC Research & Consulting, 1998), that would be covered by the PBO.
- 57_NPWR01, 57_NMID01, and 57_NAG0 – future power, M&I, and irrigation demands above and beyond the 50,000 af that the PBO covers.
- 9900538 – future irrigation use in the Wyoming portion of the Little Snake basin.

In addition to the future uses mentioned above, future projects and demands were added based on the model used for the Basin Implementation Plan by the Yampa/White Basin Round Table. These demands and structures have are placeholders for simulating future scenarios. The user is responsible for enabling the structures and checking that the results are reasonable.

- 4404325_D – Future oxbow aggregated irrigation demands to be satisfied by releases from proposed Rampart Reservoir.
- 5704204_D – Future energy demand to be satisfied by the Peabody Energy proposed Trout Creek Reservoir.
- 5801869 – Future pipeline on Morrison Creek to carry water to Stagecoach Reservoir.
- 5801919 - Future diversion structure on Elk River to meet increased Steamboat Springs municipal and industrial demand.
- 5804213_A – Future uses for Upper Yampa Water Conservancy District augmentation plan, met by releases from Stagecoach Reservoir.
- 9900538 – Future irrigation demand in Wyoming.

5.4.2 Return Flow Delay Tables (*.dly)

The ym2015.dly file, which is hand-built with a text editor, describes the estimated re-entry of return flows into the river system. Each table gives the percent of the return flow generated by month n's diversion, that reaches the stream in month n, month n+1, month n+2, etc. until extinction of the return. The file contains 10 patterns, some of which are intended for use in other CDSS basins and are not used in the Yampa model.

Irrigation return patterns are based on Glover analysis for generalized characteristics of the alluvium and an assumed distance from the recharge area to the stream. The Glover patterns were then adjusted to reflect incidental loss of return flows. Two irrigation patterns have been used in the Yampa model, one that incorporates 3 percent incidental loss (Pattern 1), and one that incorporates 7 percent incidental loss in the first month and 3 percent incidental loss in the second month (Pattern 10). In all cases, these lag times represent the combined impact of surface and subsurface returns. Pattern 1 is used predominantly in the Yampa model; Pattern 10 is used only in the Little Snake River basin below Baggs.

Pattern 4 represents immediate returns, as for municipal and industrial uses. Pattern 5 is applicable to snowmaking diversions. The return patterns used in the Yampa model are shown below in Table 5.7.

Table 5.7 - Percent of Return Flow Entering Stream in Months Following Diversion

Month n	Pattern 1	Pattern 4	Pattern 5	Pattern 10
1	75.6	100	0	71.6
2	11.3	0	0	8.3
3	3.2	0	0	3.2
4	2.2	0	0	2.2
5	1.6	0	100	1.6
6	1.2	0	0	1.2
7	0.8	0	0	0.8
8	0.6	0	0	0.6
9	0.5	0	0	0.5
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
Total	97	100	100	90
Note: month 1 is the same month as the diversion				

Where to find more information

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

5.4.3 Historical Diversion File (*.ddh)

The historical diversion file contains time series of diversions for each structure. The file is created by **StateDMI**, which reads historical diversions from Hydrobase and fills missing records as described in Section 4.4.2. The file is used for baseflow estimations at stream gage locations; developing headgate demand time series for the diversion demand file; developing average efficiency values for the diversion station file, and for comparison output that is useful during calibration.

5.4.3.1 Key Structures

For most explicitly modeled irrigation and M&I structures, **StateDMI** accesses the HydrBase for historical diversion records. For certain structures, the data was assembled from other sources and placed into an ".stm file" which **StateDMI** can be directed to read. These cases are described below under "Special Structures".

5.4.3.2 Aggregate Structures

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

Four nodes in the model represent the combined small diversions for municipal, industrial, and livestock use in four 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 historical diversions are equivalent to estimated consumptive use. Total non-irrigation consumptive use in the Yampa basin was estimated relatively early in CDSS development, as documented in the memorandum "Consumptive Use Model Non-Irrigation Consumptive Uses and Losses in the Yampa River Basin." Consumptive use of the key municipal and industrial 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 44, 55, 57, and 58 in accordance with a general distribution of M&I use identified by BBC Research in their 1998 "Yampa Valley Water Demand Study." The use is the same each year of the study.

5.4.3.3 Special Structures

Historical diversion records in HydroBase for Hayden Station (COLO UTILITES P & DL 5700512) were determined to be incorrect from 2000 through 2010. Based on discussed with Xcel Energy, the HydroBase records were replaced with monthly averages.

Stillwater Ditch (aka Five Pines Ditch)

Diversion time series for the two nodes representing the Stillwater Ditch were created outside **StateDMI** by splitting the database diversions; 72 percent of historical diversions were assigned to the Yampa basin node, and 28 percent were assigned to the Colorado basin node. The split is based on irrigated acreage on either side of the drainage divide.

Wyoming Historical Diversion Structures

Diversion time series for Cheyenne (9900528), First Mesa Canal (9900539), and Westside Canal (9900540) were obtained via the GRBP. The GRBP model study period was 1971 through1998, and the data was limited to this period or less. Cheyenne diversions were available for the entire 28 years. The irrigation diversions were available for 1983 through 1998 only. Years from 1971 through 1998 were classified in the GRBP study as being Normal, Wet, or Dry, and an annual cycle of diversions representing each of those conditions had been developed. Thus years prior to 1971 and after 1998 were filled with the Normal, Wet, or Dry diversions as appropriate. Additional data was found in the Little Snake Supplemental Supply Project report and on the Wyoming State Engineer's Office website (http://seoflow.wyo.gov/).

Historical diversions for Wyoming aggregate structures (WYD_001 through WYD_011) were estimated by dividing the irrigation water requirement for the month by an assumed monthly efficiency, and adjusting for the number of irrigation days in August and September. Irrigation water requirement had been estimated in the GRBP model for

Normal, Wet, and Dry years for these structures. Historical efficiency was difficult to estimate given the lack of diversion records. The GRBP spreadsheets circumvented the data limitation by modeling only the consumptive depletion. According to the GRBP, First Mesa Canal and Westside Canal – the only structures with good diversion records and reliable estimates of irrigated acreage – were not representative of the water-short conditions that most ditches face. It indicated that most Little Snake River ditches are water short in late summer, and typically divert for only 6 days in August and 5 days in September. Given this information, monthly efficiencies for April, May, and June were based on average efficiencies for irrigation structures in Colorado's District 54. This approach had been adopted in earlier versions of the Yampa model, before the GRBP information was available. Efficiencies for July, August, and September were set to 0.55, the efficiency used for water short conditions in the GRBP. August and September diversions were then multiplied by 6/31 and 5/30, respectively, to reflect the estimated number of irrigation days.

The GRBP provided estimated average monthly net depletions for Baggs and Dixon, and efficiency on an annual basis. Historical diversions were created for the Yampa model by dividing the monthly depletion amount for each municipality by its respective annual efficiency, then summing those values for the month. The twelve monthly diversions are the same in each year. While these estimates are very approximate, they preserve the annual diversion amount, and are detailed enough given the small magnitude of these diversions.

Historical diversions for all Wyoming structures prior to 1971 and after 1998 were filled using the methods described in Section 4.4.1.

Future Use Diversion Structures

All future use structures have historical diversions set to zero because they did not divert during the historical model period.

5.4.4 Direct Diversion Demand File (*.ddm)

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. In the Yampa model, it is set to the larger of 1) an estimated requirement for the month, and 2) the historical diversion for the month. During times when the diversion was shorted historically, the estimated requirement controls and represents what the structure would divert in order to get a full water supply. During times when the structure diverted a lot of water and operated at lower than average efficiency, the historical diversion controls. The demand represents the amount that would have been diverted given an available supply. In particular, the historical practice of using irrigation ditches to water livestock in winter, when crop requirement amounts to nothing, can be simulated when demand is approached in this way. Table 5.5 lists average annual demand for each diversion structure.

5.4.4.1 Key Structures

The estimated irrigation demand for each structure was computed as crop irrigation water requirement for each month divided by the structure's average historical efficiency for the same month. 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 system efficiency is the average efficiency over the period 1950 through 2013, as calculated by StateCU, but capped at 0.54.

The requirements for municipal and industrial diversions were estimated using recent values or averages of recent records, as recommended by the Hydrology Subcommittee of the Yampa Management Plan effort. Transbasin diversion requirements were estimated as average monthly diversions over the period 1989-2014.

Regardless of use type, the demand was then set to whichever was larger in any given month, the estimated requirement, or the historical diversion.

5.4.4.2 Aggregate Structures

Aggregated irrigation structure demand is computed as for key irrigation structures. The only difference for Colorado structures 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 system efficiency is based on efficiency of the aggregation in total. 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 set to zero, 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** creates the diversion right file, based on the structure list in the diversion station file.

The information in this file is used during simulation to allocate water in the right sequence or priority and to limit the allocation by decreed amount. The file is also an input to **StateDMI** when it is filling historical diversion time series (the *.ddh file). Based on the appropriation dates expressed in the administration number in the rights file, **StateDMI** determines the total amount of the water right during the time of the missing data, and constrains the diversion estimate accordingly. For example, suppose a ditch has two decrees, one for 2.5 cfs with an appropriation date of 1896, and the other for 6 cfs with an appropriation date of 1932. When

StateDMI estimates diversions prior to 1932, it limits them to a constant rate of 2.5 cfs for the month, regardless of the average from available diversion records. This approach was adopted so that water development over the study period could be simulated.

5.4.5.1 Key Structures

Water rights for explicitly modeled structures were taken from the HydroBase and match the State Engineer's official water rights tabulation. In addition, many structures are assigned a "free water right", with an extremely junior administration number of 99996.99999 and a decreed amount of 999.0 cfs. These allow diverters to operate under free river conditions, provided their demand is unsatisfied and water is legally available.

5.4.5.2 Aggregate Structures

Aggregated irrigation structures and diversion systems were assigned all the water rights belonging to their constituent structures. Aggregated M&I water rights were assigned an amount equal to their depletion and assigned an administration number of 1.00000.

For multistructure systems, the secondary structures retain their water rights and the common demand is met using operating rules.

5.4.5.3 Special Diversion Rights

Stillwater Ditch (aka Five Pines Ditch)

Water rights for the Stillwater Ditch were divided between the two structures representing the ditch, in accordance with the amount of irrigated acreage under each.

Wyoming Historical Diversion Structures

Wyoming rights located on tributaries of the Little Snake River, or on the Little Snake River above Slater Creek, were assigned an administration number of 90000.00000. This junior right assures the Wyoming diversions will not call out the upstream Colorado diversions in District 54.

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 structure with regard to having an impact on the river.

Three of the future use diversions do not have water rights because their demands will be satisfied by releases from reservoirs, not direct diversion rights: 44044325_D, 5704204_D, and 5804213_A.

5.5 Irrigation Files

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

5.5.1 StateCU Structure File (*.str)

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

5.5.2 Irrigation Parameter Yearly File (*.ipy)

This file is created by **StateDMI**, and contains maximum system efficiency and irrigated acreage for each irrigation structure and each year of the study period. In the Yampa model, maximum system efficiency has been assumed to be constant over the study period, at 54 percent for all structures. Irrigated acreage is based on 2010 irrigated acreage inventory. Although this is an annual time-series file, StateMod will not simulate the Yampa datasets if the irrigation parameter yearly file header is not changed from CYR to WYR. This change has to be done by hand in a text editor.

5.5.3 Irrigation Water Requirement File (*.iwr)

This file contains the time series of monthly irrigation water requirements for structures whose efficiency varies through the simulation. Irrigation water requirements for Colorado structures are generated by StateCU for the period 1950 through 2013, then filled by **StateDMI**. StateCU was executed using the Blaney-Criddle monthly evapotranspiration option, with elevation adjustment for fields lower than 6,500 feet in elevation, and high altitude crop coefficients for pasture grass above 6,500 feet in elevation. Irrigation water requirement for Wyoming structures was obtained from the GRBP, which produced Normal, Wet, and Dry year designations for 1971 through 1998. It also estimated irrigation water requirement by month in each of those types of years. From this information, a time series of irrigation water requirement was developed for each structure for 1971-1998, and **StateDMI** filled the remaining years.

Where to find more information

- Historical Crop Consumptive Use Analysis: Yampa River Basin 2015 provides details on the consumptive use analysis and associated input files.

5.6 Reservoir files

5.6.1 Reservoir Station File (*.res)

This file describes physical properties and some administrative characteristics of each reservoir in the Yampa River model. It is created by **StateDMI**, using a considerable amount of information provided in the command file. Ten key reservoirs including High Savery in Wyoming were modeled explicitly. Three aggregated reservoirs and three aggregated stock ponds in Colorado and three aggregated or minor reservoirs in Wyoming account for evaporation from numerous small storage facilities. In addition, several specific future reservoirs and two generalized future reservoir have been placed in the model network. They do not actually function in the baseline model. The modeled reservoirs are listed below in **Error! Reference source not found.** with their capacity and their number of accounts or pools:

Table 5.8 - Active Reservoirs

ID #	Name	Capacity (af)	# of Accounts
4403902	ELKHEAD RESERVOIR	24778	5
5803500	ALLEN BASIN RESERVOIR	2250	1
5803508	FISH CREEK RESERVOIR	4268	1
5803521	LESTER CK RESERVOIR	5657	1
5803540	STILLWATER RES 1	6392	8
5803631	LAKE CATAMOUNT	7422	1
5803787	STEAMBOAT_LAKE	26364	3
5804213	STAGECOACH_RESERVOIR	36439	8
5804240	YAMCOLO RESERVOIR	9621	6
44_ARY001	44_ARY001_YampaRbelCraig	23206	1
44_ARY002	44_ARY002_Yampa@Deerlodg	9122	1
44_ASY001	44_ASY001_YampaRbelCraig	8344	1
44_ASY002	44_ASY002_YampaR@Deerlod	4441	1
55_ARY003	55_ARY003_LSnakeRnrLily	1494	1
55_ASY003	55_ASY003_LSnakeRnrLily	3173	1
9903000	993000_Wyo_above (Baggs)	860	1
9903001	993001_Wyo_below (Baggs)	390	1
9903002	High Savery Reservoir	22433	1
9903004	993004_LS_Small_Resvrs	290	1

Future reservoirs are included in the model network, but not actively modeled. Table 5.9 below shows the ID used in the model and the reservoir site name. Volumes and accounts are not included. That is left to the discretion of the user. The majority of the future reservoirs were identified and investigated by the Yampa/White/Green Basin Roundtable as part of the Basin Implementation Plan (BIP). Suggested operations are included at the bottom of the ym2015B.opr file, but are inactive. It is the responsibility of the user to activate the reservoirs and verify the operations are working as intended. For more details, please refer to the BIP report (YWBRT 2015)

Table 5.9 - Future Reservoir Sites

ID #	Name
4404323	Milk Creek Reservoir Site
4404325	Rampart Reservoir Site
44_LBear1	Little Bear 1 Reservoir Site
44_MonButte	Monument Butte Reservoir Site
44_SFrk2	South Fork 2 Reservoir Site
5404208	Pothook Reservoir Site
5704204	Trout Creek Reservoir Site aka Energy Fuels Reservoir 2
5803913	Morrison Creek Reservoir Site
9903003	Wyoming Diked Wetlands
9903005	Wyoming Aggregated Future Storage
9903007	Upper Willow Creek Reservoir Site, Wyoming

5.6.1.1 Key Reservoirs

Parameters related to the physical attributes of key reservoirs include inactive storage where applicable, total active storage, area-capacity data, applicable climate stations, and initial contents. For the explicitly modeled Colorado reservoirs, storage and area-capacity information were obtained from either the Division Engineer or the reservoir owners. High Savery Reservoir parameters were collected from the Wyoming Water Development Commission and the Little Snake River Supplemental Storage Project model. Initial contents for all reservoirs are set to full in the Baseline data set.

Administrative information includes reservoir account ownership, administrative fill date, and evaporation charge specifications. This information was obtained from interviews with the Division engineer, the assistant Division engineer, the local water commissioners, and in most cases the owner/operator of the subject reservoirs. Annual administration is turned off at all reservoirs in the Yampa River model, as inferred from historical records of filling and contents.

5.6.1.2 Aggregate Reservoirs

For Colorado's aggregated reservoirs, amount of storage was based on storage decrees and Task Memo 2.09-12, "Consumptive Use Model Non-Irrigation Consumptive Use and Losses in the Yampa River Basin" (see Appendix B). Surface area for the reservoirs was developed assuming they are straight-sided pits with a depth of 25 feet.. For Colorado's aggregated stock ponds, surface area was developed assuming they are straight-sided pits with a depth of 10 feet. Initial contents were set to full. Data for Wyoming's aggregated reservoirs was provided with input from the Wyoming State Engineer's Office (see Appendix C).

5.6.1.3 Reservoir Accounts

Stillwater Reservoir

Stillwater Reservoir No. 1 (WDID 5803540) is the most upstream of the major reservoirs in the Yampa River (Bear River) drainage. It is owned by the Bear River Reservoir Co. and provides supplemental irrigation water supplies to several of the major direct flow structures in the upper Bear River. Although its decreed capacity is 6,392, the reservoir company and the water commissioner consider the active storage to be approximately 5,175 acre-feet.

Using reservoir and ditch ownership data provided by the water commissioner, the individually owned storage accounts in Stillwater Reservoir No. 1 were grouped according to the ditch structures that serve the irrigated land owned by those individuals. The active storage in the reservoir is represented in the model with seven accounts:

Account	Account Description	Structure ID	Storage Amount (ac-ft)
1	Big Mesa Ditch	5800539	444
2	Coal Creek Ditch	5800589	435
3	Lindsey Ditch	5800738	394
4	Mandall Ditch	5800763	386
5	Stillwater Ditch		
	Colorado Basin	5804686	979
	Yampa Basin	5804685	1,352
6	Aggregated Pool[1]		1,185
7	Unallocated Pool		1,217
		TOTAL	6,392

[1] Acton Ditch, Bird Ditch, Buckingham Mandall, Fix Ditch, Hernage & Kolbe, Mill Creek No. 1, Pennsylvania Ditch, Town of Yampa, Others Not in Model

Yamcolo Reservoir

Yamcolo Reservoir (WDID 5804240) is owned and operated by the Upper Yampa Water Conservancy District (UYWCD). UYWCD has allocated the active storage in Yamcolo Reservoir as follows: 1,010 acre-feet for municipal uses; 3,000 acre-feet to the Yamcolo Irrigators Association for irrigation in the upper reaches of the Bear River and 4,000 acre-feet to Tri-State Electric Association or industrial uses. The reservoir was enlarged to provide an additional 525 acre-feet of storage. This water is available for purchase each year. The dead storage of approximately 1,086 acre-feet is reserved for a conservation pool.

Ownership of the 1,010 acre-feet of municipal water comprises small holdings by the Towns of Hayden, Steamboat Springs, Phippsburg, and Yampa, as well as Morrison Creek Water & Sanitation District (WSD) and Mt. Werner WSD. With the exceptions of Steamboat Springs and Mt. Werner WSD, these entities are not modeled explicitly. Accordingly, a single aggregated M&I account has been modeled in Yamcolo Reservoir. It can be accessed for the other owners' uses if these demands are eventually incorporated into the model.

The Yamcolo Irrigators Association currently consists of about 18 individuals who irrigate land under several of the major ditch structures in the upper Bear River. When the Yampa model was first developed, separate pools were modeled for each owner, based on reservoir account and land ownership data provided by the water commissioner. Diversion records in Hydrobase, however, are not reflective of the account ownership; for example, Lindsey Ditch (5800738) was reported to have the second largest account (550 af) but its average delivery was 66 af. Big Mesa Ditch was reported to have a 500-af pool, but showed average deliveries of 795 af, and a maximum of 1807 af in one year. To reflect the flexibility with which the owners can apparently operate, the 3,000-af irrigation pool is now represented by one pool.

Pursuant to a 1992 agreement between UYWCD and Tri-State, Tri-State's 4,000 acre-foot account in Yamcolo Reservoir was effectively moved to Stagecoach Reservoir, and Stagecoach Reservoir agricultural lease water was moved up to Yamcolo Reservoir. Currently the 4,000 acre-feet of "Stagecoach Contract Water", deliverable by exchange through Yamcolo Reservoir, has been contracted primarily to Stillwater Ditch. The pool is represented in the model by one account.

The accounts modeled in Yamcolo Reservoir are:

Account	Account Description	Storage Amount (ac-ft)
1	Conservation Pool	1,086
2	Municipal and Industrial Users[2]	1,010
3	Yamcolo Irrigators Association[1]	3,000
4	Stagecoach Contract Irrigators[1]	4,000
5	New storage from dam raise	525
6	Bookover Accounting[3]	9,621
	TOTAL	9,621

[1] Acton , Big Mesa, Bird, Bijou, Buckingham Mandall, Coal Creek, Egeria, Ferguson, Fix, Hernage & Kolbe, Lindsey, Mandall, Mill Creek No. 1, Moody, Pennsylvania, Stillwater, and Wooley Ditches are included explicitly in the model
[2] Fish Creek Municipal Water Intake, operated by exchange.
[3] Bookover account not included in the TOTAL

Allen Basin Reservoir

Allen Basin Reservoir (WDID 5803500) is a small irrigation reservoir located near the headwaters of Middle Hunt Creek. Although it is smaller than the minimum reservoir capacity (4,000 acre-feet) recommended for inclusion of reservoirs in the Yampa Model, it is being included because it plays a significant role in the irrigation water supply in this supply-limited area of the Yampa River basin. The reservoir has a decreed capacity of 2,250 acre-feet which is also reported to be its active capacity. The reservoir stores water from Middle Hunt Creek as well as water imported from tributaries of South Hunt Creek, via the Allen Basin Supply Ditch (WDID 5800506).

Allen Basin Reservoir provides supplemental irrigation supplies to several direct flow ditch structures in the Hunt Creek drainage. Because they are all relatively small, a single aggregated account of 2,250 acre-feet was modeled in Allen Basin Reservoir.

Stagecoach Reservoir

Stagecoach Reservoir, the largest storage facility in the Yampa River basin, is owned and operated by UYWCD. The reservoir provides supplemental industrial, agricultural, and municipal water supplies as well as a significant conservation pool for recreational purposes.

The UYWCD originally allocated a total of 15,000 acre-feet of storage water in Stagecoach Reservoir for sale annually as follows: Municipal Users - 2,000 acre-feet; Industrial Users (Tri- State) - 9,000 acre-feet; and Agricultural Users - 4,000 acre-feet. Pursuant to two 1992 Agreements between the UYWCD and Tri-State, the parties agreed to exchange the 4,000 acre-feet of water that Tri-State is entitled to in Yamcolo Reservoir to a Tri-State account in Stagecoach and similarly exchange the 4,000 acre-feet of Agricultural water in Stagecoach upstream to storage in Yamcolo Reservoir. Pursuant to these agreements, Tri-State also reduced its original industrial allocation from 9,000 acre-feet to 7,000 acre-feet. Additional discussions with UYWCD refined the model to include the following accounts:

Account	Account Description	Storage Amount (ac-ft)
1	Tri-State Power Generation and Transmission[1]	7,000
2	Municipal and Industrial Users[2]	2,000
3	Emergency Remainder (Recreation)[3]	15,000
4	Preferred Remainder[4]	3,275
5	Augmentation Pool[5]	2,000
6	Exchange Pool[6]	4,000
7	New storage from dam raise[4]	3,184
8	Used for Accounting[7]	36,460
TOTAL		36,439

[1] Craig Power Plant (4400522)
[2] 57_AMY001, 5805066, 5800642
[3] 5804213_F2
[4] No users assigned in the baseline model
[5] 5800850, 5800922, 5800612, 58_ADY005
[6] 5802164, 5800897, 5800561, 5800756, 5800628, 58_ADY005
[7] Bookover account not included in TOTAL

Note that Stagecoach does not actively release to meet hydropower demand. Hydropower is produced as an incidental benefit when water is released for downstream users.

Stagecoach accounts are filled using a bookover operation. All of the water diverted by the reservoir water rights fill the bookover account. Next, the bookover account fills the reservoir accounts in this order:

1. Tri-state
2. Muni-pool
3. Aug-pool
4. Exch-pool
5. Raise
6. PrefRem
7. EmergRem

This operation mimics the way that UYWCD accounts for the water entering into Stagecoach reservoir and ensures that Tri-State water is the most protected.

Lake Catamount

Lake Catamount Reservoir (WDID 5803631) is located on the main stem of the Yampa River, between Stagecoach Dam and Steamboat Springs. The reservoir is used primarily for recreation for the planned residential and ski development near the lake. It is modeled simply as having a single 7,422 acre-feet conservation pool account.

Fish Creek Reservoir

Fish Creek Reservoir (WDID 5803508) is owned by the city of Steamboat Springs and used as reserve raw water storage for the city and for the Mt. Werner WSD. It was enlarged from a capacity of 1,842 acre-feet to 4,042 acre-feet in 1996. It is modeled simply as having one 4,042-af pool serving the combined demand of Steamboat Springs and Mt. Werner WSD.

Steamboat Lake

Steamboat Lake (WDID 5803787) is located on Willow Creek, a tributary of the Elk River. Owned and operated by the Colorado Division of Parks and Wildlife (CPW), it is used for recreational and industrial purposes. Construction costs for the dam and reservoir were partially paid for by the Salt River Generating Co. and Colorado-Ute Electric Association (the partners in the operation of the Hayden Station power plant) in return for a perpetual right to withdraw 5,000 acre-feet of water per year from the reservoir. This water is the supplemental water supply for the operation of the Hayden Station.

Historically, CPW has been allowed to store water above the normal spillway elevation, encroaching upon the flood surcharge capacity of the reservoir. This arrangement has been made permanent with the installation of spillway gates and acquisition of an additional water right to store in the additional capacity (approximately 3,300 acre-feet). Of this enlargement, CPW has contracted to lease up to 125 acre-feet per year to the Cyprus Empire Corp. for use in an augmentation plan. The remainder of CPW's interest in the Steamboat Lake water rights are for recreational and conservation pool purposes at the reservoir itself. Future operations include investigation of releases for instream flow purposes. Therefore, Steamboat Lake is modeled as having three accounts, the Hayden Station's 5,000 acre-feet, CPWs 18,209 acre-feet, and an instream flow account for 3,155 acre-feet. The CPW conservation account includes the 125 acre-feet leased by Cyprus Empire, whose augmentation is not explicitly represented in the Yampa Model.

Account	Structure ID	Storage Amount (ac-ft)
Hayden Station	5700512	5,000
Conservation Pool		18,209
ISF Pool		3,155
TOTAL		26,364

Lester Creek Reservoir (Pearl Lake)

Lester Creek Reservoir (WDID 5803521) is owned and operated by CPW and used exclusively for recreation and fishery purposes. The reservoir is included in the Yampa Model primarily to account for the consumptive evaporation losses from the reservoir. It has a single 5,657 acre-feet conservation pool in the Yampa River model.

Elkhead Reservoir

Elkhead Creek Reservoir (WDID 4403902) is located on Elkhead Creek, a tributary of the Yampa River just upstream of the city of Craig. The reservoir was originally constructed by the Colorado Division of Parks and Wildlife (CPW) and the Yampa Project Participants (the operating consortium for the Craig Station power plant) for recreational and industrial purposes. The Yampa Participants funded a portion of the construction in return for full use of the active storage capacity in the reservoir above elevation 6340.5, while CPW retained use of the storage capacity below this elevation.

In 1990, the city of Craig acquired all of the CPW's interests in the reservoir, subject to a contractual commitment to not encroach upon the dead storage, which is reserved as a conservation pool for the benefit of the CPW. In 1991, the reservoir was emptied to the approximate dead storage level for maintenance, and re-surveyed. From this new survey data, the city has estimated that the active capacity above the outlet works invert is about 10,422 acre-feet. Of this storage, the Yampa Participants' entitlement is estimated to be about 8,754 acre-feet and the city's entitlement about 1,668 acre-feet. In 2006, the Colorado River Water Conservation District enlarged Elkhead Reservoir to a total volume of 24,778 acre-feet. During construction, the reservoir was again surveyed, this time with the result that the volume below elevation 6,340.5 feet was 4,413 acre-feet; the pre-enlargement capacity above 6,340.5 feet was 8,408 acre-feet, and the enlargement volume was 11,957 acre-feet. Of the enlargement pool, 5,000 acre-feet was deeded to the Colorado Water Conservation Board for the purpose of maintaining base flow through critical habitat reach in the lower Yampa, on behalf of the Upper Colorado River Basin Endangered Fish Recovery Program. A conservation pool accounts for 878 acre-feet of dead storage. Accordingly, the reservoir is modeled with five accounts:

Account	Structure ID	Storage Amount (ac-ft)
Yampa Participants	5800522	8,408
City of Craig	5800581	4,413
CWCB	4402500	5,000
CRWCD	N/A	6,957
Conservation	N/A	878
	TOTAL	25,656

Wyoming Reservoirs

The model includes eight reservoir structures in Wyoming. The largest, High Savery Reservoir (9903002), began operating in 2006. It is modeled as having 22,433 acre-feet of active capacity, represented with one account. There are three structures representing aggregated small reservoirs in Wyoming. The first represents irrigation storage supply above Baggs (9903000), the second represents irrigation storage supply below Baggs (9903001), and the third represents stockponds (9903004). All of the aggregated reservoirs are less than 1,500 acre-feet in size. The State of Wyoming provided physical information for the small Wyoming reservoirs in a technical memorandum titled "Green River Basin Plan Wyoming Depletions in the Little Snake River Basin", dated August, 2000 (see Appendix C). Information for High Savery Reservoir was provided by Wyoming Water Development Commission staff.

The future reservoirs represented in StateMod for Wyoming are placeholders. Diked wetlands on Muddy Creek (9903003), Wyoming Aggregated Future Storage (9903005), and Upper Willow Creek Reservoir Site (9903007) are inactive. The user is responsible for turning the reservoirs on and ensuring that they are operating as intended.

5.6.2 Net Evaporation File (*.eva)

The evaporation file contains monthly average evaporation data (12 values that are applied in every year). The annual net reservoir evaporation was estimated by subtracting the weighted average effective monthly precipitation from the estimated gross monthly free water surface evaporation. Annual estimates of gross free water surface evaporation were taken from the National Oceanic and Atmospheric Administration (NOAA) Technical Report NWS 33. The annual estimates of evaporation were distributed to monthly values based on elevation through the distributions listed in Table 5.10. These monthly distributions are used by the State Engineer's Office.

Table 5.10 - Monthly Distribution of Evaporation as a Function of Elevation (percent)

Month	Greater than 6,500 ft	Less than 6,500 ft
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

Precipitation stations at Steamboat Springs and Yampa, Colorado, were used in the calculation of annual net reservoir evaporation for the Yampa basin. The resulting net monthly free water surface evaporation estimates for the Yampa River basin are shown below:

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
.13	-.01	-.11	-.12	-.03	.06	.15	.28	.40	.39	.29	.25

5.6.3 EOM 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 during calibration. The file is created by **TSTool**, which reads data from Hydrobase and can fill it under a variety of user-specified algorithms.

5.6.3.1 Key Reservoirs

Data for the larger reservoirs (Yamcolo, Stagecoach, and Elkhead Reservoirs, and Steamboat Lake) was provided by Division 6, collected directly from the reservoir operator, or generated by converting sporadic daily observations from Hydrobase to month-end data. The user-specified tolerance for defining the end of the month was set to 16 days. Generally, other reservoirs' contents were from monthly tables HydroBase, and filled by **TSTool**, given a pattern file containing the hydrologic condition for each month of the study period. Missing end-of-month contents were filled with the average of available content values for months with the same hydrologic condition. Table 5.11presents the on-line date for each reservoir. Historical contents in the *.eom file for the respective reservoirs are zero prior to these dates

Table 5.11 - Reservoir On-line Dates

Reservoir	On-Line Date	Enlargement Date
Allen Basin	1909	-
Stillwater	1939	-
Fish Creek	1956	1996
Steamboat Lake	1965	2008
Lester Creek	1975	-
Elkhead	1975	2006
Lake Catamount	1978	-
Yamcolo	1980	1998
Stagecoach	1988	2009
High Savery	2003	-

5.6.3.2 Aggregate Reservoirs

Aggregated reservoirs, in both Colorado and Wyoming, were assigned initial contents equal to their capacity, because there is no actual data. Aggregated reservoirs were modeled as though in operation throughout the study period.

5.6.4 Reservoir Target File (*.tar)

The reservoir target file contains minimum and maximum target storage limits for 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 are set to zero and maximum targets are set to capacity for all reservoirs, except for Lake Catamount. These targets allow maximum control of reservoir levels by storage rights and releases to meet demands.

Stillwater Reservoir uses maximum targets that help replicate winter-time releases. The operators pull the reservoir level down during the late fall and early winter. It is held at this lower level until the spring runoff. To do this, the September end-of-month target is set to 3,000 acre-feet and the August target uses the "forecast" target feature to start releasing water as necessary. The May end-of-month target is set to 6,000 acre-feet, which is the target fill that the operators try to achieve.

Lake Catamount uses maximum targets that help replicate seasonal operations apparent in the historical record, since no demands on the reservoir are currently included in the model. To do this, the October target is set to 5,200 af, about 2,200 af below the maximum capacity. StateMod's "forecast" target feature is used to control filling from November through March. During these months, the target is computed dynamically each month, based on the simulated end-of-month contents, the March target, and the number of months remaining in which to achieve the March target. The calculation assumes that the reservoir will be filled by the same amount in each month remaining in the forecast period.

Future reservoirs from the BIP are set with a maximum target of zero. They do not store water.

5.6.5 Reservoir Right File (*.rer)

The reservoir right file contains the water rights associated with each reservoir in the reservoir station file. Specifically, the parameters for each storage right include the reservoir, administration number, decreed amount, the account(s) to which exercise of the right accrues, and whether the right is used as a first or second fill.

5.6.5.1 Key Reservoirs

In general, water rights for explicitly modeled reservoirs were taken from HydroBase and correspond to the State Engineer's official water rights tabulation. The water right for High Savery Reservoir was adopted from the Little Snake model developed for the Little Snake River Supplemental Storage project.

5.6.5.2 Aggregate Reservoirs

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

5.6.5.3 Special Reservoir Rights

Yamcolo Reservoir

Yamcolo Reservoir has four absolute storage rights totaling 8,971 acre-feet. Additionally, an APEX water right of 2,500 acre-feet is not pulled from Hydrobase, but is set manually in the .rer file. All five water rights are first stored in the bookover account. This account is strictly used for accounting purposes. After a water right is added to the bookover account, the operating rules distribute the water from the bookover account to the other accounts in the following order:

1. Conservation – this is filled first because it represents the dead storage at the bottom of the reservoir and it will physically be filled before any of the other pools can be credited with water.
2. Municipal and Industrial users
3. Yamcolo Irrigators Assocation
4. Stagecoach Contract Irrigators (the exchange pool)
5. Raise

Stagecoach Reservoir

Stagecoach Reservoir is modeled as having eight storage rights. The most senior five rights are small senior transferred rights that were associated with the ditches inundated by the reservoir. The next right in terms of priority is the first large storage right for 11,614 acre-feet, which was part of the former Wessels Project. The storage right has the same priority as the Wessels Canal direct flow right, which is owned in part by Tri-State, for diversion at the Craig Station. Pursuant to a 1992 agreement between UYWCD and Tri-State, the UYWCD's storage decree is subordinated to the priority of Tri-State's Wessels Canal flow right, to the extent that there is insufficient flow for both.

The right for 20,854 acre feet is part of a conditional decree for 40,720 acre-feet, transferred from the former Pleasant Valley Reservoir site where Lake Catamount is now located. In 1994, UYWCD made 20,854 acre-feet of this conditional water right absolute at Stagecoach Reservoir.

The most junior right for 6,670 acre-feet is a refill right.

StateMod does not currently model several rights senior to the Wessels right, which were decreed originally to the Four Counties Project. UYWCD successfully sought to make Stagecoach an alternate point for the rights, which are specified as flow rates rather than storage volumes. The Four Counties rights that have been made absolute now total 151 cfs. UYWCD must inform the Division Office each year if they intend to account for use of the rights in the coming accounting year, and storage is subject to water availability at the original point of diversion. Because the rights are used irregularly, and there is has not been historical calls on the river at Stagecoach Reservoir, this feature of Stagecoach Reservoir was not included in the model.

All eight of the rights are first stored in the bookover account. This account is strictly used for accounting purposes. After a water right is added to the bookover account, the operating rules distribute the water from the bookover account to the other accounts in the following order:

1. Tri-State
2. Municipal and Industrial users
3. Augmentation
4. Exchange pool
5. Raise
6. Preferred Remainder
7. Emergency Remainder

Steamboat Lake

All of the water rights are used to fill accounts 1 and 2 (Hayden Station and Conservation Pool) on a pro-rated basis, except for 3,155 acre-feet of the original water right, which is used to fill account 3 (Instream Flow). As part of a change case, the ability to release water to meet downstream instream flow demand was added to the decreed uses of the water right, but limited to 3,155 acre-feet and the priority date as set as 1995, which is more junior that the original right.

Elkhead Creek Reservoir

Seven storage rights are used to model Elkhead Reservoir storage. Original owners of the reservoir, CPW and the power consortium known as the Yampa Participants, each had rights relating to their own pools. A right for 5,389 acre-feet was deeded by CPW to the City of Craig, and is used to fill the City's account. The Yampa Participants right for 8,310 acre-feet is used to fill the Participants' pool. Two rights with administration number 41126.00000, which is senior to the original Elkhead Reservoir rights, represent the portions of conditional rights for California Park Reservoir that were transferred to the two owners. The City of Craig's right for 4,945 acre-feet can be used as a first fill right. The Yampa Participants right for 8,754 acre-feet may only be used to refill their account. The last three rights are a disaggregation of the enlargement right of 13,000 acre-feet that was sought by the Colorado River Water Conservation District. Of this right, 5,000 acre-feet is assigned to the CWCB pool for endangered fish pool, 7,000 acre-feet is assigned to the River District's unallocated pool, and 1,000 acre-feet can be used to refill the enlargement, as allowed by the decree.

Basin Implementation Plan Reservoirs

Basin Implementation Plan reservoirs are assigned either their conditional water rights or hypothetical water rights. These future reservoirs are are not active in the Baseline data set.

5.7 Instream Flow Files

5.7.1 Instream Station File (*.ifs)

Twenty-eight instream flow stations are defined in this file, which is created by **StateDMI**. The file specifies an instream flow station and downstream terminus node (if applicable) for each reach, through which instream flow rights can exert a demand in priority. Table 5.12 lists each instream flow station included in the Yampa Model along with their location and average annual demand. In general, these rights represent decrees acquired by CWCB. The exceptions are footnoted.

5.7.2 Instream Demand File (*.ifa)

For CWCB instream flow reaches, instream flow demands were developed from decreed amounts and comments in the state engineer's water rights tabulation. The same twelve monthly instream flow demands are used for each year of the simulation. For instream flow structures representing other operations, the demand is set manually in the .ifa command file.

