# NORTHWESTERN ENERGY HYDRO FLEET
# CHEOPS MODEL
# OPERATIONS/VERIFICATION REPORT

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# Executive Summary

NorthWestern Energy (Licensee) contracted with HDR Engineering, Inc. of the Carolinas (HDR) to develop an operations model of the PPL Montana Hydro Assets (Hydros) recently acquired by NorthWestern Energy, including: the Missouri-Madison Hydroelectric Project (Federal Energy Regulatory Commission (FERC) Project No. 2188) on the Madison and Missouri Rivers; Thompson Falls Hydroelectric Project (FERC Project No. 1869) on the Clark Fork River; and the Mystic Hydroelectric Project (FERC Project No. 2301) on West Rosebud Creek. The U.S. Bureau of Reclamation (USBR) Canyon Ferry facility on the Missouri River is also included in the modeled plants and these are referred to as the "modeled system." This operations model utilizes HDR's proprietary Computer Hydro Electric Operations and Planning Software (CHEOPS).

CHEOPS utilizes daily flows, plant generating characteristics, and reservoir/plant operating criteria to simulate project operation. The program simulates operations of a plant to meet user-specified goals (e.g. maximize energy production while meeting all regulatory constraints). The model is fully capable of determining headwater elevation, headlosses, net head, turbine discharge and spill, power generation, and other user-specified variables in 15-minute increments. The NorthWestern Energy Hydro Fleet CHEOPS Model (NWE CHEOPS Model) was custom configured for the system based on the specific system constraints such as flow requirements, target reservoir elevations, powerhouse equipment constraints, and reservoir storage support between operators (NorthWestern Energy and USBR). CHEOPS utilizes daily flows, plant generating characteristics, and operating criteria of the system to simulate operation, allocate flow releases, and calculate energy production within the system. Although CHEOPS computes generation and flows at discreet 15-minute increments, it is designed for long-term analysis of the effects of operational and physical changes made to the modeled hydro system.

The purpose of this operations and verification report is to document inputs and assumptions used in the development of the model, to demonstrate that the model reasonably characterizes operations of the twelve NorthWestern Energy and one USBR developments modeled, and to demonstrate the model is adequate for use in evaluating the effects of alternative operating scenarios. Future sensitivity analyses will include an evaluation of peaking capability throughout the system. Model results presented in this report represent the model configuration as of February, 2015.

The NWE CHEOPS Model is coded to run day-to-day operations based on a single set of operating conditions or rules. Actual project operations generally follow the operating rules; however, human intervention periodically deviates from the general operating rules to accommodate day-to-day realities such as equipment failure and maintenance, changing hydrologic conditions, power demands, and other factors.

In the opinion of HDR, verification results show the operations model and the hydrologic inputs compare favorably to historical data, reasonably characterize system operations, and are appropriate for use in evaluating the effects of alternative operating scenarios on generation, reservoir levels, and outflows. The CHEOPS software and this operations model are tools that, as this report demonstrates, can be successfully used to evaluate the relative sensitivity and response of the system modeled to changing operational constraints. As with any model, accuracy is highly dependent on input data; consequently, model results should be viewed in a relative, rather than an absolute, context.

## Section 1
# Introduction

NorthWestern Energy (Licensee) contracted with HDR Engineering, Inc. of the Carolinas (HDR) to develop an operations model of the PPL Montana Hydro Assets (Hydros) recently acquired by NorthWestern Energy, including: the Missouri-Madison Hydroelectric Project (Federal Energy Regulatory Commission (FERC) Project No. 2188) on the Madison and Missouri Rivers; Thompson Falls Hydroelectric Project (FERC Project No. 1869) on the Clark Fork River; and the Mystic Hydroelectric Project (FERC Project No. 2301) on West Rosebud Creek. The U.S. Bureau of Reclamation (USBR) Canyon Ferry facility on the Missouri River is also included in the modeled plants and these are referred to as the "modeled system." This operations model utilizes HDR's proprietary Computer Hydro Electric Operations and Planning Software (CHEOPS).

HDR created the Computer Hydro Electric Operations and Planning Software (CHEOPS™) hydropower system simulation model as a flexible, reliable, and easy-to-use tool for evaluating the effects on hydropower projects resulting from a wide range of physical plant changes (e.g., turbine upgrades) and operational constraints (e.g., reservoir storage flexibility), as well as the effects of changes in hydrology or upstream regulation. One of the many strengths of CHEOPS is the degree to which each individual model may be customized to suit the particular site-specific operating characteristics of a single station or an entire river system. The model is tailored to meet the demands of the particular plant/system being modeled, and the program architecture provides a platform for investigating each project-specific feature under scrutiny.

CHEOPS utilizes daily flows, plant generating characteristics, and reservoir/plant operating criteria to simulate project operation. The program simulates operations of a plant to meet user-specified goals (e.g. maximize energy production while meeting all regulatory constraints). The model is fully capable of determining headwater elevation, headlosses, net head, turbine discharge and spill, power generation, and other user-specified variables in 15-minute increments. The NorthWestern Energy Hydro Fleet CHEOPS Model (NWE CHEOPS Model) was custom configured for the system based on the specific system constraints such as flow requirements, target reservoir elevations, powerhouse equipment constraints, and reservoir storage support between operators (NorthWestern Energy and USBR). CHEOPS utilizes daily flows, plant generating characteristics, and operating criteria of the system to simulate operation, allocate flow releases, and calculate energy production within the system. Although CHEOPS computes generation and flows at discreet 15-minute increments, it is designed for long-term analysis of the effects of operational and physical changes made to the modeled hydro system.

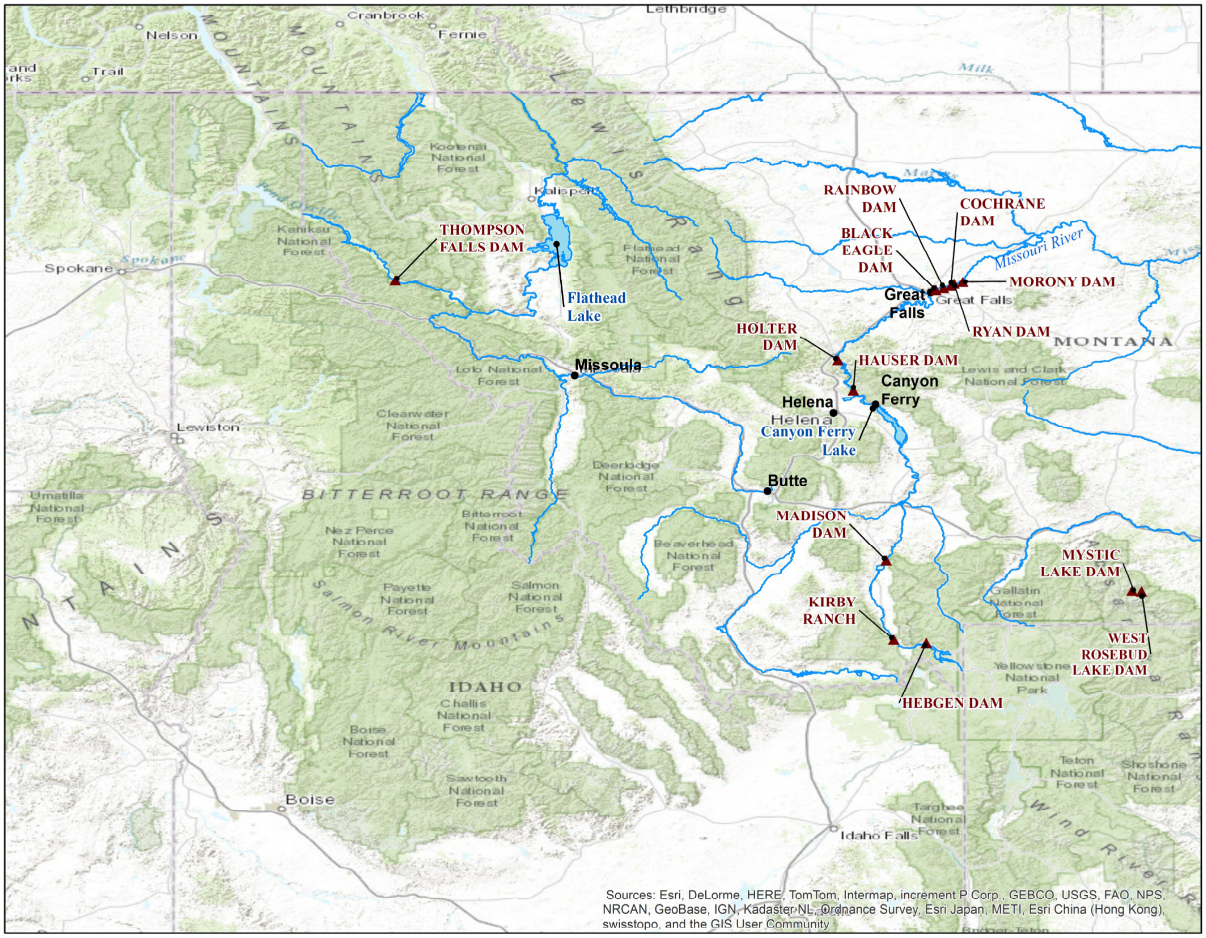
Model verification is intended to validate the input data and ability of the programmed logic to simulate daily hydroelectric and reservoir operations. A "Base Case" scenario has been established following the current system-wide operation rules outlined in the model verification process. The Base Case scenario does not include the forced elevations (historical operations) applied in the verification scenario. The Base Case scenario is used as the baseline or starting point (operating rules and settings) for all subsequent analyses. HDR performed model verification using comparisons of actual and model-estimated generation and total discharge. The verification simulation for hydrology computations was completed for the period of record 1/1/1988 through 11/30/2014, while the generation/elevation verification scenario was performed for water year 2014 (10/1/2013 – 9/30/2014) in order to capture the most recent modifications at the Rainbow project. The purpose of this report is to document inputs and assumptions used in the development of the model, to demonstrate that the model reasonably characterizes operations of the thirteen facilities modeled, and to demonstrate the model is adequate for use in evaluating the effects of alternative operating scenarios.

The NWE CHEOPS Model is coded to run day-to-day operations based on a single or limited set of operating conditions or rules. Actual project operations generally follow the operating rules; however, human intervention periodically deviates from the general operating rules to accommodate day-to-day realities such as equipment failure and maintenance, changing hydrologic conditions, power demands, and other factors. In addition to differences between modeled operations versus actual operations that include human interventions, there are also inherent discrepancies due to input data inaccuracies (e.g., differences in calculated hydrology data, turbine or generator efficiencies, or reservoir storage curves). It is important to understand model results will never completely match historical or future operations due to these differences between actual operating conditions and modeled conditions.

The NWE CHEOPS Model includes a definition of the physical capabilities at the Hebgen and West Rosebud Lake Developments and physical plus generation capabilities at the Madison, Canyon Ferry, Hauser, Holter, Black Eagle, Rainbow, Cochrane, Ryan, Morony, Thompson Falls, and Mystic Developments, as well as operational logic to reflect reservoir operations at all facilities. The Canyon Ferry operational logic in the model allows the user to define the Canyon Ferry support of the flow requirements below the Holter development ("*Operating Guidelines PPL & BOR Agrmt.pdf*").

Major features of the developments in the basin are shown in Figure 1-1. This schematic is the basis for the conceptual model that was used to develop the NWE CHEOPS Model. The NWE CHEOPS Model has thirteen nodes (the thirteen developments previously outlined) that correspond to the major hydrologic junctures in the modeled system and two flow calculation locations (Kirby Ranch downstream of Hebgen Dam and the Mystic bypass reach which is downstream of Mystic Lake Dam and upstream of Mystic Lake Powerhouse discharge) that correspond to locations of operational flow requirements. The model accounts for inflows, discharge, change in reservoir storage, and power generation at the various reservoir nodes and the flows at the two flow-only node locations.