The Steamboat Springs Boating Recreational In-Channel Diversion is represented using an instream flow node (5802591). The decree is for a variable flow rate starting at 400 cfs April 15-April 20, ramping up to peak at 1,400 cfs from June 1 – 15, and ramping down to 95 cfs from August 1 – 15. The call is only honored from 8 am to 8 pm. The Yampa/White/Green BIP approach to translating the flows into a monthly volumetric demand was followed. For more details, please refer to the BIP report (YWBRT 2015).

Two instream flow nodes are used represent the Programmatic Biological Opinion for the Yampa River at Maybell (44_FishTar) and the lower Yampa River (44_FishRch). The values used in the Yampa/White/Green BIP were applied. For more details, please refer to the BIP report (YWBRT 2015).

Two instream flow nodes are used to represent the FERC required minimum flow bypass for Stagecoach Reservoir (5804213_F2 and 5804213_F4). For more information on the reservoir operations, please refer to Section 5.6.1.3.4 Stagecoach Reservoir .

Similarly, an instream flow node is used to model a potential future bypass requirement for the future Morrison Creek Reservoir (5803913_MF).

5.7.3 Instream Right File (*.ifr)

Water rights for each instream flow reach modeled in the Yampa River basin are contained in the instream flow right file. These data were obtained from the HydroBase, as shown in Table 5.12.

Table 5.12 - Instream Flow Summary

ID	Name	Demand (af/yr)
4401448	WILLIAMS FORK RIVER MSF	14,991
4401451	EAST FK WILLIAMS F MSF-U	7916
4401452	EAST FK WILLIAMS F MSF-L	10,275
4401454	PINE CREEK MSF	664
4401456	SOUTH FK WILLIAMS FK MSF	4257
44_FishRch	Yampa PBO Fish Target	70,609
44_FishTar	Maybell PBO Fish Target	70,609
5402076	SLATER CR MSF	2172
5601272	BEAVER CREEK MSF	1827
5701009	TROUT CREEK MSF-L	3620
5801355	ELK RIVER MSF-L	47,059
5801461	WILLOW CK MSF-M2	3620
5802164	YAMPA RIVER MSF	41,207
5802202	BEAR RIVER MSF-L	8688
5802206	BIG CREEK MSF	10,860
5802214	COAL CREEK MSF	3620
5802216	DOME CREEK MSF	1448
5802219	ELK RIVER MSF-U	47,059
5802245	GREEN CREEK MSF	3620
5802254	HOT SPRING CK MSF-U	1448
5802287	NORTH FK FISH CK MSF-L	3620
5802290	OAK CREEK MSF	1448
5802291	PRIEST CREEK MSF	1448
5802304	SAND CREEK MSF	724
5802306	SERVICE CREEK MSF	4344
5802311	SODA CREEK MSF	3620
5802332	WILLOW CK MSF-L	5068
5802403	HARRISON CR MSF-L	4344
5802404	BEAR RIVER MSF-M	5744
5802409	PHILLIPS CR MSF	4344

5802475	WALTON CREEK MSF-L	11,584
5802519	HUNT CREEK MSF	3620
5802591	STEAMBOAT SPRINGS BOATIN	137,303
5802654	HOT SPRING CK MSF-L	1448
5803913_MF	MorrisonCrkMSF	9412
5804213_F2	STAGECOACHRES_FERC_20	4840
5804213_F4	STAGECOACHRES_FERC_40	28,959
5809001	MORRISON CREEK LOWER MSF	7258

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 Yampa River Model, a plan limits the monthly volume released from Elkhead Reservoir to help supplement the flows in the river to support the endangered fish recovery. The monthly volumetric limit is equal to a constant 50 cfs release from Elkhead, as specified in the 2005 Yampa PBO.

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-channel reservoir. Typically, these are reservoir operations involving two or more structures, such as a release from a reservoir to a diversion structure, a release from one reservoir to a second reservoir, or a diversion to an off-channel 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 Yampa River model, seven different types of operating rights are used:

- **Type 1** – a release from storage to the stream to satisfy an instream flow demand.
- **Type 2** - a release from storage to the stream, for shepherded delivery to a downstream diversion. 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 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 supply, and is given an administration number junior to direct flow rights at the diverting structure.

- **Type 6** – paper transfer of water from one reservoir account to another reservoir account, commonly known as a bookover. This rule is used to divert water into storage and then distribute the water to reservoir accounts based on reservoir owner or operator preference.

- **Type 9** – a release from storage to the river to meet a reservoir target. This operation is generally used in calibration and is turned off in the baseline data set.

- **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. If the destination is a reservoir (as in the only example of this right's application in the Yampa model, to fill Allen Basin Reservoir), the demand is the destination reservoir's capacity.

- **Type 27** – a release from storage tied to a reuse plan to a diversion or reservoir and corresponding plan structure directly via the river or a carrier. This rule type is used to release water stored in Elkhead Reservoir to the Fish Reach, in conjunction with a Type 47 rule (see below).

- **Type 47** – The type 47 operating rule provides a method to impose monthly and annual limits for one or more operating rules. This rule is implemented to limit the monthly releases from Elkhead Reservoir to the Fish Reach with a Type 12 Plan.

This presentation of operating rights for the Yampa model is organized according to the reservoirs involved:

Section	Description
5.8.1	Stillwater Reservoir
5.8.2	Yamcolo Reservoir
5.8.3	Allen Basin Reservoir
5.8.4	Stagecoach Reservoir
5.8.5	Lake Catamount
5.8.6	Fish Creek Reservoir
5.8.7	Steamboat Lake
5.8.8	Lester Creek Reservoir
5.8.9	Elkhead Creek Reservoir
5.8.10	High Savery Reservoir
5.8.11	BIP Reservoirs

In addition, operations are included to support future reservoir projects. They are turned off in the Baseline data set.

Where to find more information

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

5.8.1 Stillwater Reservoir

Stillwater Reservoir No. 1 (WDID 5803540) is owned by the Bear River Reservoir Company and provides supplemental irrigation water supplies to several of the major direct flow structures in the upper Bear River. Based on reservoir and ditch ownership data provided by the Division Engineer, eight storage accounts were modeled in Stillwater Reservoir No. 1, as shown below. Each account represents the combined ownership of individuals served by a specific ditch, except for accounts 7 and 8. Account 7 represents the combined small ownership by Acton, Bird, Buckingham Mandall, Fix, Hernage & Kolbe, Mill Creek No. 1, and Pennsylvania Ditches; account 8 is the unallocated account.

Account	Owner	Capacity (acre-feet)
1	BIG MESA DITCH	444
2	COAL CREEK DITCH	435
3	LINDSEY DITCH	394
4	MANDALL DITCH	386
5	STILLWATER D.-CO	979
6	STILLWATER D.-YAMPA	1,352
7	AGGREGATED POOL	1,185
8	UNALLOCATED POOL	1,217

Fourteen operating rights are used to specify Stillwater Reservoir operations:

Right #	Destination	Resvr Account	Admin #	Right Type	Description
1	Acton Ditch	7	33782.23163	2	Release to direct diversion
2	Big Mesa Ditch	1	19990.15939	2	Release to direct diversion
3	Bird Ditch	7	33782.23893	2	Release to direct diversion
4	Buckingham-Mandall Ditch	7	33782.24989	2	Release to direct diversion
5	Coal Creek Ditch (ADY_001)	2	53325.47604	2	Release to direct diversion
6	Fix Ditch	7	33782.12587	2	Release to direct diversion
7	Hern-Kolbe Ditch	7	51134.44104	2	Release to direct diversion
8	Lindsey Ditch	3	18898.14346	2	Release to direct diversion
9	Mandall Ditch	4	33782.24989	2	Release to direct diversion
10	Mill Creek No. 1 Ditch	7	51134.44104	2	Release to direct diversion
11	Pennsylvania Ditch	7	33782.19510	2	Release to direct diversion
12	Stillwater Ditch (Yampa)	6	31920.19486	2	Release to direct diversion
13	Stillwater Ditch (Colorado)	5	22071.19624	2	Release to direct diversion
14	Opr Stillwater to Target	1 through 8	99999.99999	9	Res to River by Target

Operating right 1 releases water from the aggregated account to the Acton Ditch (580500). The administration number for this operating right is junior to the Acton Ditch's direct flow rights and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the aggregated account, and the unsatisfied demand at the Acton Ditch.

Operating right 2 releases water from account 1 to the Big Mesa Ditch (5800539). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at Big Mesa Ditch.

Operating right 3 releases water from the aggregated account to the Bird Ditch (5800541). The administration number for this operating right is junior to the direct flow and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at Bird Ditch.

Operating right 4 releases water from the aggregated account to the Buckingham Mandall Ditch (5800564). The administration number for this operating right is junior to the direct flow and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the Buckingham Mandall Ditch.

Operating right 5 releases water from account 2 to enable diversion at aggregate 58_ADY001. The administration number for this operating right is junior to the aggregate's direct flow rights. This aggregate was identified as receiving water from Stillwater Reservoir in initial water commissioner meetings.

Operating right 6 releases water from the aggregated account to the Fix Ditch (5800643). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the Fix Ditch.

Operating right 7 releases water from the aggregated account to the Hernage and Kolbe Ditch (5800684). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the Hernage and Kolbe Ditch.

Operating right 8 releases water from account 3 to the Lindsey Ditch (5800738). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the Lindsey Ditch.

Operating right 9 releases water from account 4 to the Mandall Ditch (5800763). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the Mandall Ditch.

Operating right 10 releases water from the aggregated account to the Mill Ditch No. 1 (5800777). The administration number for this operating right is junior to the direct flow and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at Mill Ditch No. 1.

Operating right 11 releases water from the aggregated account to the Pennsylvania Ditch (5800821). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the Pennsylvania Ditch.

Operating right 12 releases water from account 6 to the Stillwater Ditch irrigating in Division 6 (5804685). The administration number for this operating right is junior to the direct flow right and senior to releases from Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at the destination structure.

Operating right 13 releases water from account 5 to the Stillwater Ditch irrigating in Division 5 (5804686). The administration number for this operating right is junior to the direct flow right and senior to from releases Yamcolo Reservoir. The amount of water released to the direct diversion is restricted by the amount currently available in the account.

Operating right 14 is turned ON in the baseline data set. It was used in the first calibration run, to release water to meet the historical end-of-month content if modeled contents are above historical contents after all demand-based releases occur. In the Baseline run, reservoir content is lowered during the winter due to icing concerns. The release is made from all reservoir accounts in proportion to the current contents of each account. The junior administration number ensures this is the last operating right to fire.

5.8.2 Yamcolo Reservoir

Yamcolo Reservoir (WDID 5804240) provides supplemental irrigation water to the critically water short reaches of the upper Yampa River (Bear River). It also has a relatively small pool allocated to municipal use. Yamcolo is operated with six accounts, which are listed below and described more detail in Section 5.6.1.3.2.

Account	Owner	Capacity (acre-feet)
1	Conservation	1,086
2	Yamcolo M&I Users	1,010
3	Yamcolo Irrigator Association	3,000
4	Aggregated Stagecoach Exchange Contract Irrigators	4,000
5	Raise	525
6	Bookover	9,621

Ninety operating rights are used to simulate current Yamcolo operations. After discussions with UYWCD, rules were implemented to allow any of the ditches to receive water from the Raise pool. Several rights are required to serve the various owners in the aggregated pools. Additionally, a bookover account was added to the reservoir. The storage rights are first accounted for in the bookover account. Next, the account distributes the water to the other pools in the order indicated by the rules below.

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
1	Opr Yamcolo to Target	All	99999.99999	9	Res to River by Target
2	Stillwater Ditch (Yampa)	3	31920.19487	2	Release to Diversion
3	Stillwater Ditch (Colorado)	3	31920.19487	2	Release to Diversion
4	Stillwater Ditch (Yampa)	4	31920.19487	2	Release to Diversion
5	Stillwater Ditch (Colorado)	4	31920.19487	2	Release to Diversion
6	Stillwater Ditch (Yampa)	5	31920.19487	2	Release to Diversion
7	Stillwater Ditch (Colorado)	5	31920.19487	2	Release to Diversion
8	Big Mesa	3	19990.15940	2	Release to Diversion
9	Big Mesa	5	19990.15940	2	Release to Diversion
10	Lindsey	3	18898.14347	2	Release to Diversion
11	Lindsey	5	18898.14347	2	Release to Diversion
12	Buckingham-Mandall	4	33782.24990	2	Release to Diversion
13	Buckingham-Mandall	3	33782.24991	2	Release to Diversion
14	Buckingham-Mandall	5	33782.24991	2	Release to Diversion
15	Mandall	4	33782.24990	2	Release to Diversion
16	Mandall	3	33782.24991	2	Release to Diversion
17	Mandall	5	33782.24991	2	Release to Diversion
18	Acton	4	33782.23164	2	Release to Diversion
19	Acton	3	33782.23165	2	Release to Diversion
20	Acton	5	33782.23165	2	Release to Diversion
21	Wooley	3	33782.12587	2	Release to Diversion
22	Wooley	5	33782.12587	2	Release to Diversion
23	Fix	3	33782.12588	2	Release to Diversion
24	Fix	5	33782.12588	2	Release to Diversion
25	Mill-no1	3	51134.44105	2	Release to Diversion
26	Mill-no1	5	51134.44105	2	Release to Diversion
27	Hern-Kolbe	4	51134.44104	2	Release to Diversion
28	Hern-Kolbe	3	51134.44105	2	Release to Diversion
29	Hern-Kolbe	5	51134.44105	2	Release to Diversion
30	Pennsylvania	3	33782.19511	2	Release to Diversion
31	Pennsylvania	5	33782.19511	2	Release to Diversion
32	Bird	3	33782.23894	2	Release to Diversion
33	Bird	5	33782.23894	2	Release to Diversion
34	Coal Creek (58_ADY001)	3	53325.47605	2	Release to Diversion
35	Coal Creek (58_ADY001)	5	53325.47605	2	Release to Diversion
36	Egeria	4	33782.14002	2	Release to Diversion
37	Egeria	3	33782.14002	2	Release to Diversion
38	Egeria	5	33782.14002	2	Release to Diversion
39	Bijou	3	33782.29372	4	Release to Diversion by Exchange
40	Bijou	5	33782.29372	4	Release to Diversion by Exchange
41	Moody	3	33782.29372	4	Release to Diversion by Exchange
42	Moody	5	33782.29372	4	Release to Diversion by Exchange
43	Ferguson	3	33782.29372	4	Release to Diversion by Exchange
44	Ferguson	5	33782.29372	4	Release to Diversion by Exchange
45	Fish Creek Municipal Intake	2	42156.00003	4	Release to Diversion by Exchange
46	Stafford	4	48598.00001	2	Release to Diversion
47	Stafford	5	48598.00001	2	Release to Diversion
48	Laughlin	4	37688.26815	4	Release to Diversion by Exchange
49	Laughlin	5	37688.26815	4	Release to Diversion by Exchange

50	Whipple	4	33782.13651	2	Release to Diversion
51	Whipple	5	33782.13651	2	Release to Diversion
52	BearRabvHunt	4	52960.52375	2	Release to Diversion
53	BearRabvHunt	5	52960.52375	2	Release to Diversion
54	SnowBank	4	41727.39669	4	Release to Diversion by Exchange
55	SnowBank	5	41727.39669	4	Release to Diversion by Exchange
56	BearRabvStagecoach	4	55882.43252	2	Release to Diversion
57	BearRabvStagecoach	5	55882.43252	2	Release to Diversion
58	RossiHighline	4	41727.34103	4	Release to Diversion by Exchange
59	RossiHighline	5	41727.34103	4	Release to Diversion by Exchange
60	OakDale	4	41727.34103	4	Release to Diversion by Exchange
61	OakDale	5	41727.34103	4	Release to Diversion by Exchange
62	Steamboat2 (57_ADY010)	2	54421.52272	2	Release to Diversion
63	Steamboat2 (57_ADY010)	5	54421.52272	2	Release to Diversion
64	Nickell	2	19997.19600	2	Release to Diversion
65	Nickell	5	19997.19600	2	Release to Diversion
66-70	Bookover 6 to 1 through 5	1-5	41329.00001	6	Bookover
71-75	Bookover 6 to 1 through 5	1-5	41727.39992	6	Bookover
76-80	Bookover 6 to 1 through 5	1-5	47481.37137	6	Bookover
81-85	Bookover 6 to 1 through 5	1	47905.00001	6	Bookover
86-90	Bookover 6 to 1 through 5	1	50769.50654	6	Bookover

In the first calibration run, operating right 1 releases water to meet the historical end-of-month content if modeled contents are above that value after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire. It is turned OFF in the baseline data set.

Operating right 2 through 7 release water from the Yamcolo Irrigator Association, Aggregated Stagecoach Exchange Contract Irrigators, and the Raise accounts to the Stillwater Ditch Diversion System (5804685_D) that irrigates land in the Yampa basin (Division 6) and the Stillwater Ditch (5804686) that irrigates land in the Colorado basin (Division 5). The administration numbers are junior to the Stillwater Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Stillwater Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Acton Ditch.

Operating rights 8 and 9 release water from Yamcolo Irrigator Association and the Raise accounts to the Big Mesa Ditch (5800539). The administration number is junior to the Big Mesa Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Big Mesa Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Big Mesa Ditch.

Operating rights 10 and 11 release water from Yamcolo Irrigator Association and the Raise accounts to the Lindsey Ditch (5800738). The administration number is junior to the Lindsey Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Lindsey Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Bird Ditch.

Operating rights 12 through 14 release water from the Yamcolo Irrigator Association, Aggregated Stagecoach Exchange Contract Irrigators, and the Raise accounts to the Buckingham-Mandall Ditch (5800564). The administration number is junior to the Buckingham-Mandall Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Buckingham-Mandall Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Buckingham-Mandall Ditch.

Operating rights 15 through 17 release water from Yamcolo Irrigator Association, Aggregated Stagecoach Exchange Contract Irrigators, and the Raise accounts to the Mandall Ditch (5800643). The administration number is junior to the Mandall Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Mandall Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Mandall Ditch.

Operating rights 18 through 20 release water from the Yamcolo Irrigator Association, Aggregated Stagecoach Exchange Contract Irrigators, and the Raise accounts to the Acton Ditch (5800500). The administration number is junior to the Acton Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Acton Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Acton Ditch.

Operating rights 21 and 22 release water from the Yamcolo Irrigator Association and the Raise accounts to the Wooley Ditch (5800945). The administration number is junior to the Wooley Ditch's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Wooley Ditch.

Operating rights 23 and 24 release water from the Yamcolo Irrigator Association and the Raise accounts to the Fix Ditch (5800643). The administration number is junior to the Fix Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Fix Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Fix Ditch.

Operating rights 25 and 26 release water from the Yamcolo Irrigator Association and the Raise accounts to the Mill Creek No. 1 Ditch (5800777). The administration number is junior to the Mill Creek No. 1 Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Mill Creek No. 1 Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Mill Creek No. 1 Ditch.

Operating rights 27 through 29 release water from the Yamcolo Irrigator Association, Aggregated Stagecoach Exchange Contract Irrigators, and the Raise accounts to the Hernage and Kolbe Ditch (5800684). The administration number is junior to the Hernage and Kolbe Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Hernage and

Kolbe Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Hernage and Kolbe Ditch.

Operating rights 30 and 31 release water from the Yamcolo Irrigator Association and the Raise accounts to the Pennsylvania Ditch (5800821). The administration number is junior to the Pennsylvania Ditch's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Pennsylvania Ditch.

Operating rights 32 and 33 release water from the Yamcolo Irrigator Association and the Raise accounts to the Bird Ditch (5800541). The administration number is junior to the Bird Ditch's direct flow rights and reservoir releases from Stillwater Reservoir to the Bird Ditch. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Bird Ditch.

Operating rights 34 and 35 release water from the Yamcolo Irrigator Association and the Raise accounts to aggregated diversion 58_ADY001. The administration number for this operating right is junior to the direct flow rights in the aggregate and reservoir releases from Stillwater Reservoir. This aggregate was identified as receiving water from Yamcolo in initial water commissioner meetings.

Operating rights 36 through 38 release water from the Yamcolo Irrigator Association, Aggregated Stagecoach Exchange Contract Irrigators, and the Raise accounts to the Egeria Ditch (5800622). The administration number is junior to the Egeria Ditch's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Egeria Ditch.

Operating rights 39 through 40 release water from Yamcolo Irrigator Association and the Raise accounts to allow diversions at Bijou Ditch (5800540) by exchange. The administration number for this operating right is junior to the direct flow rights at the Bijou Ditch. The amount of water released is restricted by the amount currently available in the account, unsatisfied demand at the Bijou Ditch, and the exchange potential.

Operating rights 41 and 42 release water from Yamcolo Irrigator Association and the Raise accounts to allow diversions at Moody Ditch (5800782) by exchange. The administration number for this operating right is junior to the direct flow rights at the Moody Ditch. The amount of water released is restricted by the amount currently available in the account, unsatisfied demand at the Moody Ditch, and the exchange potential.

Operating rights 43 and 44 release water from Yamcolo Irrigator Association and the Raise accounts to allow diversions at Ferguson Ditch (5800634) by exchange. The administration number for this operating right is junior to the direct flow rights at the Ferguson Ditch. The amount of water released is restricted by the amount currently available in the account, unsatisfied demand at the Ferguson Ditch, and the exchange potential.

Operating right 45 releases water from the Yamcolo Municipal and Industrial account to the Fish Creek Municipal intake (5800642) by exchange. The administration number for this operating right is junior to the direct flow right at the intake. It operates only after water has been released from Fish Creek Reservoir and Stagecoach Reservoir to satisfy the Steamboat Springs/Mt. Werner demand. The amount of water released to the direct diversion is restricted by the amount currently available in the account, unsatisfied demand at the Fish Creek Municipal Intake, and available flow from the headgate to the confluence of Fish Creek with the Yampa River.

Operating rights 46 and 47 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the Stafford Ditch (5800879). The administration number is junior to the Stafford Ditch's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Stafford Ditch.

Operating rights 48 and 49 release water from Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to allow diversions at Laughlin Ditch (5800721) by exchange. The administration number for this operating right is junior to the direct flow rights at the Laughlin Ditch. The amount of water released is restricted by the amount currently available in the account, unsatisfied demand at the Laughlin Ditch, and the exchange potential.

Operating rights 50 and 51 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the Whipple Ditch (5800933). The administration number is junior to the Whipple Ditch's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Whipple Ditch.

Operating rights 52 and 53 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the aggregate node Bear River above Hunt Creek (58_ADY003). Diversions included in the aggregate were identified as contract holders with UYWCD. The administration number is junior to the aggregate node's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the aggregate.

Operating rights 54 and 55 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the Snow Bank Ditch (5800866) by exchange. The administration number is junior to the Snow Bank Ditch's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Snow Bank Ditch, and the exchange potential.

Operating rights 56 and 57 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the aggregate node Bear River above Stagecoach Reservoir (58_ADY004). Diversions included in the aggregate were identified as contract holders with UYWCD. The administration number is junior to the aggregate node's direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the aggregate.

Operating rights 58 and 59 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the Rossi Highline Ditch (5801074) by exchange. The administration number is junior to the Rossi Highline Ditch’s direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Rossi Highline Ditch, and the exchange potential.

Operating rights 60 and 61 release water from the Aggregated Stagecoach Exchange Contract Irrigators and the Raise accounts to the Oakdale Ditch (5800807) by exchange. The administration number is junior to the Oakdale Ditch’s direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the Oakdale Ditch, and the exchange potential.

Operating rights 62 and 63 release water from the Yamcolo Municipal and Industrial, and the Raise accounts to the aggregate node Yampa River above Haden (57_ADY010). Diversions included in the aggregate were identified as contract holders with UYWCD. The administration number is junior to the aggregate node’s direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at the aggregate.

Operating rights 64 and 65 release water from the Yamcolo Municipal and Industrial, and the Raise accounts to the Nickell Ditch (5800798). The administration number is junior to the Nickell Ditch’s direct flow rights. The amount of water released to the direct diversion is restricted by the amount currently available in the account, and the unsatisfied demand at Nickell Ditch.

Operating rights 66 through 90 are all Type 6 Bookover rules. Water from account 6 (Bookover account) is released in the correct order to accounts 1 through 5. The rights are just junior to the four reservoir storage rights. This means that StateMod will store the water in account 6 and then it will be moved to the correct account.

5.8.3 Allen Basin Reservoir

Allen Basin Reservoir (WDID 5803500) is a small irrigation reservoir located near the headwaters of Middle Hunt Creek. Although it is smaller than the minimum reservoir capacity (4,000 acre-feet) generally used for inclusion in the Yampa model, it is modeled explicitly because it plays a significant role in the irrigation water supply in this water-limited area of the Yampa River basin. The reservoir has a decreed capacity of 2,250 af, which is also reported to be its active capacity.

Storage water in Allen Basin Reservoir provides supplemental irrigation supplies to several direct flow structures in the Hunt Creek drainage. Using information provided by the Water

Commissioner, the ownership sub-accounts are combined into a single pool (2,250 acre-feet) in the reservoir:

Account	Owner	Capacity (acre-feet)
1	AGGREGATED POOL	2,250

Six operating rights are used to simulate Allen Basin Reservoir activities. The first four rights control releases to the various irrigators owning shares in the reservoir. The fifth right is a release to target right for calibration. The last right relates to filling the reservoir from South Hunt Creek. Since the fill affects both a diversion station and the reservoir station, an operating right is required:

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
1	Collins Ditch	1	37688.25332	2	Release to direct diversion
2	Simon Ditch	1	23537.22472	2	Release to direct diversion
3	Lateral A Ditch	1	37688.34829	3	Release to direct diversion
4	Mill Creek Ditch	1	53325.52865	3	Release to direct diversion
5	Allen Basin Reservoir to Target	1	99999.99999	9	Res to River by Target
6	Allen Basin Reservoir	1	39254.37914	11	Direct diversion to reservoir through an intervening structure

Operating right 1 releases water from account 1 to the Collins Ditch (5800591). The administration number for this operating right is junior to the Collins Ditch direct flow rights. The amount of water released to Collins Ditch is limited by the amount currently available in the account, and unsatisfied demand at the ditch.

Operating right 2 releases water from account 1 to the Simon Ditch (5800863). The administration number for this operating right is junior to several Simon Ditch direct flow rights. The amount of water released to Simon Ditch is limited by the amount currently available in the account, and unsatisfied demand at the ditch.

Operating right 3 releases water from account 1 to the Lateral A Ditch (5800730). The administration number for this operating right is junior to several Lateral A direct flow rights. The amount of water released is limited by the amount currently available in the account, and unsatisfied demand at the ditch.

Operating right 4 releases water from account 1 to the Mill Creek Ditch (5801085). The administration number for this operating right is junior to Mill Creek Ditch direct flow rights. The amount of water released is limited by the amount currently available in the account, and unsatisfied demand at the ditch.

Operating right 5 is turned OFF in the baseline data set. In the first calibration step, it releases water to meet the historical end-of-month content if modeled contents are above historical levels after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire.

Operating right 6 supplies water to Allen Basin Reservoir from South Hunt Creek via the Allen Basin Supply Ditch (5800506). The amount of water transferred is limited by decreed amount and legally available flow under the Allen Basin Supply Ditch's single direct flow right on South Hunt Creek. Allen Basin Reservoir also has a "regular" storage right to native flows on Middle Hunt Creek, which fires before this right.

5.8.4 Stagecoach Reservoir

Stagecoach Reservoir provides supplemental municipal and industrial water supplies, as well as a significantly sized conservation pool for recreational purposes. The reservoir is represented in the model as having the four pools listed below. History and ownership of these pools are described in Section 5.6.1.

Account	Account	Storage (ac-ft)
1	Tri-State Power Generation and Transmission	7,000
2	Municipal and Industrial Users	2,000
3	Emergency Remainder (Recreation)	15,000
4	Preferred Remainder	3,275
5	Augmentation Pool	2,000
6	Exchange Pool	4,000
7	New storage from dam raise	3,184
8	Used for accounting purposes	36,460

Operations are implemented to model the FERC minimum environmental flow requirement immediately downstream of Stagecoach. From August to November, Stagecoach is required to bypass inflow or 40 cfs, whichever is less. If inflows drop below 20 cfs, Stagecoach is required to release water from storage to ensure that 20 cfs of flow enters the river below the reservoir. From December to July, Stagecoach is required to bypass inflow or 40 cfs, whichever is less, with no requirement to release from storage. To capture this requirement in the model, two instream flow nodes are located below the reservoir: 5804213_F2 and 5804213_F4. From August to November, 5804213_F2 has a demand of 20 cfs and an operating rule will release water to meet the demand if the flow in the river is insufficient. It has a demand of zero the rest of the year. Node 5804213_F4 has a constant demand of 40 cfs and a priority that is just senior to the first major Stagecoach storage water right. This ensures that Stagecoach will bypass flow to try to meet the 40 cfs requirement. However, it does not have an operating rule, so Stagecoach will only bypass inflow, it will not release from storage

Forty rules specify current Stagecoach operations in the model:

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
1	Opr Stagecoach to Target	All	99999.99999	9	Reservoir to River by Target
2	FERC min flow	3	99999.99999	1	Release to Instream Flow
3	Craig Power Plant (TriState)	1	45290.44866	2	Release to Diversion
4	Hayden	2	1.00001	2	Release to Diversion
5	YampaR ISF	6	99999.99998	1	Release to Instream Flow
6	Sandhofer	5	45655.30468	2	Release to Diversion
7	Weiskopf	5	33782.19520	2	Release to Diversion
8	Suttle	6	55882.55684	2	Release to Diversion
9	Brumback	6	33782.23528	4	Release to Diversion by Exchange
10	Lyon2	6	33782.23163	4	Release to Diversion by Exchange
11	Dever	5	41523.00001	2	Release to Diversion
12	Steamboat Well A	2	51494.00001	2	Release to Diversion
13	Mt.Werner Water and San	2	51494.00001	2	Release to Diversion
14	Steamboat Well G & H	2	51134.46722	2	Release to Diversion
15	Excelsior	6	33145.30468	4	Release to Diversion by Exchange
16	Fish Creek Municipal Intake	2	42156.00002	4	Release to Diversion by Exchange
17	YampaRabvSte	6	55882.51987	2	Release to Diversion
18	YampaRabvSte	5	55882.51987	2	Release to Diversion
19	Walker Ditch	2	53077.00001	2	Release to Diversion
20	Bookover 8 to 1	8	40815.00001	6	Bookover
21	Bookover 8 to 2	8	40815.00001	6	Bookover
22	Bookover 8 to 5	8	40815.00001	6	Bookover
23	Bookover 8 to 6	8	40815.00001	6	Bookover
24	Bookover 8 to 7	8	40815.00001	6	Bookover
25	Bookover 8 to 4	8	40815.00001	6	Bookover
26	Bookover 8 to 3	8	40815.00001	6	Bookover
27	Bookover 8 to 1	8	41727.39992	6	Bookover
28	Bookover 8 to 2	8	41727.39992	6	Bookover
29	Bookover 8 to 5	8	41727.39992	6	Bookover
30	Bookover 8 to 6	8	41727.39992	6	Bookover
31	Bookover 8 to 7	8	41727.39992	6	Bookover
32	Bookover 8 to 4	8	41727.39992	6	Bookover
33	Bookover 8 to 3	8	41727.39992	6	Bookover
34	Bookover 8 to 1	8	53691.53387	6	Bookover
35	Bookover 8 to 2	8	53691.53387	6	Bookover
36	Bookover 8 to 5	8	53691.53387	6	Bookover
37	Bookover 8 to 6	8	53691.53387	6	Bookover
38	Bookover 8 to 7	8	53691.53387	6	Bookover
39	Bookover 8 to 4	8	53691.53387	6	Bookover
40	Bookover 8 to 3	8	53691.53387	6	Bookover

Operating right 1 is turned OFF in the baseline data set. In the Historical run, it releases water to meet the historical end-of-month content if modeled contents are above historical levels after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire.

Operating right 2 releases water from the Emergency Remainder account to the FERC minimum flow demand represented at node 5804213_F2. This is an instream flow node that has a demand of 20 cfs from August to November. The junior administration number ensures that releases for any other purpose can satisfy the 20 cfs before releases from storage are made.

Operating right 3 releases water from the Tri-State account to the Craig Power Plant (4400522). The administration number for this operating right is junior to direct flow right at the Craig Station . The amount of water released to the direct diversion is restricted by the amount currently available in the account, and unsatisfied demand at Craig Station.

Operating right 4 releases water from the Municipal and Industrial Users to the town of Hayden. Hayden municipal demands are part of the aggregated municipal diversion node 57_AMY001. The aggregated municipal diversion nodes are assigned an administration number of 1.0001 to ensure that they are always met. The administration number for this operating right is junior to the direct flow right.

Operating right 5 releases water from the Exchange Pool account to the Upper Yampa River Instream Flow. UYWCD will contract water to CWCB for release from Stagecoach to support flows in the instream flow reach. However, this operation only occurs when the contract is in place. The decision to purchase water is made on a yearly basis. The administration number is very junior to prevent the reservoir from making releases to the instream flow if satisfied from native flow or releases to other users.

Operating right 6 releases water from the Augmentation Pool account to the Sandhofer Ditch (5800850). The administration number for this operating right is junior to the Sandhofer Ditch's direct flow right . The amount of the release is limited by the amount of water available in the account and unsatisfied demand.

Operating right 7 releases water from the Augmentation Pool account to the Weiskopf Ditch (5800922). The administration number for this operating right is junior to the Weiskopf Ditch's direct flow right . The amount of the release is limited by the amount of water available in the account and unsatisfied demand.

Operating right 8 releases water from the Exchange Pool account to the Suttle Ditch (5800897). The administration number for this operating right is junior to the Suttle Ditch's direct flow right. The amount of the release is limited by the amount of water available in the account and unsatisfied demand.

Operating right 9 releases water from the Exchange Pool account to the Brumback Ditch (5800561) by exchange. The administration number for this operating right is junior to the Brumback Ditch's direct flow right . The amount of the release is limited by the amount of water available in the account, unsatisfied demand, and the exchange potential.

Operating right 10 releases water from the Exchange Pool account to the Lyon 2 Ditch (5800756) by exchange. The administration number for this operating right is junior to the Lyon

2 Ditch's direct flow right. The amount of the release is limited by the amount of water available in the account, unsatisfied demand, and the exchange potential.

Operating right 11 releases water from the Augmentation Pool account to the Dever Ditch (5800612). The administration number for this operating right is junior to the Dever Ditch's direct flow right. The amount of the release is limited by the amount of water available in the account and unsatisfied demand.

Operating right 12 releases water from the Municipal and Industrial Users account to City of Steamboat Springs municipal well A demands (5805055). The administration number for this operating right is junior to the City's right. The amount of future release will be limited by the amount of water available in the account and unsatisfied demand.

Operating right 13 releases water from the Municipal and Industrial Users account to Mt. Werner municipal well demands (5805066). The administration number for this operating right is junior to the Mt. Werner's right. The amount of future release will be limited by the amount of water available in the account and unsatisfied demand.

Operating right 14 releases water from the Municipal and Industrial Users account to Mt. Werner municipal well G and H diversion system demands (5805059_D). The administration number for this operating right is junior to the Mt. Werner's right. The amount of future release will be limited by the amount of water available in the account and unsatisfied demand.

Operating right 15 releases water from the Exchange Pool account to the Excelsior Ditch (5800628) by exchange. The administration number for this operating right is junior to the Excelsior Ditch's direct flow right. The amount of the release is limited by the amount of water available in the account, unsatisfied demand, and the exchange potential.

Operating right 16 releases water from the Municipal and Industrial Users account to allow diversion by exchange at the Fish Creek Municipal Intake. The administration number for this operating right is junior to the direct flow right at the intake. The right fires ahead of releases from the municipal account in Yamcolo Reservoir, which can also satisfy the Fish Creek municipal demand by exchange. The amount of the diversion and release is limited by the amount of water available in the account, unsatisfied demand, and legally available flow from the Fish Creek headgate downstream to the confluence of Fish Creek with the Yampa River.

Operating right 17 releases water from the Exchange Pool account to the aggregated diversion node on the Yampa above Steamboat Springs (58_ADY005). There are multiple contract holders with UYWCD that are grouped together in the aggregate node. The administration number for this operating right is junior to the most junior direct right in the aggregate. The amount of the release is limited by the amount of water available in the account and unsatisfied demand.

Operating right 18 releases water from the Augmentation Pool account to the aggregated diversion node on the Yampa above Steamboat Springs (58_ADY005). There are multiple contract holders with UYWCD that are grouped together in the aggregate node. The administration number for this operating right is junior to the most junior direct right in the aggregate. The amount of the release is limited by the amount of water available in the account and unsatisfied demand.

Operating right 19 releases water from the Municipal and Industrial Users account to Walker Ditch (5700611), which provides water to the City of Hayden. The administration number for this operating right is junior to the Walker Ditch right. The amount of future release will be limited by the amount of water available in the account and unsatisfied demand.

Operating rights 20 through 40 are all Type 6 bookover rules. Water from account 8 is released in the correct order to accounts 1 through 7. The rights are just junior to the each of the eight reservoir storage rights. This means that StateMod first will store the water in account 8 and then will move the water stored under each water right to the correct account.

Operating right 41 through 43 represent operations to support future projects and uses. They are turned off in the Baseline data set.

5.8.4 Lake Catamount

Lake Catamount Reservoir (WDID 5803631) was built primarily for recreation for the planned residential and ski development near the lake. To date, that use has not developed. According to the Division 6 engineer and water commissioner, the reservoir is normally operated to keep it full. Historically, there has been a practice to lower the reservoir by releasing approximately 2,000 acre-feet in October to protect against the formation of frazil ice near the reservoir inlet during the winter months. The model includes only one account and one operating right for Lake Catamount.

Account	Owner	Capacity (acre-feet)
1	CONSERVATION POOL	7,422

Right #	Destination	Reservoir Account	Admin #	RightType	Description
1	Lake Catamount to Target	1	99999.99999	9	Res to River by Target

Operating right 1 is turned ON in the baseline data set, unlike the similar rights at other reservoirs in the Yampa model. The maximum monthly targets for Lake Catamount reflect the pre-winter lowering of the reservoir, followed by a slow fill through the winter. This right causes Lake Catamount to release about 2,000 af in October, and reservoir storage rights affect the winter filling.

5.8.6 Fish Creek Reservoir

Fish Creek Reservoir (WDID 5803508) is owned by the city of Steamboat Springs and is used as reserve raw water storage for the city and for the Mt. Werner Water & Sanitation District. According to city personnel, the direct flow rights are generally sufficient to satisfy the demand through the end of July. At that time, the physical supply in Fish Creek begins to decrease and it is necessary to supplement the direct flow diversions with water released from storage in Fish Creek Reservoir. Fish Creek Reservoir is modeled with a single account.

Account	Owner	Capacity (acre-feet)
1	STEAMBOAT SPRINGS/MT. WERNER WSD	4,042

Two operating rights are used to simulate Fish Creek Reservoir's operations:

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
1	Fish Creek Municipal Intake	1	42156.00001	2	Release for direct diversion
2	Fish Creek Resvr to Target	1	99999.99999	9	Res to River by Target

Operating right 1 releases water from account 1 to the downstream Fish Creek Municipal Intake (5800642). The administration number for this operating right is junior to the direct flow rights at the Fish Creek Municipal Intake. The amount of the release is limited by the amount currently available in the account, and unsatisfied demand at the Fish Creek Municipal Intake.

Operating right 2 is turned OFF in the baseline data set. In the first calibration step, it releases water to meet the historical end-of-month content if modeled contents are above historical levels after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire.

5.8.7 Steamboat Lake Reservoir

Steamboat Lake (WDID 5803787) is used primarily for recreational purposes, and as back-up supply for the Hayden power station. These purposes are reflected in the reservoir's two modeled accounts:

Account	Owner	Capacity (acre-feet)
1	HAYDEN STATION	5,000
2	CONSERVATION POOL	18,209
3	ISF POOL	3,155

Two operating rights are used to simulate Steamboat Lake:

Right #	Destination	Reservoir Account	Admin #	RightType	Description
1	Hayden Station	1	36195.17381	2	Release for direct diversion
2	Steamboat Lake to Target	1	99999.99999	9	Res to River by Target

Operating right 1 releases water in account 1 when the direct flow rights decreed for operating the Hayden Station (5700512) are insufficient to satisfy demand at the power plant. The administration number for this operating right is junior to the direct flow rights for Hayden Station. The amount of the release is limited by the amount currently available in the account, and unsatisfied demand at the diversion.

Operating right 2 is turned OFF in the baseline data set. In the first calibration step, it releases water to meet the historical end-of-month content if modeled contents are above historical levels after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire.

5.8.8 Lester Creek Reservoir

Lester Creek Reservoir (WDID 5803521, aka Pearl Lake) is located on Lester Creek, a tributary of the Elk River downstream of Steamboat Lake. The reservoir is owned and operated by CPW and used exclusively for recreational and fishery purposes. It is modeled with a single account and a single operating right:

Account	Owner	Capacity (acre-feet)
1	CONSERVATION POOL	5,657

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
1	Lester Creek Resvr to Target	1 through 3	99999.99999	9	Res to River by Target

Operating right 1 is turned OFF in the baseline data set. In the first calibration step, it releases water to meet the historical end-of-month content if modeled contents are above historical levels after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire.

5.8.9 Elkhead Creek Reservoir

Elkhead Creek Reservoir (WDID 4403902) is located on Elkhead Creek, a tributary of the Yampa River, just upstream of the city of Craig. Explanation of the five accounts in Elkhead Reservoir are explained in Section 5.6.1.3.9.

Account	Owner	Capacity (acre-feet)
1	Craig Power Plant	8,408
2	Craig Municipal and Industrial	4,413
3	Conservation	878
4	CWCB Enlargement	5,000
5	CRWCD Enlargement	6,957

Four rights are used to simulate Elkhead Creek Reservoir:

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
0	Release Limit Plan	NA	1.0	47	Release Limit plan
1	Craig Power Plant (Tri-State)	1	45290.44866	2	Release to direct diversion
2	Craig Water Supply Pipeline	2	36295.24106	2	Release to direct diversion
3	Endangered Fish Critical Habitat Reach	4	99997.00001	27	Release to minimum flow
4	Release to Storage Target	All	99999.99999	9	Res to River by Target

Operating right 0 is the accounting plan limit rule. The monthly release limits are set in this rule and are tracked. The annual limit resets in October.

Operating right 1 supplies industrial water to satisfy shortages at the Craig Station Units 1 and 2 after the senior direct flow rights have been diverted through the Craig Station Ditch and Pipeline (4400522). The administration number for this operating right is junior the direct flow right at the diversion. It is equivalent to the administration number for the release from Stagecoach Reservoir. The amount of the release is restricted by the amount currently available in the account, and unsatisfied demand at Craig Station.

Operating right 2 supplies storage water to satisfy shortages to the City of Craig's municipal demand after the City's direct flow water rights on the Yampa River have been exercised. The administration number for this operating right is junior to the direct flow right at the diversion. The amount of water released to the Craig Water Supply Pipeline is restricted by the amount currently available in the account, and unsatisfied demand.

Operating right 3 releases water from the CWCB account to satisfy the instream flow demand at node 44_FishRch, as limited by the type 47 operating rule. For more information on the instream flow demand, please refer to the instream flow section. The type 47 rule limits the releases from Elkhead to no more than 50 cfs. The release is also limited to the minimum of account contents and the deficit to the target flow. The administration number is very junior to allow any other water in the river to satisfy the instream flow demand before making a release from storage.

Operating right 4 is turned OFF in the baseline data set. In the first calibration step, it releases water to meet the historical end-of-month content if modeled contents are above historical levels after all demand-based releases occur. The junior administration number ensures this is the last operating right to fire.

5.8.10 High Savery Reservoir

High Savery Reservoir (WDID 9903002) is located on Savery Creek, a north side tributary of the Little Snake River near in Wyoming. The reservoir has a capacity of 22,433 acre-feet, and provides a supplemental supply to downstream irrigators.

Storage water in High Savery Reservoir provides supplemental irrigation supplies to many downstream irrigators. These users are represented in the Yampa model in aggregate structures. Wyoming's model of the Little Snake basin, developed for the Little Snake River Supplemental Storage Study, was relied on to identify the project beneficiaries, order of operations, and switch settings.

Account	Owner	Capacity (acre-feet)
1	IRRIGATION POOL	22,433

Eleven operating rights are used to simulate High Savery Reservoir releases.

Right #	Destination	Reservoir Account	Admin #	Right Type	Description
1	WYD_006	1	55304.00000	2	Release to direct diversion
2	WYD_007	1	55306.00000	2	Release to direct diversion
3	WYD_010	1	55307.00000	2	Release to direct diversion
4	5400583	1	55308.00000	2	Release to direct diversion
5	54_ADY023	1	55309.00000	2	Release to direct diversion
6	5400531	1	55311.00000	2	Release to direct diversion
7	5400594	1	55313.00000	2	Release to direct diversion
8	WYD_005	1	55315.00000	2	Release to direct diversion
9	WYD_002	1	55317.00000	4	Release to diversion by exchange
10	WYD_003	1	55318.00000	2	Release to direct diversion
11	WYD_004	1	55320.00000	4	Release to diversion by exchange

All operating rights releases water from account 1. The administration numbers for the operations are generally junior to the direct flow rights for the destination structures. The deliveries by exchange (rights 9 and 11) are currently turned off as they are in Wyoming's model.

5.8.11 Basin Implementation Reservoirs

Suggested operations for the Basin Implementation Reservoirs are included at the bottom of the ym2015B.opr file. They are inactive in the baseline data set. It is the responsibility of the user to activate the BIP reservoirs and verify that the operations work as intended.

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 Yampa model characterizes it, under these assumptions.

6.1 Baseline Streamflows

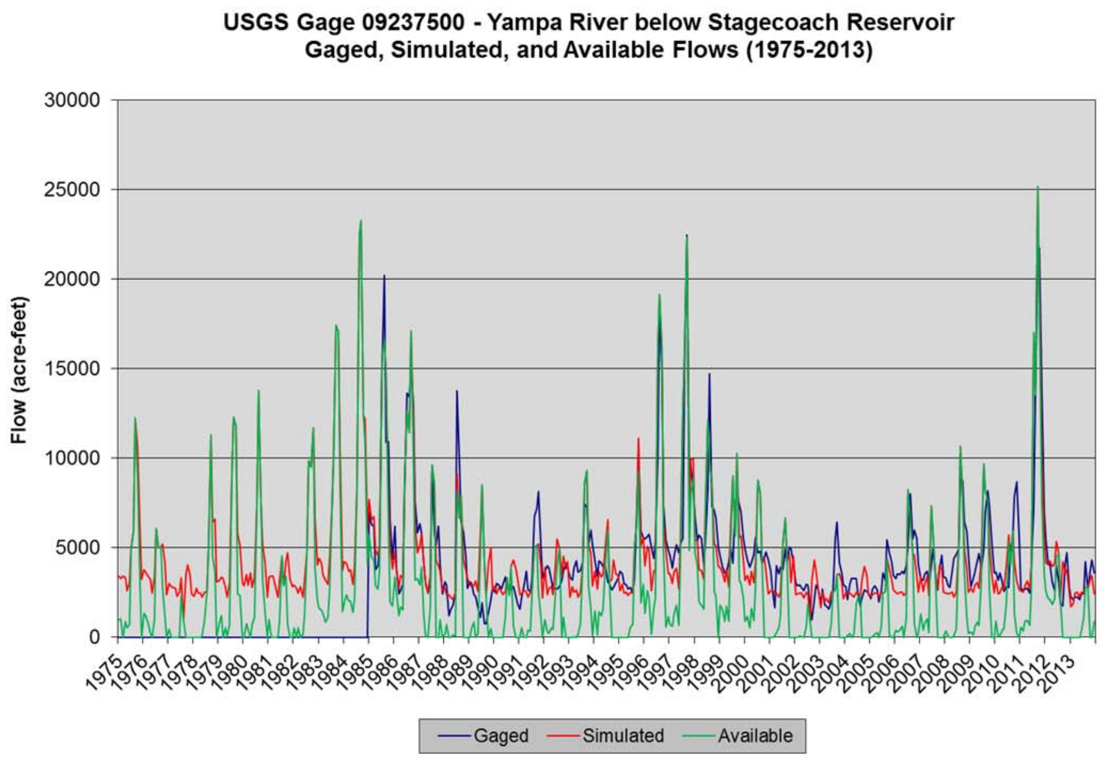
Table 6.1 shows, for each gage, the average annual flow from the Baseline simulation, based on the entire simulation period (1909 through 2013). Simulated averages vary from historical averages because more recent changes to demand and reservoir use are projected over the entire simulation period. The 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, downstream diversion demand or downstream reservoir storage demand; it represents the water that could be diverted by a new water right. The available flow is less than or the same as the total simulated flow.

Temporal variability of the historical and Baseline simulated flows is illustrated in Figures 6.1 through 6.6. 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 for the same 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.

In general, Baseline flows are slightly lower than historical flows and exhibit the same monthly distribution. The exception is the gage below Stagecoach Reservoir, which is directly impacted by operations at Stagecoach. The historical gage averages reflect only 14 years of reservoir regulated flow, while in the simulation, Stagecoach Reservoir operates for the entire period.

Table 6.1 - Simulated Baseline Average Annual Flows for Yampa River Gages (1908-2013)

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
09236000	Bear River Near Toponas	28,087	4,825
09237500	Yampa River Bl Stagecoach Reservoir	58,194	35,745
09238900	Fish Creek At Upper Station	44,670	42,862
09239500	Yampa River At Steamboat Springs	321,043	222,485
09241000	Elk River At Clark	241,270	190,976
09242500	Elk River Near Milner	387,742	334,419
09244410	Yampa River Bl Diversion nr Hayden	732,150	683,585
09245000	Elkhead Creek Near Elkhead	43,837	42,524
09245500	North Fork Elkhead Creek	14,308	14,110
09246920	Fortification Creek near Fortification	7,534	6,767
09247600	Yampa River Below Craig	921,215	855,516
09249000	East Fork Of Williams Fork	83,729	75,036
09249200	South Fork Of Williams Fork	30,872	26,845
09249750	Williams Fork At Mouth	155,976	150,938
09251000	Yampa River Near Maybell	1,094,746	954,097
09253000	Little Snake River Near Slater	170,009	161,679
09255000	Slater Fork Near Slater	58,158	56,340
09255500	Savery Creek near Upper Station	37,833	30,674
09258000	Willow Creek Near Dixon	7,555	4,652
09260000	Little Snake River Near Lily	421,189	420,428
09260050	Yampa River At Deerlodge Park	1,473,570	1,473,092



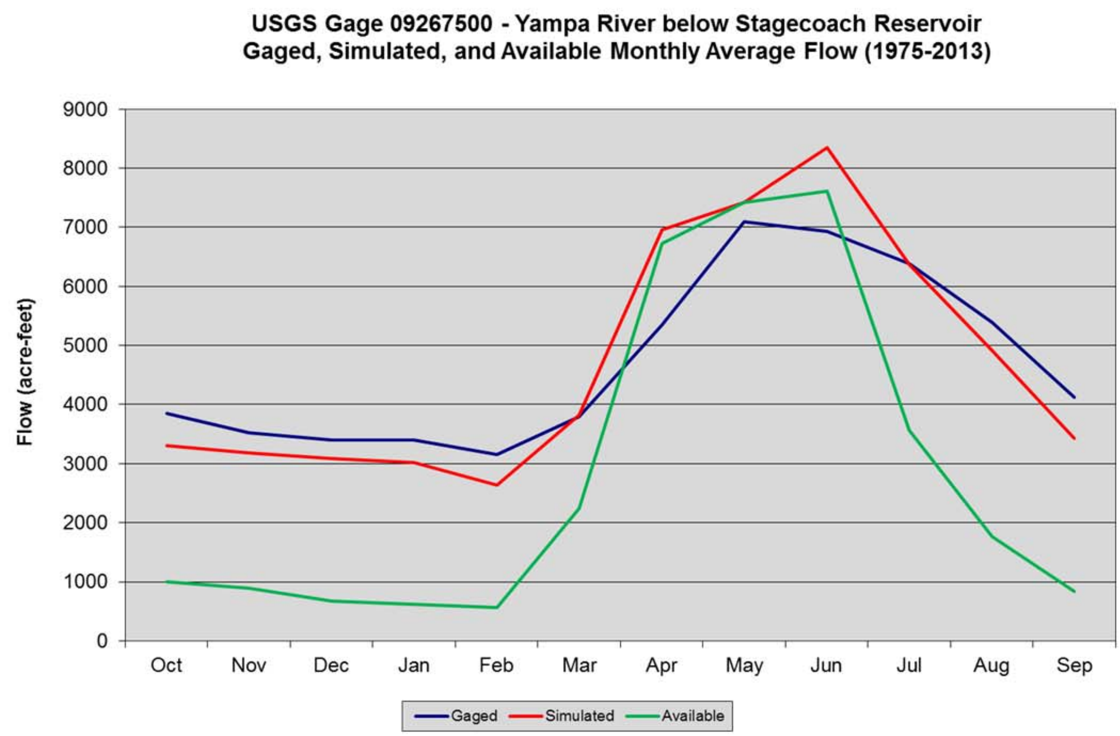
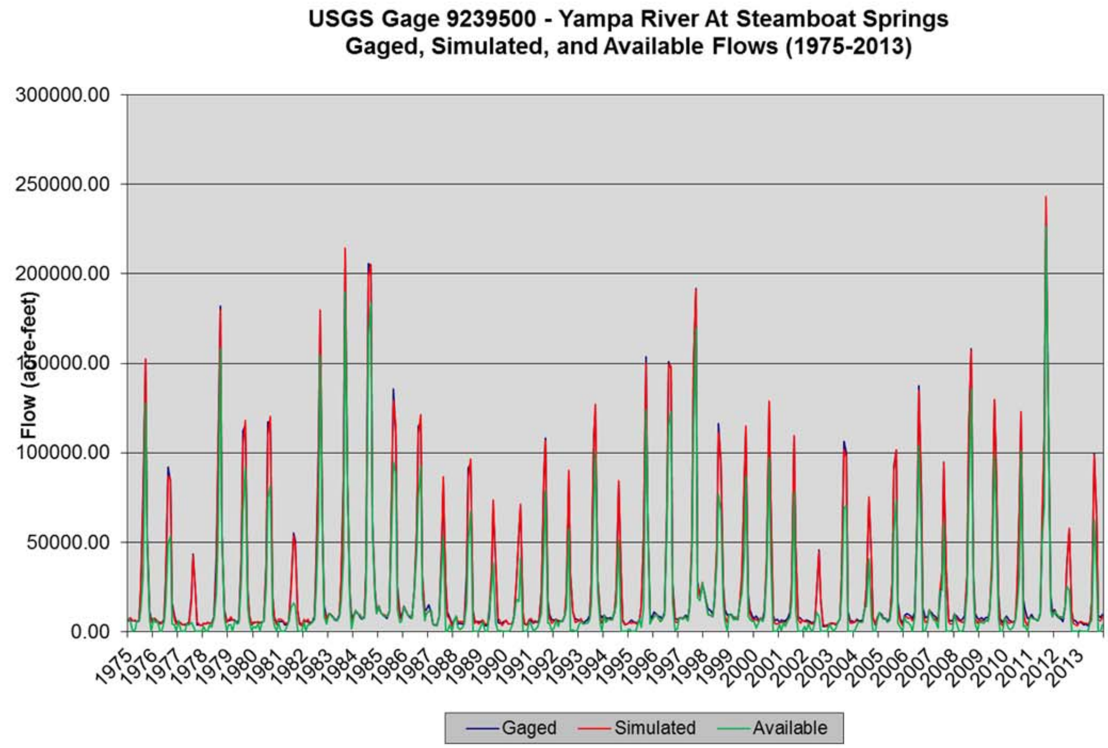


Figure 6.1 - Gaged, Baseline Simulated, and Available Flows (Yampa River below Stagecoach Reservoir)



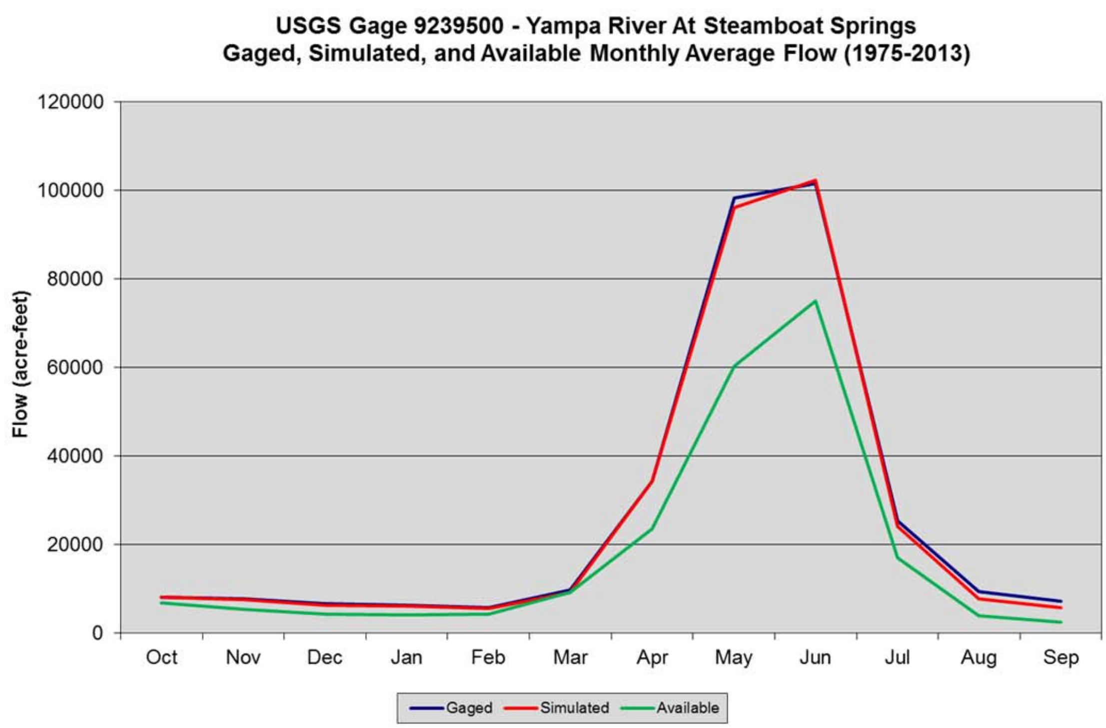
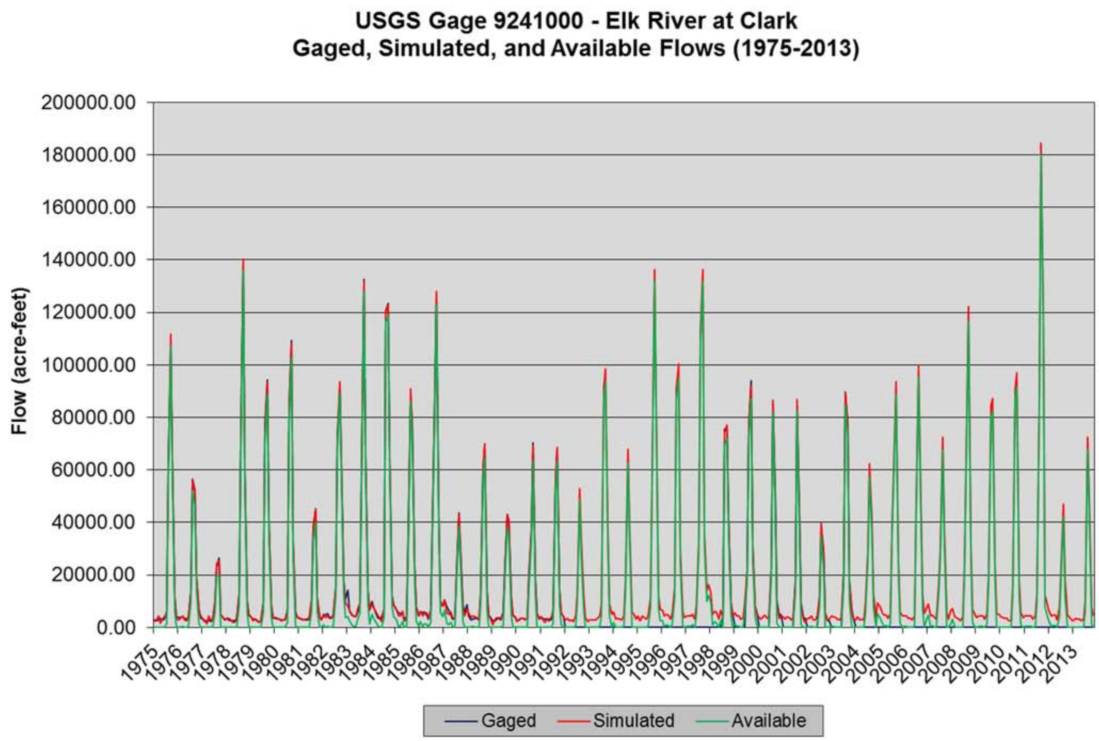


Figure 6.2 - Gaged, Baseline Simulated, and Available Flows (Yampa River at Steamboat Springs)



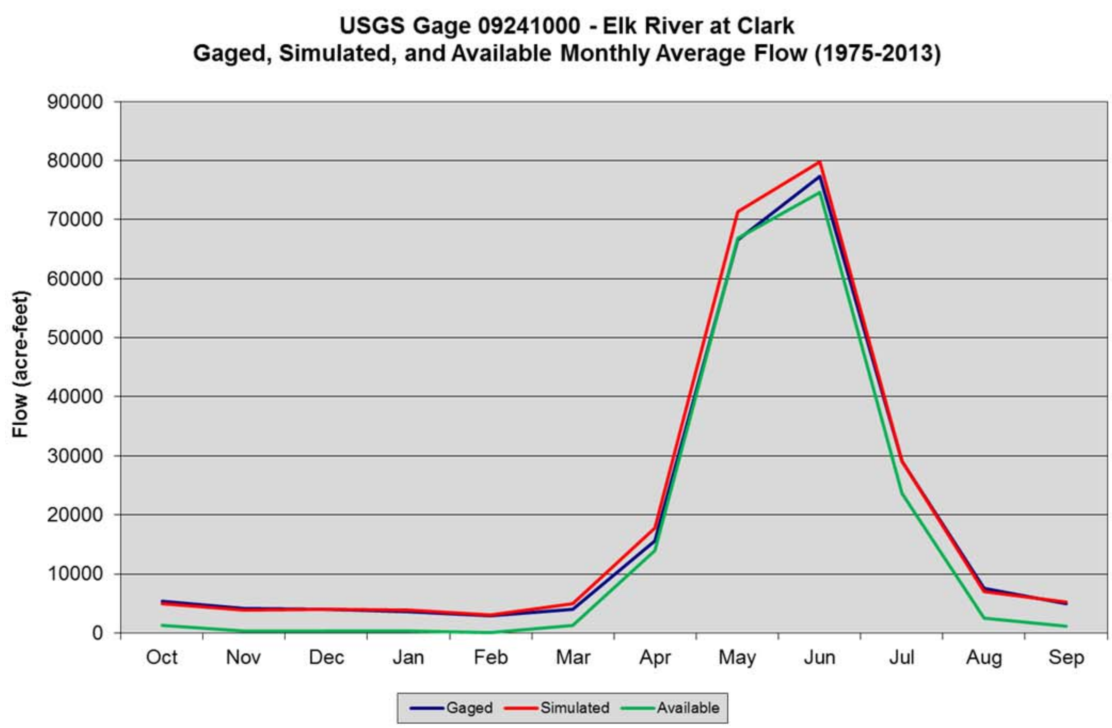
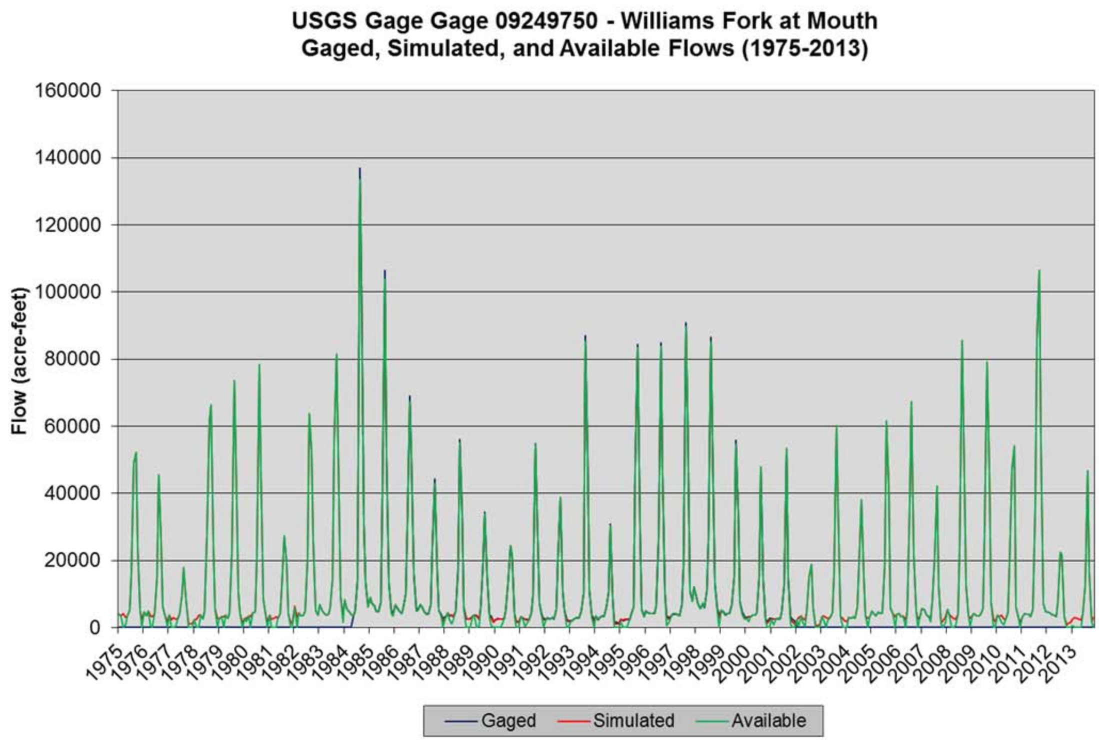


Figure 6.3 - Gaged, Baseline Simulated, and Available Flows (Elk River at Clark)



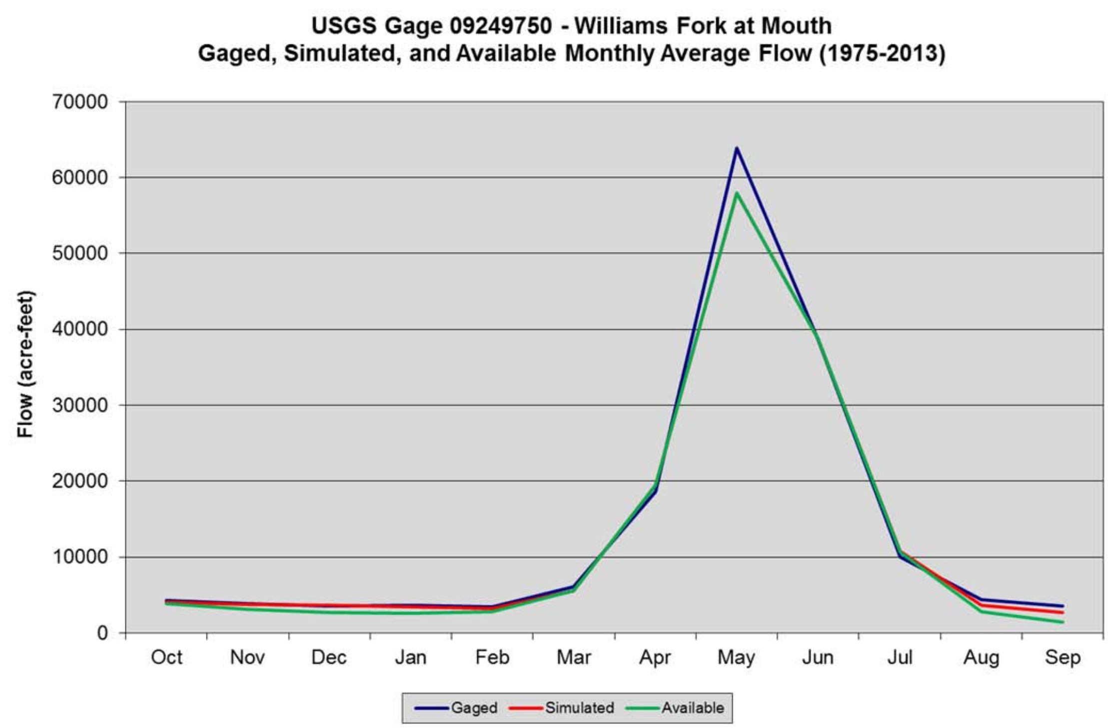
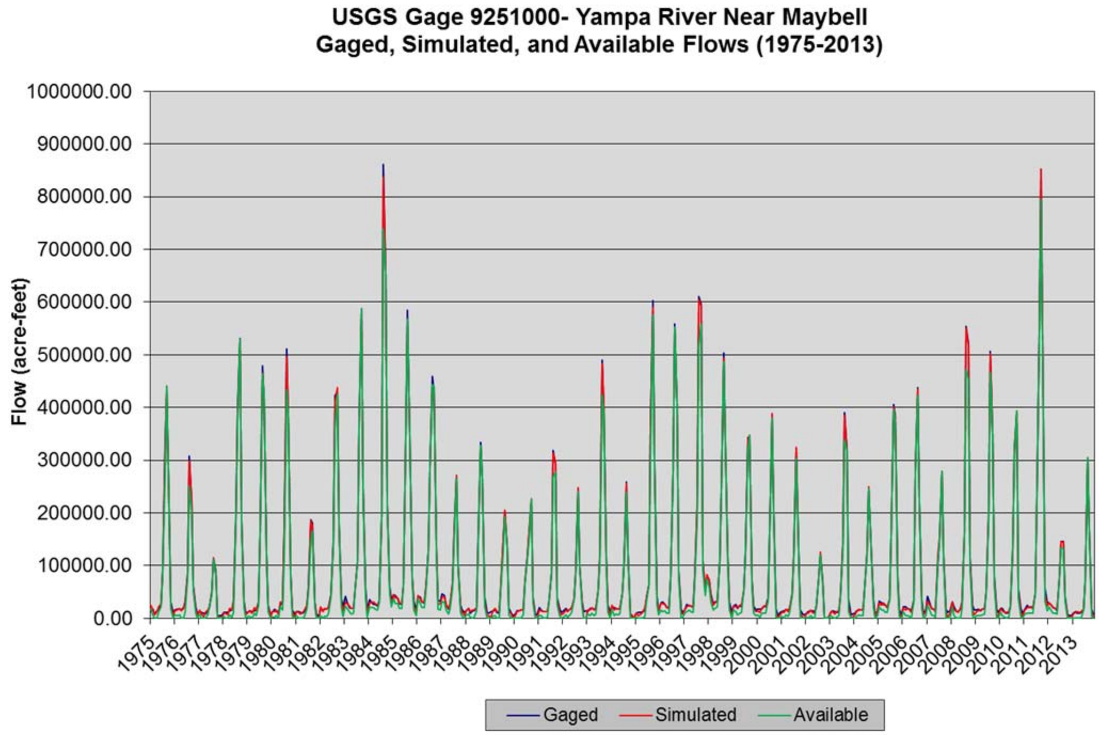


Figure 6.4 - Gaged, Baseline Simulated, and Available Flows (Williams Fork at Mouth)



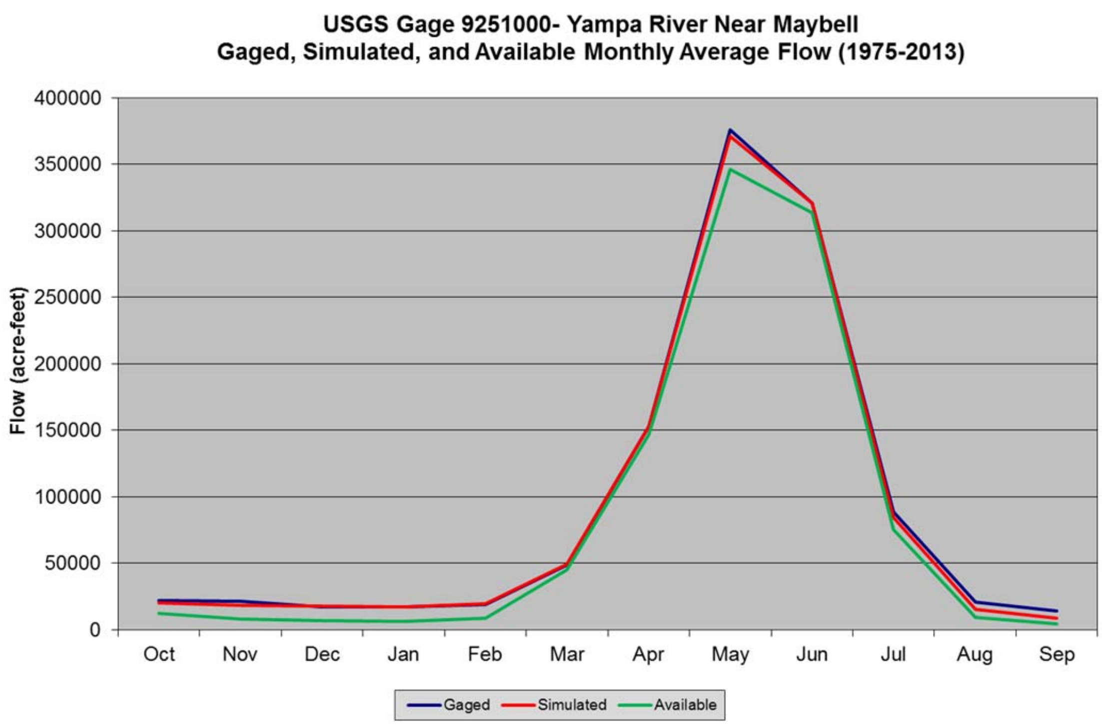
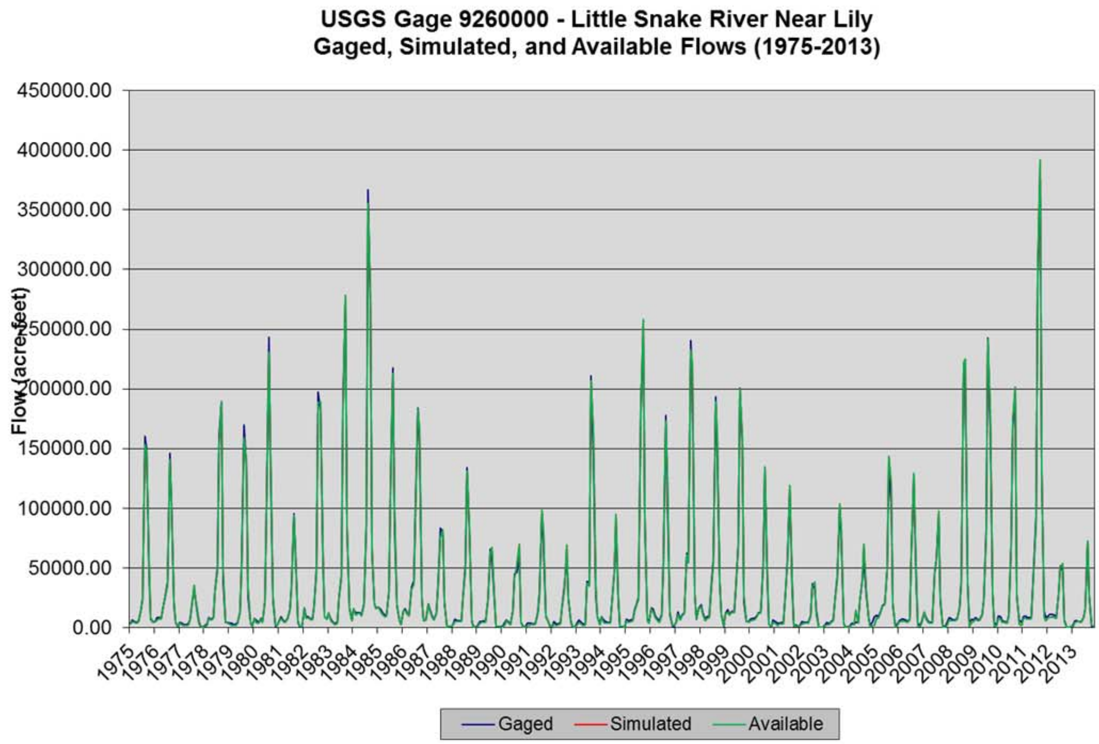


Figure 6.5 - Gaged, Baseline Simulated, and Available Flows (Yampa River near Maybell)



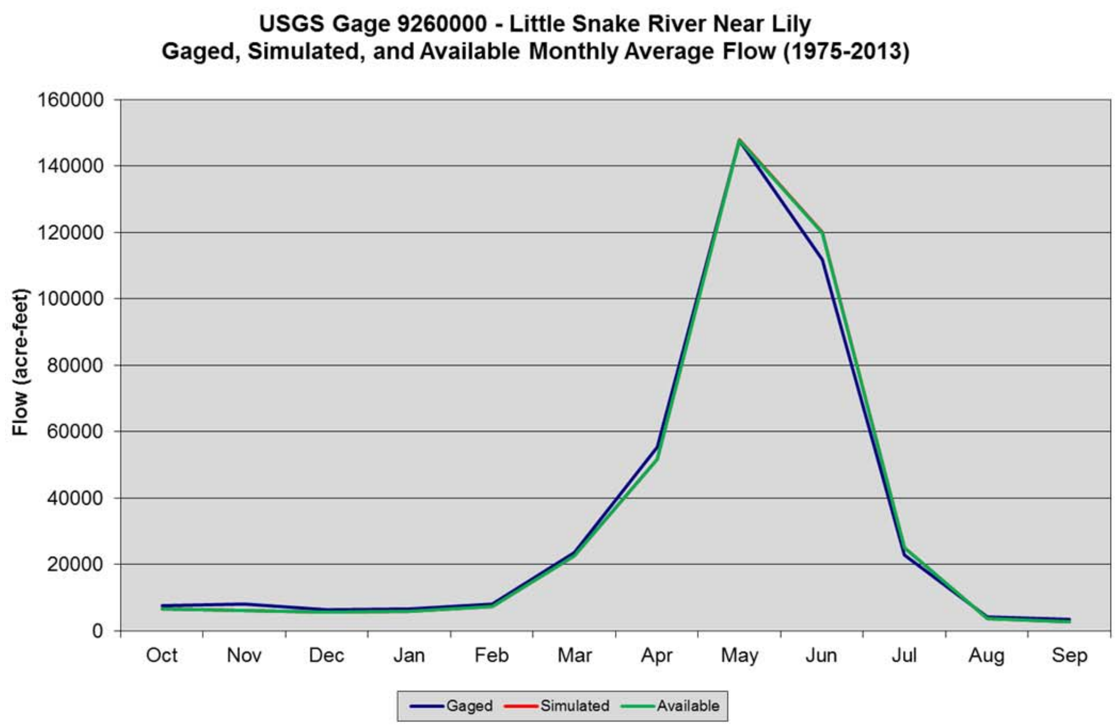


Figure 6.6 - Gaged, Baseline Simulated, and Available Flow (Little Snake River near Lily)

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 Yampa 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 Yampa 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 occur. 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. Baseflow at the next downstream gage may be modeled correctly, but stream gains have been modeled as entering the system further downstream than their actual point of entry, thereby shorting the tributary structure(s). 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, reservoirs responded to demands, and were permitted to seek the level required to meet the demands. Model results were again scrutinized, this time focusing on the operations. For example, operating criteria in the form of monthly targets might be added for reservoirs that operate for unmodeled reasons such as flood control, hydropower generation, or winter maintenance. As another example, where reservoir history revealed that annual administration was not strictly observed, the annual administration feature was removed.