**FIGURE 1-1**
**NORTHWESTERN ENERGY HYDRO FLEET**



## Section 2
# Project Data

NorthWestern Energy owns and operates the developments of Hebgen, Madison, Hauser, Holter, Black Eagle, Rainbow, Cochrane, Ryan, Morony, Thompson Falls, Mystic Lake, and West Rosebud Lake. The USBR owns and operates the Canyon Ferry Development. Each development is simulated within the NWE CHEOPS Model and consists of dams and multi-unit powerhouses as shown in Table 2-1.

**TABLE 2-1**
**NORTHWESTERN ENERGY CHEOPS MODEL PLANTS**

| Development | Upstream Reservoir | Downstream Reservoir | FERC Project No. | Drainage Area (square miles) |
|---|---|---|---|---|
| Hebgen | — | Madison | 2188 | 932 |
| Madison | Hebgen | Canyon Ferry | 2188 | 2,208 |
| Canyon Ferry | Madison | Hauser | — | 15,908 |
| Hauser | Canyon Ferry | Holter | 2188 | 16,723 |
| Holter | Hauser | Black Eagle | 2188 | 16,977 |
| Black Eagle | Holter | Rainbow | 2188 | 22,909 |
| Rainbow | Black Eagle | Cochrane | 2188 | 22,920 |
| Cochrane | Rainbow | Ryan | 2188 | 22,942 |
| Ryan | Cochrane | Morony | 2188 | 22,947 |
| Morony | Ryan | — | 2188 | 23,054 |
| Thompson Falls | — | — | 1869 | 20,924 |
| Mystic Lake | — | West Rosebud Lake | 2301 | 48 |
| West Rosebud Lake | Mystic | — | 2301 | 65 |

## 2.1 Hebgen Development (FERC Project No. 2188)

Hebgen Reservoir is located near Grayling, Montana, and inundates the Madison River Valley adjacent to the western edge of Yellowstone National Park, in the vicinity of West Yellowstone Montana, but beyond the boundaries of the Park. Hebgen Dam is used to store and regulate approximately 387,000 acre-feet of water, with a crest elevation of 6,546 feet. All vertical elevations referenced in this report are National Geodetic Vertical Datum (NGVD) 1929 unless noted. There are no generating facilities at this development; discharges are released through the outlet works and a side-channel spillway.[1] Hebgen is operated as a storage facility, with releases providing head and flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Maintain a continuous minimum flow of 150 cubic feet per second (cfs) in the Madison River as measured at the United States Geological Survey (USGS) gage 06038500 and a continuous minimum flow of 600 cfs at USGS gage 06038800 near the Kirby Ranch.
- Limit flows at USGS gage 06038800 near Kirby Ranch to no more than 3,500 cfs.
- Limit changes in outflow from Hebgen Dam to no more than 10 percent per day for the entire year.
- Maintain the elevation of Hebgen Reservoir between 6,530.26 and 6,534.87 feet (normal full pool elevation) from June 20 through October 1. In a typical year, operate the Hebgen Development so that Hebgen Reservoir would refill to approximately its full pool elevation of 6,534.87 feet in late June or early July, then maintain Hebgen Reservoir near its full pool elevation until September 1. Between September 1 and March 31 of a typical year, draft Hebgen Reservoir to approximately an elevation of 6,524 feet. During this period, as Hebgen Reservoir is being drafted, to the extent practical given the variability of inflows to Hebgen Reservoir, maintain a reasonably uniform discharge from the Hebgen Development. After April 1 of a typical year, operate the Hebgen Development to refill Hebgen Reservoir to at least elevation 6,530.26 feet by June 20.
- Implement Article 419 Madison River Flushing Flow Plan (provide up to 3,500 cfs at USGS gage 06038800 for a minimum of 3 days in years when volume in both runoff and forecast and Hebgen storage triggers are met).
- Implement the Missouri River Coordination Agreement with the USBR (dated March 30, 1972, amended June 8, 1979). For the purpose of implementing the Missouri River Coordination Agreement with USBR, drafting of the Hebgen Reservoir shall not begin until all storage in Canyon Ferry Reservoir above elevation 3,769 feet (28 feet below Canyon Ferry's normal full pool) has been utilized.

[1] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

For modeling purposes:

- Due to the infrequency, the Madison River Flushing Flow Plan flows are not included in the definition of the Base Case scenario.
- Release requirements which are measured at USGS gage 06038800 are simulated based on Hebgen releases plus the incremental inflow to Kirby Ranch. This duplicates actual operations.

## 2.2 Madison Development (FERC Project No. 2188)

Madison Dam is located near McAllister, Montana, on the Madison River approximately 63 river miles downstream from Hebgen Dam and impounds approximately 42,000 acre-feet of water storage, known as Ennis Lake[2]. The Madison Development includes a powerhouse with four turbine-generator units with a maximum capacity of approximately 9 megawatts (MW) (*Hydro Capacity-Limits Rev 9.xlsx*). Madison is operated as a base load, run-of-river generating facility, with releases providing head and flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Operate Madison Dam as a base load, run-of-river project (i.e., the dam shall not be used for peaking, load following, or providing non-spinning operating reserves).
- Coordinate with the operation of the Hebgen Development to maintain a continuous minimum flow of 1,100 cfs in the Madison River as measured at USGS gage 06041000 downstream from the Madison Development.
- Maintain the elevation of Ennis Lake between 4,840 and 4,841 feet (normal full pool) when ice is absent and at 4,839 feet between early December and early April.
- Provide an instantaneous minimum spawning flow of 200 cfs in the bypass reach from April 1 through June 30 and an instantaneous minimum (maintenance) flow of 80 cfs in the bypass reach from July 1 through March 31.
- Do not reduce flow in the Madison bypass reach from 600 cfs to minimum flow by more than 100 cfs per hour, and do not increase flow from less than 600 cfs to 600 cfs by more

[2] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

than 100 cfs per hour (except when needed to meet the 1,100 cfs minimum flow below the powerhouse or to avoid overfilling Ennis Lake).

- Implement Article 419 Madison River Flushing Flow Plan.
- Implement Article 420 Flow Restoration Plan (restore full river flow within 40 minutes after a full plant trip).
- Implement Article 413 Final Madison River Pulse Flow Protocol (implement both the Madison Decision Support System (DSS) program or backup manual protocol, shown below, as required).

**TABLE 2-2**
**LOWER MADISON RIVER (BELOW MADISON DAM)**
**MANUAL PULSE FLOW PROTOCOL**

| **Manual Protocol** | **Tomorrow's Predicted Maximum Air Temperature (deg F) at Three Forks and Corresponding Pulse Flow (cfs)** | | | | |
|---|---|---|---|---|---|
| **Today's Maximum Powerhouse Water Release Temperature (deg F)** | **Air Temp >= 80 and < 85** | **Air Temp >= 85 and < 90** | **Air Temp >= 90 and < 95** | **Air Temp >= 95 and < 100** | **Air Temp >= 100 and < 105** |
| greater or equal to **68** and less than **69** | 1,150 | 1,150 | 1,150 | 1,150 | 1,400 |
| greater or equal to **69** and less than **70** | 1,150 | 1,150 | 1,400 | 1,600 | 1,600 |
| greater or equal to **70** and less than **71** | 1,150 | 1,400 | 1,600 | 1,800 | 2,000 |
| greater or equal to **71** and less than **72** | 1,400 | 1,450 | 1,600 | 1,800 | 2,100 |
| greater or equal to **72** and less than **73** | 1,450 | 1,600 | 1,800 | 2,000 | 2,400 |
| greater or equal to **73** and less than **74** | 1,600 | 1,800 | 2,100 | 2,600 | 2,800 |
| greater or equal to **74** and less than **75** | 1,800 | 2,600 | 2,600 | 2,800 | 3,000 |
| greater or equal to **75** | 2,600 | 2,800 | 3,200 | 3,200 | 3,200 |

For modeling purposes:

- The bypass flow ramping rate restrictions are not simulated in the model. If desired, the bypass flow ramping rate functionality could be added to the model with additional custom coding.
- Due to the infrequency, the Madison River Flushing Flow Plan flows are not included in the definition of the Base Case scenario.
- Since CHEOPS does not model plant outage due to tripping, the Flow Restoration Plan is not modeled.

- CHEOPS does not currently use temperature inputs to implement scheduling and release logic. The Madison River Pulse Flow Protocol will be implemented through use of scheduling by month and day to allow for alternatives analysis.

## 2.3 Canyon Ferry Development

The Canyon Ferry Development is located near Helena, Montana, on the Missouri River below the confluence of the Madison, Jefferson, and Gallatin Rivers approximately 110 river miles downstream of Madison Dam. The spillway capacity at Canyon Ferry Dam is 150,000 cfs, and the total reservoir capacity is 2,051,000 acre-feet at elevation 3,800.00. Four river outlets are in the spillway section of the dam. The maximum discharge capacity of these outlets is 9,500 cfs. One 156-inch-diameter pumping intake pipe is embedded in the concrete of the dam near the left abutment for the Helena Valley Pumping Plant for irrigation water supply. Three 162-inch-diameter penstock pipes for the power generating units are embedded in the dam near the right abutment. The powerhouse is on the right downstream toe of the dam adjacent to the spillway apron. The powerhouse houses three 16,667-kW, vertical-shaft generators driven by 23,500-horsepower turbines. (http://www.usbr.gov/projects/Facility.jsp?fac_Name=Canyon+Ferry+Dam&groupName=Overview)

Canyon Ferry provides for flood control, generation, and irrigation. The Helena Valley Pumping Plant diverts water into a conveyance system which provides irrigation to the Helena Valley and the City of Helena/Helena Lake consumptive uses. Water is generally discharged into groundwater or surface water which rejoins the Missouri River at or above the Hauser Reservoir.

Operated by the USBR, Canyon Ferry provides the usable storage for providing continuous flows in the Missouri River from Lake Hauser down to the Morony tailrace. Coordinating agreements exist to provide for a consistent flow from Holter Reservoir, and NorthWestern Energy is responsible for meeting flow requirements from below Holter to the USGS gage 06090300 below Morony Dam, following the operational requirements outlined in the Canyon Ferry Operating Criteria ("*Operating Guidelines PPL & BOR Agrmt.pdf*").

## 2.4 Hauser Development (FERC Project No. 2188)

Hauser Dam is located near Helena, Montana, on the Missouri River approximately 15 river miles downstream from Canyon Ferry Dam and impounds approximately 11,060 acre-feet of water storage, consisting of Hauser Reservoir and Helena Lake.[3] The Hauser Development includes a powerhouse with six turbine-generator units with a maximum capacity of approximately 16.8 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Hauser is operated as a base load, run-of-river generating facility, with releases providing flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Operate the Hauser Dam as a base load, run-of-river project (i.e., the dam shall not be used for peaking, load following, or providing non-spinning operating reserves).
- Maintain the elevation of Hauser Reservoir and Lake Helena between 3,634.4 and 3,635.4 feet (normal full pool) and maintain continuous, stable flows in the Missouri River immediately below Hauser Dam.
- Limit to 10 percent, the difference between the daily average flow measured just below Hauser Dam (at a USGS gauging station to be installed) and the daily average inflow to Hauser Reservoir and Lake Helena. For this purpose, the inflow to Hauser Reservoir and Lake Helena shall be calculated based on the measured flow below Hauser Dam and the change in storage content of Hauser Reservoir and Lake Helena.
- Limit the difference between the highest hourly average flow and the lowest hourly average flow (as measured at the USGS gauging station to be installed) on any day to no more than the sum of (a) 10 percent of the previous day's average flow at the gauging station and (b) any increase or decrease in releases from Canyon Ferry Dam occurring on the day in question or on the day immediately preceding or the day immediately following the day in question.
- Limit changes in the hourly average flow measured at the gauging station to be installed to no more than 5 percent of the previous hour's average flow.