The model at the conclusion of the second step is considered the calibrated model.

7.2 Historical Data Set

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

7.2.1 Demand file

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

7.2.2 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. If capacity changed midway through the study period (e.g., Fish Creek Reservoir), the Historical model takes the enlargement into account.

7.3.3 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 all reservoirs (except for Lake Catamount – see Section 5.6.4). In both calibration runs, when water is released to a downstream diversion, enough water is released to meet the diverter’s historical diverted amount, regardless of the efficiency of that operation.

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 crop supply, based on historical efficiency ▪ Non-irrigation structures – estimated current demand	▪ Historical diversions
Reservoir station (*.res)	▪ Initial content = full	▪ Initial content = Storage on 09/1908.
Reservoir target (*.tar)	▪ Current maximum capacity	▪ First step – historical end of month contents, 0 prior to historical operation ▪ Second step – 0 prior to construction, historical maximum capacity
Operational right (*.opr)	▪ No release to target operations	▪ First step - release-to-target operations allow reservoirs to release to target contents ▪ Second step - 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 Yampa model.

7.3.1 Baseflow Calibration

Previous modeling efforts have focused on increasing baseflows at headwater tributaries and distributing enough water to mainstem baseflow nodes that shortages in historical diversions are minimized. This approach can result in StateMod over-simulating the gains between observed streamflow gages. StateMod compensates for excess water in the river by calculating a negative gain term. It is understood that the White River is a naturally gaining river and baseflow should increase from upstream to downstream. To address losing reaches, significant effort was spent on baseflows during calibration.

Reaches where the combined upstream baseflow is larger than the downstream flow were identified and efforts made to improve the baseflow calibration. This included examining filled end-of-month reservoir contents and diversion records, and adjusting return flow locations. In previous modeling efforts, the approach was to include all available USGS streamgages were included in the model regardless of their measurement period. This was shown to cause problems in the baseflow filling algorithm when the streamgage had a short period of record that did not represent dry, average, and wet conditions. For the current effort, streamgages with limited period of records were removed when the filling techniques introduced either a positive or negative flow bias to the model.

7.3.2 Yampa River Upstream of Stagecoach Reservoir

The previous calibration effort had relied heavily on the neighboring gage for all of the headwater tributaries upstream of Stagecoach Reservoir, in some cases creating losing reaches. This approach was not necessary because there are large positive gains observed between USGS gage 09236000 and 09237500 and the timing of flows on the headwater tributaries is very similar to the timing of the gains observed in the reach. The neighboring gage approach was replaced with the "gains approach". This method is preferred because it maintains the water balance between USGS gages. The historically observed shortages increased slightly from the previous calibration effort, but the simulated flows on the tributaries are more realistic.

The Buckingham Mandall Ditch (5800564) was organized into a multi-structure with Pony Creek Ditch (5800826) and Just Ditch (5800710). This more accurately captures the ability of the structures to supply water to the same irrigated acreages.

7.3.3 Stagecoach Reservoir

In preliminary model runs, simulated flows for the gage 09237500 Yampa River below Stagecoach Reservoir did not match historical flows in later years (1989 through 2013). Specifically, historical content records showed more draw-down than simulated based on modeled reservoir demand. Conversations with the UYWCD indicated that historically, operations to release water have been made independent of downstream demand. Therefore, for the Historical calibration, reservoir targets were set to historical end-of-month and the release to target rule was turned on.

7.3.4 Yampa River Upstream of Lake Catamount

Four headwater tributaries contribute flow to the Yampa River downstream of Stagecoach Reservoir and upstream of Lake Catamount. Special attention was paid to Beaver Creek (a tributary to Morrison Creek) and Morrison Creek. Two future projects are proposed for the Morrison Creek area and correctly estimating the available flow on the tributary is important. The Colorado DWR installed a streamgage near the mouth of Morrison Creek (MORBSCCO) in

May 2009. The period of record is too short to include in the model; comparison of simulated flows to observed flows yielded good results.

7.3.5 Fish Creek Basin

Initial baseflow estimates above the Fish Creek gage resulted in numerous negative values. The problem stemmed from the enlargement of the Fish Creek Reservoir in the mid-1990s. Normal CDSS data filling techniques for the historical end-of-month contents did not take this into account. Missing values throughout the study period were filled with average contents computed for the combined pre-enlargement and post-enlargement periods. This problem was corrected with additional commands in the filling algorithm to limit recorded data used to fill pthe re-enlargement and post-enlargement period. This refinement improved both the balance above the Fish Creek gage, and the baseflow gain term for the gage reach bounded downstream by the Steamboat Springs gage. The Fish Creek gage is one of the upstream gages for this reach.

7.3.6 Yampa River above Hayden

There are several months with negative gains (losses) in this reach of the river. The most likely cause is the incomplete period of record for the gages. While the USGS gage at Steamboat Springs has excellent records from 1910 to present, the other two gages are missing significant periods of time. The Elk River at Milner gage is active from 1904 through 1927 and 1990 to present. Normally, a gage with a compromised period of record would not be added to the network, but the other gage on Elk River has been deactivated (USGS 09241000, Elk River at Clark). Similarly, the Yampa River below Diversion, near Hayden gage was active from 1965 through 1986. This short period of record was supplemented by filling with scaled observations from gage 09244490 (Yampa River above Elkhead Creek near Hayden). The scaling factor was based on the area*precipitation ratio of the gages. Filling some of the missing data reduced the total amount of negative gains.

The missing streamflow is filled by the Mixed Station Model, which has a robust algorithm, but does not check for consistency in filled results among nearby gages. Therefore, the filled data can be over or under estimating natural flows and resulting in negative gains.

To avoid distributing negative gains to headwater tributaries, the neighboring gage approach was used for all tributaries to this reach.

7.3.7 Trout Creek Basin

Trout Creek is the site of a future reservoir project proposed by Peabody Energy. The report *Preliminary Draft Hydrology and Streamflow Assessment Study Report* was prepared to support the reservoir feasibility study. A previous version of the Yampa River StateMod model was modified to support the hydrology assessment and those modifications have been incorporated into the updated Yampa River model. The neighboring gage approach was used for the headwaters of the Trout and Fish Creek with the USGS gage 09241000 (Elk River at Clark). However, the Trout Creek Basin is at significantly lower elevation than the Elk River at Clark gage and, confirmed by temporary gaging, the peak runoff occurs earlier in the season. The natural flow time series was modified in TSTool so that 14 percent of the May flow volume is shifted to April; maintaining the annual flow volume and the volume in other months. This is performed in the TSTool file “ShiftTroutCreek.TSTool”. The shift is applied to baseflow nodes 5701009, 5700612, and 5700544.

7.3.8 Elk River Basin

The network diagram was corrected for the Elk River Basin. Several ditches were not located correctly with relationship to confluences with tributaries. The gains approach was implemented for almost all of the tributaries to the Elk River; however two baseflow nodes are assigned the neighboring gage approach in order to delay the melt compared to the mainstem gains: 5800663 and 5800695. Delaying the melt for these locations reduced the late season shortages.

7.3.9 Little Snake Basin

The following describes previous calibration issues related to the development phase in which the Wyoming portion of the Little Snake basin was added to the model, using information from the State of Wyoming’s Green River Basin Plan and Little Snake River spreadsheet model. No additional calibration of the Little Snake Basin occurred with this model update.

Initially, the mass balance for the purpose of estimating baseflow at the Lily gage produced many negative values, primarily in dry Octobers. The previous version of the model featured fairly high October diversions in Wyoming, based on the U.S. Bureau of Reclamation’s CULR annual figures, distributed to monthly. Therefore, there were enough diversions to add to the gaged flow to boost the baseflow positive even when the gage was very low or zero. However, both the GRBP consumptive use analysis and GRBP diversion records showed no October diversions in this area at all. After reviewing the GRBP, the following adjustments were made sequentially to reduce October return flows and improved the baseflow estimation above the Lily gage:

1. According to GRBP, most structures irrigate only 6 days in August and 5 days in September. Historical diversions (which had heretofore been estimated as crop irrigation requirement divided by .55, the maximum efficiency used in GRBP) for Wyoming aggregates below Baggs were recomputed for August and September , multiplying each by a fraction representing irrigation days as a fraction of the entire month (6/31 for August and 5/30 for September).
2. The same adjustment was made to Wyoming aggregates above Baggs.

3. Incidental losses below Baggs were changed from 3 percent to 10 percent. This change was made to both Wyoming and Colorado structures. Changing only the first month of the return flow pattern had virtually no impact on October return flows, as October diversions were nearly all zero. The 10 percent loss was next characterized as 7 percent occurring in the first month of the return, and 3 percent occurring in the second month. While high losses are credible in this area, it is believed that these are more related to delivery and overland or tailwater returns, rather than groundwater returns, so the loss was not "pushed" into the second month, even though that would have helped the balance.

These adjustments reduced the number of occurrences of negative baseflows, and their magnitudes, but it did not eliminate them. Furthermore, there were many months when the baseflow gain between 09257000 Little Snake River near Dixon and 09260000 was negative. The one headwater node in this reach, WYD_009 (headwater node on Muddy Creek), was assigned zero flow in these months. Therefore, a "setprfgage" command was added to the **StateDMI** command file to supply positive flows in the upper reaches of this basin. Every available Little Snake gage was checked to find the one that would generally produce the smallest amount of flow on Muddy Creek. Gage 09255500 Savery Creek near Upper Station was selected, although it probably results in higher simulated than actual flows on Muddy Creek. To reduce the amount of water entering the mainstem from Muddy Creek, the lowest node on Muddy Creek (993003) was made a baseflow point. Area was taken from the drainage area of a short term USGS gage near the mouth of Muddy Creek, and precipitation was estimated based on surrounding precipitation terms and field observations of the basin.

July and August shortages in the upper Little Snake were occurring because water was being bypassed to meet Westside and First Mesa demand. Those structures would sweep the river, but then the baseflow gain would enter the stream at the Dixon gage (09257000), which was simulating higher than actual. Several steps were taken in succession:

1. WYD_006 was made a baseflow point so that WYD_006, First Mesa, and Westside would have access to the gain at the Dixon gage. The structures are all very close to the gage.
2. The return flow point for Westside Canal had been WYD_011, after the GRBP spreadsheet model. GRBP didn't have the aggregated Colorado node 54_ADY023 as an option for the return location, and review of the mapping indicated that it would be appropriate to make the returns available to the Colorado aggregate.
3. Priority of Westside Canal, First Mesa Canal, WYD_007, WYD_009, and WYD_011 was lowered, to be junior to most Slater and Willow Creek rights (other than an enlargement or two). Since Wyoming administration numbers are not available and/or consistent with Colorado's, previous versions of the model simply endowed Wyoming structures with rights that were senior to Colorado rights in the Little Snake, to prevent Colorado rights from calling out the Wyoming rights. This

approach proved detrimental to the upper tributaries that come out of Colorado, and was therefore modified.

Structures on Willow Creek remained shorted because of physical availability. The Willow Creek Ditch (5400591) was particularly shorted. In previous versions of the model, it had been made a baseflow node. In the context of the previous version's hydrology, this placed more water in Willow Creek most of the time. In this model, because the Dixon gage was added to the model, and because the late season diversions in Wyoming were so different, there were many more baseflow losses below the Willow Creek gage and the Lily gage, and the baseflow node at the Willow Creek Ditch served at critical times to reduce flow rather than add to it. Therefore, the node was changed so that it is no longer a baseflow node. This improved shortages but did not eliminate them. Further review revealed that the Willow Creek Ditch's historical diversion records are often higher than baseflow at the gage, which is just hundreds of feet upstream. Relative locations of the ditch and the gage were confirmed in a conversation with Bob Plaska (Division Engineer, Division 6). The discrepancy can be attributed to few observations at the headgate and the State's carry forward filling method.

7.4 Calibration Results

Calibration of the Yampa River model is considered very good as all streamflow gages deviate from historical values by one percent or less, on an average annual basis. More than half the diversion structures' shortages are at or below 1 percent on an annual basis, and the basin-wide shortage is 1.9 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 Yampa River model, for the calibration period (1975-2013). Following are observations based on the summary table:

- Surface water inflow to the basin averages 2.07 million acre-feet per year, and surface water outflow averages 1.88 million acre-feet per year.
- Annual diversions amount to approximately 540,000 acre-feet on average.
- Approximately 173,000 acre-feet per year is 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 Yampa River Model (af/yr)

Month	Inflow	Return	From Soil Moisture	Total Inflow	Diversions	Resvr Evap	Stream Outflow	Resvr Change	To Soil Moisture	Soil Moistur e Change	Total Outflow	Inflow - Outflow	CU
OCT	37,189	18,912	961	57,062	18,981	751	37,570	-1202	1,005	-44	57,062	0	5,256
NOV	32,844	10,248	0	43,092	7,172	-28	30,392	5556	442	-442	43,092	0	1,444
DEC	27,950	8,134	0	36,084	6,731	-303	29,238	418	251	-251	36,084	0	1,534
JAN	27,941	7,250	0	35,191	6,600	-323	28,872	43	166	-166	35,191	0	1,454
FEB	31,597	6,192	0	37,789	6,120	-80	32,020	-271	120	-120	37,789	0	1,338
MAR	83,782	6,419	0	90,201	7,457	371	80,618	1755	223	-223	90,201	0	1,785
APR	247,074	11,230	711	259,014	16,972	942	235,033	5356	1,486	-776	259,014	0	4,502
MAY	659,154	50,668	2,249	712,071	96,572	1777	608,669	2803	5,695	-3446	712,070	0	30,073
JUN	634,398	93,086	1,495	728,979	169,735	2512	559,414	-4177	6,965	-5469	728,979	0	52,789
JUL	207,170	71,423	4,541	283,135	116,589	2389	163,735	-4119	1,575	2966	283,134	0	46,503
AUG	51,554	39,114	5,710	96,378	52,702	1742	38,086	-1861	510	5199	96,378	0	25,931
SEP	31,027	27,325	3,585	61,937	33,525	1481	25,625	-2279	823	2762	61,937	0	14,476
Avg Total	**2,071,679**	**350,002**	**19,252**	**2,440,932**	**539,156**	**11,231**	**1,869,273**	**2020**	**19,262**	**-10**	**2,440,931**	**0**	**187,084**

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

7.4.2 Streamflow Calibration Results

Table 7.3 summarizes the annual average streamflow for water years 1975 through 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. Differences between gaged and simulated average annual streamflows are within 1 percent. Figures 7.1 through 7.7 (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. 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.

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	
09236000	29,633	29,731	169	1%	Bear River Near Toponas
09237500	56,399	56,335	-156	0%	Yampa River Below Stagecoach Reservoir
09238900	46,630	46,626	-133	0%	Fish Creek At Upper Station
09239500	319,743	319,647	-201	0%	Yampa River At Steamboat Springs
09241000	231,396	231,446	-59	0%	Elk River At Clark
09242500	375,151	375,047	5	0%	Elk River near Milner
09244410	809,677	809,707	-342	0%	Yampa River Below Diversion near Hayden
09245000	42,324	42,324	0	0%	Elkhead Creek near Elkhead
09245500	*No gage during calibration period*				North Fork Elkhead Creek near Elkhead
09246920	7,588	7,599	-11	0%	Fortification Creek near Fortification
09247600	911,530	911,475	56	0%	Yampa River below Craig
09249000	*No gage during calibration period*				East Fork of Williams Fork near Pagoda
09249200	28,073	28,072	0	0%	South Fork of Williams Fork near Pagoda
09249750	154,432	154,532	-101	0%	Williams Fork At Mouth
09251000	1,120,083	1,120,171	-530	0%	Yampa River Near Maybell
09253000	168,891	168,925	-34	0%	Little Snake River Near Slater
09255000	61,113	61,245	-131	0%	Slater Fork Near Slater
09255500	39,077	39,092	-15	0%	Savery Creek at Upper Station

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
09258000	8,030	8,074	-44	-1%	Willow Creek Near Dixon
09260000	405,988	408,562	-2,574	-1%	Little Snake River Near Lily
09260050	1,508,234	1,511,890	-3,656	0%	Yampa River At Deerlodge Park

7.4.3 Diversion Calibration Results

Table 7.4 summarizes the average annual shortage (deviation of simulated from historical diversion) for water years 1975 through 2013, on a sub-basin basis. 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 1.9 percent in the calibration run. Estimated diversions are within a few percentages of recorded diversions except in a couple areas:

- Shortages in District 58 are generally confined to ungaged tributaries in the upper Bear River, likely due to distribution of baseflows to ungaged locations. The model uses the same distribution factors in every simulation month, whereas, in reality, the percentage contribution of sub-basins may change from month to month.
- The Union Ditch (580914) is shorted because the water rights were transferred to Stagecoach Reservoir as consumptive use credits. The majority of the ditch service area was inundated by Stagecoach Reservoir. Seasonal diversions continue to support wetlands and are charged against the consumptive use credits.
- During simulation, the Allen Basin Supply ditch diverts less than it did historically. In the model, the diversion is limited by available capacity in the reservoir rather than headgate demand.
- Structures in the Fortification Creek, Marapos Creek (Williams Fork tributary), and Milk Creek basins continue to exhibit greater shortages than other tributaries. Adjustments made to baseflow hydrology during calibration reduced the shortages compared to previous modeling efforts.

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

Tributary or Sub-basin	Historical	Simulated	Historical minus Simulated	
			Volume	Percent
Upper Yampa River (Stagecoach Reservoir gage and above)	106,952	102,352	4,600	4.3
Yampa River (Stagecoach Reservoir to Elk River)	41,377	39,986	1,391	3.4
Elk River	37,977	37,924	53	0.1
Trout Creek	12,657	12,063	594	4.7
Elkhead Creek	6,593	6,379	213	3.2
Fortification Creek	7,855	7,175	679	8.7
Yampa River (Elk River to Craig gage)	72,415	72,374	41	0.1
Williams Fork	34,557	34,072	485	1.4
Yampa River (Williams Fork to Little Snake River)	62,825	62,601	224	0.4
Upper Little Snake River (above Muddy Creek)	117,122	100,332	16,789	14.3
Lower Little Snake River (Muddy Creek and below)	51,721	50,540	1,180	2.3
Yampa River below Little Snake River	12,905	12,683	222	1.7

7.4.4 Reservoir Calibration Results

Figures 7.8 through 7.11 (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:

- During the 70's and 80's, Stillwater reservoir does not appear to make large enough releases. The observed end of month content time series is fairly incomplete for that time period, and required significant filling. The reservoir operations included in StateMod are better at mimicking operations starting in the mid-1990s.

- Yamcolo reservoir matches releases during dry years, but not during wetter years. It is possible that during average or wet years, StateMod does not generate a reservoir demand because diversions are satisfied from direct diversions, but it appears that irrigators still requested reservoir releases.

- Fish Creek Reservoir generally does not make enough releases. Baseflows into the reservoir may be too high, or reservoir operations not accounted for in StateMod may be occurring.

- Elkhead Reservoir does not simulate much use. Historically, Elkhead has released water for the Craig Power Plant and for the CWCB fish flows.

7.5.5 Irrigation Consumptive Use Calibration Results

Table 7.5 compares StateCU estimated crop consumptive use with StateMod estimated crop consumptive use for explicit structures, aggregate structures, and basin total (exclusive of Wyoming, where lack of ditch specific irrigated lands, diversion records, and crops preclude a reliable StateCU estimate). Note that only crop consumptive use is shown: consumptive use attributable to municipal, industrial, or transbasin diversions is not included. As shown, both explicit and aggregate structure consumptive use are less than StateCU results.

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

Comparison	StateCU Results (af/yr)	Calibration Run Results (af/yr)	% Difference
Explicit Structures	84,984	82,969	2%
Aggregate Structures	40,355	40,283	0%
Basin Total (within Colorado)	126,569	123,252	3%

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

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
4400501	654	628	26	4	W R DEAKINS DITCH
4400506_D	1060	1060	0	0	Wideman Ditch DivSys
4400509	935	935	0	0	WILSON DITCH
4400511	2503	2472	30	1	WISCONSIN DITCH
4400514	357	355	2	0	WOOLEY & JOHNSON D
4400516	335	317	17	5	YAMPA DITCH
4400517	1224	1224	0	0	YAMPA VAL STOCK BR CO D
4400518	349	343	6	2	YELLOW JACKET DITCH NO 1
4400519	159	159	0	0	YELLOW JACKET DITCH NO 2
4400522	12112	12112	0	0	CRAIG STATION D & PL #1
4400524	167	167	0	0	A Q DITCH 1
4400527	263	263	0	0	AIR LINE IRR D
4400529	572	551	21	4	BEHRMAN DITCH 1
4400533	183	127	56	31	ANDERSON DITCH
4400541	711	711	0	0	BAILEY DITCH
4400570	1342	1342	0	0	CARD DITCH
4400572	83	83	0	0	CARRIGAN-AVERILL D
4400573	703	594	109	15	CATARACT DITCH
4400581	1803	1803	0	0	CRAIG WATER SUPPLY PL
4400583	2724	2724	0	0	CROSS MTN PUMP - GROUNDS
4400584	2574	2570	4	0	CROSS MTN PUMP NO 1
4400585	347	346	0	0	CRYSTAL CK DITCH
4400586	2237	2237	0	0	D D & E DITCH
4400587	1438	1438	0	0	D D FERGUSON D NO 2
4400589	6214	6214	0	0	DEEP CUT IRR D
4400590	1301	1288	13	1	DEER CK & MORAPOS D
4400593	381	369	12	3	DENNISON & MARTIN D
4400601	721	721	0	0	DUNSTON DITCH
4400607_D	5250	5227	24	0	Egry Mesa Ditch DivSys
4400611	919	758	161	18	ELK TRAIL DITCH
4400612	657	537	120	18	ELKHORN IRR DITCH
4400613	236	236	0	0	ELLGEN DITCH
4400614	337	292	45	13	ELLIS & KITCHENS D

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
4400628	335	334	1	0	GIBBONS WILSON JORDAN D
4400635	451	451	0	0	GRIESER DITCH
4400638	311	309	1	0	HADDEN BASE DITCH
4400644	268	267	2	1	HARPER DITCH 1
4400645	208	200	9	4	HARPER DITCH 2
4400647	769	678	91	12	HAUGHEY IRR DITCH
4400650	17	17	0	2	HIGHLINE MESA BAKER D
4400651	1787	1761	26	1	HIGHLAND DITCH
4400652	875	875	0	0	HIGHLAND AKA HIGHLINE D
4400660	417	417	0	0	J A MARTIN DITCH
4400661	597	594	2	0	J P MORIN DITCH
4400670	218	218	0	0	J W KELLOGG D 2
4400674	137	135	2	1	JUNIPER DITCH
4400675	3220	3220	0	0	JUNIPER MTN TUNNEL
4400677	1556	1552	3	0	K DIAMOND DITCH
4400681	349	327	22	6	LAMB IRR DITCH
4400687	2180	2180	0	0	LILY PARK D PUMP STA NO
4400688	1513	1315	197	13	LITTLE BEAR DITCH
4400691	1029	1029	0	0	M DITCH
4400692	2132	2095	37	2	MARTIN CK DITCH
4400694	16631	16631	0	0	MAYBELL CANAL
4400695	75	75	0	0	MAYBELL MILL PIPELINE
4400698	280	275	6	2	MCDONALD DITCH
4400699	672	655	17	2	MCKINLAY DITCH NO 1
4400700	1264	1213	51	4	MCKINLAY DITCH NO 2
4400702	1691	1691	0	0	MCINTYRE DITCH
4400706	530	530	0	0	MILK CK DITCH
4400711	824	818	6	1	MOCK DITCH
4400716	119	119	0	0	MULLEN DITCH
4400720	477	467	10	2	MYERS DITCH NO 1
4400723	913	912	0	0	NICHOLS DITCH NO 1
4400724	1750	1735	15	1	NORVELL DITCH
4400726	56	56	1	1	OWEN CARRIGAN DITCH
4400729	1751	1747	4	0	PATRICK SWEENEY D
4400731	1310	1310	0	0	PECK IRRIG D

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
4400735	624	623	1	0	PINE CK DITCH
4400740	710	710	0	0	RATCLIFF DITCH
4400747	177	176	2	1	ROBY D AKA ROBY D NO 1
4400748	159	158	1	1	ROBY DITCH NO 2
4400749	76	76	0	0	ROUND BOTTOM D NO 1
4400750	280	280	0	0	ROUND BOTTOM D NO 2
4400751	105	105	0	0	ROUND BOTTOM DITCH
4400763	1117	1109	8	1	SMITH DITCH
4400765	926	854	72	8	SOUTH SIDE DITCH
4400770	224	224	0	0	STARR IRRIG DITCH
4400776	396	281	115	29	SULLIVAN SEEPAGE D
4400778	1421	1416	5	0	SUNBEAM DITCH
4400785	738	677	62	8	TIPTON IRR DITCH
4400786	1482	1476	5	0	TISDEL D NO 2
4400790	1218	1218	0	0	UTLEY DITCH
4400801	1172	1172	0	0	CROSS MOUNTAIN PUMP DITC
4400806	215	215	0	0	ELLGEN NO 2 DITCH
4400808_D	177	174	3	2	Five Pines Pump DivSys
4400812	223	223	0	0	HART DITCH
4400814	516	513	3	1	HIGHLINE DITCH
4400820	1214	1214	0	0	LOWRY SEELEY PUMP
4400821	259	259	0	0	MACK DITCH
4400830	1310	1310	0	0	OLD SWEENEY DITCH
4400834	297	295	2	1	ROWLEY PUMP STATION
4400851	360	347	12	3	MORGAN DITCH
4400863_D	2199	2189	10	0	Henry Sweeney Ditch
4400998	326	307	19	6	DRY COTTONWOOD DITCH 1
4401122	1819	1807	12	1	VAUGHN PUMP
4402001	126	123	3	2	ASHBAUGH PUMP NO 1
4402029	0	0	0	0	Fut. Yampa R Milk Crk
4402207	222	222	0	0	BROCK D VANTASSEL TRANS
4402214	218	169	49	23	WISE DITCH ALT PT
4404325_D	0	0	0	0	Fut Oxbow Rampart Res
44_ADY012	1046	1026	19	2	Diversion Aggregate
44_ADY013	3203	3203	0	0	Diversion Aggregate

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
44_ADY014	4465	4465	0	0	Diversion Aggregate
44_ADY015	3233	3233	0	0	Diversion Aggregate
44_ADY016	4377	4377	0	0	Diversion Aggregate
44_ADY017	655	655	0	0	Diversion Aggregate
44_ADY018	1788	1788	0	0	Diversion Aggregate
44_ADY019	2636	2630	6	0	Diversion Aggregate
44_ADY025	4536	4314	222	5	Diversion Aggregate
44_AMY001	742	742	0	0	44_AMY001_YampaRbelCraig
44_FDP001	0	0	0	0	44_FDP_WD_44
44_WSA	0	0	0	0	44_WSA_EDFdemand
5400500	379	369	9	2	ANDERSON DITCH
5400507	1195	1171	24	2	BEELER DITCH
5400513	1081	1018	63	6	CLARK BUTLER WESTFALL D
5400531	2281	2250	32	1	HEELEY DITCH
5400532	1304	1279	24	2	HOME SUPPLY DITCH
5400543	978	963	14	1	LUCHINGER DITCH
5400548	1300	1300	0	0	MORGAN & BEELER D
5400549	714	710	4	0	MORGAN SLATER DITCH
5400554	308	252	56	18	PERKINS FOX DITCH
5400555	1032	1001	31	3	PERKINS IRR DITCH
5400564	623	616	7	1	SALISBURY DITCH
5400568	847	842	5	1	SLATER FORK DITCH
5400570	605	535	69	11	SLATER PARK DITCH NO 1
5400571	308	264	45	14	SLATER PARK DITCH NO 2
5400574_D	965	746	219	23	Slater Park Ditch DivSys
5400583	5233	5230	3	0	TROWEL DITCH
5400590	15541	3233	12308	79	WEST SIDE CANAL
5400591	2114	1851	263	12	WILLOW CK DITCH
5400592	353	345	8	2	WILSON DITCH
5400594	579	579	0	0	WOODBURY DITCH
5401070_D	520	476	43	8	Anderson D Grieve DivSys
5402068	653	602	52	8	STATE LINE WW DITCH
5402075	446	432	15	3	WILLOW CK SEEP & WASTE D
54_ADY020	6409	6323	87	1	Diversion Aggregate
54_ADY021	2205	2191	14	1	Diversion Aggregate

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
54_ADY022	6595	6489	106	2	Diversion Aggregate
54_ADY023	21211	20944	267	1	Diversion Aggregate
5500504	1104	1054	50	5	ESCALANTA PUMP 2
5500506	2079	2079	0	0	MAJORS PUMP NO 2
5500507	874	874	0	0	NINE MILE IRR DITCH
5500508	724	724	0	0	NINE MILE IRR PL
5500509	1537	1537	0	0	ONECO PUMP NO 2
5500513	592	591	0	0	VISINTAINER DITCH
5500519	730	730	0	0	RINKER PUMP D
5500537	1536	1536	0	0	LEFEVRE NO 1 PUMP
5500538	194	194	0	0	DUNN PUMP & PL
5501011	810	810	0	0	DEWEY SHERIDAN D
5501081	1967	1956	12	1	RAFTOPOULOS LSR PUMP
5502034	155	155	0	0	HAYSTACK PUMP
55_ADY024	1108	521	587	53	Diversion Aggregate
55_ADY026	404	404	0	0	Diversion Aggregate
55_AMY003	13	13	0	0	55_AMY003_LSnakeRnrLily
55_FDP001	0	0	0	0	Fu_Dev_55
5600536	472	472	0	0	THOMAS DOUDLE DITCH
5600562	125	125	0	0	MCKNIGHT NO 1
5600621	279	279	0	0	GOODMAN DITCH
56_ADY027	6934	6934	0	0	Diversion Aggregate
56_FDP001	0	0	0	0	Diversion Aggregate
5700508_D	3141	3141	0	0	Brock Ditch DivSys
5700510	4002	4000	2	0	CARY DITCH CO DITCH
5700512	4884	4884	0	0	COLO UTILITIES D & PL
5700517	681	621	60	9	DAVID M CHAPMAN DITCH
5700519	811	811	0	0	DENNIS & BLEWITT D
5700524	458	428	29	6	EAST SIDE DITCH
5700525	519	510	9	2	EAST SIDE DITCH 2
5700535	381	381	0	0	ERWIN IRRIGATION DITCH
5700539	5900	5900	0	0	GIBRALTAR DITCH
5700544	873	852	21	2	HIGHLAND DITCH
5700545	925	904	21	2	HOMESTEAD DITCH
5700555_D	1047	967	81	8	Last Chance Ditch DivSys

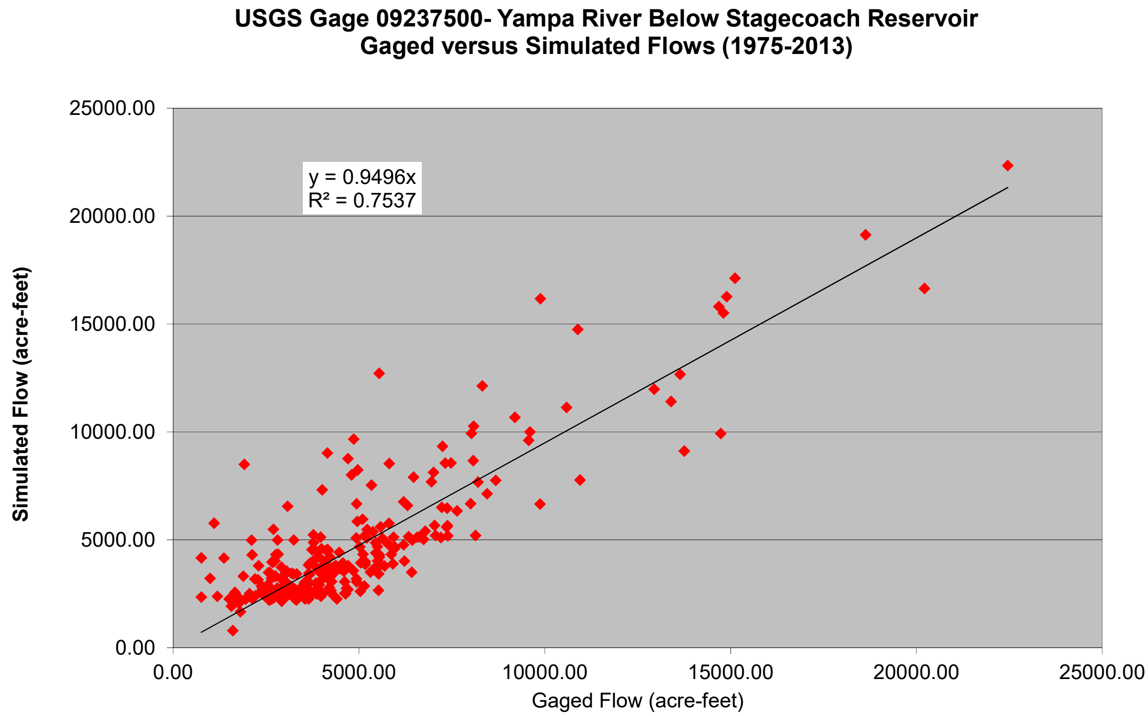
WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
5700561	457	393	63	14	MALE MOORE CO DITCH
5700563	3530	3530	0	0	MARSHALL ROBERTS DITCH
5700576_D	866	815	51	6	Orno Ditch DivSys
5700579_D	846	846	0	0	R E Clark Ditch DivSys
5700584	528	528	0	0	SADDLE MOUNTAIN DITCH
5700592	7010	7010	0	0	SHELTON DITCH
5700608	776	776	0	0	TROUT CREEK DITCH 3
5700609	222	216	6	3	TROUT CREEK DITCH 2
5700611	5665	5665	0	0	WALKER IRRIG DITCH
5700612	113	111	2	1	WEST SIDE DITCH
5700622	2647	2647	0	0	WILLIAMS IRRIG DITCH
5700623_D	722	705	17	2	Williams Park Ditch DivS
5700635	1036	984	52	5	KOLL DITCH
5700675	135	135	0	0	UTTERBACK ENL COLO UTE D
5702083	240	239	2	1	DRY CREEK DIVERSION
5704204_D	0	0	0	0	Fut Peabody Trout Res
5704629	1403	1297	106	8	RICH DITCH
57_ADY009	907	901	6	1	Diversion Aggregate
57_ADY010	1721	1721	0	0	Diversion Aggregate
57_ADY011	2305	2299	5	0	Diversion Aggregate
57_ADY012	1653	1620	32	2	Diversion Aggregate
57_AMY001	484	484	0	0	57_AMY001_YampaRabCraig
57_FDP001	0	0	0	0	Fu_Dev_57
57_NAG01	0	0	0	0	Nu_Ag_Dev
57_NMID01	0	0	0	0	Nu_Fu_M&I
57_NPWR01	0	0	0	0	Nu_Fu_Pwr
5800500	1453	1453	0	0	ACTON D
5800506	166	458	-292	-177	ALLEN BASIN SUPPLY D
5800508	1032	1006	26	3	ALPHA DITCH
5800530	2234	2234	0	0	BAXTER DITCH
5800532	263	239	24	9	BEAVER CREEK D
5800539	4123	4102	21	1	BIG MESA DITCH
5800540	201	200	1	0	BIJOU DITCH
5800541	1595	1595	0	0	BIRD DITCH
5800556	403	399	3	1	BRINKER CREEK DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
5800559	575	575	0	0	BROOKS DITCH
5800561	295	295	0	0	BRUMBACK DITCH
5800564	2346	2346	0	0	BUCKINGHAM MANDALL D
5800568	1322	1322	0	0	BURNETT DITCH
5800569	198	194	4	2	BURNT MESA D
5800574	272	272	0	0	C R BROWN MOFFAT COAL D
5800577	1066	1066	0	0	CAMPBELL DITCH
5800582	467	467	0	0	CHARLES & A LEIGHTON D
5800583_D	314	314	0	0	Charles H Kemmer Ditch D
5800588	714	714	0	0	CLARK & BURKE DITCH
5800590	127	124	3	3	COLEMAN DITCH
5800591	734	734	0	0	COLLINS DITCH
5800599	628	628	0	0	CULLEN DITCH 2
5800604	128	124	4	3	DAY DITCH
5800612	456	456	0	0	DEVER DITCH
5800618	1578	1578	0	0	DUQUETTE DITCH
5800622	1497	1497	0	0	EGERIA DITCH
5800623	1014	1013	0	0	EKHART DITCH
5800626	2667	2659	8	0	ELK VALLEY DITCH CO. D.
5800627	2305	2021	285	12	ENTERPRISE DITCH
5800628	290	290	0	0	EXCELSIOR DITCH
5800634	842	836	7	1	FERGUSON DITCH
5800640	381	367	14	4	FIRST CHANCE DITCH
5800642	2151	2151	0	0	FISH CR MUN WATER INTAKE
5800643	1471	1471	0	0	FIX DITCH
5800649_D	1787	1787	0	0	Franz Ditch DivSys
5800662	1904	1904	0	0	GRAHAM & BENNETT D
5800663	523	523	0	0	GREER DITCH
5800665	162	161	1	0	GUIDO DITCH
5800684	887	887	0	0	HERNAGE & KOLBE DITCH
5800685	356	356	0	0	HIGH MESA IRR D
5800687	347	325	22	6	HIGHLINE BEAVER DITCH
5800694	2075	2075	0	0	HOOVER JACQUES DITCH
5800695	785	784	0	0	HOT SPGS CR HIGHLINE D
5800710	212	198	14	7	JUST DITCH