[3] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

- Enhance downstream power production, as required by the Missouri River Coordination Agreement, if extreme drought conditions persist for an extended period. The maximum required draft for this purpose is to elevation 3,621 feet. Drafting Hauser Reservoir and Lake Helena for this purpose is only required after all of the storage in Canyon Ferry Reservoir and Hebgen Reservoir has been utilized.
- Implement Article 420 Flow Restoration Plan (restore full river flow within 30 minutes after a full plant trip).
- Implement Article 415 Flow Window Excursion Plan (annual report to MDFWP, U.S. Fish and Wildlife Service [USFWS], and FERC on all flow excursion events, causes, and corrective actions).

For modeling purposes:

- Since CHEOPS does not model plant outage due to tripping, the Flow Restoration Plan is not modeled.

## 2.5 Holter Development (FERC Project No. 2188)

Holter Dam is located near Wolf Creek, Montana, on the Missouri River approximately 26 river miles downstream from Hauser Dam and impounds approximately 240,000 acre-feet of water storage, consisting of Holter Lake.[4] The Holter Development includes a powerhouse with four turbine-generator units with a maximum capacity of approximately 48 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Holter is operated as a base load, run-of-river generating facility, with releases providing flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Operate Holter Dam as a base load, run-of-river project (i.e., the dam shall not be used for peaking, load following, or providing non-spinning operating reserves).

[4] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

- Maintain the elevation of Holter Reservoir between 3,563 and 3,564 feet (normal full pool) and maintain continuous, stable flows in the Missouri River immediately below the Holter Development.
- Limit to no more than 10 percent the difference between the daily average flow measured just below Holter Dam (USGS gage 06066500) and the daily average inflow to Holter Reservoir. For this purpose, the inflow to Holter Reservoir shall be calculated based on the measured flow at USGS gage 06066500 and the change in storage content of Holter Reservoir.
- Limit the difference between the highest hourly average flow and the lowest hourly average flow (as measured at USGS gage 06066500) on any day to no more than the sum of (a) 10 percent of the previous day's average flow at USGS gage 06065500 and (b) any increase or decrease in releases from Canyon Ferry Dam occurring on the day in question or on the day immediately preceding or immediately following the day in question.
- Limit changes in the hourly average flow measured at USGS gage 06065500 to no more than 5 percent of the previous hour's average flow.
- Implement Article 420 Flow Restoration Plan (restore full river flow within 30 minutes after a full plant trip).
- Implement Article 415 Flow Window Excursion Plan (annual report to MDFWP, USFWS, and FERC on all flow excursion events, causes, and corrective actions).
- May temporarily (for a period of a few to several days) increase flows from the Holter Development during and immediately preceding periods of extreme cold to maintain or enhance power production at the Great Falls Developments (Black Eagle, Rainbow, Cochrane, Ryan, and Morony) downstream. The Licensee shall endeavor to minimize the reservoir drafts and downstream flow fluctuations caused by this type of operation by coordinating the increased flows from the Holter Development with increased flows from the Canyon Ferry Project:

STANDARD OPERATING PLAN (SOP) EMERGENCY WINTER FLOWS BELOW HOLTER DAM

- Initiate request for emergency winter flows when weather forecast for Great Falls consistently (at least 2-3 days in a row) predicts 3 or more consecutive days with below-zero daily minimum temperatures.
- Peak flow condition can be maintained for several days if necessary until conditions indicate river flow is returning to pre-event levels.
- Avoid emergency winter flow requests during trout spawning season in November and March unless absolutely necessary. If special releases are needed during this period, attempt to minimize the amount of flow change.
- Monitor weather forecasts for Great Falls twice daily (morning and late afternoon) during the planning stage and make flow requests at the last possible moment while being sure adequate time is allocated for required internal and external communication.
- Make every reasonable effort to cancel or reduce the flow request if forecasts change or extreme cold weather abates.

For modeling purposes:

- The SOP emergency winter flows are not included in the definition of the Base Case scenario.
- Since CHEOPS does not model plant outage due to tripping, the Flow Restoration Plan is not modeled.

## 2.6 Black Eagle Development (FERC Project No. 2188)

Black Eagle Dam is located near Great Falls, Montana, on the Missouri River approximately 93 river miles downstream from Holter Dam and impounds approximately 1,820 acre-feet of water storage.[5] The Black Eagle Development includes a powerhouse with three turbine-generator units with a maximum capacity of approximately 27.9 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Black Eagle is operated as a generating facility, with releases providing flow to the downstream

[5] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Operate Black Eagle Dam as a base load, run-of-river project.
- Maintain the elevation of Black Eagle Reservoir near its normal full pool elevation of 3,290 feet.
- Spill a minimum of 200 cfs at Black Eagle Dam between the hours of 9:00 a.m. and 8:00 p.m. on weekends and holidays during the summer, beginning with the Memorial Day weekend and ending with the Labor Day weekend (except during years when the April–June natural runoff into Canyon Ferry Reservoir is less than 900,000 acre-feet [50 percent of the 1961–1990 average]).
- Implement Article 403 Black Eagle Drawdown Plan (specific drawdown rates to limit reservoir sediment re-suspension and downstream transport).
- May increase generation above the normal run-of-river level for up to four hours to provide short-term generation reserves.

For modeling purposes:

- Based on discussions with NorthWestern Energy operations staff, the 200 cfs minimum spill flow is actually performed regardless of the Canyon Ferry runoff. This is likewise simulated as a requirement, regardless of the runoff, in the Base Case scenario.
- The four hours of available short-term generation reserves are not included in the definition of the Base Case scenario; this will be evaluated in future analyses.

## 2.7 Rainbow Development (FERC Project No. 2188)

Rainbow Dam is located near Great Falls, Montana, on the Missouri River approximately 3 river miles downstream from Black Eagle Dam and impounds approximately 1,237 acre-feet of water storage.[6] The Rainbow Project was re-developed in 2013 and includes a new powerhouse with one turbine-generator unit with a maximum capacity of approximately 62 MW (*Hydro Capacity-*

[6] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

*Limits Rev 9.xlsx*). The original Rainbow powerhouse has been abandoned. Rainbow is operated as a generating facility, with releases providing flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Operate Rainbow Dam as a base load, run-of-river project.
- Maintain the elevation of Rainbow Reservoir near its normal full pool elevation of 3,224 feet.
- Spill a minimum of 200 cfs at Rainbow Dam between the hours of 9:00 a.m. and 8:00 p.m. on weekends and holidays during the summer, beginning with the Memorial Day weekend and ending with the Labor Day weekend (except during years when the April–June natural runoff into Canyon Ferry Reservoir is less than 900,000 acre-feet [50 percent of the 1961–1990 average]).
- Implement Article 403 Rainbow Drawdown Plan (specific drawdown rates to limit reservoir sediment re-suspension and downstream transport).
- May increase generation above the normal run-of-river level for up to four hours to provide short-term generation reserves.

For modeling purposes:

- Based on discussions with NorthWestern Energy operations staff, the 200 cfs minimum spill flow is actually performed regardless of the Canyon Ferry runoff. This is likewise simulated as a requirement, regardless of the runoff, in the Base Case scenario.
- The four hours of available short-term generation reserves are not included in the definition of the Base Case scenario; this will be evaluated in future analyses.

## 2.8 Cochrane Development (FERC Project No. 2188)

Cochrane Dam is located near Great Falls, Montana, on the Missouri River approximately 3 river miles downstream from Rainbow Dam and impounds approximately 8,464 acre-feet of water storage.[7] The Cochrane Development includes a powerhouse with two turbine-generator units with a maximum capacity of approximately 71 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Cochrane is operated as a generating facility, with releases providing flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- At its discretion, operate the Cochrane Development to provide base load generation, short-term generation reserves, load-following generation, and, on a coordinated basis with the Ryan and Morony Developments, peaking generation.
- During base load operation, maintain the elevation of Cochrane Reservoir near its normal full pool elevation (currently 3,116.5 feet and proposed 3,120 feet).
- During operations other than base load, maintain the elevation of Cochrane Reservoir between 3,105 and 3,116.5 feet until the Rainbow Development has been modified and between 3,110 and 3,120 feet thereafter.
- Implement Article 403 Cochrane Drawdown Plan (specific drawdown rates to limit reservoir sediment re-suspension and downstream transport).

For modeling purposes:

- The capability of peaking operations and generation reserves are not included in the definition of the Base Case scenario; this will be evaluated in future analyses.

[7] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

## 2.9 Ryan Development (FERC Project No. 2188)

Ryan Dam is located near Great Falls, Montana, on the Missouri River approximately 2 river miles downstream from Cochrane Dam and impounds approximately 3,653 acre-feet of water storage.[8] The Ryan Development includes a powerhouse with six turbine-generator units with a maximum capacity of approximately 64.8 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Ryan is operated as a generating facility, with releases providing flow to the downstream hydroelectric developments, following the operational requirements (*NWEhydrooperationsplan.docx*):

- At its discretion, operate the Ryan Development to provide base load generation, short-term generation reserves, load-following generation, and, on a coordinated basis with the Cochrane and Morony Developments, peaking generation.
- During base load and other operations, maintain the elevation of Ryan Reservoir near its normal full pool elevation of 3,037 feet by coordinating operations with the Cochrane Development.
- Spill a minimum of 200 cfs at Ryan Dam between the hours of 9:00 a.m. and 8:00 p.m. on weekends and holidays during the summer, beginning with the Memorial Day weekend and ending with the Labor Day weekend (except during years when the April–June natural runoff into Canyon Ferry Reservoir is less than 900,000 acre-feet [50 percent of the 1961–1990 average]).
- Implement Article 403 Ryan Drawdown Plan (specific drawdown rates to limit reservoir sediment re-suspension and downstream transport).

For modeling purposes:

- Based on discussions with NorthWestern Energy operations staff, the 200 cfs minimum spill flow is actually performed regardless of the Canyon Ferry runoff. This is likewise simulated as a requirement, regardless of the runoff, in the Base Case scenario.

[8] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

- The capability of peaking operations and generation reserves are not included in the definition of the Base Case scenario; this will be evaluated in future analyses.

## 2.10 Morony Development (FERC Project No. 2188)

Morony Dam is located near Great Falls, Montana, on the Missouri River approximately 4 river miles downstream from Ryan Dam and impounds approximately 13,889 acre-feet of water storage.[9] The Morony Development includes a powerhouse with two turbine-generator units with a maximum capacity of approximately 49 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Morony is operated as a re-regulating generating facility, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Operate the Morony Development as a base load project with outflows approximately equal to inflows into the Great Falls developments upstream.
- Do not operate the Morony Development for peaking, load following, or providing non-spinning operating reserves.
- Use the Morony Development to re-regulate releases from the Cochrane and Ryan Developments when they are operated to provide short-term reserve generation, load-following generation, or peaking generation.
- During base load operations at the Ryan and Cochrane developments, maintain the elevation of Morony Reservoir between 2,885 and 2,888 feet.
- During Ryan and Cochrane operations other than base load, maintain the elevation of Morony Reservoir between 2,878 and 2,888 feet.
- Limit to 10 percent, the difference between the daily average flow measured just below Morony Dam (at USGS gage 06090300) and the daily average inflow to the Great Falls Developments. For this purpose, the inflow to the Great Falls Developments shall be calculated based on the measured flow at USGS gage 06090300 and the change in storage content of Black Eagle, Rainbow, Cochrane, Ryan, and Morony Reservoirs.

[9] Federal Energy Regulatory Commission (FERC). 2000. Missouri-Madison Hydroelectric Project, FERC No. 2188, Order Issuing New License. September 2000.

- Limit the difference between the highest hourly average flow and the lowest hourly average flow (as measured at USGS Gage No. 6 903) on any day to no more than the sum of (a) 15 percent of the previous day's average flow at USGS gage 06090300 and (b) the greater of the sum of the differences between the highest hourly average flow and the lowest hourly average flow measured as inflows to Black Eagle on the day in question or the day preceding the day in question.
- Limit changes in the hourly average flow measured at USGS gage 06090300 to no more than 7.5 percent from the previous hour's average flow.
- Implement Article 403 Morony Drawdown Plan (specific drawdown rates to limit reservoir sediment re-suspension and downstream transport).