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
5800714	2149	2149	0	0	KELLER DITCH
5800717	1152	1152	0	0	KINNEY DITCH
5800721	534	528	6	1	L L WILSON D
5800722	411	411	0	0	LAFON DITCH
5800728	595	595	0	0	LARSEN DITCH
5800730	604	604	0	0	LATERAL A DITCH
5800731	290	288	1	0	LAUGHLIN DITCH
5800738	1197	1197	0	0	LINDSEY DITCH
5800749	380	380	0	0	LOWER PLEASANT VALLEY D
5800756	356	356	0	0	LYON DITCH 2
5800763	4233	4233	0	0	MANDALL DITCH
5800767	332	329	4	1	MAYFLOWER DITCH
5800777	413	413	0	0	MILL DITCH 1
5800782	205	205	0	0	MOODY DITCH
5800783	3032	3028	4	0	MORIN DITCH
5800798	924	924	0	0	NICKELL DITCH
5800801	299	299	0	0	NORTH HUNT CREEK DITCH
5800805	700	697	3	0	OAK CREEK DITCH
5800807	524	522	2	0	OAK DALE DITCH
5800808	1021	1014	7	1	OAKTON DITCH
5800809	206	206	0	0	OLD CABIN DITCH
5800811	224	224	0	0	OLIGARCHY DITCH
5800813	434	432	2	0	PALISADE DITCH
5800821	1462	1462	0	0	PENNSYLVANIA DITCH
5800826	303	278	25	8	PONY CREEK D
5800830	163	150	12	8	PRIEST DITCH
5800844	325	325	0	0	SAGE HEN DITCH
5800847_D	360	359	0	0	Sand Creek Ditch DivSys
5800850	370	369	1	0	SANDHOFER DITCH
5800863	1660	1660	0	0	SIMON DITCH
5800866	709	638	70	10	SNOW BANK DITCH
5800868	1908	1810	99	5	SODA CREEK DITCH
5800872	577	577	0	0	SOUTH SIDE DITCH
5800879	2542	2433	109	4	STAFFORD DITCH
5800895_D	1142	1141	1	0	Sunnyside Ditch 1 DivSys

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
5800897	2299	2299	0	0	SUTTLE DITCH
5800908	712	712	0	0	TRULL MORIN DITCH
5800914	1328	651	676	51	UNION DITCH
5800915_D	966	966	0	0	Upper Elk River D Co Div
5800916	1065	1065	0	0	UPPER PLEASANT VALLEY D
5800917	424	421	3	1	VAIL SAVAGE DITCH
5800920	10218	9476	742	7	WALTON CREEK DITCH
5800922	510	505	4	1	WEISKOPF DITCH
5800924	166	165	0	0	WELCH & MONSON D
5800928	417	414	4	1	WHEELER BROS DITCH
5800933	553	553	0	0	WHIPPLE DITCH
5800939	304	304	0	0	WINDSOR DITCH
5800940	590	590	0	0	WITHER DITCH
5800943_D	638	518	120	19	Woodchuck Ditch DivSys
5800944	2273	2273	0	0	WOOLERY DITCH
5800945	1157	1157	0	0	WOOLEY DITCH
5800980	556	519	37	7	GABIOUD DITCH
5801021	859	859	0	0	LEE IRRIGATION D
5801035	546	546	1	0	NORTH SIDE DITCH
5801074	438	430	8	2	ROSSI HIGHLINE DITCH
5801084	165	147	19	11	ROSSI DITCH 1
5801085	489	489	0	0	MILL CREEK DITCH
5801428	477	475	2	0	THOMPSON SEEP WASTE D
5801583	46516	43998	2518	5	STAGECOACH HYDROELECTRIC
5801869	0	0	0	0	Fut Morrison Crk 04CW10
5801919	0	0	0	0	Fut STEAMBOAT ELK RIVER
5802374	278	278	0	0	STEAMBOAT SKI CORPORATIO
5804213_A	0	0	0	0	Stagecoach Aug Plan
5804630	222	222	0	0	Dome_Creek_Ditch
5804684	676	674	2	0	Sarvis Ditch
5804685_D	4822	4818	4	0	Stillwater Ditch DivSys
5804686	1676	1676	0	0	Stillwater to Colorado
5805055	111	110	1	1	STEAMBOAT MUN WELL A
5805059_D	155	154	1	1	Mt Werner Wells G and H
5805066	356	356	0	0	MT WERNER YAMPA DIV

WDID	Historical	Simulated	Historical minus Simulated		Structure Name
			Volume	Percent	
58_ADY001	2008	2008	0	0	Diversion Aggregate
58_ADY002	3984	3963	21	1	Diversion Aggregate
58_ADY003	4571	4561	10	0	Diversion Aggregate
58_ADY004	2849	2849	0	0	Diversion Aggregate
58_ADY005	4745	4745	0	0	Diversion Aggregate
58_ADY006	2053	2053	0	0	Diversion Aggregate
58_ADY007	2938	2938	0	0	Diversion Aggregate
58_ADY008	4454	4454	0	0	Diversion Aggregate
58_AMY001	1342	1342	0	0	58_AMY001_AMY001_Yampa@S
58_FDP001	0	0	0	0	Fu_Dev_58
9900528	11448	11433	15	0	Cheyenne_City
9900538	0	0	0	0	New_Wyo_Ag
9900539	15397	14642	755	5	WY_First_Mesa_Canal
9900540	23417	21928	1489	6	WY_Westside_Canal
WYD_001	1132	1104	28	2	WY_Divs_blw_Slater_Creek
WYD_002	666	608	58	9	WY_Divs_abv_High_Savery
WYD_003	1299	1260	39	3	WY_Divs_blw_High_Savery
WYD_004	1385	1342	42	3	WY_Divs_btwn_gages_Svery
WYD_005	5678	4953	725	13	WY_Divs_lower_SaveryCrk
WYD_006	1237	1208	29	2	WY_Divs_blw_SaveryCreek
WYD_007	9526	9404	122	1	WY_Divs_blw_WillowCreek
WYD_008	115	109	6	5	WY_Baggs&Dixon
WYD_009	2547	2486	61	2	WY_Divs_Muddy_Creek
WYD_010	1449	1438	11	1	WY_Divs_blw_Muddy_Creek
WYD_011	4500	4472	27	1	WY_Divs_abv_StateLine
4400501	654	628	26	4	W R DEAKINS DITCH
4400506_D	1060	1060	0	0	Wideman Ditch DivSys
Basin Total	**565,631**	**540,798**	**24,833**	**2**	



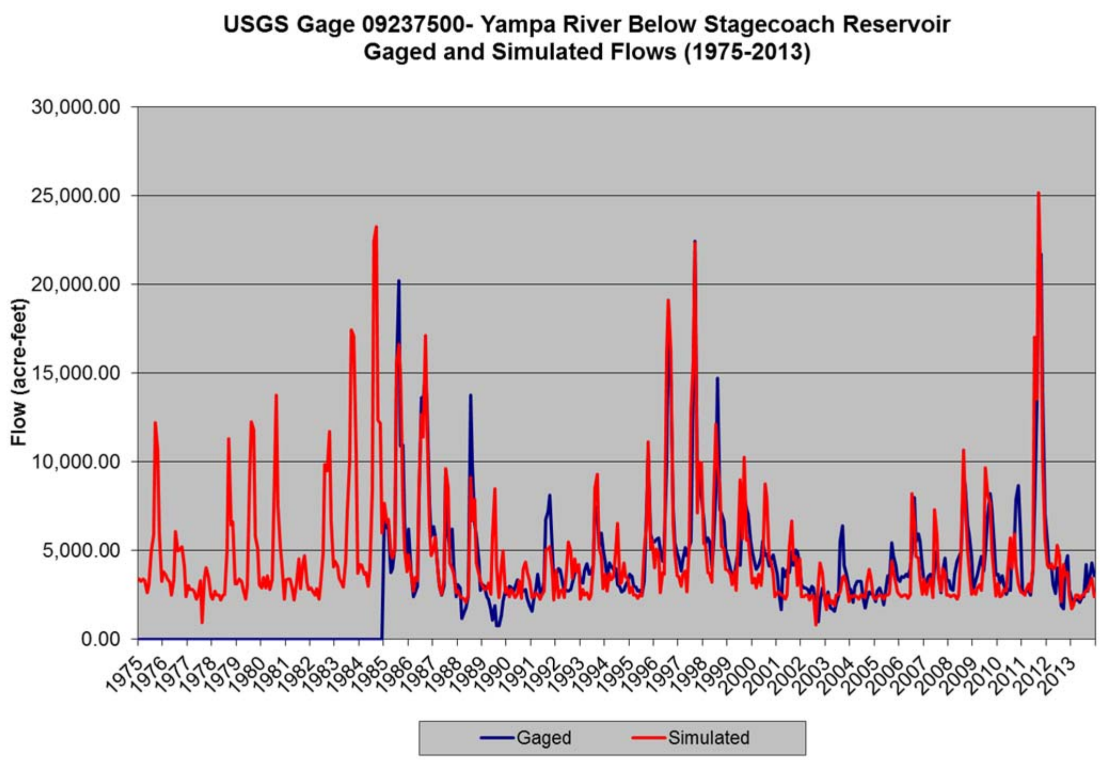
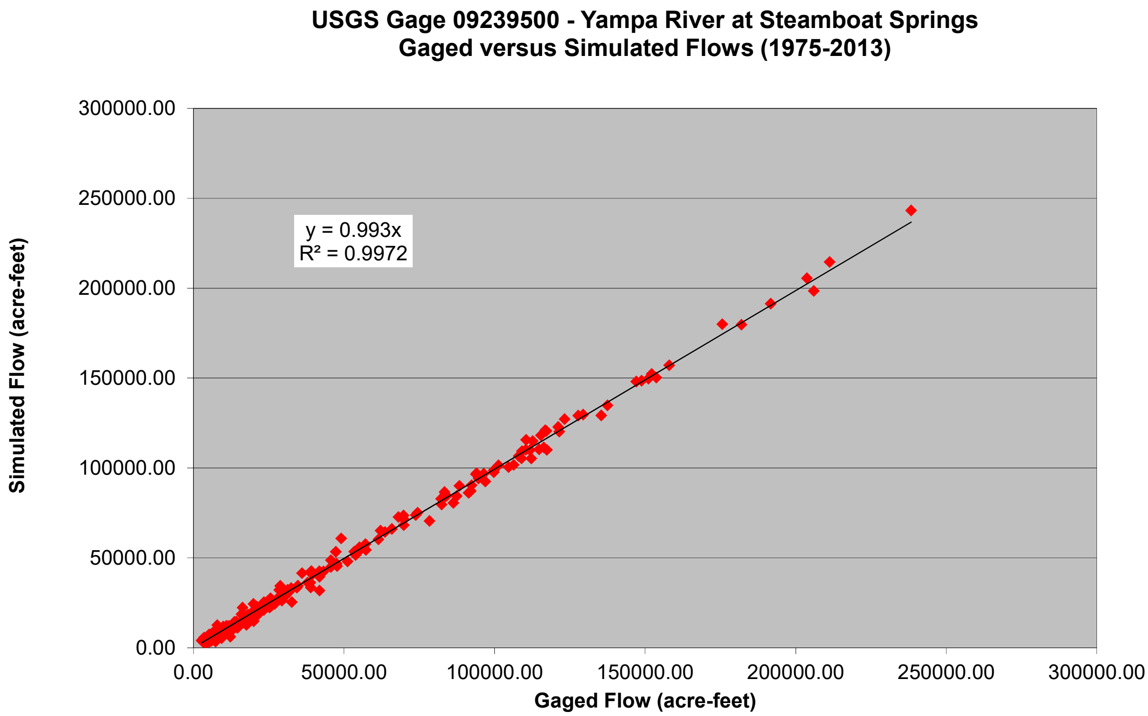


Figure 7.1 - Streamflow Calibration – Yampa River below Stagecoach Reservoir



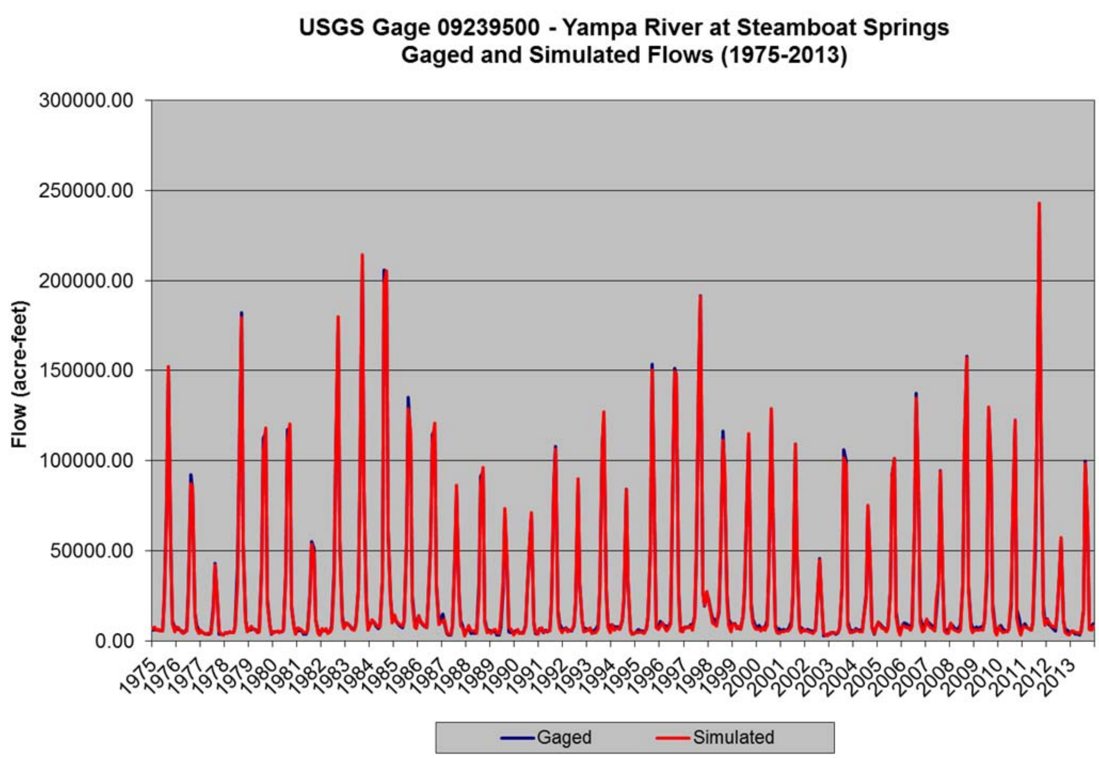
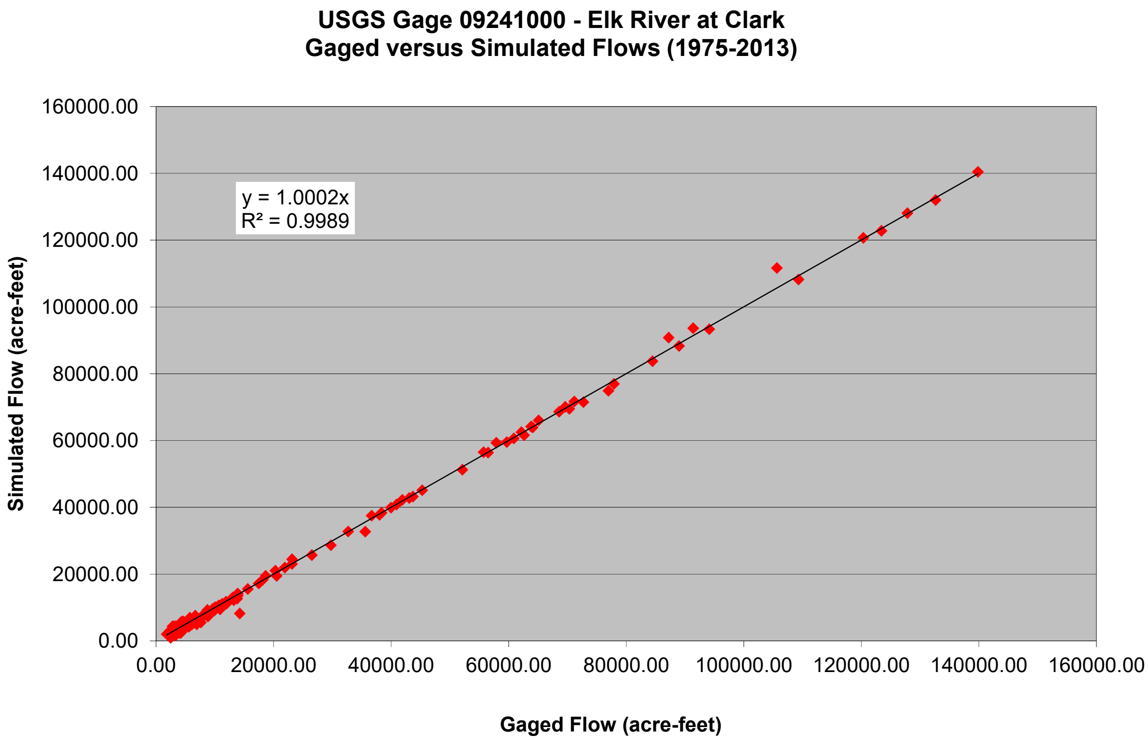


Figure 7.2 - Streamflow Calibration – Yampa River at Steamboat Springs



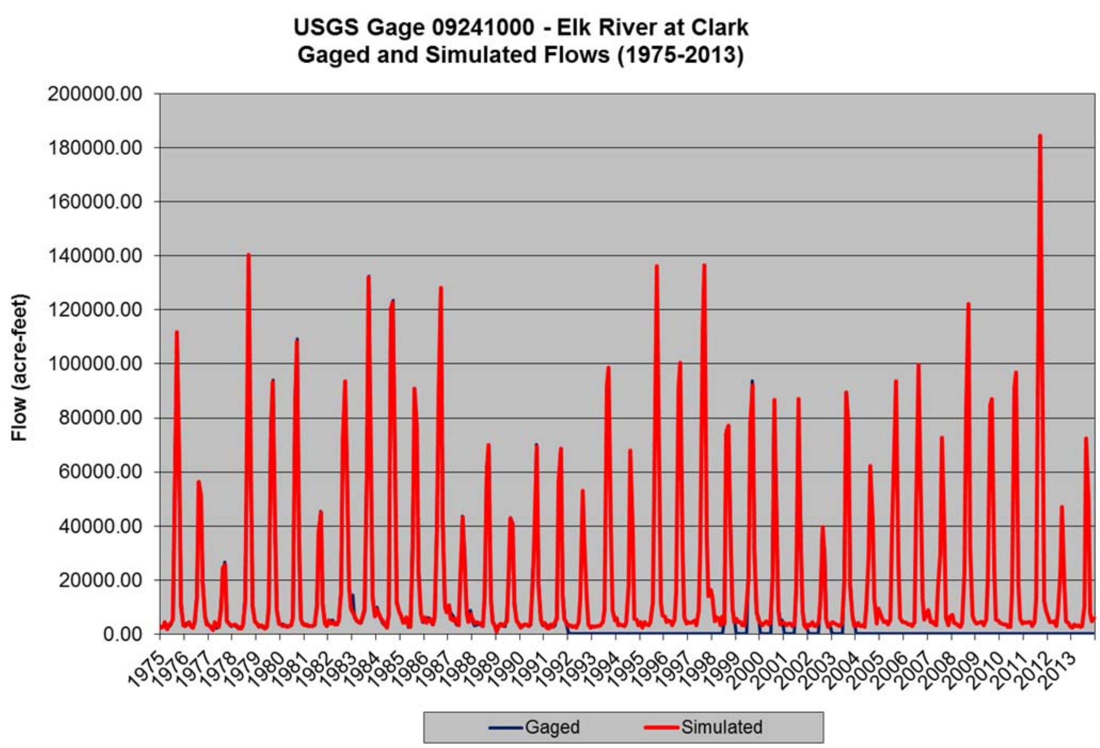
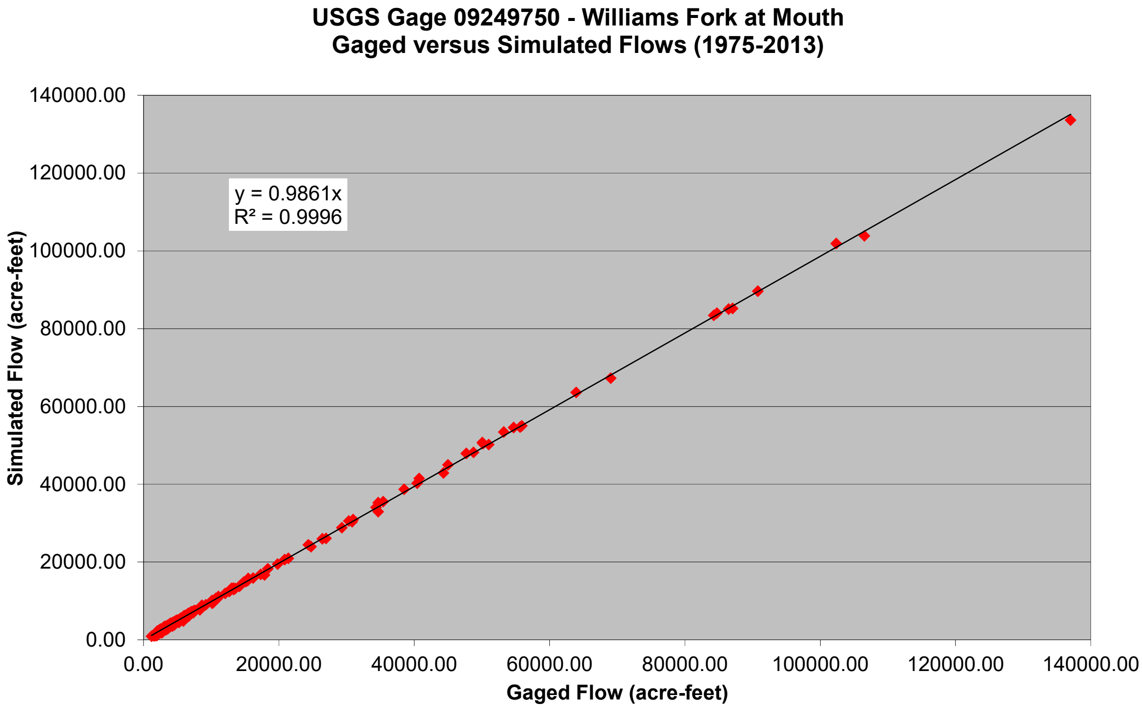


Figure 7.3 - Streamflow Calibration – Elk River at Clark



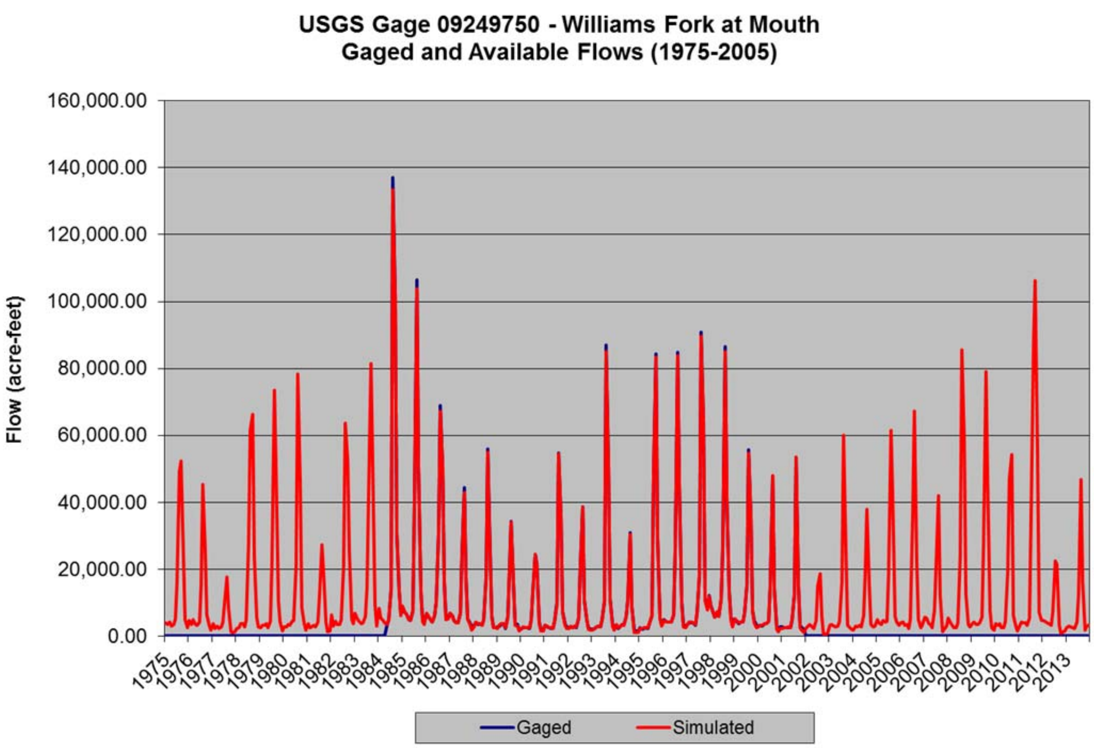
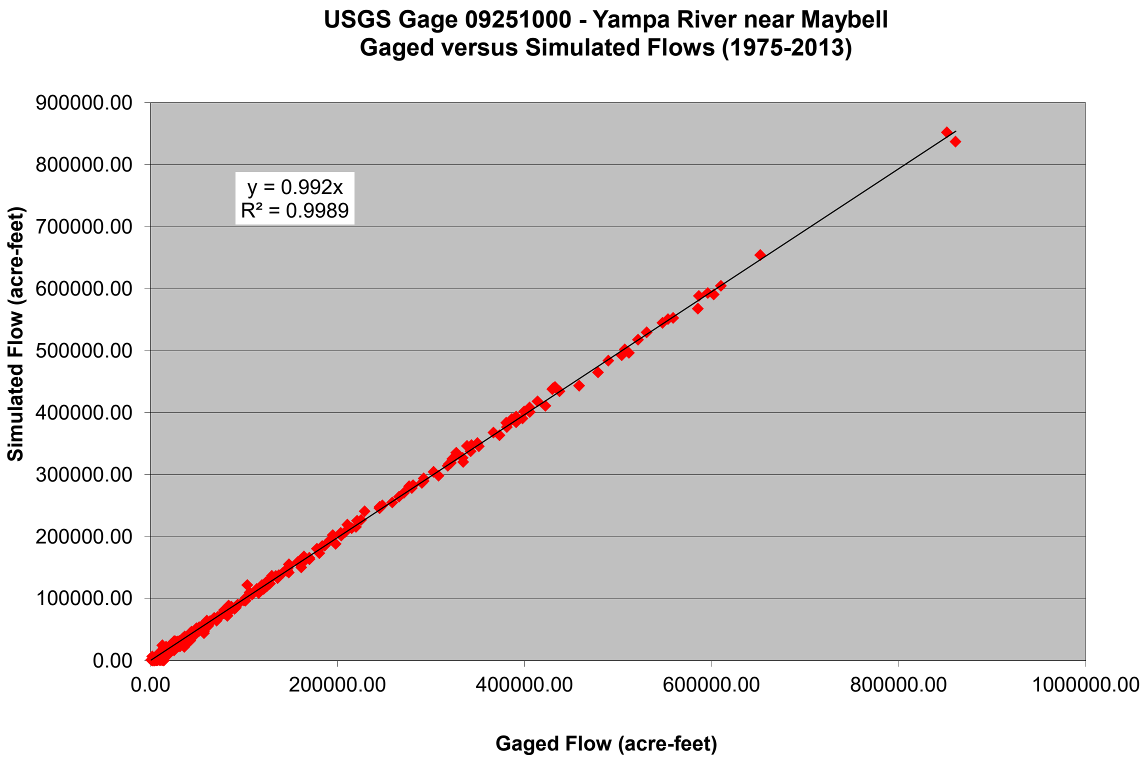


Figure 7.4 - Streamflow Calibration – Williams Fork at Mouth



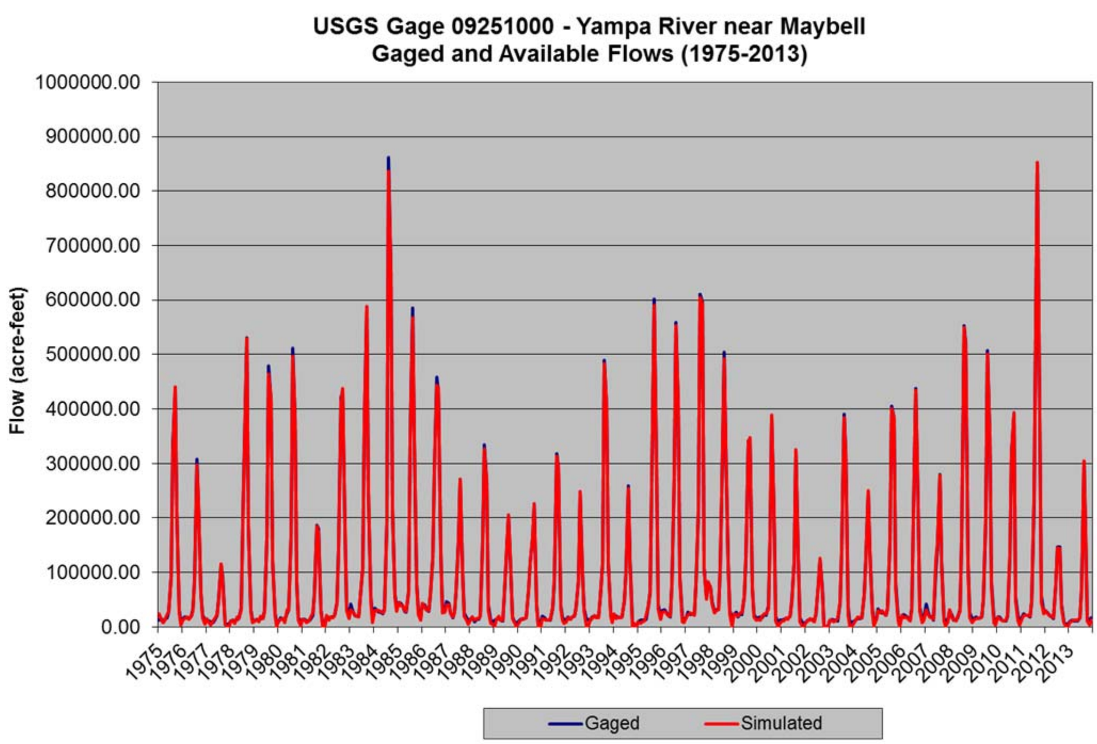
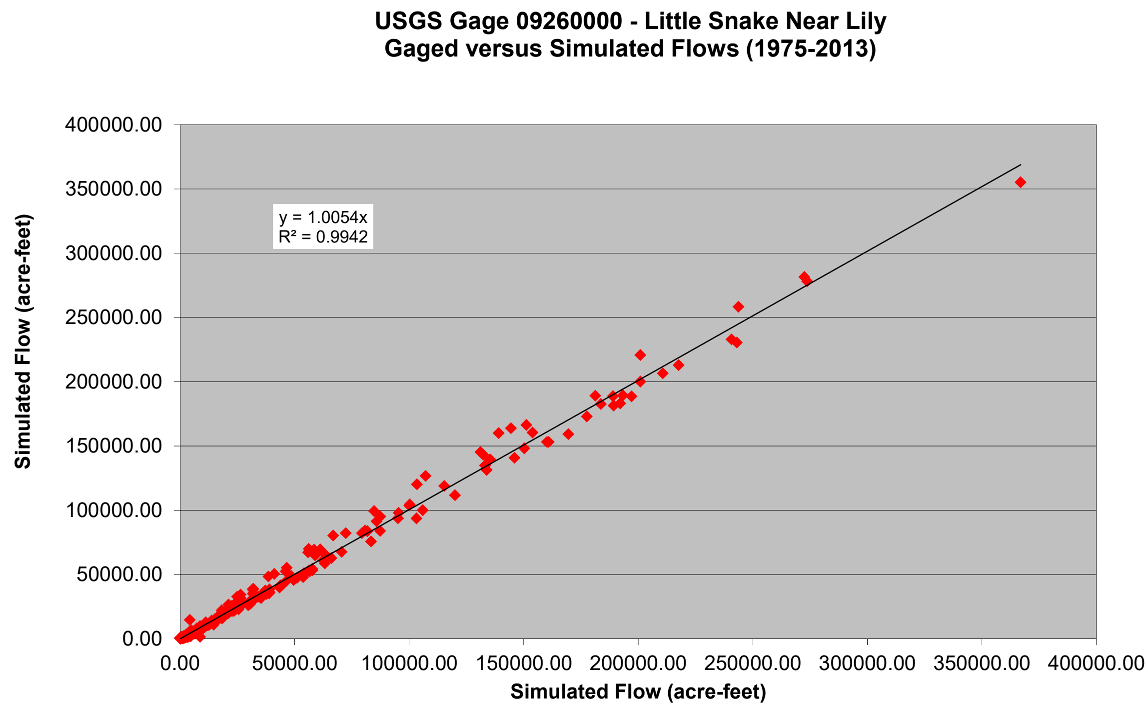