## 2.11 Thompson Falls Development (FERC No. 1869)

Thompson Falls Dam is located on the Clark Fork River in Thompson Falls, Montana, and impounds approximately 15,733 acre-feet of water storage (*RESERVOIR-CAPACITY.xls*). Thompson Falls Development includes two powerhouses. One powerhouse has 6 turbine-generator units with a maximum capacity of 39.2 MW (*Hydro Capacity-Limits Rev 9.xlsx*), and the second powerhouse has a single turbine-generator unit with a maximum capacity of approximately 59 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Thompson Falls is operated as a generating facility, following the operational requirements (*NWEhydrooperationsplan.docx*):

- At its discretion, operate the Thompson Falls Development to provide base load generation, generation reserves, or load-following generation.
- Maintain the elevation of Thompson Falls Reservoir between 2,396.5 and 2,392.5 feet.
- Release a continuous instantaneous minimum flow of 6,000 cfs, or river inflow, whichever is less, below the Thompson Falls Project.
- Release the USFWS and FERC-approved Thompson Falls Fish Ladder flows from mid-March to late October depending on weather (flows cease when freeze conditions are imminent).

For modeling purposes:

- Based on discussions with NorthWestern Energy operations staff, fish ladder flows of typically 80 cfs from mid-March through late October are released. Supplemental attraction flows are sometimes released through spillway gates for test purposes but have not been standardized. The Base Case scenario is configured to release 80 cfs from March 15 through October 25 annually. Other options are available as sensitivity analyses.

## 2.12 Mystic Lake Development (FERC No. 2301)

Mystic Lake Dam is located on the West Rosebud Creek near Roscoe, Montana, and impounds approximately 20,997 acre-feet of water storage (*RESERVOIR-CAPACITY.xls*). Mystic Lake Development includes a powerhouse with two turbine-generator units with a maximum capacity of approximately 12 MW (*Hydro Capacity-Limits Rev 9.xlsx*). Mystic Lake is operated as a storage and generating facility, following the operational requirements (*NWEhydrooperationsplan.docx*):

- At its discretion, operate the Mystic Lake Development to provide base load generation, generation reserves, or load-following generation.
- Maintain a minimum water surface elevation at Mystic Lake of 7,663.5 feet from July 10 to September 15 each year.
- Provide for a minimum flow release of 20 cfs, unless inflow is less or maintenance prevents the release, downstream as measured at the USGS gage 06204070.
- Provide continuous minimum flows and ramping rates on West Rosebud Creek as follows:
    - o During fall, winter, and spring months (September through May) the Licensee shall provide a minimum bypass reach flow of 5 cfs with the option to provide up to 11 days (selected at Licensee's discretion) each month of 4 cfs as measured at the upper weir, located upstream of the return flow from the powerhouse. Any release of 4 cfs, even if less than a full 24 hour period, shall count toward the 11-day-per-month maximum.

- o During summer months (June through August) the Licensee shall provide a minimum bypass reach flow of 10 cfs as measured at the upper weir.
- o During the entire year, the Licensee shall ramp descending bypass reach flows below 10 cfs at 2 cfs per hour maximum, as measured at the upper weir. No ramp rate limits are required at flows above 10 cfs.

For modeling purposes:

- The bypass flow ramping rate restrictions are not simulated in the model. If desired, the bypass flow ramping rate functionality could be added to the model with additional custom coding.
- Bypass flows of 5 cfs from September through May and 10 cfs at all other times are simulated in the definition of the Base Case scenario. Lower flow excursions and bypass flow ramping rates are not simulated in the definition of the Base Case scenario.

## 2.13 West Rosebud Lake Development (FERC No. 2301)

West Rosebud Lake Dam is located on the West Rosebud Creek near Roscoe, Montana, approximately 13 river miles downstream of Mystic Lake Dam and impounds approximately 389 acre-feet of water storage (*RESERVOIR-CAPACITY.xls*). West Rosebud Lake is operated as a storage facility, following the operational requirements (*NWEhydrooperationsplan.docx*):

- Provide for a minimum flow release of 75 cfs (SOP) from October 1 through November 30, 43 cfs (SOP) from December 1 through April 15, at all other times 20 cfs (401 Water Quality Certification) except when natural inflow is less than 20 cfs or when maintenance of facilities prevents such a release, as measured at the USGS gage 06204070.
- Under normal, routine operation of the Mystic Lake Hydroelectric Project by Licensee during the descending limb of the West Rosebud Creek annual hydrograph, provide for West Rosebud Creek Whitewater Flow Enhancement.
    - o When the Wednesday noon stream flow reported at the USGS gage 06204050 is greater than 400 cfs, no whitewater flow enhancement will be provided.

- When the Wednesday noon stream flow reported on the USGS gage 06204050 is between 286 cfs and 400 cfs, Licensee will endeavor to release 500 cfs for 5 hours from the West Rosebud Lake Dam on the following Saturday and Sunday, except:
  - When the following Friday noon stream flow reported on the USGS gage 06204050 is less than 270 cfs due to rapidly decreasing inflow, Licensee will endeavor to release 500 cfs for 5 hours from the West Rosebud Lake Dam on the following Saturday only.
- When the Wednesday noon stream flow reported on the USGS gage 06204050 is between 250 cfs and 285 cfs, Licensee will endeavor to release 500 cfs for 5 hours from the West Rosebud Lake Dam on the following Saturday only, except:
  - When the following Friday noon stream flow reported on the USGS gage 06204050 is less than 250 cfs due to rapidly decreasing inflow, a Saturday release will not be provided.
- When the Wednesday noon stream flow reported on the USGS gage 06204050 is less than 250 cfs, no whitewater flow enhancement will be provided.
- Licensee will endeavor to operate West Rosebud Lake below 6,397.6 feet and above 6,395.0 feet elevation during whitewater flow enhancement events.
- Minimum flow below West Rosebud Lake during whitewater flow enhancements will be maintained at 200 cfs or greater as measured at the USGS gage 06204070.
- Whitewater releases from West Rosebud Lake Dam will begin at 8:30 a.m. Peak flow (near 500 cfs) will reach the Emerald Lake Outlet between approximately 11:00 a.m. and 12:00 noon and will continue for approximately 2.5 hours, gradually reducing to pre-enhanced base flow conditions thereafter.
- When the Wednesday noon stream flow reported on the USGS gage 06204050 indicates a pending whitewater flow enhancement on the following weekend, Beartooth Paddlers and American Whitewater will endeavor to communicate this information to the paddling community through social media, websites, email, and other means.
- Rapidly decreasing flows as reported on the USGS gage 06204050 can, on rare occasions, cause whitewater flow enhancements to be less than optimal on the first

and second day of a 2-day flow enhancement, when releases of 500 cfs for less than a 5-hour duration from West Rosebud Lake Dam occur.

## 2.14 Hydrology

The objective for the hydrology task was to compute mean daily synthesized inflow to each node or calculation point within the NWE CHEOPS Model. The purpose of developing synthesized flow data is to characterize historical stream flows that would have occurred with no influence from the NWE CHEOPS Model nodes.

The development of synthesized inflow began with a compilation of the available USGS gages in the vicinity of each computation point and to prorate drainage areas to the area of interest. Proration requires at least one reference gage with reliable data of sufficient duration and a hydrology that is reasonably similar to the hydrology of the basin/streamreach of interest. The reference location(s) should be similar in basin characteristics to the basin of interest, it should have good streamflow data for a sufficiently long period of record, and if possible, be unimpaired or minimally impaired by reservoirs to reduce cumulative errors associated with gage summations. If the flow data for the reference watershed is reasonably accurate, then the proration method is very effective when applied to watersheds with similar physical characteristics (e.g., climate, topography, elevation, geology). However, as the physical characteristics of the watershed of interest deviate from that of the reference watershed, the prorated unimpaired flow data will include deviations that are related to the degree of differences in watershed characteristics. For this reason, gages within each basin of interest were selected and storage operations were backed out of the gage records.

The synthesized flow data was estimated using a combination of proration, summation, and adjusted data to smooth the random fluctuations and to correct negative flow values. The proration method estimates flows for a region of interest by utilizing one or more reference basins with available representative data. The proration method gives an estimate of flows for a given watershed of interest by scaling the reference basin as follows:

$$Q_{target} = \left( \frac{A_{target}}{A_{reference}} \right) Q_{reference}$$

Where: $Q_{target}$ is the flow (cfs) for the basin of interest,

$Q_{reference}$ is the flow (cfs) for the reference basin,

$A_{target}$ is the drainage area (square miles) for the basin of interest,

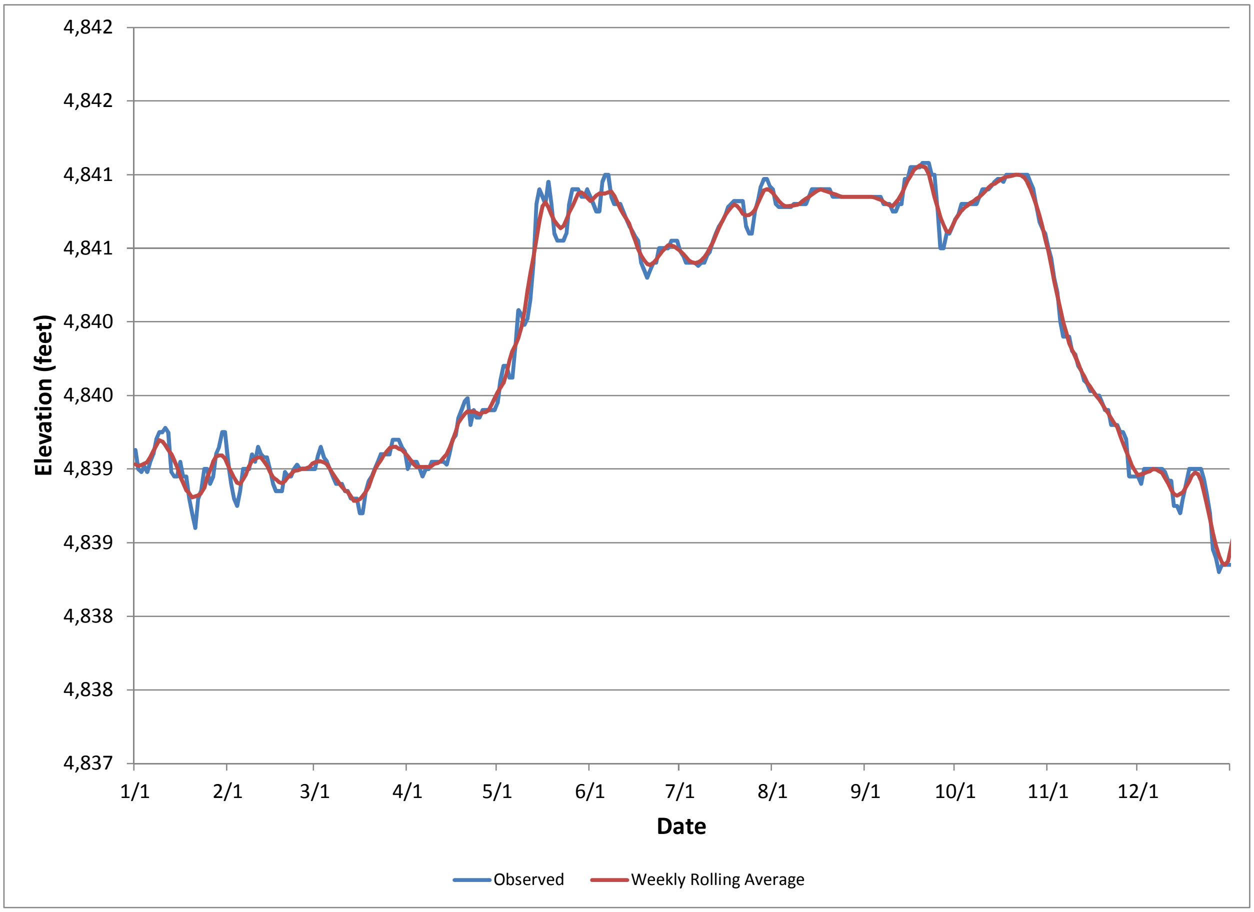
$A_{reference}$ is the drainage area (square miles) for the reference basin.