Figure 7.5 - Streamflow Calibration – Yampa River near Maybell



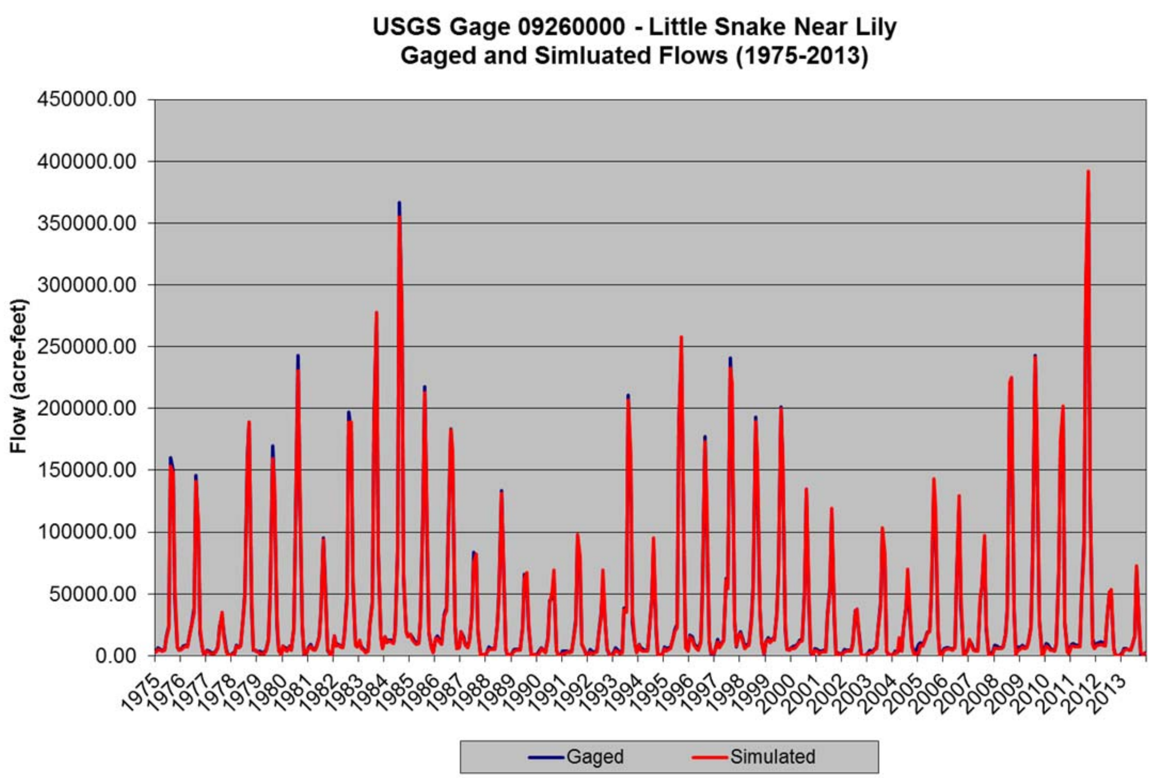


Figure 7.6 - Streamflow Calibration - Little Snake River near Lily

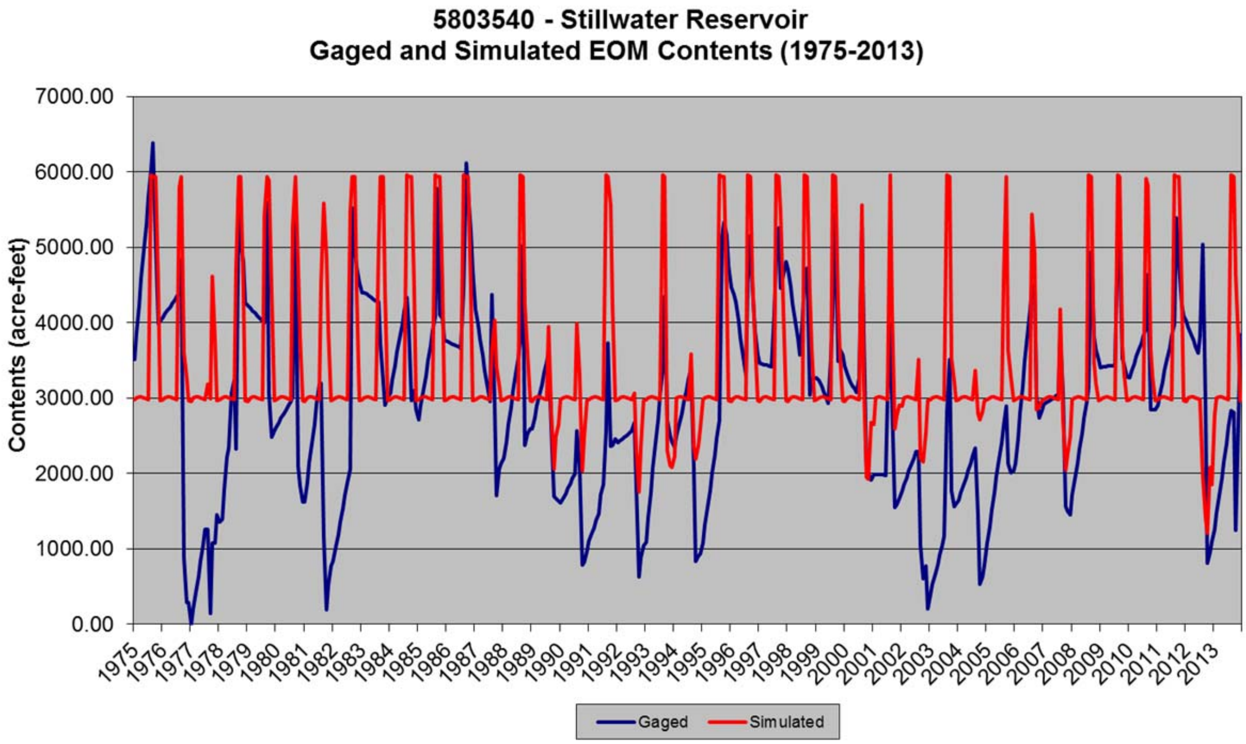


Figure 7.7 - Reservoir Calibration – Stillwater Reservoir

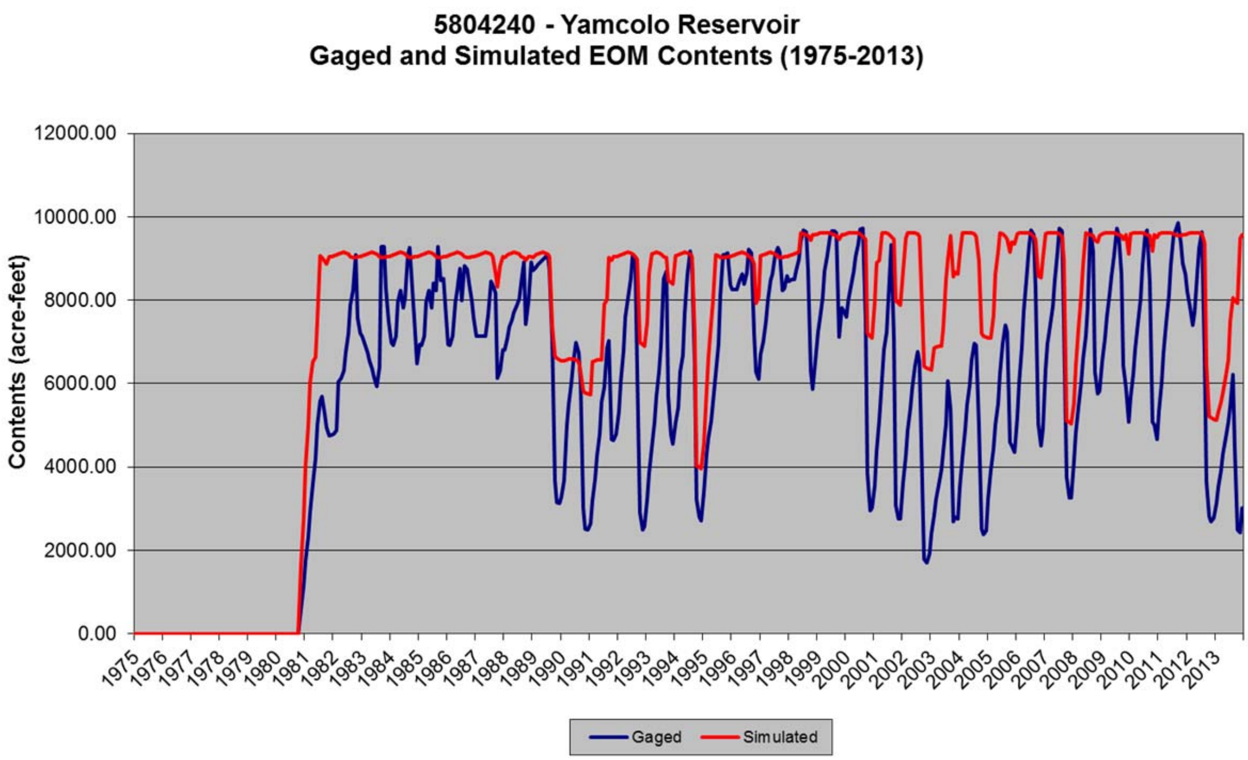


Figure 7.8 - Reservoir Calibration – Yamcolo Reservoir

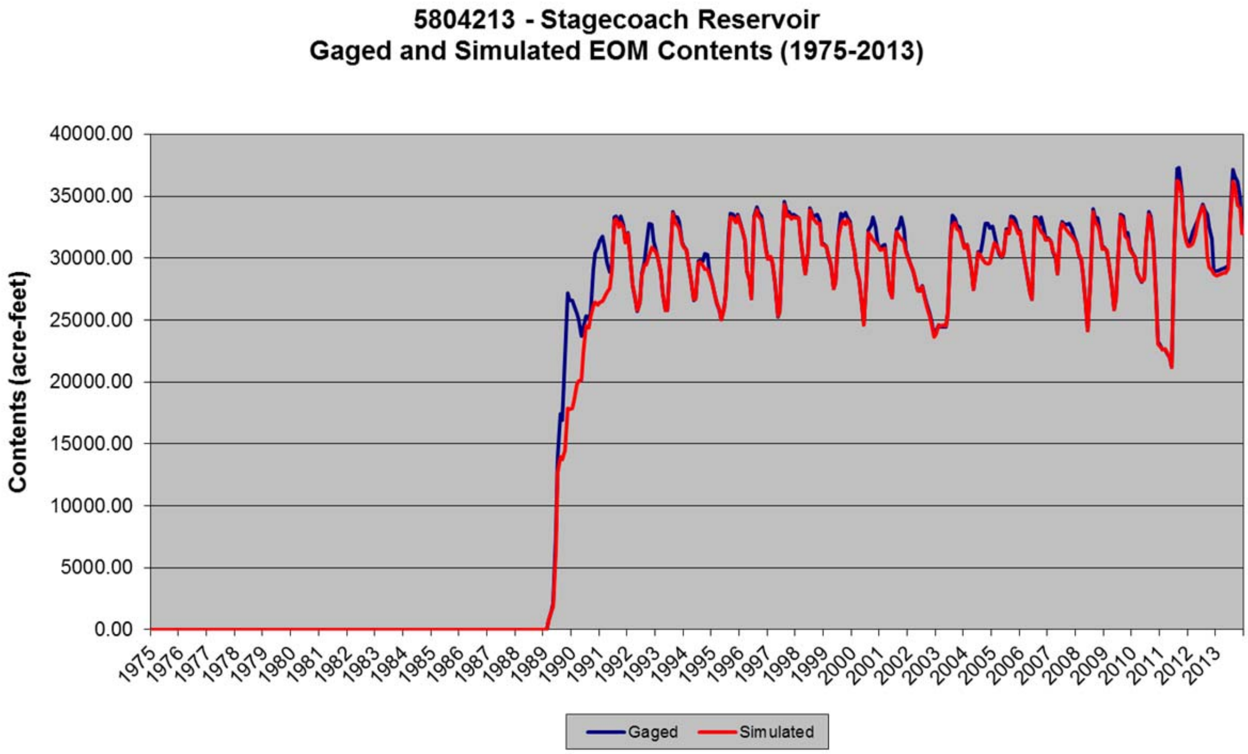


Figure 7.9 - Reservoir Calibration – Stagecoach Reservoir

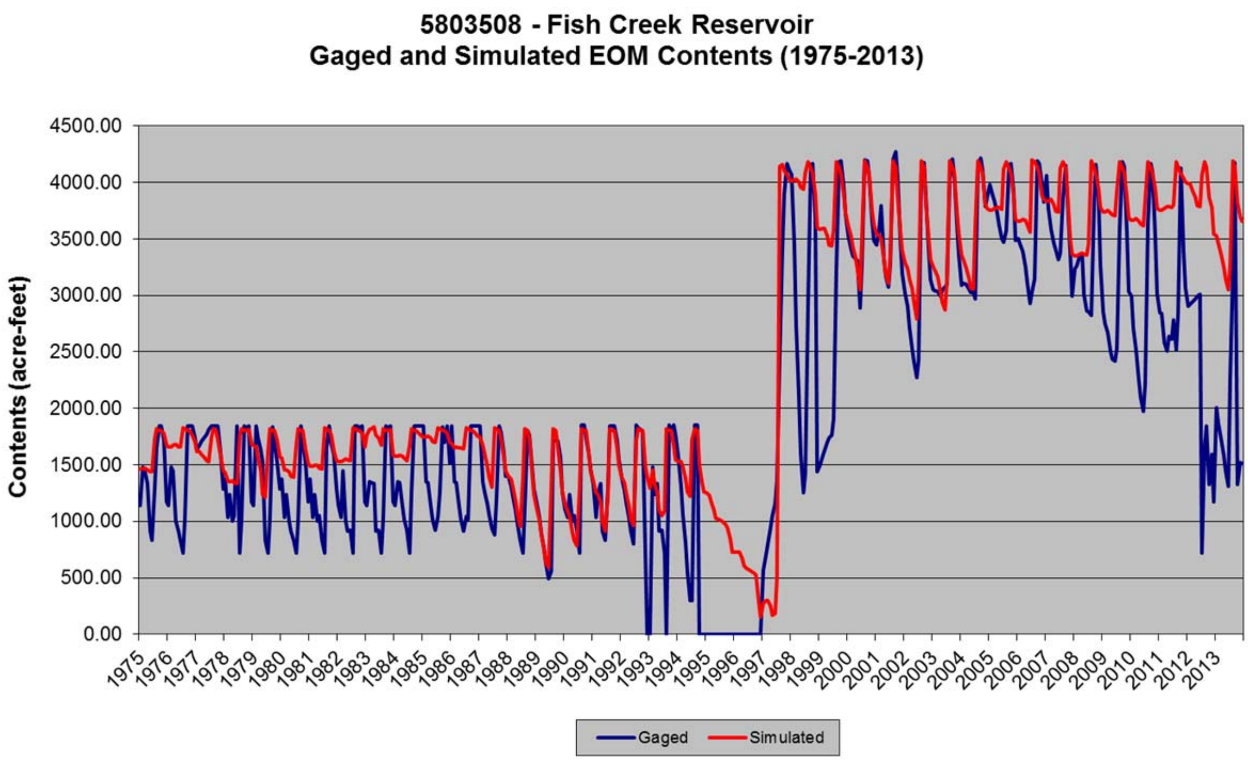


Figure 7.10 - Reservoir Calibration - Fish Creek Reservoir

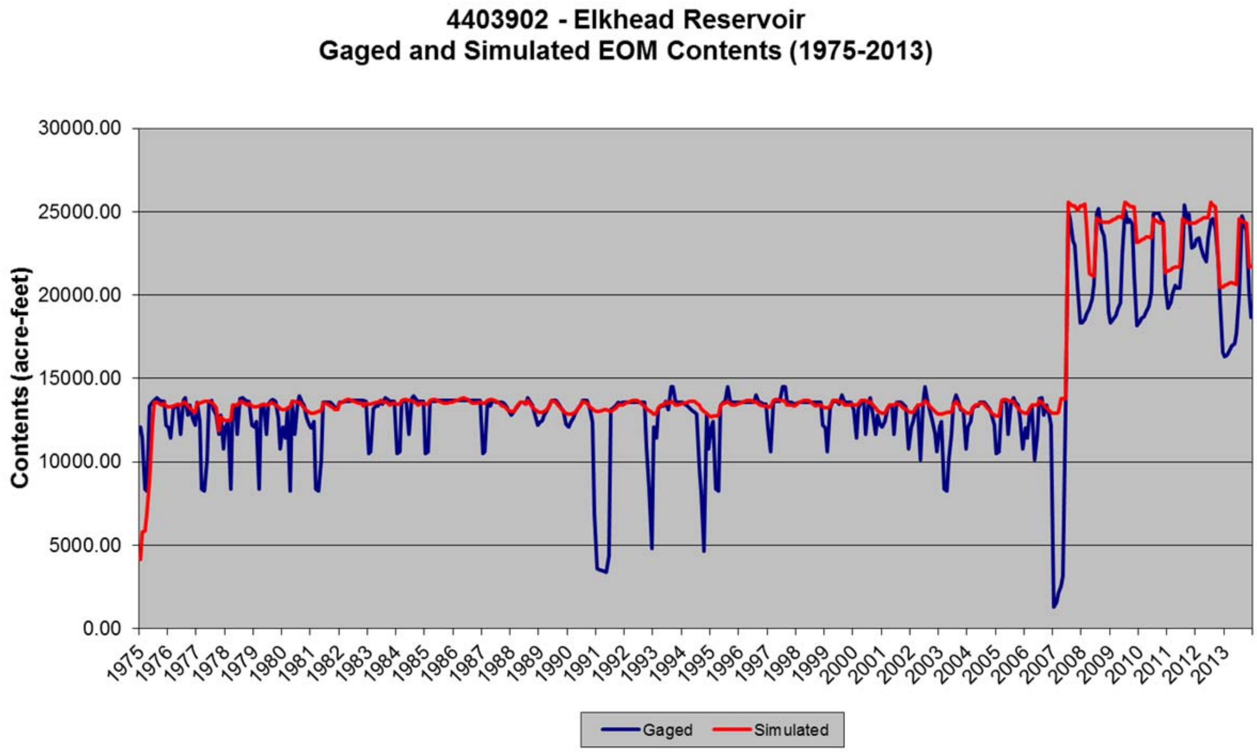


Figure 7.11 - Reservoir Calibration – Elkhead Reservoir

Appendix A

Aggregation of Irrigation Diversion 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 Part 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 Yampa 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 multistructures, based on their association with other structures as outlined in Part 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 Yampa River Basin modeling effort to general group structures by tributaries with combined acreage less than 3,000.
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: Yampa River Basin Aggregation Summary

Aggregation ID	Aggregation Name	No. of Structures	2005 Acres	2010 Acres
44_ADY012	Elkhead Creek	10	377	346
44_ADY013	Yampa River bl Craig	27	955	1,077
44_ADY014	East Fork Williams Fork	28	1,086	1,144
44_ADY015	South Fork Williams Fork	18	571	561
44_ADY016	Williams Fork	30	866	885
44_ADY017	Milk Creek above G Spring	6	263	189
44_ADY018	Milk Creek	10	470	551
44_ADY019	Yampa River near Maybell	15	632	1,123
44_ADY025	Yampa River at Deerlodge	10	383	491
54_ADY020	Little Snake river near Slater	15	1,463	1,520
54_ADY021	Little Snake River above Slater	11	377	354
54_ADY022	Slater Creek	18	1,624	1,636
54_ADY023	Little Snake above Dry Gulch	22	3,900	3,250
55_ADY024	Little Snake river near Lily	3	156	114
55_ADY026	Yampa River at Green River	2	23	9
56_ADY027	Green River	27	1,244	1,185
57_ADY009	Below Trout Creek Reservoir	11	301	303
57_ADY010	Yampa River near Hayden	18	260	267
57_ADY011	Yampa River above Elkhead	21	726	744
57_ADY012	Above Trout Creek Reservoir	11	318	321
58_ADY001	Upper Bear River	10	245	250
58_ADY002	Chimney Creek	23	706	742
58_ADY003	Bear River above Hunt Creek	23	844	1,004
58_ADY004	Bear River above Stagecoach	19	588	601

58_ADY005	Yampa River above Steamboat	42	1,043	1,342
58_ADY006	Elk River near Clark	20	638	848
58_ADY007	Middle Elk River	34	1,185	1,561
58_ADY008	Lower Elk River	33	957	1,019

Table A-2 shows the number of structures in the aggregation and the total the 2005 and 2010 aggregated acreage. None of the individual structures in the aggregates have recent diversion records. These structures are only included in the StateCU model.

Table A-2: No Diversion Aggregation Summary

Aggregation ID	Aggregation Name	No. of Structures	2005 Acres	2010 Acres
44_AND012	Elkhead Creek	5	138	135
44_AND013	Yampa River bl Craig	3	123	110
44_AND016	Williams Fork	5	23	212
44_AND018	Milk Creek	1	0	3
44_AND019	Yampa River near Maybell	3	66	28
54_AND021	Little Snake River above Slater	3	63	86
57_AND011	Yampa River above Elkhead	1	15	15
58_AND003	Bear River above Hunt Creek	1	104	104
58_AND004	Bear River above Stagecoach	2	49	50
58_AND005	Yampa River above Steamboat	1	6	6
58_AND006	Elk River near Clark	1	3	3
58_AND007	Middle Elk River	3	6	6
58_AND008	Lower Elk River	1	26	23

Table A-3 indicates the structures in the diversion systems. Table A-4 indicates the structures in the multi-structure systems. StateCU treats diversion systems and multi-structures systems the same. StateMod makes a distinction between the two types of associated structures. Details are provided in Part 2 of this Appendix.

Table A-3: Multi-Structure and Diversion System Summary

Diversion System ID	Structure Name	WDID
5700544, Highland Ditch Multistructure	HIGHLAND DITCH	5700544
	WEST SIDE DITCH	5700612
5700611, Walker Irrigation Ditch Multistructure	WALKER IRRIG DITCH	5700611
	DRY CREEK DIVERSION	5702083
4400506_D, Wideman Ditch DivSys	WIDEMAN DITCH	4400506
	HUSTON DITCH	4400657
	MILK CK DITCH 1	4400707
4400607_D, Egry Mesa Ditch DivSys	EGRY MESA DITCH	4400607
	SCOTT ROBERTSON DITCH	4400759
4400808_D, Five Pines Pump DivSys	FIVE PINES PUMP NO 1	4400808

	FIVE PINES PUMP NO 2	4401247
4400863_D, Henry Sweeney Ditch	HENRY SWEENEY DITCH	4400863
	HENRY SWEENEY D ALT PT	4402326
5400574_D, Slater Park Ditch DivSys	SLATER PARK DITCH NO 3	5400572
	SLATER PARK DITCH NO 5	5400574
5401070_D, Anderson D Grieve DivSys	ANDERSON D GRIEVE HEADGT	5401070
	ANDERSON D GRIEVE HG AP1	5401171
5700508_D, Brock Ditch DivSys	BROCK DITCH	5700508
	EARLE IRR DIVERSION	5702046
5700555_D, Last Chance Ditch DivSys	LAST CHANCE DITCH	5700555
	LAST CHANCE EXT	5700750
5700576_D, Orno Ditch DivSys	ORNO DITCH	5700576
	KNOTT WASTE WATER DITCH	5701155
5700579_D, R E Clark Ditch DivSys, R E Clark Ditch DivSys	CHENEY DITCH	5700511
	MILNER CLARK GULCH D	5700567
	R E CLARK DITCH	5700579
5700623_D, Williams Park Ditch DivSys	WILLIAMS PARK DITCH	5700623
	SPENCER DIVERSION	5701034
	WM L YOAST D 1,2 ALT PT	5701240
5800583_D, Charles H Kemmer Ditch DivSys	CHARLES H KEMMER D	5800583
	WHITEWATER SEEPAGE DITCH	5801621
5800649_D, Franz Ditch DivSys	FRANZ DITCH	5800649
	WINTER IRR DITCH	5801096
5800826_D, Poney Creek Ditch DivSys	JUST DITCH	5800710
	PONY CREEK D	5800826
5800847_D, Sand Creek Ditch DivSys	SAND CREEK DITCH	5800847
	MCPHEE DIVERSION	5801595
5800895_D, Sunnyside Ditch 1 DivSys	COULTON CREEK DITCH	5800595
	SUNNYSIDE DITCH 1	5800895
5800915_D, Upper Elk River D Co DivSys	UPPER ELK RIVER D CO. D	5800915
	HEADACHE D NO 2	5801635
5800943_D, Woodchuck Ditch DivSys	WOODCHUCK D SODA CK HG	5800943
	WOODCHUCK D GUNN CK HG	5801091
5804685_D, Stillwater Ditch DivSys	ADOBE DITCH	5800501
	DESERT DITCH	5800611
	STILLWATER DITCH	5804685

Figure A-1 shows the spatial boundaries of each aggregation. **Exhibit A**, attached, lists the diversion structures represented in each aggregate, while **Exhibit B** lists the diversion structures represented in each respective no diversion aggregate. Both Exhibit A and Exhibit B provide a comparison of the 2005 and 2010 irrigated acreage.

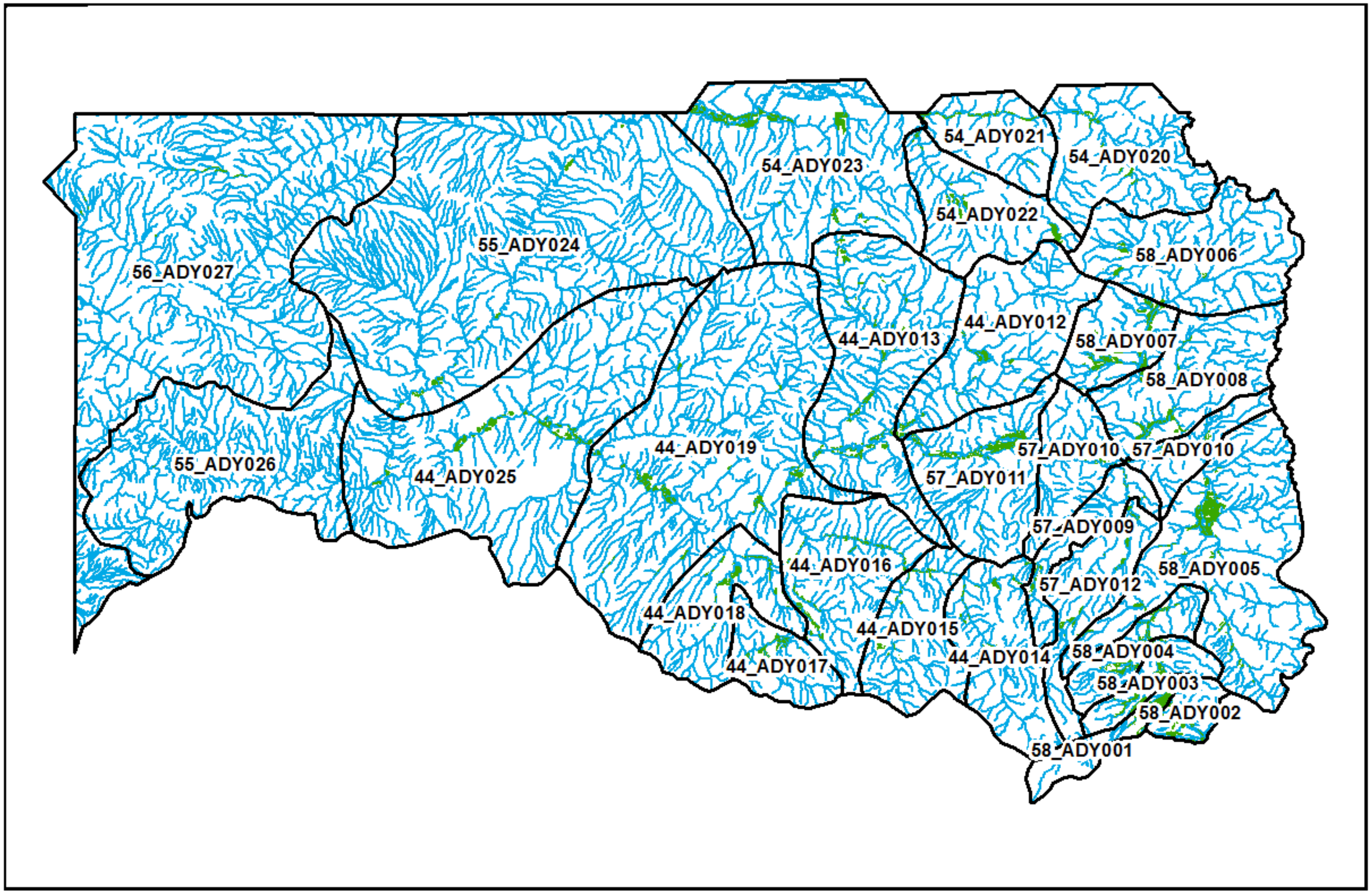


Figure A-1. Aggregate Structure Boundaries.

Exhibit A: Diversion Structures in each Aggregate Structure

Aggregation ID	Structure Name	WDID	2005 Acres	2010 Acres
44_ADY012, Elkhead Creek	Herbert L Frink D	4400649	29	29
	Oldham D No 2	4400725	186	149
	Pitney Pump Station	4400840	12	12
	Pitney Ditch No 1	4400841	6	5
	Pitney Ditch No 2	4400842	29	31
	Pitney Ditch No 3	4400843	6	6
	Starr Irr Ditch Alt Pt	4401188	43	55
	Frentress Pump No. 1	4401962	17	16
	Pitney Ditch No 4	4402099	6	7
	Morgan Creek Ditch 2	5700569	43	37
44_ADY013, Yampa River below Craig	Wolfe Ditch	4400513	56	41
	Baker Cottonwood D	4400542	39	25
	Louie Pl & Ditch	4400689	80	75
	Mcdonald & Hall D	4400697	61	24
	Mesa Irr Ditch	4400704	0	127
	Millspaugh Ditch	4400710	32	36
	Taylor Ditch	4400783	20	20
	Van Dorn Irrig P L	4400791	34	34
	Cook Ditch	4400800	58	56
	Duzik Pump Div	4400805	48	48
	Johnson & Wyatt Enl D	4400817	0	59
	Mcnamara No 1	4400823	10	10
	Mcnamara No 2	4400824	10	10
	Yampa Valley Golf Div	4400836	62	62
	Benner Ditch	4400857	18	7
	Drescher Ditch	4400875	70	96
	Morton Ditch	4401102	69	76
	Andy Ditch	4401275	35	29
	Little Suzy Ditch	4401775	20	17
	Read Winslow Water	4401924	100	79
	Warner Ditch	4402026	8	0
	Pyeat Ditch No 1	4402100	0	8
	Elmer Bertha Mack Pump	4402371	38	29
	Craig Well #1	4405015	0	20
	Craig Well #2	4405016	0	20
	Mack Pump #2	4405075	49	38
	Mack Pump #3	4405076	38	29
44_ADY014, East Fork Williams Fork	Beardslee Ditch	4400543	40	40
	Beardslee Ditch No 1	4400544	4	4

	Beardslee Ditch No 2	4400545	4	9
	Beardslee Ditch No 3	4400546	5	5
	Beardslee Mesa D	4400547	15	15
	Beardslee West Side D	4400548	17	17
	Brush Ck Ditch	4400560	9	13
	Bunker Ditch No 2	4400563	119	119
	Carlos Ditch	4400571	17	17
	Dubeau & Dunckley Ditch	4400600	170	170
	East Side Grieser D	4400603	17	17
	Egry Ditch No 1	4400605	9	9
	Egry Ditch No 2	4400608	72	71
	Mcfadden Ditch	4400701	36	36
	Mesa Ditch	4400703	32	32
	Miller No 2 Ditch	4400709	22	22
	Post Ck Ditch	4400737	9	9
	Rider Ditch	4400743	9	9
	Sampson Ditch	4400755	70	70
	Sellers Crowell Ditch	4400761	170	170
	Taylor D No 1	4400780	37	37
	Turner Ditch	4400787	42	42
	Holderness Ditch	4400815	6	7
	Tutt Ditch No 1	4401068	0	16
	Tutt Ditch No 2	4401069	0	16
	Tutt Ditch No 3	4402107	0	16
	Marion Yoast Outlet D	5700562	107	107
	Mcsweeney Ditch	5701061	49	49
44_ADY015, South Fork Williams Fork	8 F Ditch No 2	4400520	21	13
	8 F Ditch No 1	4400521	63	59
	Alex Heron No 1 Ditch	4400531	39	34
	Butler Ditch	4400565	18	18
	Cabins Ct No 1	4400567	9	9
	Camp Ck Ditch	4400569	23	20
	Ellis Ditch	4400615	45	32
	Hobson Ditch	4400653	36	36
	Indian Run Ditch	4400658	30	26
	John Lyons Ditch	4400667	20	20
	Johnson Ditch	4400671	50	50
	Le Claire Ditch	4400683	15	15
	Pagoda Ck Ditch	4400727	71	75
	Sand Creek Ditch	4400756	45	66
	Scott Ditch	4400758	16	17
	South Fork Ditch	4400764	34	34

	Sullivan Ditch	4400773	36	36
	Fisher Ditch No 1	4400807	0	2
44_ADY016, Williams Fork	Weisbeck Ditch	4400504	14	23
	Worthington Ditch	4400515	61	59
	B Dayton Ditch	4400539	48	37
	Biggs Irr Ditch	4400556	138	79
	Deer Ck Ditch	4400591	29	32
	Deer Ditch	4400592	0	67
	Hughes Irrig D	4400655	0	5
	J T Jarvis Ditch	4400662	17	17
	J W Kellogg D 1	4400669	62	62
	Pagoda Ditch	4400728	20	18
	Pike Ditch	4400734	29	28
	Robertson Ditch	4400746	20	20
	Shears Deal Ditch	4400762	50	36
	Stanley Irrig Ditch	4400769	22	72
	White Rail Pump No 1 Ap	4400792	17	9
	Clark Pumpsite No. 1	4400802	13	14
	Hamill Ditch	4400850	67	67
	Jeffway Gulch Ditch	4400866	0	9
	Hathhorn Pump	4400915	4	3
	Shears Deal Ditch Ap 2	4401183	34	34
	South Side Ditch Ext	4401281	40	35
	Hathhorn Pumpsite No 1	4401356	6	6
	Deakins Field Sprinkler Alt Pt	4401418	8	14
	Berry Gulch Ditch 1	4401923	49	17
	Haggerty Ditch No 2	4402077	34	36
	Utley Pump	4402171	23	24
	Gilmar Ranch Irr D	4402284	23	23
	Clark Pumpsite Ap No. 2	4402352	6	7
	Clark Pumpsite Ap No. 4	4402354	13	13
	Hathhorn Pumpsite #3	4402390	20	22
44_ADY017, Milk Creek above G Spring	Aldrich Ditch	4400530	133	62
	Beaver No 1 Ditch	4400551	7	9
	Beaver No 2 Ditch	4400552	18	17
	John Roscorla Ditch	4400668	70	70
	Rye Grass Ditch	4400752	7	7
	Seilaff Ditch	4400760	28	25
44_ADY018, Milk Creek	Elk Horn Ditch	4400610	64	37
	Hulett & Torrence D	4400656	25	89
	James Pipeline	4400664	0	7
	Mountain Meadows D	4400715	145	145

	Peter Uehlein D	4400733	28	28
	Spring Creek Ditch 2	4400768	38	53
	Taylor Ditch	4400782	33	21
	John Collom And Spring Creek Ditch	4400859	100	105
	A Q Ditch	4401108	37	37
	H Kourlis Ranch D 3	4402227	0	29
44_ADY019, Yampa River near Maybell	Five Fifty Five Ditch	4400555	251	248
	Bogenschutz Ditch	4400557	71	67
	Hall & Harrison D	4400641	17	62
	Morgan Ditch	4400713	62	62
	Roberts Ditch	4400745	28	36
	Ellgen Ditch Ap Pump	4400981	37	38
	Big Gulch Pump Diversion	4401272	0	37
	Maudlin Gulch Ditch	4401288	0	131
	Big Gulch Diversion	4401361	0	18
	Stoffle Pump & Pl	4401392	1	0
	Lewis Pump	4402134	12	0
	Kourlis Ditch Ab1	4402309	0	163
	Ellgen Sprinkler	4402377	63	40
	Culverwell Ditch	4402480	0	66
	Bord Gulch Well	4405053	91	156
44_ADY025, Yampa River at Deerlodge	Buffams Ditch	4400561	0	34
	Myers Ditch No 2	4400719	57	39
	Nichols Ditch No 2	4400721	0	30
	Pearce Ditch	4400730	70	70
	Lily Park D Pump Sta No 2	4400819	147	147
	Cross Mtn Pump No 2	4400861	26	67
	Deception Cr Ditch	4401088	0	23
	Chew Pump	4401268	51	51
	Silver Water Pump	4401397	9	9
	Haskins Pump Diversion	4401707	22	22
54_ADY020, Little Snake near Slater	Bedrock Ck Ditch	5400506	0	58
	Behrman Ditch	5400508	84	84
	Brighton Ditch	5400510	197	197
	Hancock Ditch	5400528	53	53
	Honnold Ditch	5400533	22	22
	Independence Ck Ditch	5400534	32	32
	J B Temple Ditch	5400536	11	32
	Rathjen Ditch	5400557	72	72
	South Fork D No 2	5400577	140	140
	St Louis Ditch	5400578	77	57

	Summit Ck D	5400580	100	100
	Unknown Ck Ditch	5400585	93	92
	West Fork Ditch	5401107	171	171
	Blackmore Ditch	5401108	79	79
	Dudley Ck Ditch	5401117	329	329
54_ADY021, Little Snake above Slater	Fleming Ditch	5400524	6	6
	Lake Fork Ditch	5400541	66	66
	North Side Ditch	5400550	15	15
	Oscar Beeler-Robidoux D	5400551	76	76
	Robidoux Ditch	5400562	61	61
	Fly Ditch	5400701	31	31
	Anderson Ditch No 2	5400711	30	30
	Porter Salisbury Pump1&2	5401038	16	16
	Eio Ditch	5401075	7	7
	Robidoux Ditch No 2	5402047	41	41
	Roy E Ditch	5402119	29	7
54_ADY022, Slater Creek	Basin Ditch	5400504	230	138
	Baxter Ditch	5400505	140	140
	Decker Ditch No 1	5400517	224	224
	Decker Ditch No 2	5400518	251	251
	Duncan Ditch No 1	5400519	289	289
	Duncan Ditch No 2	5400520	95	95
	Lake Ck Ditch	5400540	29	29
	Lester Ditch	5400542	82	82
	Mary E Hoffman Ditch 1	5400544	28	28
	Mary E Hoffman Ditch 2	5400545	32	32
	Peisker Ditch	5400552	39	39
	Showalter Ditch	5400565	3	3
	Skunk Creek Ditch	5400567	28	28
	Slater Park Ditch Hgd 2	5400569	97	97
	Slater Park Ditch No 4	5400573	25	25
	Vincent Ditch	5400588	0	105
	Rochelle Ditch No 2	5400625	12	12
	Rochelle Ditch No 1	5402085	20	20
54_ADY023, Little Snake above Dry Gulch	Davidson Ditch	5400515	112	74
	Davidson Dutton D	5400516	119	119
	Gold Valley Ditch	5400527	129	138
	Jebens Seep Waste Water	5400537	284	295
	Mccarger Ditch	5400547	119	115
	Read Winslow Ditch	5400558	181	81
	Rico Ditch	5400559	95	97
	Single Ditch	5400566	13	13

	Snake R Irrig Canal	5400575	312	312
	Wood Kettleson D	5400593	223	0
	Georgiou Ditch	5400653	112	74
	Jons Seep & Waste W D 1	5401044	193	193
	Jons Seep & Waste W D 2	5401045	162	162
	West Side C Peppler Ext	5401057	231	231
	West Side C Chrstnsn Ext	5401058	162	162
	West Side C Fourmile Lat	5401073	356	380
	Gibson Blair Ditch	5401076	736	736
	Mcstay Pump No 1	5402058	84	0
	Mcstay Pump No 2	5402059	84	0
	Timberlake Spg No 1	5402070	34	0
	Timberlake Spg No 2	5402071	121	30
	Norma Ryan Ditch	5402128	38	38
55_ADY024, Little Snake near Lily	Escalanta Pump 1	5500503	22	22
	Majors Pump No 1	5500505	43	43
	Gordon C. Winn Pump 1	5500514	91	49
55_ADY026, Yampa River at Green River	Hells Canyon Ditch	5502035	12	5
	Studebaker Pump	5502037	12	5
56_ADY027, Green River	Bassett Spring 1	5600521	33	33
	Bassett Spring 2	5600522	33	33
	Beaver Ditch	5600524	47	47
	Upper Buffham Ditch	5600528	19	11
	Cottonwood Ditch No 1	5600533	9	9
	Cottonwood Ditch No 2	5600534	20	20
	Guiterrez No 1	5600551	18	0
	Mcknight No 2	5600563	7	4
	Popper Ditch No 1	5600568	58	0
	Prestopitz Ditch	5600570	78	156
	Rouff No 2 Ditch	5600572	82	82
	Sparks Ditch	5600573	78	0
	Spitze Ditch	5600574	0	4
	Wilson Ditch (A.C.)	5600583	157	132
	Yarnell Ditch No 1	5600584	59	32
	Yarnell Ditch No 2	5600585	83	133
	Thomas Doudle No 2	5600586	11	12
	Watson Ditch	5600595	31	31
	Bull Canyon Gulch Ditch	5600596	5	3
	Sugarloaf D No 1	5600599	134	134
	Dickinson Ditch No 1	5600603	23	23
	Dickinson Ditch No 2	5600627	15	15

	Cove Ditch 1	5601045	0	13
	Vermillion Ditch	5601180	207	222
	Johnny S Spring	5601273	33	33
	Allen Ditch No 1	5602066	0	3
	Simpson Well 2	5605006	5	3
57_ADY009, Trout Creek	Bonas Ditch	5700507	34	34
	David M Chapman Ditch 2	5700518	16	16
	Helfenbein Seepage D	5700543	24	24
	Jones Kleckner Ditch	5700552	41	39
	Lieske Ditch	5700556	48	48
	Middle Creek Ditch	5700565	28	28
	Pine Grove Ditch	5700578	68	68
	Redbird Ditch	5700581	34	34
	Slough Ditch	5700593	16	23
	South Highland Ditch	5700594	17	17
	Spruce Hill Ditch	5700598	6	6
	Tempke Ditch	5700599	66	66
	Thompson Ditch 2	5700601	64	64
	William H Jones Ditch	5700620	54	49
	William R Appel D	5700621	23	23
	Rocky Ditch	5700749	3	6
	Alex Ditch	5701013	17	17
	Fuller Ditch	5701048	11	11
	Mitchem Diversion	5701064	2	2
	Burch Ditch	5703001	7	7
	Hunter No 1 Res	5703541	15	15
	Apple Res	5703549	28	29
57_ADY010, Yampa River near Hayden	Hammond Ditch	5700540	3	2
	Tow Creek Ditch 1	5700603	24	24
	Wolf Mountain Res	5703516	9	0
	Borland Ditch	5800548	26	26
	Homer Seepage D	5800693	3	4
	Murphy Ditch 1	5800792	2	4
	Steamboat Cemetery Pl	5801045	18	18
	Yampa Pump	5801655	2	2
	Blue Mountain Diversion	5801682	1	1
	Memorial Park Diversion	5801694	2	2
	Ninth Street Pumphouse	5801899	9	15
	Felix Borghi Alt Pt No 4	5801989	22	31
	Steamboat Springs Final Treatment Effluent Pl	5802117	72	72
	Duquette D - Sampson Hg	5802160	4	4

	Willett Ap To Woolery Ditch	5802177	18	18
	Eiteljorg Pump	5802502	8	8
	Steamboat Gc Pond 2	5803709	36	36
	Riverbend Well 1	5805079	1	1
57_ADY011, Yampa River above Elkhead	Bates Ditch	5700502	1	1
	Burback D & Pump Plant	5700509	22	22
	Flanders D & Pump Plant	5700536	79	79
	Frentress Pump & Pl	5700537	0	40
	J C Temple D 1	5700551	44	46
	Sage Creek Res Outlet	5700586	31	0
	Whiteman D & Pump Plant	5700618	72	72
	Yoast Pumping Plant	5700628	49	62
	Burback Pumping Plant	5700639	15	15
	Erwin Irr D Burrell Tran	5700752	20	20
	Bates Ditch South Hg	5700760	4	5
	Welsh #3	5701205	3	4
	Dry Ck Ditch Alt Pt B	5701211	83	83
	J C Temple D 2 Alt Pt 1	5701218	97	97
	J C Temple D 2 Alt Pt 2	5701219	66	54
	Hollatz Ditch Hdg 2	5701229	23	27
	Temple Diversion 1	5702088	23	23
	Hollatz Ditch Hdg 1	5702125	4	4
	Cottonwood Pond	5703655	80	78
	Cozzens Walrod Reservoir	5703775	9	10
	Yampa Park Well #1	5705041	1	1
58_ADY001, Upper Bear River	Baumfalk Ditch 1	5800528	11	11
	Cox Ditch	5800596	16	16
	Ekstrom Seep Waste D	5800624	9	10
	F D Hutchinson Irr Ditch	5800630	110	110
	Ira J Van Camp D	5800699	17	25
	Lancaster Ditch	5800723	58	58
	Pat Lucas Ditch	5800819	10	10
	Schalnus Ditch	5801271	7	0
	Hammer Ditch	5801795	3	6
	Nesbitt Ditch Alt Pt 2	5801975	5	5
58_ADY002, Chimney Creek	Beaver Ditch	5800533	37	37
	Bowers Ditch	5800552	63	63
	Crowner Res Dist D	5800598	41	41
	Daisy Ditch	5800602	25	25
	Finger Rock Ditch	5800636	25	25
	Gibbs Ditch	5800660	6	6
	Independent Highline D	5800698	48	48