For reservoirs, the “summation method” incorporates the determination of inflows using the hydrologic water budget equation:

$$Qi = Qo + \Delta S + losses$$

where the inflow (Qi) equals outflow (Qo) plus the change in storage (ΔS) plus losses (evaporation and water withdrawals). Inaccuracies were found in some of the reservoir storage and discharge data, manifested as negative inflows, as well as random fluctuations in the synthesized flow data. Minor deviations in reservoir elevation readings can result in significant changes in volume. Therefore, the daily reservoir elevation records were smoothed using a weekly rolling average elevation. Figure 2-1 is an example of the effects of the smoothing.

**FIGURE 2-1**
**MADISON SMOOTHED FOR CALANDER YEAR 1988**




It has been assumed that historical water use (withdrawals/returns) and evaporation are representative for alternative analyses and have not been removed from the USGS gage records, and, therefore, are accounted for in this synthesized hydrology dataset. Hydrology for the NWE CHEOPS Model was synthesized using the following reference gages and logic:

- ***Hebgen*** - USGS gage 06038500 (at outlet of Hebgen development with records rated as "excellent" by the USGS) daily average flow with Hebgen weekly rolling average storage operations backed out. Negative inflows removed by averaging adjacent daily inflows, overall inflow volume unadjusted.

- ***Kirby Ranch and Madison*** - USGS gage 06041000 (at outlet of Madison Development with records rated as "good" by the USGS) daily average flow minus the daily average flow for USGS gage 06038500 (at outlet of Hebgen Development), Madison weekly rolling average storage operations backed out, and then prorated to each incremental drainage area of interest by direct drainage area proration. Negative inflows removed by averaging adjacent daily inflows, overall inflow volume unadjusted.

- ***Canyon Ferry, Hauser and Holter*** - USGS gage 06066500 (at outlet of Holter Development with records rated as "good" by the USGS) daily average flow minus daily average flow for USGS gage 06041000 (at outlet of Madison Development) delayed by one day; Holter, Hauser, and Canyon Ferry weekly rolling average storage operations backed out; and then prorated to each incremental drainage area by direct drainage area proration. Unadjusted for negative inflows due to high water use and evaporative losses.
- ***Black Eagle*** - USGS gage 06078200 (upstream of Black Eagle Development with records rated as "good" by the USGS) daily average flow minus daily average flow for USGS gage 06066500 (at outlet of Holter Development) delayed by one day, and then summed with USGS gage 06090300 (at outlet of Morony Development with records rated as "good" by the USGS) daily average flow minus daily average flow for USGS gage 06078200 (upstream of Black Eagle Development); Morony, Ryan, Cochrane, Rainbow, and Black Eagle weekly rolling average storage operations backed out; and then daily average flows prorated to each incremental drainage area between USGS gage 06078200 and Black Eagle Dam by direct drainage area proration. Periods of missing data for USGS gage 06078200 (upstream of Black Eagle Development) filled in by direct drainage area proration of USGS gage 06090300 (at outlet of Morony Development with records rated as "good" by the USGS) daily average flows. Negative inflows removed by averaging adjacent daily inflows, overall inflow volume unadjusted.
- ***Rainbow, Cochrane, Ryan, and Morony*** - USGS gage 06090300 (at outlet of Morony Development with records rated as "good" by the USGS) daily average flow minus daily average flow for USGS gage 06078200 (upstream of Black Eagle Development); Morony, Ryan, Cochrane, Rainbow, and Black Eagle weekly rolling average storage operations backed out; and then daily average flows prorated to each incremental drainage area by direct drainage area proration. Negative inflows removed by averaging adjacent daily inflows, overall inflow volume unadjusted.

- ***Mystic Lake, Mystic Bypass Reach, West Rosebud Lake*** - USGS gage 06204050 (at outlet of Mystic Lake Development with records rated as "good" by the USGS) daily average flow with Mystic Lake weekly rolling average storage operations backed out, and then prorated to the incremental drainage area by direct drainage area proration. Negative inflows removed by averaging adjacent daily inflows, overall inflow volume unadjusted.
- ***Thompson Falls*** - USGS gage 12389500 (upstream of Thompson Falls Development on the tributary to the Clark Fork River, Thompson River with records rated as "good" by the USGS) daily average flows prorated to the incremental drainage area between Thompson Falls Dam and USGS gage 12389000, and then added to the USGS gage 12389000 (upstream of Thompson Falls Development with records rated as "good" by the USGS) daily average flows.

The historical period of record (POR) used to synthesize the flow data is from January 1, 1988 through November 30, 2014. This period is the longest period of available daily data for all the necessary reservoir and stream flow points simulated in the NWE CHEOPS Model. This study period includes representative wet, dry, and normal periods, as shown in the representative table for Hebgen (Table 2-3). The synthesized hydrology was simulated through the NWE CHEOPS Model for the POR to confirm that the hydrology compared favorably against both USGS gages records (for the closest available gage) and historical NorthWestern Energy operational data; these comparisons are presented in Appendix A.

**TABLE 2-3**
**RANKED HEBGEN ANNUAL AVERAGE FLOW (CFS)**

| Calendar Year | Flow (cfs) | Calendar Year | Flow (cfs) | Calendar Year | Flow (cfs) |
|---|---|---|---|---|---|
| **2007** | 779 | **1994** | 884 | **2000** | 1,086 |
| **1988** | 807 | **1990** | 921 | **2012** | 1,093 |
| **2001** | 829 | **2005** | 942 | **1993** | 1,193 |
| **2004** | 842 | **1991** | 981 | **2011** | 1,231 |
| **2003** | 850 | **1989** | 1,006 | **1995** | 1,239 |
| **2013** | 854 | **2014** | 1,014 | **1998** | 1,328 |
| **2002** | 859 | **2009** | 1,014 | **1999** | 1,383 |
| **2010** | 868 | **2008** | 1,028 | **1996** | 1,419 |
| **1992** | 878 | **2006** | 1,054 | **1997** | 1,596 |

## Section 3
# Operations Model – Base Case

## 3.1 Logic

Figures 3-1 and 3-2 give an overview of the model logic in sequence.

**FIGURE 3-1**
**CHEOPS MODEL EXECUTION FLOW CHART**

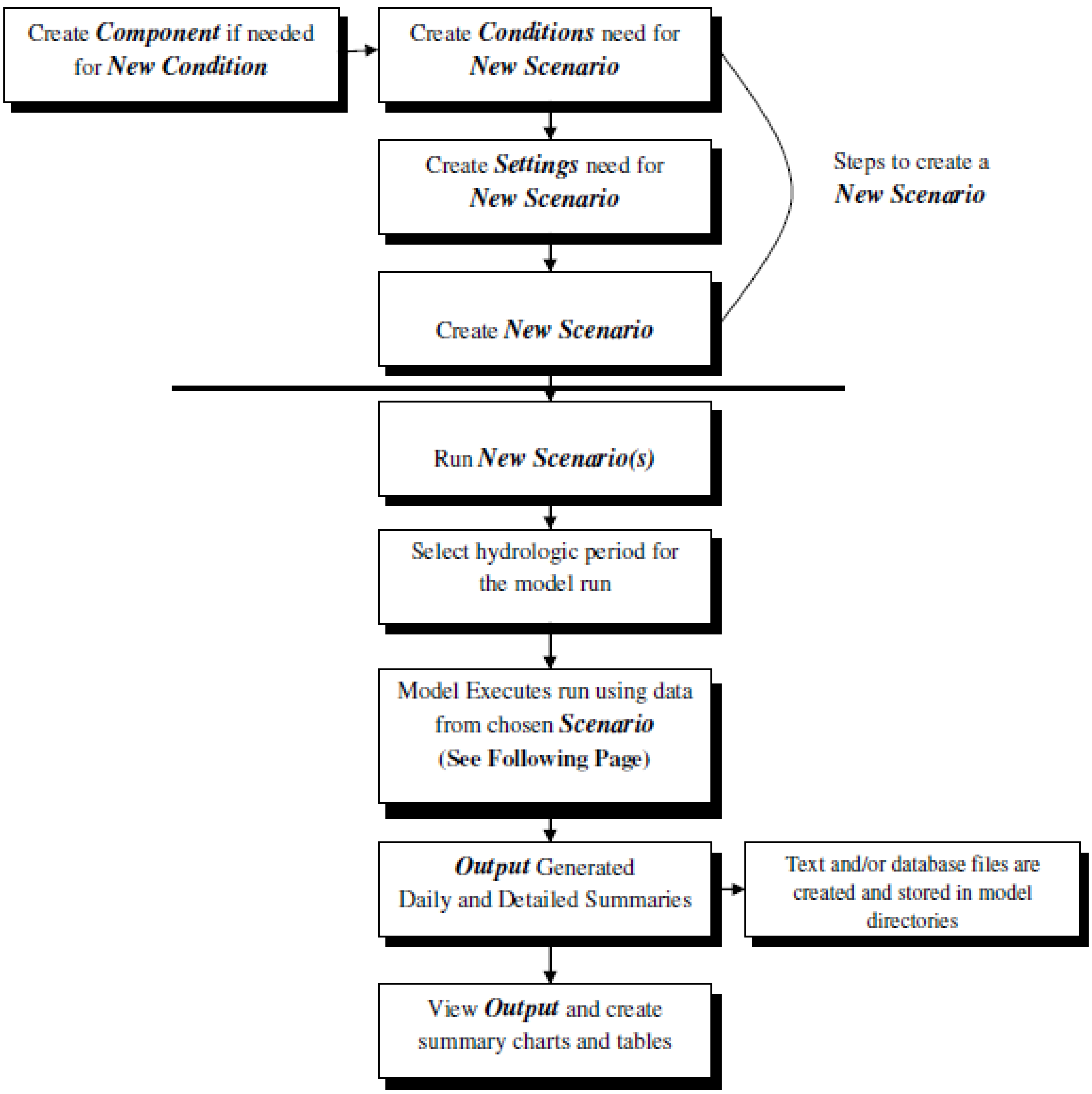
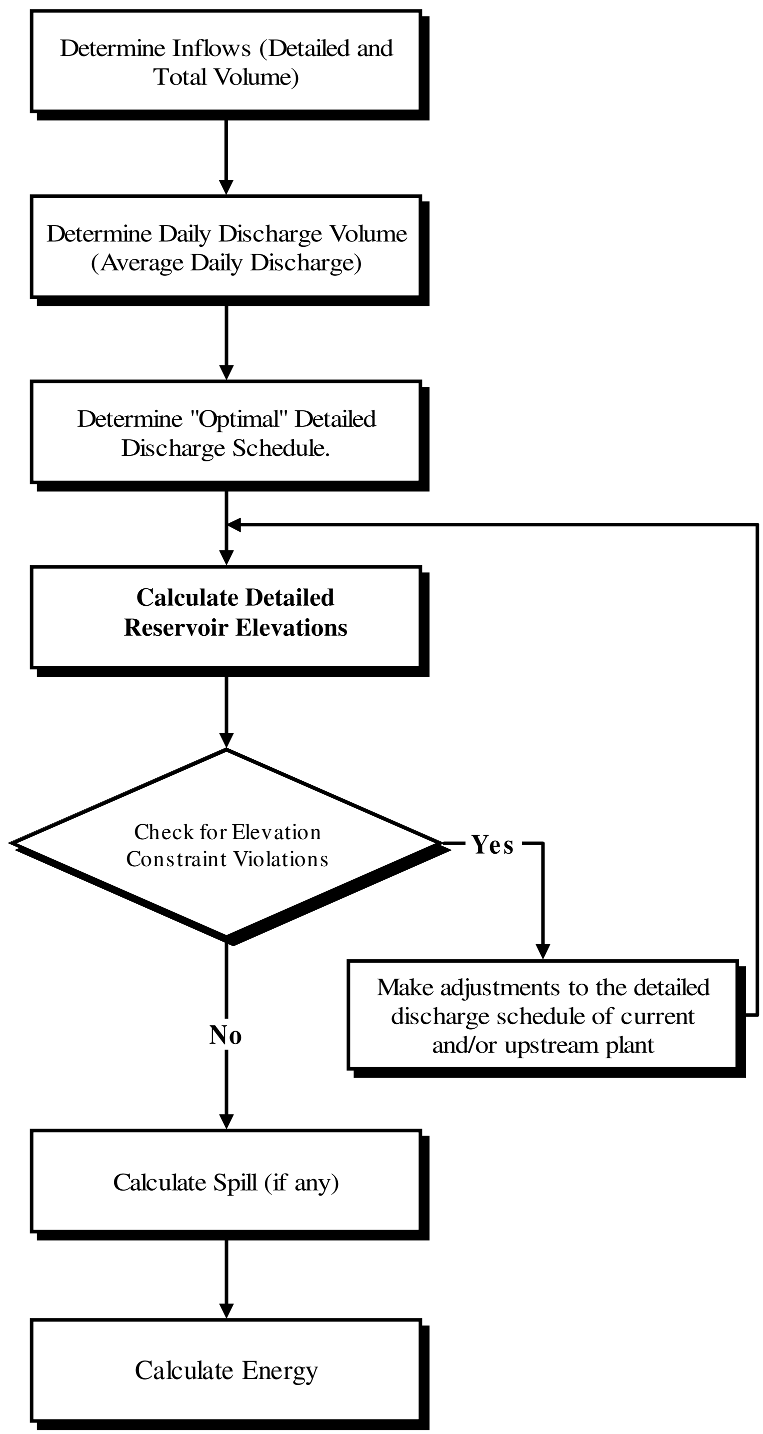


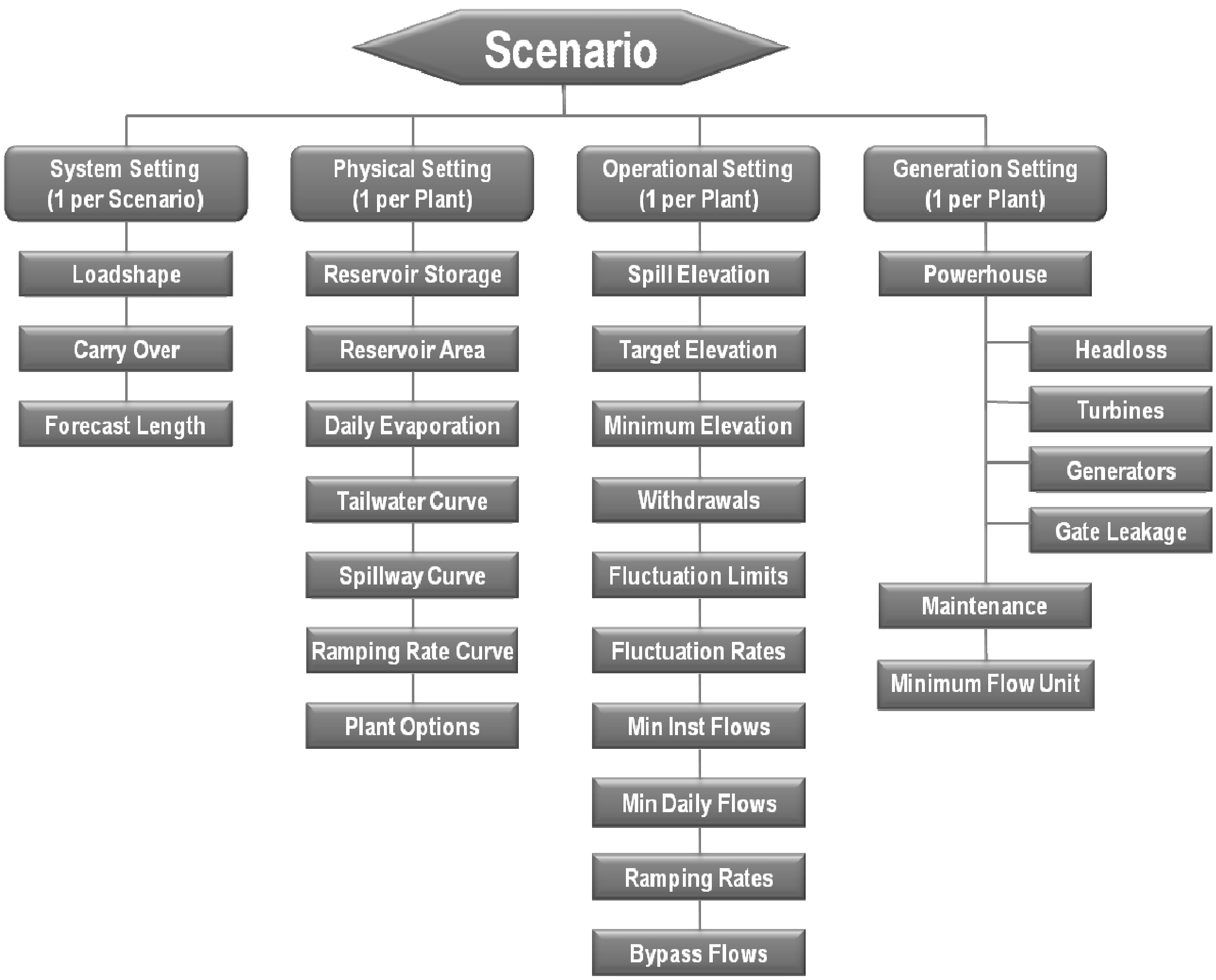
**FIGURE 3-2**
**CHEOPS SCHEDULING FLOW CHART**



## 3.2 Input Data

The project data listed in the following subsections shows the general operational constraints and physical parameters used in the NWE CHEOPS Model to define the existing configuration used in both the Verification and the Base Case scenario setups. The following sections are organized following the four components that define a CHEOPS scenario, as shown in Figure 3-3. Each component of the Base Case scenario for each development is outlined in detail in Appendix B.

**FIGURE 3-3**
**CHEOPS SCENARIO**



## 3.2.1 System Data

### 3.2.1.1 Loadshapes and Energy Values

This section contains the loadshape and energy value data common to all of the developments within the NWE CHEOPS Model. The CHEOPS loadshape defines the daily schedule of relative power pricing and the hour durations of each price in the peak, off-peak, and shoulder periods. The model uses the loadshape data to schedule the release of water throughout the day, prioritizing generation during peak periods. The Verification and Base Case scenarios are simulated with a generic loadshape with 16 hours of peak each day.

### 3.2.1.2 Carry-Over Elevations Condition

The Carry-Over Elevations Condition controls how to treat the beginning- and end-of-year elevations. The model begins the run on January 1 of the start year with each reservoir at its target elevation. If the scenario is run for a multiple-year period, then the model can either start subsequent years with the reservoirs at the target elevations or at the end-of-previous-year elevations.

The Carry-Over Elevations is selected (the checkbox is checked) in the Base Case scenario. Therefore, the model will carry-over the end-of-year elevations to the next year, and reservoirs will start the next year at the ending elevations of the previous year.

### 3.2.1.3 Forecast Set-Up Condition

The Forecast Set-Up Condition requires two inputs: a number of forecast days and an accuracy of the forecast. The number of days is how many days the model looks ahead in the inflow file to calculate how much water is going to be received. The Base Case scenario is set up to look 1 day ahead with 100 percent accuracy. Since the model has "perfect" forecasting as it looks at the actual inflow file, the accuracy setting allows the user to adjust the model's ability to forecast accurately. The accuracy setting adjusts inflow by a fixed multiple. The model looks ahead the given number of days, adds up the inflows, multiplies those inflows by the entered accuracy value, then schedules releases based on this forecasted inflow volume. If the accuracy setting is not 100 percent (1), then the forecasted volume is not accurate. By running the model with 90 percent (.9) accuracy, and then running again at 110 percent (1.1) accuracy, the user can simulate operations where the operator has an ability to forecast inflows plus or minus 10 percent.

#### 3.2.1.4 Metering Loss

Metering loss is a percent reduction to the gross generation calculated by the model. This value, entered as a whole number, accounts for line loss and transformer loss between the generator leads and the revenue meter. Additionally, station service and a general reduction for unscheduled outage factor can be included for the model to output a generation value net of losses, outages, and station service. There is a 0.32 percent metering loss included in the Base Case scenario (“*Aux Loads” tab of “Generator info – JCummings.xlsx*”).

### 3.2.2 Physical Data

#### 3.2.2.1 Reservoir Storage Curves

The Reservoir Storage Curve is a tabulated link between the reservoir elevation and reservoir volume. The elevations are in units of “feet” and the volumes are in “acre-feet.” The model uses this curve to calculate elevations based on inflows and model-determined releases.

#### 3.2.2.2 Reservoir Area Curves

The Reservoir Area Curve is a tabulated link between the reservoir elevation and reservoir surface area. The elevations are in units of “feet” and the areas are in “acres.” The model uses this curve to calculate the surface area and uses this data for computing evaporation losses. However, for the Base Case and Verification scenarios the reservoir area curves are not entered as the evaporation is included in the synthesized hydrology and, therefore, not simulated; if desired, this could be broken out of the hydrology for future analyses.

#### 3.2.2.3 Monthly Evaporation

Evaporation is based upon a monthly varying coefficient that measures the evaporative loss per reservoir. This evaporative loss is not strictly composed of losses due to evaporation, but rather a net change to inflows due to evaporation, direct precipitation to water surface, precipitation runoff, and changes to evapotranspiration losses. Evaporation is accounted for in the hydrology data set and not entered into the model using this input condition.

#### 3.2.2.4 Tailwater Data

The Tailwater Curve relates the powerhouse tailwater elevation to the developments' outflow. In cases where the powerhouse releases directly into a downstream reservoir, the downstream reservoir's elevation is used to compute tailwater elevation. The elevation is in units of "feet" while the flow is in cubic feet per second, or "cfs." The tailwater elevation is subtracted from the reservoir elevation to calculate the gross head used in determining powerhouse output.

#### 3.2.2.5 Spillway Capacity

The Spillway Curve contains the data relating reservoir elevation (feet) and spillway discharge capacity (cfs). This data allows the model to determine the maximum amount of water that can be spilled at the current reservoir elevation and is the sum of all spillway conveyances with gates open to maximum setting. The NWE CHEOPS Model allows for a simple spillway relationship of elevation and flow; therefore, all spillways, including gates, are modeled as a relationship of elevation and flow.

#### 3.2.2.6 Plant Operation Type

The Plant Operation Type is how the CHEOPS model classifies and operates the plants. Four different components are used to describe the operation of the plants.

- Min Powerhouse Flow – All plants in this model have zero (0) value entered, as the turbine input curves define the lowest operating flow of the units.