	Kauffman Spg 2 & P L	5800712	13	13
	Little Mountain D	5800741	63	63
	North Side Adams D	5800802	14	14
	Kauffman Ditch	5800851	13	13
	South Side Ditch	5800867	40	42
	South Side Adams D	5800871	6	6
	Todd Cr D	5800904	3	3
	Wheeler D 6	5800929	11	11
	Wheeler D 7	5800931	4	4
	Wheeler D	5800932	0	25
	Beaver Creek Ditch 2	5801190	44	44
	Christensen D 1, Alt 2	5801403	24	35
	Crowner Ditch 1	5801405	75	75
	Bills Ditch	5801406	106	106
	Crowner Ditch 2	5801409	32	32
	Beaver Creek Ditch #3	5802604	9	9
58_ADY003, Bear River above Hunt Creek	Bluff Ditch	5800543	53	53
	Dora Irr D	5800615	31	31
	East Side Waste D	5800620	5	5
	Hardscrabble Ditch	5800676	0	18
	Hill Ditch	5800689	87	87
	Hoag Laughlin Ditch	5800691	63	63
	Homer Buttricks D	5800692	87	87
	Laramore Ditch	5800725	58	59
	Lawson Cr Ditch	5800732	23	23
	Meadow Brook D 1	5800770	20	34
	Meadow Brook D 2	5800771	20	21
	Meadow Brook D 3	5800772	20	21
	Mohr Ditch	5800781	0	68
	Patton Ditch	5800820	0	45
	Powell Ditch 1	5800827	62	66
	Powell Ditch 2	5800828	46	55
	Spring Branch D	5800875	46	46
	Watson Creek Ditch	5800921	45	45
	Whiteley Ditch	5800934	97	97
	Whiteley Nelson D Sys	5800935	67	0
	River Ditch	5801102	14	14
	Whiteley Nelson Ditch	5802880	0	14
	Nelson Ditch	5802881	0	53
58_ADY004, Bear River above Stagecoach	Barr Ditch	5800522	23	23
	Bomgardner Ditch	5800544	11	11
	Bull Creek D	5800566	111	110

	C R Brown Ditch	5800573	77	77
	C W Ditch	5800575	30	30
	Lower Hunt Creek Ditch	5800748	12	12
	Martin Ditch	5800764	31	31
	Max Hoff Ditch	5800765	34	34
	Osborne D	5800812	21	21
	Rockhill Ditch	5800838	24	24
	Rossi Irrigating Ditch	5800843	19	19
	Speckled Trout Ditch	5800873	26	26
	Tom Watson Ditch 1	5801081	16	16
	Rockwall Ditch 2	5801086	20	20
	Crawford Diversion 3	5801451	7	7
	Redmond Ditch No 1	5801541	25	25
	Upper Hoff Ditch	5801689	24	24
	Old Cabin D Alt Point	5801710	64	77
	Egeria D Alt Hg 3	5801798	14	14
58_ADY005, Yampa River above Steamboat	Agate Creek Ditch	5800502	42	42
	Andy Morrison D	5800509	30	24
	Bonard Ditch	5800545	16	15
	Bouton Ditch 1	5800550	0	15
	Bouton Ditch 2	5800551	0	19
	Cook Brothers Ditch	5800593	76	76
	Fahey Cole D	5800631	182	232
	First Ditch	5800641	81	81
	Grouse Creek Ditch	5800664	53	72
	J L Smiths Emma Smith Cr	5800703	24	24
	Lyon Ditch	5800755	43	43
	Morrison Creek Ditch 2	5800786	17	17
	Muddy Ditch 2	5800790	0	57
	Muddy Ditch 1	5800791	0	97
	Nay Ditch	5800794	32	32
	North Side Ditch	5800803	22	22
	Pioneer Ditch	5800825	8	8
	Steamboat Gardens D	5800884	31	31
	Summer S Goldsworthy D	5800894	63	63
	Trentaz Bear River D	5800905	25	25
	Zuffery Bear River Ditch	5800956	40	40
	Willow Run Ditch	5801063	2	2
	Balanced Rock Ditch	5801072	8	8
	Jones Ditch	5801073	27	27
	Locker Spring 1	5801108	4	4
	Evenson Davis Ditch 1	5801211	1	2

	Evenson Davis Ditch 2	5801212	1	1
	Evenson Davis Ditch 3	5801213	2	3
	Evenson Davis Ditch 4	5801214	7	10
	Palmer Ditch No 5	5801562	11	11
	Sheraton Golf Course Pmp	5801591	87	87
	Lodwick Pond Outlet D	5801616	3	3
	Palmer Ditch No 6	5801656	0	23
	Trafalgar Park Irr Diver	5801782	19	19
	Bonard Ditch No 2	5801868	0	17
	Spencer Ditch	5801933	1	1
	J Hart Ditch Hg 2	5801981	22	22
	Bouton Ditch 3	5802004	0	4
	Silver View D Alt Pt. 2	5802151	50	50
	Gene & Georgia D	5802422	6	6
	Frank & Lena D	5802423	6	6
	Old Siegrist Pit Diversion	5805092	1	0
58_ADY006, Elk River near Clark	Centennial Placer D Hg 1	5800580	8	8
	Chris Fetcher Ditch	5800587	50	50
	Diamond Park Ditch	5800613	25	15
	Frye Syst D 2	5800651	14	23
	Frye Syst D 1	5800653	106	240
	James Wheeler Ditch	5800706	20	20
	Lula Park Ditch	5800754	24	34
	Morris Taylor D	5800784	17	29
	Reddert Ditch	5800833	18	26
	Reynolds Humphery D	5800835	46	68
	Rose Wheeler D 3	5800842	96	94
	Pirates Hideout Ditch	5801037	8	4
	Glenns Ditch	5801702	3	3
	Centennial Placer D Hg 2	5801703	35	35
	Boat House Pump & Pl	5801878	2	14
	Murphy Ditch Fetcher Ext And Enl	5801997	137	137
	Glenns Ditch Alt Pt	5802130	4	4
	Trullinger Irrigation Ditch	5802176	18	18
	Roy S Diversion	5802580	2	3
	Wildflower Pond	5803609	7	24
58_ADY007, Middle Elk River	Asher Ditch	5800513	25	25
	Borland Vail Ditch	5800549	24	79
	Cantrell Ditch 2	5800579	9	73
	Ducey Ditch	5800617	28	28
	E Coleman Ditch	5800619	35	35

	Follett Ditch	5800647	41	41
	Gates Savage Ditch	5800657	122	107
	Gates Williams Ditch	5800659	145	193
	H P Williams D 1	5800671	28	28
	Highline Ditch	5800688	160	248
	Lower Winkleman Creek Ditch	5800751	10	10
	Maddox Ditch	5800759	27	27
	Maddox Ditch 2	5800760	27	30
	May Ditch	5800766	4	4
	Miller Ditch	5800779	30	48
	Norman Ditch	5800800	42	42
	Semotan Ditch	5800857	34	36
	Smith Ditch	5800864	76	76
	Smith Ditch	5800865	70	66
	Stanton Fetcher D 2	5800880	17	17
	Stanton Fetcher D 1	5800881	24	24
	Tufly Ditch 1	5800910	16	16
	Tufly Ditch 2	5800911	10	10
	South Side D	5801044	20	24
	Wommer Ditch	5801068	3	30
	Jake Ditch	5801596	53	58
	Coleman Ditch Alt Pt	5801784	31	58
	Buckner Turner Miller Hg	5801785	23	41
	Norman Ditch Hg 2	5801999	20	20
	Norman Ditch Hg 3	5802000	6	8
	Semotan Ditch	5802413	6	11
	Pen No. 7 Ditch	5802653	3	26
	Lee Reservoir	5803520	11	13
	M&M Pond	5803735	7	11
58_ADY008, Lower Elk River	Baalhorn Ditch	5800516	23	0
	Belton Waste Ditch	5800534	3	5
	Big Creek Canal D	5800537	47	47
	H E Turner Ditch	5800670	11	11
	Harms Ditch	5800677	44	44
	Highland Ditch	5800686	41	41
	James Hangs Ditch	5800705	7	7
	Look Seepage D 1	5800743	22	23
	Look Waste Water D 1	5800746	49	50
	Look Waste Water D 2	5800747	42	39
	Mcfadden Ditch	5800768	7	8
	Mountain Meadow Ditch	5800789	39	39
	O Neal Ditch	5800804	18	18

	Price Ditch	5800829	95	95
	Rock Cr Ditch	5800837	11	11
	St Johns Ditch	5800878	47	48
	Trull Ditch	5800907	55	72
	Sandelin Ditch No1	5801038	18	17
	Sandelin Ditch No2	5801039	7	19
	Aultman Ditch	5801095	27	27
	Warrick Spring	5801151	2	2
	Felix Borghi Alt Pt No 3	5801773	23	28
	Price Ditch Alt Pt	5801962	12	24
	Keller D Cavanagh Ap	5801996	76	92
	Trissel Ditch Alt Pt	5802122	98	98
	Trull Morin D Alt Pt	5802123	21	25
	Wheeler Div Sys Alt 1	5802341	10	10
	Nicholson D Ditch Ck Hg	5802543	38	55
	Cabin Creek Ditch	5802566	25	25
	Brust Pump No. 2	5802764	3	5
	Keller Ditch Goose Ck Hg	5802795	29	30
	Moose Willow Pond	5803588	1	1

Exhibit B: Diversion Structures in each "No Diversion Records" Aggregate Structure

Aggregation ID	Structure Name	WDID	2005 Acres	2010 Acres
44_AND012, Elkhead Creek	Pitney Pump Diversion 2	4402322	8	6
	Pitney Pump Diversion 3	4402323	10	8
	Pitney Pump Diversion 4	4402324	10	9
	Pitney Pump Diversion 5	4402325	6	6
	Kitchens & Kleckner Res	4404437	105	105
44_AND013, Yampa River below Craig	Bill Ditch 1	4402116	14	14
	Drescher Res	4403686	70	96
	Biskup Reservoir	4403824	39	0
44_AND016, Williams Fork	Averill Ditch	4400538	0	184
	Spring Gulch Livestock Diversion	4401394	7	12
	Deer Run Pump	4401414	4	4
	Sulphur Ditch	4402350	4	4
	Clark Pumpsite Ap No. 3	4402353	9	8
44_AND018, Milk Creek	Jos Collom Desert Land D	4400673	0	3
44_AND019, Yampa River near Maybell	Floyd Ditch	4400809	0	20
	Bowers Pump Diversion	4402313	0	8
	Culverwell Reservoir	4403736	66	0
54_AND021, Little Snake River above Slater	Baggs Ditch	5400503	15	15
	Gold Blossom Ditch	5400526	22	44
	Kilgour Ditch	5400539	26	26
57_AND011, Yampa River above Elkhead	Headquarters Well	5705042	15	15
58_AND003, Bear River above Hunt Creek	Whiteley Nelson Res	5803547	104	104
58_AND004, Bear River above Stagecoach	Boor Ditch 3	5802610	25	25
	Boor Ditch 4	5802611	25	25
58_AND005, Yampa River above Steamboat	Bar Bee Lake	5803826	6	6
58_AND006, Elk River near Clark	Rock Creek Ranch Pond 2	5803637	3	3
58_AND007, Middle Elk River	Mikes Ditch	5801389	4	4
	Twin Creek Pump 1	5802796	1	1
	Twin Creek Pump 2	5802797	1	1
58_AND008, Lower Elk River	Lake Windemere Res	5803519	26	23

Part 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.

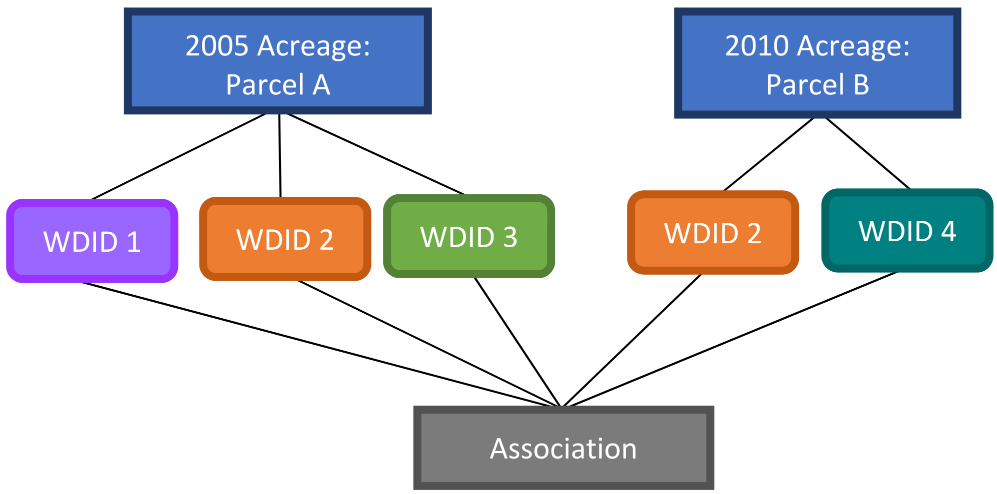


Figure A-2. Example of integrating the CDSS irrigated acreage coverage to identify associated structures.

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.

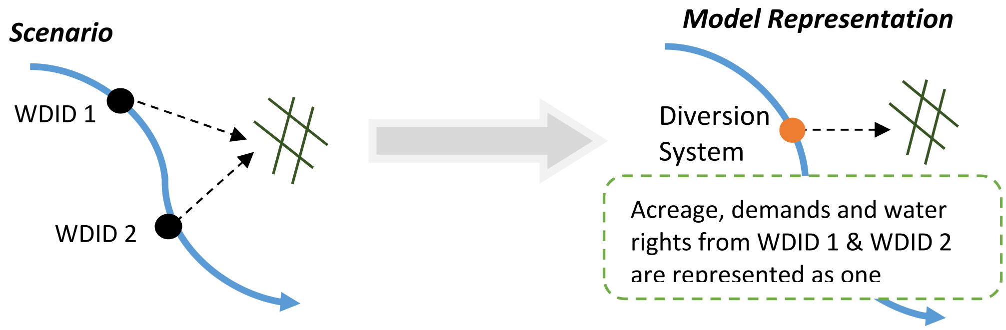


Figure A-3. Model Representation of a Diversion System.

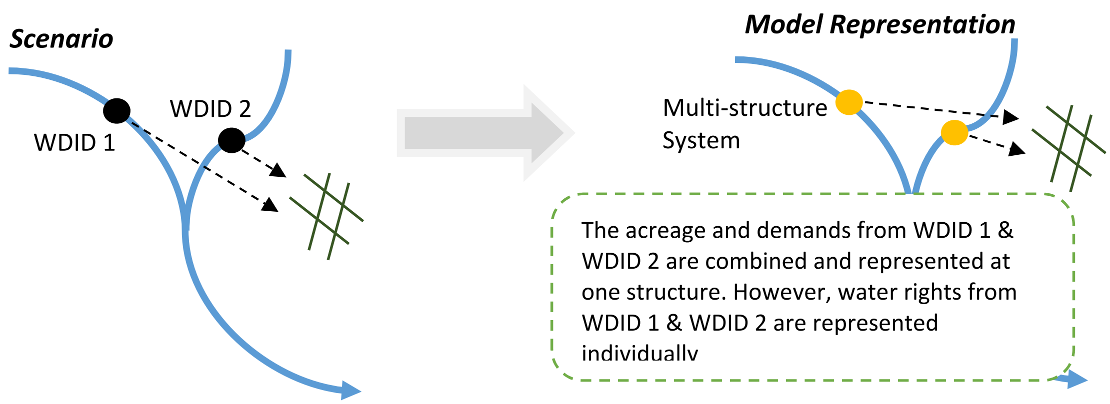


Figure A-4. Model Representation of a Multi-structure System.

- 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 Sub task 3.10
Yampa River Basin Aggregated Municipal and Industrial Use

2. CDSS Memorandum Sub task 3.11
Yampa River Basin Aggregated Reservoirs and Stock Ponds

TO: File

FROM: Revised by Ray Alvarado 3/99

Meg Frantz

SUBJECT: **Task 3.10 - Yampa River Basin Aggregated Municipal and Industrial Use**

Introduction

This memo describes the results of Sub task 3.10 Yampa River Basin Aggregated Municipal and Industrial Use. The objective of the task was as follows:

> *Aggregate municipal and industrial uses not explicitly modeled in Phase II to simulate their depletive effects in the basin.*

Approach

The aggregated municipal and industrial nodes are used in the Phase IIIa model to represent all consumptive use which is:

1. not explicitly modeled, and
2. not an irrigation direct diversion, reservoir storage, or evaporation from reservoirs and stockponds.

Total consumptive use in the Yampa basin was estimated in CRDSS Task 2.09-12, documented in the memorandum "Consumptive Use Model Non-Irrigation Consumptive Uses and Losses in the Yampa River Basin." The approach in this task was to identify municipal and industrial consumptive use which was modeled explicitly in the Phase II model. These values were then subtracted from the estimated total consumptive use attributable to municipal, mineral, thermal electric, and livestock use, according to the above referenced memorandum. The aggregated M&I nodes in the Phase IIIa model represent the remaining amount of use.

Task Memorandum 2.09-12 summarizes transmountain diversions, as well as the uses mentioned above. The summary shows transbasin agricultural diversions to the Upper Colorado basin by the Dome Creek Ditch, which was not included in the Phase II model because it did not meet the cutoff criterion for key structures. It was decided that, as a general rule, transbasin diversions should be handled explicitly by the model. Therefore, Dome Creek and the Dome Creek Ditch were added to the model in conjunction with this task.

Results

M&I Consumptive Use in the Phase II Model: Exhibit 1 presents average annual diversions and depletions of seven municipal or industrial diversions in the Phase II model, for 1975 to 1991. The structures were identified by searching the direct flow diversion summary (Table 4.2.1a Yampa River Basin Model Water Resources Planning Model) for irrigated acreage of -999 or 0, or average annual efficiency of either 100 or 0 percent. Consumptive use values in the exhibit were taken from the Water Supply Summary (*.xsu) for the Phase II historical scenario, to which the modeled efficiency was applied to determine consumptive use. The exhibit also shows the County-HUC location of each structure.

Basinwide M&I Consumptive Use: Exhibit 2 summarizes the relevant tables of Task Memorandum 2.09-12, and assigns consumptive use to the three primary hydrologic units in the basin (14050001, 14050002, and 14050003). Exhibit 3 is a map showing the hydrologic units within the Yampa basin. While mineral and thermal electric consumption were presented in Task Memorandum 2.09-12 by hydrologic unit, municipal and livestock consumption were available only by county. This location breakdown in the original data provided a rationale for representing aggregated M&I consumption in the Phase IIIa model with three nodes, one for each of the primary hydrologic units. Consumptive use according to Task Memorandum 2.09-12 was thus assigned to hydrologic unit by the following rules:

- Hydrologic units for mineral resource and thermal electric consumptive use were taken directly from Task Memorandum 2.09-12.
- "Municipal" population was assigned to the appropriate hydrologic unit because municipality locations are known and discrete. All municipalities listed in Task Memorandum 2.09-12 are in hydrologic unit 14050001.
- "Rural" population for Garfield County was assigned to hydrologic unit 14050001, because all of Garfield County within the Yampa basin is contained in that unit.
- "Rural" population in Moffat, Rio Blanco, and Routt Counties was summed and split evenly among the three hydrologic units, because actual distribution is unknown.
- Basinwide livestock consumptive use was split evenly into thirds, and one third was assigned to each hydrologic unit.
- Thermal electric demands were left as quantified in Phase II.

Aggregated Consumptive Use for the Phase IIIa Model: Exhibit 4 shows two tables that show the difference between basinwide depletions by other uses ("Other CU") and the explicitly modeled M&I depletions ("Ph2 StateMod") at the basin wide level and the aggregated M&I node by water district. In order to preserve the basinwide estimate of other consumptive uses (Task Memo 2.09-12) as the basis of total consumptive use in the Phase IIIa model, "Total Difference" was taken as the algebraic sum of the negative municipal difference and the positive industrial difference, except for thermal electric, which was left constant, at 17063 acre-feet per year.

A time series of monthly demands for the study period was created by hand for each aggregated M&I node. Demand for every month in the study period was based on the work that BBC Research & Consulting did for the 1998 Yampa Valley Water Demand Study. The time series are in Statemod matrix format, in files named *44_AMY001.stm*, 55*_AMY003.stm*, *57_AMY001* and 58*_AMY001.stm*. These series were incorporated in the .ddh and .ddm files by using the -replace option in **demandts**. This process is described more fully in Task Memorandum 3.09.

The aggregated M&I nodes were located at the upper end of the water divisions since M&I use is used throughout the water districts.

Each aggregated M&I node was assigned a water right decree adequate to permit the maximum monthly demand, expressed in cfs. They were also each assigned an administration number of 1.0.

Specific steps followed in executing Sub task 3.10 are described in Exhibit 5**.**

Comment

There is a somewhat large discrepancy between consumptive use in the "thermal electric" use category, as reported in Task Memo 2.09-12, and the historical diversions (which are 100 percent depletive) of the Craig and Hayden power stations combined, as modeled in Phase II. Task Memo 2.09-12 reports average annual thermal electric use as 17,063 af/yr. Demand for the two power stations, which is based on historical diversions, totals 11,468 af/yr, for a difference of 5,595 af/yr. It is unlikely that a single large user was overlooked in the Phase II model, based on the research and interviews with water commissioners that were carried out as part of the Phase II effort. It is also unlikely that consumptive use for power generation is dispersed among many small users. Since only additional M&I uses, not quantified in Phase II, were being determined, the difference between thermal electric in Phase II and Task Memo 2.09-12 was ignored. It is believed that the thermal electric values used in Phase II are more accurate and were not changed.

EXHIBIT 1

M&I Consumptive Use in Phase II Model (Historical Scenario)
(values in acre-feet/year)

Water Supply Summary Output (yampaH.xsu file)

Station ID	County-HUC	Name	Efficiency (%)	Average Annual Diversions	Average Annual CU
Industrial					
440522	Moffat 14050001	Craig Sta D + PL	100	6443	6443
440695	Moffat 14050002	Maybell Mill Pipeline	100	117	117
570512	Routt 14050001	Colo Utilities D A PL	100	5025	5025
581583	Routt 14050001	HeadGate Derived From DI	0	2689	0
582374	Routt 14050001	Steamboat Ski snowmaking	20	52	10.4
	Industrial subtotal			14326	11595.4
Municipal					
440581	Moffat 14050001	Craig Water Supply PL	Monthly	1581	634
580642	Routt 14050001	Fish Cr Pipeline A	Monthly	1804	659.95
	Municipal subtotal			3385	1294
TOTAL				17711	12889.35

EXHIBIT 2

Summary of tables in Task Memorandum and assignment of Other CU to Hydrologic Unit

Municipal Use

from Tables 7 (Municipal Population), 8 (Rural Population), and 11(Municipal Consumptive Use)

		1985	1986	1987	1988	1989	1990	Average
14050001	Municipal pop. - all counties	16786	16873	16960	17046	17133	17220	17003
	Rural pop. - Garfield county	244	249	253	258	262	267	256
	Subtotal (14050001)	17030	17122	17213	17304	17395	17487	17259
	CU (subtotal / 16.1)							1072
Unknown	Rural pop. - Moffat	2746	2621	2495	2370	2244	2118	2432
	Rural pop. - Rio Blanco	169	167	165	163	162	160	164
	Rural pop. - Routt	4514	4494	4474	4454	4434	4414	4464
	Subtotal (Unknown hyd. unit)	7429	7282	7134	6987	6840	6692	7061
	CU (subtotal / 16.1)							439
	Municipal Use by hydrologic unit:							
14050001	CU for 14050001 + one-third of CU							1218.1
14050002	One third of CU for Unknown							146.2
14050003	One third of CU for Unknown							146.2
	Total							1511

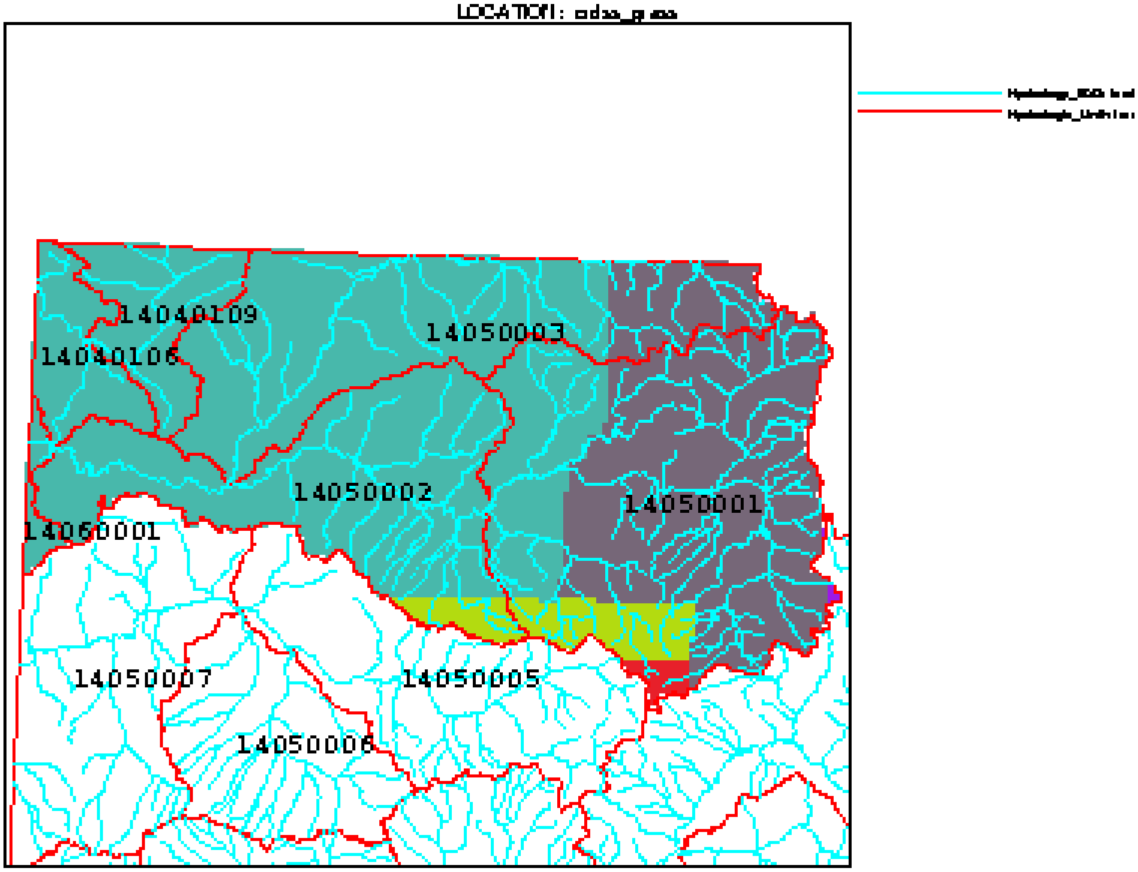
Industrial Use

		1985	1986	1987	1988	1989	1990	Average
Table 3 - Livestock Consumptive Use by County								
	Garfield	10	10	10	10	10	10	10.0
	Moffat	329	322	314	333	351	370	336.5
	RioBlanco	48	48	48	48	47	47	47.7
	Routt	383	374	365	372	379	385	376.3
	Livestock use total							771
Table 12 - Mineral Resource Consumptive Use by hydrologic unit								
	14050001	986	979	972	965	959	952	968.8
	14050002	347	388	428	468	508	549	448.0
	14050003	213	244	276	307	338	370	291.3
	Mineral use total							1708
Table 13 - Thermal Electric Consumptive Use by hydrologic unit								
	14050001	15590	16220	16849	16875	18108	18738	17063.3
	ThermalElec use total							17063
	Industrial use by hydrologic unit:							0
14050001	One third of livestock CU + mineral CU + thermal electric CU							18289
14050002	One third of livestock CU + mineral CU							704.8
14050003	One third of livestock CU +mineral CU							548.2
	Total							19542

Notes:

1. Relationship "Municipal CU = population / 16.1" is from Task Memo 2.09-12

TITLE : COUNTIES ON THE WESTERN SLOPE OF COLORADO
LOCATION:



SCALE:

Colorado River
Decision Support System
(CRDSS)

Colorado Department of Natural Resources
Colorado Water Conservation Board
Colorado Division of Water Resources
Developed by IDS group at Colorado State University

EXHIBIT 4

Table 1
M&I Consumption Not Modelled in Phase II

Uses	Basin Wide
Municipal	
Total	1510.5
Phase II	1294.0
Difference	216.5
Industrial	
Total	19542.0
Phase II	17180.0
Difference	2362.0
Total Diff.	**2578.5**

Table 2
Other CU not accounted for in Phase II

Aggregate Node	Percent of Total(3)	Average Annual CU
44_AMY001	28.8	742.6
55_AMY003(1)	0.4	9.8
56_AMY001(2)	0.1	3.0
57_AMY001	18.7	483.1
58_AMY001	52.0	1340.5
Total	100.0	2579.0

1) Water District 54 included in this aggregate node.
2) Not included in Phase III
3) Based on 1998 “Yampa Valley Water Demand Study”

EXHIBIT 5

Sub task 3.10 was completed by following these steps:

1. Go through the list of diversion structures in the Phase II documentation and find all “Other” types of uses. The way to identify them is by looking for acreage set to zero or 999., or efficiency set to 0. or 100. or anything else unusual. Note wdid’s and efficiencies.

2. Run the Phase II model for the historical scenario and get an .xsu report. This reports diversions for each structure and each year, as well as average monthly and annual diversion across the study period by structure. You really want CU, not diversions, but the .xcu report does not have the study period averages.

3. Find the structures in the .xsu report that you identified in Step 1. as having “Other” use. Pull these into a spreadsheet. Enter efficiencies for the structures by hand, and multiply to get CU. If the efficiencies are monthly, calculate the annual CU. [If the.xcu report is changed in future to summarize CU across years for each structure, this step will be unnecessary.]

4. Use the VDB to look at County and HUC, and just get a handle on geographics. This is one way to check on County-HUC of Phase II structures you are unsure of. Print a map (Exhibit 3). Don’t use County-HUC labels because they come out as black bars. Use just HUC or just County.

5. Review the Phase II Consumptive Uses and Losses report. Create spreadsheet that assigns total use to appropriate geographical area (Exhibit 2). Hydrologic unit was selected as basis for three different nodes because of the way data was reported.

6. Once the area represented by each node has been identified, go back to the spreadsheet of Step 3. and group together the Phase II consumptive use by these areas and summarize (Exhibit 1).

7. Create a third spreadsheet that calculates the difference in average annual CU between your Step 5. spreadsheet and your Step 6. spreadsheet, by node (Exhibit 4).

8. Decide where the nodes need to fit into the network, modify the .net file accordingly and run *makenet*.

9. Edit the *commands_dds* file to include setdiv instructions that give each structure a name and set demsrc to 6 in the structure file. **Watright** automatically puts in acreage of -999 and diversion capacity of 999, so those fields don’t need to be changed in the setdiv’s.

10. Edit commands_dds file to include a setdivr to assign and adminstrative number of 1.00000 to all aggregate M&I nodes.

11. Run **watright** with the new *commands_dds*.

12. By hand, create a .stm file of diversions (which are also demands) for each M&I node. It will have exactly the same monthly amounts in each year of the study period. Use an existing .stm file as a template in order to preserve correct format. Put these files in the demandts subdirectory.

When command files for generating the demand files become available, edit them to include -seteff instructions for the aggregated M&I nodes. Efficiencies should all be set to 1.0. Also, edit them to include replace instructions, referencing the .stm files created in Step 12.

TO: File

FROM: Revised by Lisa Wade 2015

Revised by Ray Alvarado 3/99

Roger Sonnichsen & Meg Frantz

SUBJECT: **Sub task 3.11 Yampa River Basin Aggregate Reservoirs and Stock Ponds**

Introduction

This memo describes the approach and results obtained under Sub task 3.11, 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 in the basin.*

Approach and Results

Reservoirs and Stock Ponds: Table 1 presents 1) the net absolute storage rights that were modeled in Phase II, 2) net absolute storage rights to be added as aggregated reservoirs in Phase IIIa, and 3) stock ponds to be add as aggregated reservoirs in Phase IIIa. The Phase II reservoir information was obtained from the Phase II reservoir rights file. The absolute decree amount presented in Table 1 for “Total Aggregated Reservoirs” was produced by running **watright** with the -aggres option. The storage presented in Table 1 for “Total Aggregated Stock Ponds” was taken from the year 2 Task Memo 2.09-12, “Consumptive Use Model Non-Irrigation Consumptive Uses and Losses in the Yampa River Basin” (11/19/96).

TABLE 1

Phase	Reservoir	Absolute Decree (AF)	Percent of Total
Phase II	Stillwater Res 1	6,392	4
Phase II	Yamcolo	10,345	6
Phase II	Allen Basin	2,249	1
Phase II	Stagecoach	47,447[1]	27
Phase II	Lake Catamount	11,800	7
Phase II	Fish Creek	1,841	1
Phase II	Steamboat Lake	26,364	15
Phase II	Lester Creek	5,657	3
Phase	Elkhead	13,699	8
Subtotal		125,794	72
Phase IIIa	Total Aggregated Reservoirs	33822	19
Phase IIIa	Total Aggregated Stock Ponds	15958 (capacity)	9
Subtotal		49780	28
Total		175574	100

[1]Conditional decree, but built

Number of Structures and Location: Based on location, the Phase IIIa reservoirs and stock ponds were incorporated into the model as six aggregated structures. Three operational reservoirs were used to model the net absolute decreed storage. Storage was assigned to the three nodes on the basis of water district, as shown in Table 2. Three non-operational reservoirs were used to model the stock ponds; total capacity was partitioned to the three nodes based on USGS hydrologic unit, as reported in Task Memo 2.09-12, and presented in Table 3. The placement of each structure within the model network is shown in Exhibit 1 of Section D.1.

TABLE 2
Operational Reservoirs

ID	WD	Name	Capacity(AF)	%
44_ARY001	57&58	ARY_001_YampaRbelCraig	23,206	69
44_ARY002	44	ARY_002_YampaR@Deerlodge	9,122	27
55_ARY003	54&55	ARY_003_LsnakeRnrLily	1,494	4
		Total:	33,822	100

TABLE 3
Non-Operational Stock Ponds

ID	HUC	Name	Capacity(AF)
44_ASY001	14050001	ASY_001_YampaRbelCraig	8,344
44_ASY002	14050002	ASY_002_YampaR@Deerlodge	4,441
55_ASY003	14050003	ASY_003_LsnakeRnrLily	3,173
		Total:	15,958

Each aggregated reservoir and stock pond was assigned one account and an initial storage equal to their capacity listed above. Each aggregated reservoir was assumed to be 25 foot deep. Each stock pond was assumed to be 10 foot deep. Each aggregated reservoir and stock pond was assigned a 2-point area-capacity curve. The first curve point is zero capacity and zero area. The second curve point on the area-capacity table is total capacity with area equal to a total capacity divided by the depth (either 25 or 10 feet). The net evaporation station 10001 as described in Phase II Yampa basin documentation (Section "4.3.2.1 Estimation of Annual Net Evaporation") was assigned to each structure at 100 percent. The Administration of 1 time fill was set to October for each structure. All other parameters were left as the default for each structure.

Target Contents, and End-of-Month Data: Each aggregated reservoir and stock pond was designed to maintain maximum volume, filling to account for evaporation losses. The end-of-month data used in the baseflow calculations was set to the target values.

Water Rights: Water rights associated with each aggregated reservoir and aggregated stock ponds were assigned an administration number equal to 1.00000.

EXHIBIT 1

Sub task 3.11 was completed by executing these steps:

1. Edit *yampa.net* file for the six aggregated reservoirs.

2. Create a *command.res* file that includes the command -aggres and -wrclass, where the -wrclass command is the same as that used in Sub task 3.05. Run **watright** using this *command.res* file.

3. Manually edit the *.res file created in Phase II for the six aggregated reservoirs.

4. Manually edit the *.rer file created in Phase II for the six aggregated reservoirs. Use the *.rag file, output by **watright** under step 2 above, for the breakdown of water rights by administration number. Manually calculate each storage right for each reservoir.

5. Manually edit the *.opr file created in Phase II for the three operational reservoir rules.

6. Use **tstools** to create a *H.tar file. Run **tstools** using a command file that builds the *.tar file from a *zero.del* file and a *.stm file for each reservoir and stock pond in the model. Each *.stm file is a **Statemod** format file.

10. Use **tstools** to create a *.eom file. Run **tstools** using a command file that builds the *.eom file from a *.stm file for each reservoir and stock pond in the model. Each *.stm file is a **Statemod** format file.

Appendix C

1. Green River Basin Plan
   Wyoming Depletions in the Little Snake River Basin

2. Yampa River Modeling Assumptions used for Wyoming's Historic, Current and Future Uses on the Little Snake River

TECHNICAL MEMORANDUM

SUBJECT: **Green River Basin Plan**
Wyoming Depletions in the Little Snake River Basin

PREPARED BY: States West Water Resources Corporation

Introduction

The Little Snake River is not directly tributary to the Green River in Wyoming. It is tributary to the Yampa River which ultimately flows into the Green in Dinosaur National Monument in northwestern Colorado. A programmatic biological opinion will be prepared to address the potential effects of the "Management Plan for Recovery of the Endangered Fishes of the Yampa River Basin and Continuation of Existing Human Water Uses and Future Water Development." The purpose of the Management Plan is to allow for the use and future development of Yampa River Valley water resources and to protect and promote the recovery of the four endangered fish species which reside in the Upper Colorado River Basin. The development of the Management Plan is occurring as an activity of the ongoing Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin, which has been ongoing since 1988. The State of Wyoming is a participant in the Recovery Program and is participating in the development of the Management Plan. This memorandum documents current estimates of depletions due to activities in Wyoming, and presents estimates of depletions out to year 2045.

The average annual water yield from the Little Snake River Basin in total is 428,000 acre-feet (Hawkins and O'Brien, 1997). Sources of depletions in Wyoming include irrigated agriculture, environmental use, municipal use and transbasin diversions for the City of Cheyenne. As of 1994, total Wyoming depletions in the basin were estimated at 39,900 acre-feet annually (Burns & McDonnell, 1999, Appendix D).