- Plant Operation Type – This is how the CHEOPS model classifies and operates the plant. There are seven plant operation types: Non-Generating, Strictly Peaking, Peaking with Ramp Rates, Re-Regulating, Fill and Spill, Run-of-River (Daily Average), and Run-of-River (Instantaneous).
  - A *Non-Generating Plant* is a plant that does not have a powerhouse but has the ability to control releases. (Hebgen and West Rosebud Lake)
  - A *Strictly Peaking Plant* is a plant that can instantaneously peak from no release to a maximum release. The model schedules powerhouse releases to generate as much as possible during the peak period, followed by secondary-peak, and then the off-peak periods. This plant type can be scheduled to have two peak periods in the day depending upon loadshape input. (Canyon Ferry, Thompson Falls, and Mystic. Black Eagle, Rainbow, Cochrane and Ryan peaking capability will be evaluated through a separate sensitivity analysis.)
  - A *Peaking with Ramp Rates Plant* prioritizes its release in the peak periods but it is constrained by ramping rates. This plant will not double peak but will ramp up to the high daily release, remain at constant release, and then ramp back down to the off-peak release. This type of plant can handle tailwater ramping rates based on stage (feet/time), flow (flow/time), or percent-change of flow (flow/time).
    - **Note:** This Plant Operation Type must be selected if the user is investigating ramping rates at a particular plant. It is not enough to simply enter in an assumed ramping rate. Both constraints (Plant Operating Type set to Peaking with Ramp Rates or Re-Regulating, and a Ramping Rate constraint imposed) must be entered for the ramping rates to be used.
  - A *Re-Regulating Plant* is scheduled for a constant release for the entire day, ramps to the next day's release, and releases constant flows again. This type of plant is usually found downstream from a peaking plant and is frequently the last plant in the system, with the goal of smoothing out peaked powerhouse flows. This Plant Operating Type can use ramping rates to determine how quickly the plant is allowed to change from one flow to another. If no ramping rate is specified, the plant will step from one day's daily average/continuous flow to the next day's flow. (Morony, Hauser, Holter,

Black Eagle, Rainbow, and Cochrane and Ryan when not in peaking evaluation. Hauser, Holter, Black Eagle, Rainbow, and Cochrane and Ryan are simulated as Re-Regulating plants versus daily average Run-of-River to allow for the implementation of the ramping rate restrictions on discharges)

  - A *Fill and Spill Plant* is scheduled like a strictly peaking plant except that it is expected to spill. This type of plant is usually found downstream from a much larger plant with little intervening storage. The fill and spill plant turbine discharge capacity is usually undersized. Use of this plant type triggers the model to prioritize aggressive operation of the upstream plant rather than reschedule the high capacity plant to avoid spill at the downstream fill and spill plant.
  - A *Pure Run-of-River (Daily Average) Plant* is a plant where inflows are generally equal to outflows on a daily average basis. The plant can use storage to maintain minimum instantaneous flows, and will increase reservoir elevation up to the spill elevation to minimize spill and use the volume for generation on subsequent days. (Madison)
  - A *Pure Run-of-River (Instantaneous) Plant* releases its inflow on a 15-minute basis. This plant releases the maximum of its capacity or inflow and spills the excess.
- Delinked Owner – Sets the level of water conveyance support a plant receives and provides to other plants operated by the same licensee/operator. All plants in the model have this value unchecked, meaning the plants provide supporting operation to other plants operated by the same owner.
- Delinked System – Sets the level of support a plant receives and provides to other plants operated by other licensees/operators in the modeled system. Most plants in this model have this condition checked, meaning the default CHEOPS logic for support between plants is not in effect for plants operated by different operators. The plants are set up using different owners to organize the plants into common support groups. For example, Hebgen and Madison are set to have the same owner, meaning Hebgen will support Madison flow requirements and constraints. Canyon Ferry is set with a different owner number, thus “typical” CHEOPS support logic will not apply from Madison or Hebgen to Canyon Ferry. Other inputs are used to control how Madison supports Canyon Ferry

according to agreements. Hauser and Holter are set as a common owner, thus Hauser will support Holter to the extent possible given its own constraints and rules. Since Hebgen and Holter are in different owner groups, the typical support within the CHEOPS logic is not applicable between these plants.

### 3.2.3 Operational Data

#### 3.2.3.1 Spill and Minimum Elevations

The Spill, or Flood Control, elevation relates to a variety of physical situations (spillway crest, partial gate coverage, maximum normal pool, etc.), but it represents the elevation at which the model will begin to simulate spill to avoid increasing water elevation. Under a strictly peaking plant, when the model calculates an end of period elevation above the Spill elevation, the model will calculate spill as well as the turbine/diversion discharge. The model's logic, under a strictly peaking plant, also attempts to reduce or eliminate occurrences when the reservoir elevation exceeds the spill elevation.

The Minimum elevation is the minimum allowable reservoir elevation and is the point at which discretionary discharges will be ceased. The elevation could be set by regulations or by a physical limit (lowest available outlet invert). Bypass flows, withdrawals, wicket gate leakage, and evaporation can draw the reservoir below this level. The model will operate to eliminate occurrences when the reservoir elevation dips below this elevation.

#### 3.2.3.2 Target Elevations

The Target Elevation is the user-defined elevation that the model attempts to meet (targets) as the end-of-day reservoir elevation. The model straight line interpolates between user input points to identify a target elevation for each day. The model will deviate from the target to accommodate forecasted inflows, to meet the plant's own outflow requirements or constraints, and to support downstream minimum flow requirements and capacities.

#### 3.2.3.3 Water Withdrawals

The Water Withdrawals allows the user to model water removal and return that represents consumptive uses and returns such as irrigation and municipal water supply. However, for the Base Case and Verification scenarios water withdrawals are not simulated as they are included in the synthesized hydrology (this assumes that historic water uses are representative); if desired, this could be broken out of the hydrology for future analyses.

#### 3.2.3.4 Minimum Flows

Minimum flow requirements can be applied on either a daily average or instantaneous basis. Minimum Instantaneous Flows are flows that must be released either through the low-level outlet or through the powerhouse, 24 hours a day. The Minimum Daily Flows are defined as a daily average flow (cfs), that the plant must release for the day. The model will meet these requirements before scheduling any excess water. The user can also set these constraints with an Or Inflow option. The Or Inflow option sets the flow requirement equal to the lesser of the user-defined flow or the total inflow into the plant. The total inflow is the sum of the discharges from the upstream plant(s) plus the incremental accretion above this plant.

A minimum daily average flow requirement may not be discharged as a continuous flow throughout the day. Depending upon the plant type, the scheduling logic may discharge most or all of the water during peak demand periods at higher flow rates, but the daily average flow from the powerhouse will equal the specified flow requirement.

#### 3.2.3.5 Maximum Flows

The model allows a Maximum Flow constraint to be applied to discretionary discharges from a plant. This will limit operations to restrict flow to a maximum of the defined limit. The Base Case scenario definition includes maximum flow limitations at Hebgen (measured at Kirby Ranch flow calculation location), Canyon Ferry, and Rainbow. For the Hebgen maximum flow requirement, the model automatically applies the incremental accretions between Hebgen and

Kirby Ranch, and sets Hebgen maximum outflow to be the difference between the user inputted value and the day's accretions at Kirby Ranch.

#### 3.2.3.6 Recreation Flows

The Recreation Flows are used to input plant output requirements that change within a day, and vary from the standard requirement from the plant. This condition is being used in the Base Case scenario definition at Hebgen to account for the 600 cfs flow requirement at Kirby Ranch and the 200 cfs aesthetic flows at Black Eagle, Rainbow, and Ryan.

#### 3.2.3.7 Bypass Flows

The Bypass Flows represents flows that are released through the dam, bypassing the powerhouse, and not available for generation. These requirements may include items such as bypass reach flows, upstream/downstream fish passage/attraction water, sluice gate discharges, and dam leakage. The user can define this constraint as Or Inflow. The Or Inflow option sets the bypass flow equal to the lesser of the user-defined flow or the inflow into the plant. The inflow is the sum of the upstream plant's release, bypass return flow, and the incremental accretion flows between the upstream plant and the current plant. Bypass flows can draw the reservoir below the minimum elevation. Bypass flows are simulated at Madison, Canyon Ferry (to account for water to Lake Helena), Thompson Falls, Mystic Lake, and West Rosebud Lake.

#### 3.2.3.8 Flashboards

For the purposes of this analysis, all flashboards are being simulated in the spillway capacity curves.

### 3.2.4 Generation Data

All unit performance information was modeled based on the information available at the time of model development. The unit performance information in the Base Case scenario is based on the best available data for each powerhouse. In some instances the units are simulated with a total unit performance, entered into the turbine input, based on gross head. All of the unit performance information included in the Verification and Base Case scenarios is outlined in Appendix B. The performance of each individual unit was calibrated based on the best available information for that unit, as outlined in the unit descriptions in Appendix B. Comparisons of the 15-minute model simulated, hourly historical PI, and historical daily power versus flow values for each powerhouse are presented in Appendix C.

#### 3.2.4.1 Headloss Coefficients

The CHEOPS model allows two common headloss coefficients for each plant and an individual coefficient for each unit. Headloss for each unit is calculated by multiplying the unit's common coefficient by the total flow for that common coefficient squared added to the individual coefficient multiplied by the individual unit flow squared. The formula is:

$$H_i = \left( \sum_{j=1}^{n} F_j \right)^2 h_c + F_i^2 h_i$$

Where:

- $H_i$ is the unit headloss in feet
- $h_c$ is the common coefficient for the $i^{th}$ unit
- $h_i$ is the individual coefficient for the $i^{th}$ unit
- $F_i$ is the flow for the $i^{th}$ unit
- j runs from 1 to n
- n is the number of units that have the same common coefficient as the unit i

#### 3.2.4.2 Turbine Efficiency Curves

Turbine performance is entered by plant and as flow versus efficiency at five separate net heads.

#### 3.2.4.3 Generator Efficiency Curve

The generator data, like the turbine data, is entered by plant and then associated with a unit. The generator performance data is a relationship of generator output versus generator efficiency.

The generator condition includes a maximum generator output. This value is the maximum generator output the model will allow, assuming there is turbine capacity to meet this limit. The model will limit generator output based on the generator maximum capacity setting.

#### 3.2.4.4 Wicket Gate Leakage

The Wicket Gate Leakage flow is active only during times of non-generation. Thus, during periods of non-generation, this leakage flow is used to make up all or a portion of the minimum flow requirement. Current wicket gate leakage is not simulated in the NWE CHEOPS Model.

#### 3.2.4.5 Powerhouse Weekend Operations

The Powerhouse Weekend Operations Condition permits the simulation of reduced powerhouse operations during Saturdays and/or Sundays. All bypass flow requirements are still met since bypass flows are not powerhouse dependent. Minimum instantaneous and minimum daily average flow requirements will be met by bringing the powerhouse online for the required flow only. This condition removes the “inflow plus change-in-storage” component from consideration in computing a desired daily discharge. During high inflow times with little usable storage, the model will bring the powerhouse online to generate with outflows, rather than permit spilling. There are no plants in the NWE CHEOPS Model which have sufficient storage and discretionary discharges to take advantage of this setting.

#### 3.2.4.6 Plant Flow Type

The Plant Flow Type specifies that a powerhouse should operate the turbines at the peak efficiency discharge point rather than the maximum gate setting. For Run-of-River plant types, this setting is not utilized, as the plants will be set to Maximum Flow operating type. For other plant operation types, specify TRUE (checked box) if the plant should generally be scheduled to operate at the best efficiency point. Leaving the box unchecked will result in more detailed scheduled operations occurring at the maximum gate setting for the turbine units. This tends to result in slightly more peak period generation. For the Base Case scenario definition all of the

Run-of-River plants are set to Maximum Flow operating type. For peaking plants, except Canyon Ferry, all are set to run at maximum flow capacity if the hydrology allows.

#### 3.2.4.7 Maintenance

The maintenance schedule provides the functionality to take one or more units out of service for all or part of each year for a scenario run. There are currently no outages in the Base Case scenario definition.

Section 4

# Operations Model Calibration/Verification Process

Verification is intended to validate the NWE CHEOPS Model input data and logic so the "Base Case" scenario may be used as the baseline for all subsequent scenario analyses. HDR performed model verification using comparisons of actual and model estimated generation and discharge from each node. Verification of the model was completed using hydrology and operations for water year 2014 (10/1/2013 through 9/30/2014). Generation data is commonly available for hydropower developments and is a metered value that has good accuracy compared to other forms of data that are not metered or based on estimated values with lower accuracy.