No current depletions are explicitly associated with either industrial or domestic uses. Industrial uses are small and generally included within municipal demand estimates. Domestic uses are also small. To the extent they are comprised of individual small wells serving residential populations, domestic uses will not significantly affect surface water flows.

Therefore, determination of current and future demands consists of updating municipal, agricultural and City of Cheyenne depletions, and projecting them out to year 2045. Additional depletions are estimated for future environmental and industrial uses.

Municipal Depletions

According to Purcell (2000), municipal demands in the Little Snake River Basin are created by uses in the towns of Baggs and Dixon. Between the two, a total of 76 acre-feet of water is currently depleted. Burns and McDonnell (ibid.) provide a higher current municipal depletion of

106.8 acre-feet. Current population estimates are 375, 300 for Baggs and 75 for Dixon, for a current use rate of 0.20 acre-feet/person-year using Purcell's numbers. To project these depletions to year 2045, population projections outlined by Watts (2000a) are used. While Watts proposes three growth scenarios, only the moderate growth scenario is used herein. This scenario is based on U.S. Census Bureau projections.

According to Watts, Baggs and Dixon, together, would experience total growth of 10.8 percent from 2000 to 2030. Projected to 2045, or another 15 years beyond the 2030 horizon looked at by Watts, gives a growth total of 16.2 percent. This projection is performed by linear extrapolation, which is satisfactory in this case because the moderate growth curve is linear in later years.

Therefore, projecting municipal demands consists of taking existing use and increasing it by the expected percentage population increase. A current depletion of 76 acre-feet annually, increased by 16.2 percent, gives a 2045 municipal depletion of 88 acre-feet per year.

City of Cheyenne Depletions

Part of the City of Cheyenne's water supply system is comprised of the Stage I and Stage II Projects. These projects consist of collection and transmission systems in the Little Snake River Drainage. Water is collected from several tributaries of the Little Snake River and delivered to a tunnel that transports the water under the continental divide to Hog Park Reservoir in the North Platte River Basin. Storage in Hog Park Reservoir is released to replace water diverted to Cheyenne through the Rob Roy supply components of the Stage I and II Projects, which transport water from the North Platte River Basin to the South Platte River Basin. The current amount of water diverted from the Little Snake Basin, based on the 1995-1997 usage period, is 14,400 acre-feet per year.

Maximum annual capacity of the Stage I/II system is dictated by the larger of the potential yield of this system (21,000 acre-feet, Black and Veatch, 1994) versus the one-fill limitation on Hog Park Reservoir (22,656 acre-feet). In this case, maximum potential depletion allowed to the Little Snake River Basin is therefore 22,656 acre-feet. The City of Cheyenne has no current plan to enlarge the Stage I/II system, however, its capacity will be reached in the 2040-2050 time frame under current growth estimates.

Agricultural Depletions

Agricultural depletions arise from the consumptive use of water by irrigated crops and pasture. Determination of this depletion requires estimates of the current irrigated acreage in the basin and of actual crop consumptive requirements.

O'Grady, et al, (2000) calculated the amount of irrigated lands in the Little Snake Basin using 1983-1984 aerial photography corrected by 1997-1999 infrared satellite imagery. This work resulted in an estimate of current irrigation of Wyoming lands totaling 15,929 acres. Crop distribution in the basin was previously estimated to be 75 percent grass hay, 11 percent alfalfa and 14 percent irrigated pasture (Western Water Consultants, 1992).

Maximum consumptive use of these crops is only achieved with a full water supply. Consumptive irrigation requirement (CIR) at Dixon, or that amount needed in excess of rainfall to produce a crop, was determined by Trelease et al. (1970), as modified by Pochop, et al. (1992) to be 22.78 inches (1.9 feet) for alfalfa and 20.96 inches (1.75 feet) for pasture grass (or grass hay). Modifications to these numbers to include mountain meadow hay were developed for the Green River Basin Water Plan. For this type of hay, it has been determined that the irrigated lands above Baggs would experience 19.59 inches (1.63 feet) of annual CIR. For purposes of depletion estimation, the following distribution was used: lands above Baggs were represented by 89 percent mountain meadow hay and 11 percent alfalfa, with lands below Baggs represented by 89 percent pasture grass/grass hay and 11 percent alfalfa. From irrigated lands mapping, there exist 11,571 acres above Baggs and 4,358 acres below Baggs.

Under the cropping and irrigated lands percentages given above, the total crop-weighted CIR would be as follows:

Crop	**Above Baggs**	**Below Baggs**	**Total**
Grass Acres	10,298	3,879	14,194
Meadow/Grass CIR, ft.	1.63	1.75	
Grass Total CIR, AF	16,786	6,788	23,574
Alfalfa Acres	1,273	479	1,755
Alfalfa CIR, ft.	1.9	1.9	
Total Alfalfa CIR, AF	2,419	910	3,329
Total CIR, AF	19,205	7,698	26,903

These CIR calculations equate on a crop-weighted basis to 1.66 feet of CIR above Baggs and 1.77 feet below Baggs. Estimates of actual agricultural depletions (and review of irrigation diversion records) have shown less depletion than full CIR would dictate, which is to be expected. Estimates of agricultural depletion, based on studies prepared for High Savery Reservoir (Burns and McDonnell, ibid.), indicate the basin to currently receive about a 75 percent supply without storage. Current agricultural depletions are therefore estimated to be 20,050 acre-feet per year. It is recognized that in practice full CIR is usually not achievable unless fields are flat and irrigation timing is precise. Nonetheless, full CIR values provide a reasonable calculation of the needs and demands of the aggregate irrigation in the basin.

High Savery Dam

Depletions associated with the High Savery Dam project are expected to average 7,724 acre-feet per year as given in the Record of Decision, Final Environmental Impact Statement, Little Snake Supplemental Irrigation Water Supply project (Department of the Army Corps of Engineers, June 5, 2000). Of this amount, approximately 869 acre-feet per year is attributable to evaporation from the reservoir itself, leaving 6,855 acre-feet as the depletion associated with supplemental irrigation practices. This project assumes no additional irrigated acres will be brought under production; it provides supplemental late-season water to existing lands. Adding the 20,050 acre-feet of existing depletion to 6,855 acre-feet due to High Savery provides a total agricultural depletion of 26,905 acre-feet, or essentially a 100 percent water supply based on full CIR. Because High Savery has already had a biological opinion issued, it is included in the environmental baseline under current depletions even though it has yet to be constructed.

Other Projects

In 1995, several dikes were permitted on Muddy Creek by the Little Snake River Conservation District with assistance from several state and federal agencies, including the Wyoming Water Development Commission, the Bureau of Reclamation, and the Bureau of Land Management. These dikes, and the impoundments behind them, are permitted for stock and wetland purposes, and have since been constructed.

According to the reservoir permit maps, the three constructed impoundments have a total surface area of 113.5 acres, resulting in an evaporative depletion of 284 acre-feet per year at a net evaporation rate of 30 inches.

Future Depletions

The projects listed below were developed in large part with input from the Little Snake River Conservation District, and reflect their plans and desired ability to further develop the water resources of the basin.

Environmental Uses

Additional Wetlands Construction

The Little Snake River Conservation District has demonstrated the desire and ability to construct wetland habitat for wildlife, stock and riparian benefits. As quantified earlier, the District in the last 5 years has constructed wetlands with estimated depletions amounting to almost 300 acre-feet per year. Future efforts by the District are anticipated to increase the amount of wetlands by a factor of three, thus creating a future depletion on the order of 1,000 acre-feet.

Little Snake River Basin Small Reservoirs Project

A feasibility report evaluating several small reservoirs in the basin was completed by Lidstone and Anderson in 1998. This report, sponsored by the Little Snake River Conservation District, looked at the feasibility of constructing up to 34 small impoundments for purposes of stock watering, rangeland improvement, and wildlife enhancement. The study resulted in a list of 12 reservoir sites to be considered for Level III design and construction funding. Currently, one reservoir is slated for construction with a second dependent on the availability of funding. For this estimate, the two slated for construction funding are considered as existing depletions, and the remaining ten considered as adding depletions for the 2045 scenario.

The two impoundments under existing funding are Ketchum Buttes 25 and Smiley Draw 27. State Engineer records indicate reservoir surface areas of 10.6 and 8.9 acres, respectively. Assuming a net evaporation of 30 inches (same as High Savery Dam, considered as representative), the total depletions for these impoundments average 49 acre-feet per year (27 and 22 acre-feet, respectively).

The 10 impoundments for possible future construction are as follows:

Reservoir	Surface Area, ac.	Depletion, acre-feet
Blue Gap 16	50.1	125
Blue Gap 27	14.6	37
Browns Hill 21	2.9	7
Garden Gulch 3	2.8	7
Garden Gulch 32	19.9	50
Ketcham Buttes 34	5.5	14
Peach Orchard Flat 34	88.6	222
Pine Grove Ranch 1	7.7	19
Pole Gulch 27	0.7	2
Riner 28	52.2	131

Total
614

Agricultural Uses

Miscellaneous Stock Reservoirs

The Little Snake River Conservation District has indicated that due to siltation and other causes of loss, stock reservoirs are being replaced and will continue to be replaced over the next 45 years. Hundreds of stock reservoirs currently exist in the basin, and at the rate of five per year over 200 new ponds will be constructed by 2045. These new ponds will vary in size, and it is estimated that up to 2,000 acre-feet of depletion will be attributable to their construction and storage.

Dolan Mesa Canal

Currently there is a water right and one enlargement for an irrigation supply project from Savery Creek, the Dolan Mesa Canal. Together, these rights are permitted to serve 1,600 acres. The lands are currently not irrigated, but the possibility exists that current or subsequent owners may try to bring the lands under irrigation. If all 1,600 acres were irrigated, depletion estimates (using 1.66 feet of CIR) would total 2,656 acre-feet.

Willow Creek Storage

Users in the State of Colorado are seeking to implement a storage project on Willow Creek, which flows into the Little Snake River south of Dixon, WY.. The Little Snake River Conservation District has expressed interest in becoming a joint applicant in the project to increase its size and serve lands in Wyoming. Under a Willow Creek reservoir, approximately 1000 acres would be served. The depletion associated with this use would amount to 1,660 acre-feet.

Cottonwood Creek

The Little Snake River Conservation District has indicated that a project is being considered that would have its source of supply water from Cottonwood Creek, tributary to the Little Snake River north of Dixon, WY. The project, anticipated to be brought before the Wyoming Water Development Commission in the fall of 2000, would add 500 acres of irrigation. The depletion associated with this use would amount to 830 acre-feet.

Grieve Reservoir

Grieve Reservoir, which washed out in the summer of 1984, is being considered for rehabilitation and enlargement. This reservoir, if enlarged, is anticipated to serve 300 acres in addition to the original grounds irrigated from the pre-existing structure. The depletion associated with this use would amount to 500 acre-feet.

Muddy Creek

The Muddy Creek Watershed is a candidate for diversions to irrigate up to 1,200 acres of pasture in the lower reaches north of Baggs, WY. At 1.77 feet of consumptive irrigation requirement, this project would result in depletions amounting to 2,100 acre-feet.

Focus Ranch

The Focus Ranch property has a need for supplemental irrigation for 200 acres. The source for this water, likely from storage, is the Roaring Fork near the National Forest boundary. At 0.5 acre-foot per acre supplemental need, this project would result in a depletion of 100 acre-feet.

Pothook – Beaver Ditch

The Little Snake River Conservation District has indicated that a project totaling approximately 400 acres could be brought into production near the confluence of Savery Creek and the Little Snake River. These lands may once have been considered to be served by the Beaver Ditch under an earlier study by the USBR as part of the Savery-Pothook project. At 1.77 feet per acre of consumptive irrigation requirement, this project would result in depletions amounting to 700 acre-feet.

The sum total of projected depletions for the additional agricultural projects listed above is 10,546 acre-feet annually.

Industrial Uses

Industrial use projections outlined by Watts (2000b) are used as a starting point to project future industrial use depletions to year 2045 for the Little Snake River Basin. Watts' industrial use projections do not purport to guess in what areas of the basin industrial use will grow, only that the growth will probably come from established industries. While Watts proposes three growth scenarios, only the moderate growth scenario is used herein (as was done with the projections for municipal use as described above). A reasonable approach given the non-spatial nature of industrial demand projections for the Green River Basin is to assign growth in industrial water demand on an area-weighted basis. To do otherwise would effectively discount that industrial growth will likely occur in the Little Snake River Basin. Wyoming's portion of the Little Snake River drainage (approx. 852,000 acres) is about 6.4 percent of the land area of the portion of the Green River Basin located in Wyoming (approx. 13,349,000 acres) (Chris Jessen, personal communication). Applying this basin area percentage (6.4 percent) to the moderate industrial growth projection of 40,000 acre-feet per year yields 2,560, rounded to 3,000 acre-feet per year, of industrial water demand in year 2045. Application of the high industrial demand projection would yield an estimate of about 6,400 acre-feet per year. Maintaining the State of Wyoming's ability to provide industrial water when demand arises in the next 45 years is critically important. Based on the above, the future depletion estimate includes 3,000 acre-feet per year.

Summary of Current and Future Depletions

The following current depletion estimates are presented:

Current Use	Depletion, AF/YR
Municipal (In-Basin)	76
City of Cheyenne	14,400
Agricultural	20,050
High Savery Reservoir	7,724

Diked Wetlands	284
Small Reservoirs	49
Total	**42,583**

Future depletions (year 2045) are estimated to be:

Future Use	Depletion, AF/YR
Municipal (In-Basin)	88
City of Cheyenne	22,656
Agricultural	20,050
High Savery Reservoir	7,724
Diked Wetlands	1,284
Small Reservoirs	663
Additional Agricultural Uses	10,546
Industrial Use	3,000
Total	**66,011**

For comparison, these depletions are compared to annual flows seen at one gage on the Little Snake River. The gage, Little Snake River near Dixon, WY (9-2570) provides an indication of the annual flows seen in the river. In addition, two tributaries contributing to flow in the river not included in the gage data are Muddy Creek and Willow Creek. Estimates of flows in these tributaries are also provided. Data are taken from USGS reports, which would already reflect depletions.

Gage or Tributary	Average Annual Flow, AF
Little Snake River near Dixon (1911-1971)	372,600
Muddy Creek (1987-1991)	10,690
Willow Creek (1954-1993)	7,440
Total	**408,860**

Summary

These depletions are independent of the amount of water *available* to Wyoming under provisions of the Upper Colorado River Basin Compact and the Colorado River Compact. The State of Wyoming's apportionment of the waters of the Colorado River System exists in perpetuity. Wyoming therefore continues to retain the right to develop all its available water resources under those Compacts in accordance with current governmental permitting requirements.

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DRAFT

MEMORANDUM

TO: Yampa River Project Management Team

FROM: Ray Alvarado and John Shields
Revised by Lisa Wade

DATE: October 22, 2001
Revisions Made by the Wyoming State Engineer's Office on November 1, 2001
Revisions Made by Lisa Wade for the 2015 StateMod calibration update regarding High Savery Reservoir information received from the Wyoming Water Development Commission, Project Manager Jason Mead

SUBJECT: Yampa River Modeling Assumptions used for Wyoming's historic, current and future uses on the Little Snake River.

This memorandum addresses the modeling assumptions used in coming up with Wyoming's historic, current and future depletions on the Little Snake River. Information supplied by the Wyoming State Engineer's Office in an August 23, 2000 technical memorandum titled "Green River Basin Plan Wyoming Depletions in the Little Snake River Basin" (note: this memorandum is found in "Appendix B" of the final draft of "A Management Plan for the Yampa River Basin" dated October 2001) as well as data in a spreadsheet provided by the Wyoming State Engineer's Office and labeled "DepletionBreakoutsProject_Wyo.xls" were used.

Historic Conditions

Agriculture

To develop natural flows for the Little Snake, (which are used as the starting point for the CRDSS modeling) Wyoming's historic uses were needed. A total of five nodes were added to the Yampa model to represent agricultural, municipal/industrial uses that are above and below Baggs, Wyoming. Uses by the City of Cheyenne and the High Savery Reservoir were included as separate modeling nodes. The High Savery Reservoir was located on the main stem upstream of Baggs, but is not operated during the historic period. Figure 1 shows the model network diagram that includes the Wyoming nodes. All nodes depicting Wyoming uses are labeled with a 990 prefix. Table 1 lists the model ID for Wyoming's water uses.

Figure 1

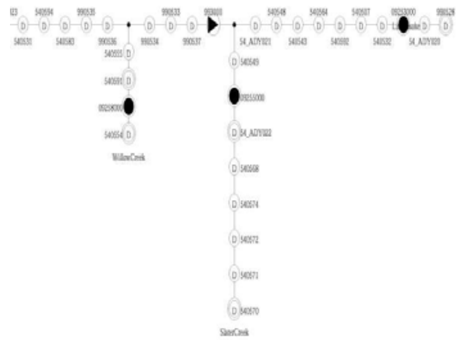

Table 1
Modeling Nodes for Wyoming

Modeling ID	Name
990535	Agricultural Uses below Baggs, Wyo.
990536	M/I Uses below Baggs, Wyo.
990534	Agricultural Uses above Baggs, Wyo.
990533	Agricultural Uses above Baggs, Wyo.
990537	M/I Uses above Baggs, Wyo.
993000	Existing Reservoirs above Baggs, Wyo.
993001	Existing Reservoirs below Baggs, Wyo.
993002	High Savery Reservoir
993003	Diked Wetlands
993004	Stock Ponds
993005	New Ag. Resevoir
990538	New Agricultural Use
990528	City of Cheyenne

A spreadsheet provided by the Wyoming State Engineer's Office, named "DepletionBreakoutsProject_Wyo.xls" was used to estimate annual historic depletion data. This spreadsheet contains the 1971-1995 depletions as determined for the Consumptive Use and Lose Report (CULR) by Wyoming. For the Little Snake, data for CRSS Reach 500; HUC's 14050003 and 14050004 were used. Since only annual depletion amounts were estimated, monthly distributions for the diversions and depletions had to be developed for agricultural and municipal/industrial uses.

For purposes of this analysis, the monthly distributions of the annual values for Wyoming's 1971-1995 agricultural uses were assumed to be distributed based on historic use distribution pattern established for similar uses in Water District 54 in Colorado. Water District 54 borders the Wyoming/Colorado stateline, with the Little Snake River being the main source for irrigators. Agricultural uses upstream of Baggs were modeled as two nodes since the depletions were large. Tables 2 and 3 give the monthly breakdown by year for Wyoming's agricultural nodes that will be modeled to replicate historic use.

Table 2
Wyoming's Estimated Monthly Agriculture Depletions for 990533 & 990534
Above Baggs, Wyo. in acre-feet

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1971	0	0	0	0	0	0	0	253	3778	3676	563	47	8317
1972	40	0	0	0	0	0	34	1640	3606	1489	544	82	7435
1973	18	0	0	0	0	0	1	29	3933	2636	655	56	7327
1974	32	0	0	0	0	0	0	878	3697	2023	1365	856	8850
1975	498	0	0	0	0	0	0	264	2523	2611	807	147	6851
1976	126	0	0	0	0	0	0	1270	1958	1528	618	125	5625
1977	136	0	0	0	0	0	42	1482	1324	497	123	110	3715
1978	12	0	0	0	0	0	0	295	2998	2244	883	294	6726
1979	89	0	0	0	0	0	1	229	2931	2422	894	402	6967
1980	425	0	0	0	0	0	0	39	3278	2112	576	144	6575
1981	39	0	0	0	0	0	0	1497	2520	1781	367	336	6541
1982	184	0	0	0	0	0	0	281	2276	2777	621	49	6188
1983	77	0	0	0	0	0	17	249	3056	2414	746	410	6970
1984	172	0	0	0	0	0	30	654	2110	2206	652	382	6206
1985	242	0	0	0	0	0	0	274	1852	1906	1574	927	6775
1986	1259	0	0	0	0	0	0	1358	2965	2178	1265	689	9714
1987	302	0	0	0	0	0	0	2639	2021	2093	2064	1972	11091
1988	1506	0	0	0	0	0	0	2490	2905	2673	1964	1163	12705
1989	1278	0	0	0	0	0	62	4152	4192	2045	809	518	13056
1990	75	0	0	0	0	0	212	2819	4867	2468	709	865	12015
1991	108	0	0	0	0	0	0	1532	3319	1763	717	617	8056
1992	145	0	0	0	0	0	0	2960	2849	1580	748	442	8725
1993	109	0	0	0	0	0	0	1151	3875	2383	1042	456	9017
1994	147	0	0	0	0	0	539	3324	3242	1806	835	476	10369
1995	177	0	0	0	0	0	40	233	2941	4243	933	486	9051

Table 3
Wyoming's Estimated Monthly Agriculture Depletions for 990535
Below Baggs, Wyo. in acre-feet

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1971	0	0	0	0	0	0	0	62	928	903	138	12	2043
1972	10	0	0	0	0	0	8	403	886	366	134	20	1827
1973	4	0	0	0	0	0	0	7	966	648	161	14	1800
1974	8	0	0	0	0	0	0	216	908	497	335	210	2174

1975	122	0	0	0	0	0	0	65	620	642	198	36	1683
1976	31	0	0	0	0	0	0	312	481	375	152	31	1382
1977	33	0	0	0	0	0	10	364	325	122	30	27	913
1978	3	0	0	0	0	0	0	72	737	551	217	72	1653
1979	22	0	0	0	0	0	0	56	720	595	220	99	1712
1980	104	0	0	0	0	0	0	9	805	519	142	35	1615
1981	10	0	0	0	0	0	0	368	619	437	90	82	1607
1982	45	0	0	0	0	0	0	69	559	682	152	12	1520
1983	19	0	0	0	0	0	4	61	751	593	183	101	1712
1984	42	0	0	0	0	0	7	161	518	542	160	94	1525
1985	60	0	0	0	0	0	0	67	455	468	387	228	1664
1986	319	0	0	0	0	0	0	344	750	551	320	174	2458
1987	74	0	0	0	0	0	0	645	494	512	505	482	2713
1988	371	0	0	0	0	0	0	613	715	658	483	286	3127
1989	311	0	0	0	0	0	15	1011	1021	498	197	126	3180
1990	18	0	0	0	0	0	52	688	1188	602	173	211	2933
1991	26	0	0	0	0	0	0	373	809	430	175	150	1963
1992	35	0	0	0	0	0	0	715	688	382	181	107	2107
1993	27	0	0	0	0	0	0	287	967	595	260	114	2251
1994	35	0	0	0	0	0	130	799	779	434	201	115	2493
1995	44	0	0	0	0	0	10	58	732	1055	232	121	2251

Table 4 presents the average monthly headgate efficiencies used to estimate historic diversions. These values are those established from data collected from Colorado Water District 54, which, as explained above, borders the Wyoming/Colorado Stateline and which has the Little Snake River as the main source of water supply for irrigation uses. These efficiencies were used for the entire 1971-1995 period.

Table 4
Headgate Efficiencies used to Estimate Wyoming's Historical Diversions

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average	9	0	0	0	0	0	19	23	24	35	39	28

Municipal and Industrial

Wyoming's municipal and industrial annual depletions were also taken from the "DepletionBreakoutsProject_Wyo.xls" spreadsheet. Monthly depletions were calculated by dividing the annual value by 12 and then rounding the resultant figure to the nearest whole number. Monthly values were adjusted to get to the annual value when needed. Tables 5 and 6 show the monthly distribution that will be used in the Yampa River Basin model. Monthly diversions were estimated by dividing the monthly depletions shown in Tables 5 and 6 by 30 percent. The rationale for assuming that the municipal and industrial uses only consume 30 percent of the diverted amount is on uses within Colorado.

Table 5
Monthly Depletions for M&I uses above Baggs, Wyo.
Acre-Feet

Water Year	WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1971	990536	2	2	2	2	2	2	2	2	2	2	2	2	24
1972	990536	2	2	2	2	2	2	2	2	2	2	2	2	24
1973	990536	2	2	2	2	2	2	2	3	3	3	3	3	29
1974	990536	3	2	2	2	3	3	3	3	3	3	3	3	33
1975	990536	3	3	3	3	3	3	3	4	4	3	3	3	38
1976	990536	4	3	4	4	4	4	4	4	4	4	4	4	47
1977	990536	5	4	5	5	5	5	5	5	5	5	5	5	59
1978	990536	5	4	4	4	4	5	5	5	5	5	5	5	56
1979	990536	5	4	5	5	5	5	5	5	5	5	5	5	59
1980	990536	5	5	5	5	5	5	5	6	6	6	6	6	65
1981	990536	5	5	5	5	5	5	5	6	5	5	5	5	61
1982	990536	5	5	5	5	5	5	5	6	5	5	5	5	61
1983	990536	5	4	4	4	4	4	4	5	5	5	5	5	54
1984	990536	4	3	4	4	4	4	4	4	4	4	4	4	47
1985	990536	1	1	1	1	1	1	1	1	1	1	1	1	12
1986	990536	1	1	1	1	1	1	1	1	1	1	1	1	12
1987	990536	1	1	1	1	1	1	1	1	1	1	1	1	1
1988	990536	1	1	1	1	1	1	1	1	1	1	1	1	1
1989	990536	1	1	1	1	1	1	1	1	1	1	1	1	1
1990	990536	1	1	1	1	1	1	1	1	1	1	1	1	1
1991	990536	5	4	4	4	4	5	5	5	5	5	5	5	56
1992	990536	7	7	7	7	7	7	7	7	7	7	7	7	84
1993	990536	10	10	10	10	10	10	10	11	11	11	10	10	123
1994	990536	13	13	13	13	13	13	13	14	13	13	13	13	157
1995	990536	17	16	16	17	17	17	17	17	17	17	17	17	202

Table 6
Monthly Depletions for M&I uses below Baggs, Wyo.
Acre-Feet

Water Year	WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1971	990537	4	3	3	3	4	4	4	4	4	4	4	4	45
1972	990537	4	3	3	3	3	4	4	4	4	4	4	4	44
1973	990537	4	4	4	4	4	4	4	5	5	5	5	5	53
1974	990537	5	5	5	5	5	5	5	6	5	5	5	5	61
1975	990537	6	5	5	6	6	6	6	6	6	6	6	6	70
1976	990537	7	7	7	7	7	7	7	8	8	8	7	7	87
1977	990537	9	9	9	9	9	9	9	10	9	9	9	9	109
1978	990537	9	8	8	8	8	8	9	9	9	9	9	9	103
1979	990537	9	9	9	9	9	9	9	10	9	9	9	9	109
1980	990537	10	10	10	10	10	10	10	10	10	10	10	10	120
1981	990537	9	9	9	9	9	9	9	10	10	10	10	10	113
1982	990537	9	9	9	9	9	9	9	10	10	10	10	10	113
1983	990537	8	8	8	8	8	8	8	9	9	9	9	9	101
1984	990537	7	7	7	7	7	7	7	8	8	8	8	7	88
1985	990537	6	6	6	6	6	6	7	7	7	7	7	7	78
1986	990537	6	6	6	6	6	6	7	7	7	7	7	7	78
1987	990537	6	5	5	5	5	5	6	6	6	6	6	6	67
1988	990537	4	3	3	3	4	4	4	4	4	4	4	4	45
1989	990537	3	2	2	3	3	3	3	3	3	3	3	3	34
1990	990537	3	2	2	3	3	3	3	3	3	3	3	3	34
1991	990537	7	6	6	6	6	6	7	7	7	7	7	7	79
1992	990537	11	11	11	11	11	11	11	12	12	12	11	11	135
1993	990537	16	15	16	16	16	16	16	16	16	16	16	16	191
1994	990537	21	20	20	20	20	20	21	21	21	21	21	21	247
1995	990537	24	24	24	24	24	24	24	25	25	25	24	24	291

Reservoir Evaporation

Estimation of the amount of reservoir evaporation that occurred in the Little Snake River Basin was made in the U.S. Bureau of Reclamation's "Consumptive Uses and Losses Report" for 1991-1995. The Wyoming State Engineer's Office segregated the data found in the USBR's Technical Memorandum for the 1991-1995 CULR into the "DepletionBreakoutsProject_Wyo.xls" spreadsheet.

For modeling purposes, two reservoirs will be added to the network that represents aggregated historic reservoir evaporation for above and below Baggs, Wyoming. Table 7 lists the reservoirs that are associated with the modeled reservoirs and the annual evaporation.

Table 7
Historic Reservoir Evaporation
Acre-Feet

Modeled Reservoir	WDID	Structures included	Net Annual Evaporation
Above Baggs, Wyo.	993000	Beavers, Highline, Sheep Mountain	144
Below Baggs, Wyo.	993001	J.O., Little Robber	65
		Total	209

City of Cheyenne

Annual transmountain diversions by the City of Cheyenne were obtained from the Wyoming State Engineer's Office Wyoming for the years 1969-1999. Monthly diversions were estimated by using the 1998 monthly distribution, also obtained from Wyoming. Table 8 gives the monthly diversions that will be used in the Yampa River Basin model. Since the water is exported out of basin, all diversions by Cheyenne will be 100 percent depletive to the Little Snake River.

Table 8
City of Cheyenne Estimated Monthly Diversions
Acre-Feet

Water Year	WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1969	990528	0	0	0	0	0	0	45	3688	4053	403	16	2	8207
1970	990528	0	0	0	0	0	0	44	3575	3928	391	16	2	7955
1971	990528	0	0	0	0	0	0	25	2021	2220	221	9	1	4496
1972	990528	0	0	0	0	0	0	40	3233	3552	353	14	1	7193
1973	990528	0	0	0	0	0	0	45	3651	4012	399	16	2	8124
1974	990528	0	0	0	0	0	0	38	3130	3439	342	14	1	6965
1975	990528	0	0	0	0	0	0	28	2286	2512	250	10	1	5086
1976	990528	0	0	0	0	0	0	42	3426	3765	374	15	2	7624
1977	990528	0	0	0	0	0	0	24	1945	2137	212	8	1	4327
1978	990528	0	0	0	0	0	0	38	3116	3424	340	14	1	6933
1979	990528	0	0	0	0	0	0	45	3690	4055	403	16	2	8211
1980	990528	0	0	0	0	0	0	43	3474	3817	379	15	2	7730
1981	990528	0	0	0	0	0	0	30	2450	2692	268	11	1	5451
1982	990528	0	0	0	0	0	0	53	4306	4731	470	19	2	9581
1983	990528	0	0	0	0	0	0	28	2259	2482	247	10	1	5027
1984	990528	0	0	0	0	0	0	14	1115	1226	122	5	1	2482
1985	990528	0	0	0	0	0	0	54	4408	4843	481	19	2	9807
1986	990528	0	0	0	0	0	0	67	5441	5979	594	24	2	12107
1987	990528	0	0	0	0	0	0	46	3766	4138	411	16	2	8379

1988	990528	0	0	0	0	0	0	39	3166	3478	346	14	1	7044
1989	990528	0	0	0	0	0	0	69	5613	6167	613	24	3	12489
1990	990528	0	0	0	0	0	0	77	6244	6861	682	27	3	13894
1991	990528	0	0	0	0	0	0	91	7398	8129	808	32	3	16462
1992	990528	0	0	0	0	0	0	69	5595	6148	611	24	3	12450
1993	990528	0	0	0	0	0	0	129	10527	11566	1150	46	5	23422
1994	990528	0	0	0	0	0	0	79	6460	7098	706	28	3	14374
1995	990528	0	0	0	0	0	0	67	5458	5997	596	24	2	12144
1996	990528	0	0	0	0	0	0	94	7647	8402	835	33	3	17014
1997	990528	0	0	0	0	0	0	78	6345	6972	693	28	3	14119
1998	990528	0	0	0	0	0	0	82	6683	7343	730	29	3	14870
1999	990528	0	0	0	0	0	0	73	5956	6545	651	26	3	13253

The Colorado's current CRDSS Yampa River Water Resource Planning model incorporated historic depletions at the 100 percent level and is the product of CRDSS Phase IIIb work tasks. Under Task IIIb, the Yampa input data sets were revised to include the 1909 - 1998 water year period. These revisions included new data filling techniques for missing baseflow data (baseflows for the 1909-1974 period were estimated using the USGS Mixed Station linear regression model).

Current Conditions

From technical memorandum "Green River Basin Plan Wyoming Depletions in the Little Snake River Basin", current use listed on page 7 was used for current annual depletions.

Agricultural

Listed on page 7 of the technical memorandum, 20,050 acre-feet is the average depletion under current conditions with an additional 6,855 acre-feet coming from the High Savery Project for a total of 26,905 acre-feet. Table 8 shows how the 26,905 acre-feet of depletions were split between above and below Baggs, Wyoming. Of the 26,905 acre-feet, 23,964 acre-feet are above Baggs, Wyoming and 2,941 acre-feet below. Monthly distribution shown in Table 9 is based on the average distribution derived from Tables 2 and 3. Since the construction of the High Savery Project has not yet been completed, this seems to be a reasonable assumption as to the point of use of the water.

Table 9
Agricultural Depletions under Current Conditions
Acre-Feet

990533	593	0	0	0	0	0	97	2603	3830	2689	1283	887	11982
990534	593	0	0	0	0	0	97	2603	3830	2689	1283	887	11982
990535	146	0	0	0	0	0	23	639	940	660	315	218	2941
Total	1332	0	0	0	0	0	217	5845	8600	6038	2881	1992	26905

Municipal and Industrial

Under current conditions, the 76 acre-feet of depletions occurring due to municipal and industrial uses (as identified in the August 23, 2000 Wyoming Technical Memorandum) are assumed to be distributed on the basis shown in Table 10. The basis of this distribution is, as described above, using the monthly depletions values, dividing the annual value by 12 and then rounding the resultant figure to the nearest whole number.

Table 10
Municipal and Industrial under Current Conditions
Acre-Feet

WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
990536	2	2	2	2	2	2	2	2	2	2	2	2	27
990537	4	4	4	4	4	4	4	4	4	4	4	4	49
Total	6	6	6	6	6	6	6	6	6	6	6	6	76

Reservoir Evaporation

All of Wyoming's agricultural uses modeled will have access to this water. Reservoir evaporation will be based on evaporation rates used for Elkhead Reservoir.

High Savery Reservoir

High Savery Reservoir was recently constructed and came on-line in 2006. It provides supplemental irrigation water to the Savery Creek and Little Snake River valleys in the southeastern corner of Wyoming's Green River Basin. Located high on Savery Creek in Carbon County, High Savery impounds 22,433 AF. The reservoir is owned and permitted by the State of Wyoming, and operated by the Savery - Little Snake Water Conservancy District. The storage – area curve is presented in the table below.

Storage (acre-feet)	Surface Area (acres)
0.0	0.0
10.3	4.1
47.7	10.9
126	20.3
261	33.9
457	44.2
707	56.0
1,006	63.5
1,348	73.4
1,754	89.2
2,239	105.0
2,802	120.0
3,448	138.0
4,180	155.0
5,003	174.0
5,772	192.0

5,927	196.0
6,772	214.0
6,963	219.0
8,114	242.0
9,390	269.0
10,802	296.0
12,356	325.0
14,056	355.0
15,913	388.0
17,928	419.0
20,101	450.0
22,433	482.0

City of Cheyenne

Current diversions for the City of Cheyenne will be set at 14,400 acre-feet per year and will have a monthly distribution shown in Table 11. The basis for the monthly distribution of the annual amount was estimated by using the 1998 monthly distribution.

Table 11
City of Cheyenne Current Diversions
Acre-Feet

WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
990528	0	0	0	0	0	0	79	6472	7111	707	28	3	14400

Diked Wetlands

In its August 23, 2000 technical memorandum titled "Green River Basin Plan Wyoming Depletions in the Little Snake River Basin" (note: this memorandum is found in "Appendix B" of the final draft of "A Management Plan for the Yampa River Basin" dated October 2001), the Wyoming State Engineer's Office and their consultant stated the following:

"In 1995, several dikes were permitted on Muddy Creek by the Little Snake River Conservation District with assistance from several state and federal agencies, including the Wyoming Water Development Commission, the Bureau of Reclamation, and the Bureau of Land Management. These dikes, and the impoundments behind them, are permitted for stock and wetland purposes, and have since been constructed. According to the reservoir permit maps, the three constructed impoundments have a total surface area of 113.5 acres, resulting in an evaporative depletion of 284 acre-feet per year at a net evaporation rate of 30 inches." For modeling purposes, a reservoir node will be included to represent the three dikes.

Small Reservoirs

Current stock reservoir depletion was estimated in the August 23, 2000 memorandum by the Wyoming State Engineer's Office and their consultant as amounting to 49 acre-feet per year. The assumed distribution of the evaporation from these miscellaneous reservoirs (which will be modeled as one aggregate reservoir) will be the same as that determined by the State of Colorado for Colorado Water District No. 54.

Future Conditions (2045)

Agricultural

The existing depletions used for "current conditions", 26,950 acre-feet will continued to be used under future conditions. An additional 5,200 acres is anticipated coming online in the future and will be supplied by reservoirs. For modeling purposes, the 5,200 acres will be modeled as one node with it supply coming from a single reservoir. Table 12 lists the structure and proposed acreage and estimated depletion that will be modeled as a single structure.

Table 12
Future Agricultural

Name	Acreage	Estimated Depletion, af
Dolan Mesa Canal	1,600	2,656
Willow Creek Storage	1,000	1,660
Cottonwood Creek	500	830
Grieve Reservoir	300	500
Muddy Creek	1,200	2,100
Focus Ranch	200	100
Pothook-Beaver Ditch	400	700
Total	5,200	8,546

Municipal and Industrial

For future conditions the 88 acre-feet of municipal depletions was combined with the 3,000 acre-feet for industrial for a combined total of 3,088 acre-feet shown in Table 13.

Table 13
Municipal and Industrial under Current Conditions
Acre-Feet

WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
990536	91	91	91	91	91	91	91	92	92	92	92	92	1097
990537	166	165	166	166	166	166	166	166	166	166	166	166	1991
Total	257	256	257	257	257	257	257	258	258	258	258	258	3088

City of Cheyenne

Future diversions for the City of Cheyenne will be set at 22,656 acre-feet per year and will have a monthly distribution shown in Table 14. The assumed monthly distribution of the diversions will be the same as that used/assumed for the current diversions. This assumption is made on the basis that the future use of water by Cheyenne is likely to be for the same uses in the same months of the year when the population of Cheyenne is larger in the future and seems reasonable for purposes of this analysis.

Table 14
City of Cheyenne Current Diversions
Acre-Feet

WDID	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
990528	0	0	0	0	0	0	125	10182	11188	1112	44	5	22656

Diked Wetlands

For purposes of this analysis, an additional 1,000 acre-feet of additional wetland depletions will be added to diked wetland model node.

Small Reservoirs

Depletions due to small reservoirs will increase by 614 acre-feet according to the August 23, 2000 technical memorandum titled "Green River Basin Plan Wyoming Depletions in the Little Snake River Basin". An additional 2,000 acre-feet will be modeled to account for miscellaneous additional stock reservoirs.

Since these reservoirs will most likely have as their purposes and water uses stock watering, rangeland improvement and wildlife enhancement, for purposes of this analysis the assumption was made that the depletion will be handled as reservoir evaporation. That evaporation is assumed to have the same monthly distribution as assumed for reservoir evaporation occurring in Colorado Water District 54, which, as explained above, borders the Wyoming/Colorado Stateline.

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