Generation is a measure of available flow and storage volume, which relates to inflows and reservoir elevations. When performing verification of water quantity models with power generation, it is common to find discrepancies between observed data and modeled output for generation and reservoir elevation when looking at a small sample of time periods (day, week, or month). This is due to the difference between the set of rules provided in the model when compared to the day-to-day decisions common in large power developments that respond to power grid demands as well as storm forecasts and other non-measured impacts on the reservoir and equipment. Modeled results for each verification scenario were compared with historic generation, powerhouse flow, and reservoir levels. In addition to verifying the model under different hydrologic conditions, it was also important to select relatively recent years for model verification under conditions that are representative of current operating conditions.

As previously stated, the NWE CHEOPS Model is coded to run day-to-day operations based on general operating conditions or rules. The model follows these rules strictly, 24 hours per day and 365 days per year, similar to an automated operation. Actual project operations generally follow the operating rules; however, human intervention periodically deviates from the general operating rules to accommodate day-to-day realities such as equipment failure and maintenance, changing hydrologic conditions, power demands and energy pricing, and other factors. In addition to differences between modeled operations versus actual operations that include human interventions, there are also inherent discrepancies due to input data inaccuracies (e.g., differences in hydrology data, turbine or generator efficiencies, or reservoir storage curves). It is important to understand that, due to these differences between actual operating conditions and modeled conditions, model results will never completely match historical operations.

The goal of the single year verification scenario is to obtain annual total modeled generation for each plant that is within 5 percent of historical generation. In cases where the modeled results exceeded the 5 percent goal, potential causes for the differences were examined to determine whether the difference was due to deviations in model setup, historical deviations in operations, or discrepancies in the reconstructed hydrology data.

## 4.1 Summary of Modeled Results versus Historical Data

Verification of the NWE CHEOPS Model was performed using historical operations data provided by NorthWestern Energy and publicly available data from the USBR. Verification of the model was performed using two different scenarios, or model runs. The first (historical baseline) performs a verification of the model hydrologic data for the POR (1/1/1988 through 11/30/2014). The second verification scenario was conducted for the specific water year 2014 (V_2014 WY). Model results presented in this report represent the model configuration as of February, 2015.

### 4.1.1 Historical Baseline

The historical baseline results were compared to historical operations (total discharge) at each reservoir for the hydrologic period 1/1/1988 through 11/30/2014. This scenario is based on the Base Case scenario definition and does not necessarily represent how the Hydros were operated on a daily or even monthly basis; the intent of this scenario is to verify the synthetic hydrology is representative of the historical/recorded hydrology within the modeled system. Table 4-1 and Figures A-1 through A-13 (Appendix A) show the daily and cumulative modeled (verification scenario) discharges from each of the reservoirs as compared to the historical (observed) discharges and USGS gages records for the same period. For the hydrologic period 1/1/1988 through 11/30/2014, with the exception of Black Eagle, the NWE CHEOPS Model simulated cumulative discharges for each development compare favorably with the available site specific historical cumulative discharges. It appears that the historical operations data at Black Eagle may be underestimating the spill/leakage occurring at the site as the synthetic hydrology compares favorably at Holter and Rainbow, which are upstream and downstream of Black Eagle.

**TABLE 4-1**
**MODELED TOTAL DISCHARGE COMPARED TO HISTORICAL AND USGS RECORDS**

| Development | Percent Difference from Daily Historical Operations | Percent Difference from Daily USGS |
|---|---|---|
| Hebgen | -1.6% | 0.1% |
| Madison | 0.9% | 0.8% |
| Canyon Ferry | -2.3% | 1.1%[1] |
| Hauser | -0.2% | -0.9%[2] |
| Holter | -0.6% | -0.5% |
| Black Eagle | 4.4% | 7.7%[3] |
| Rainbow | 1.2% | -1.6%[4] |
| Cochrane | 1.3% | -1.5%[4] |
| Ryan | 1.4% | -1.5%[4] |
| Morony | 2.2% | -2.1% |
| Thompson Falls | 0.4% | NA[5] |
| Mystic Lake | 14.2%[6] | 0.3% |
| West Rosebud Lake | NA | 0.7% |

1. USGS gage upstream of reservoir and does not account for the entire drainage area.
2. Full period of record (1/1/1988 through 11/30/2014) unavailable at the USGS gage 06065500.
3. Upstream USGS gage prorated to drainage area of Dam through direct drainage area proration.
4. Downstream USGS gage prorated to drainage area of Dam through direct drainage area proration.
5. The USGS Gage 12391400 is downstream of Noxon and includes the incremental drainage and operations below Thompson Falls and is, therefore, not used for comparison.
6. The historical plant operations do not include the incremental inflows between Mystic Lake Dam and the USGS gage 06204050, additionally it appears as though the operations data may have underestimated periods of spill/leakage from the dam.

### 4.1.2 Scenario V_2014WY

The V_2014 WY scenario was established following the general operating requirements of the system (same rule logic as the Base Case scenario, Section 3). Differences in this scenario include setting different target elevations such that the model will attempt to operate the reservoir pools as they were historically, where actual spills were performed, and turbine-generator unit outages were set to reflect historical availability (where data was available) for water year 2014. The historical outages were based on the outage event data ("*Raw_EventData.*CSV") provided by NorthWestern Energy, and adjusted by reviewing PI data for units electively not run or run in spinning reserve mode.

For this scenario, each reservoir was set to have target elevations which approximated historical elevations and historical unit outages, as best could be determined from the available historical data. Additionally, at certain plants spills were forced in an attempt to simulate the reported spill flows (daily average records provided by NorthWestern Energy). As shown in Table 4-2, simulated generation on an annual basis is within 5 percent at all of the developments except Madison and Thompson Falls. Based on a review of the power versus flow comparisons in Appendix C and the monthly generation comparison, Table 4-2, the model is overestimating the generation capability at Madison during high flows. The reduction of generation capability at Madison during high flows could be refined with additional information. As shown on the power versus flow comparisons in Appendix C and the monthly generation comparison, Table 4-2, the model is overestimating generation at Thompson Falls during the lower flow periods. It is unclear if the overestimation is due to imprecise unit performance input, less than optimal historical dispatch of the powerhouses, or historically higher tailwater due to Noxon operations.

**TABLE 4-2**
**V_2014WY: MODELED VERSUS HISTORICAL GENERATION COMPARISON**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Historical (MWh)** | | | | | | | | | | | | | |
| | **2013** | | | **2014** | | | | | | | | | |
| **2014 WY** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Total** |
| **Madison** | 4,452 | 4,227 | 4,493 | 5,167 | 4,383 | 5,358 | 5,031 | 5,201 | 4,869 | 5,208 | 5,241 | 4,569 | 58,199 |
| **Canyon Ferry** | 21,642 | 20,870 | 23,171 | 21,477 | 21,484 | 33,250 | 38,698 | 37,001 | 29,481 | 33,118 | 26,643 | 26,398 | 333,233 |
| **Hauser** | 8,931 | 8,478 | 9,242 | 8,481 | 8,663 | 11,605 | 10,214 | 7,295 | 11,316 | 12,027 | 12,056 | 11,456 | 119,764 |
| **Holter** | 16,359 | 16,448 | 18,190 | 17,050 | 17,506 | 25,474 | 25,543 | 29,268 | 24,992 | 27,334 | 22,890 | 21,504 | 262,558 |
| **Black Eagle** | 9,336 | 8,825 | 6,779 | 7,463 | 6,374 | 13,601 | 14,557 | 15,135 | 14,657 | 11,671 | 10,783 | 10,434 | 129,615 |
| **Rainbow** | 23,806 | 22,968 | 23,619 | 22,404 | 21,720 | 38,004 | 43,536 | 45,172 | 42,428 | 38,378 | 32,622 | 30,575 | 385,232 |
| **Cochrane** | 16,210 | 15,376 | 15,890 | 15,717 | 15,377 | 29,696 | 35,740 | 39,310 | 33,119 | 25,573 | 23,453 | 18,400 | 283,861 |
| **Ryan** | 29,138 | 28,468 | 28,641 | 27,374 | 26,807 | 41,482 | 39,580 | 46,422 | 44,990 | 42,169 | 39,650 | 38,446 | 433,167 |
| **Morony** | 17,527 | 16,886 | 16,576 | 16,246 | 15,035 | 17,683 | 17,163 | 17,711 | 19,115 | 29,574 | 24,258 | 23,423 | 231,197 |
| **Thompson Falls** | 34,041 | 32,613 | 31,947 | 38,548 | 34,045 | 45,243 | 60,891 | 55,829 | 53,999 | 61,514 | 35,980 | 25,808 | 510,458 |
| **Mystic** | 5,643 | 3,487 | 5,485 | 5,003 | 3,937 | 3,154 | 1,800 | 4,318 | 8,065 | 8,616 | 8,696 | 7,014 | 65,218 |
| **System Total** | 187,085 | 178,646 | 184,033 | 184,930 | 175,331 | 264,550 | 292,753 | 302,662 | 287,031 | 295,182 | 242,272 | 218,027 | 2,812,502 |
| **NorthWestern Energy Plants** | **165,443** | **157,776** | **160,862** | **163,453** | **153,847** | **231,300** | **254,055** | **265,661** | **257,550** | **262,064** | **215,629** | **191,629** | **2,479,269** |
| **Modeled (MWh)** | | | | | | | | | | | | | |
| | **2013** | | | **2014** | | | | | | | | | |
| **2014 WY** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Total** |
| **Madison** | 4,565 | 4,298 | 4,658 | 5,351 | 4,636 | 5,904 | 5,321 | 5,836 | 5,458 | 5,927 | 5,992 | 4,772 | 62,718 |
| **Canyon Ferry** | 21,245 | 20,184 | 23,130 | 21,397 | 21,141 | 35,499 | 39,106 | 41,056 | 27,256 | 33,351 | 25,543 | 26,885 | 335,793 |
| **Hauser** | 9,177 | 8,702 | 9,533 | 8,813 | 8,757 | 11,933 | 10,368 | 7,569 | 11,078 | 11,864 | 11,822 | 11,492 | 121,108 |
| **Holter** | 17,664 | 16,751 | 18,931 | 17,433 | 16,649 | 25,686 | 24,928 | 27,823 | 24,645 | 28,283 | 23,235 | 22,130 | 264,158 |
| **Black Eagle** | 10,523 | 10,101 | 8,418 | 7,892 | 7,461 | 12,817 | 14,035 | 13,982 | 13,642 | 11,653 | 10,633 | 10,298 | 131,455 |
| **Rainbow** | 25,032 | 24,371 | 24,955 | 23,133 | 25,151 | 37,286 | 45,529 | 47,458 | 45,466 | 39,492 | 33,722 | 31,144 | 402,739 |
| **Cochrane** | 17,324 | 16,779 | 17,089 | 16,232 | 17,617 | 29,204 | 37,570 | 38,359 | 35,800 | 27,179 | 24,181 | 18,544 | 295,878 |
| **Ryan** | 30,747 | 30,367 | 29,321 | 30,368 | 30,338 | 42,255 | 40,517 | 45,273 | 45,215 | 43,258 | 42,011 | 39,442 | 449,112 |
| **Morony** | 17,999 | 17,429 | 17,450 | 17,441 | 16,135 | 17,652 | 17,633 | 13,836 | 16,919 | 30,692 | 25,158 | 23,981 | 232,325 |
| **Thompson Falls** | 35,666 | 35,650 | 35,300 | 41,717 | 36,821 | 47,847 | 60,155 | 58,989 | 56,489 | 61,082 | 39,618 | 27,609 | 536,943 |
| **Mystic** | 5,860 | 3,439 | 5,921 | 5,318 | 3,935 | 3,169 | 2,062 | 4,343 | 7,930 | 8,548 | 8,813 | 7,030 | 66,368 |
| **System Total** | 195,802 | 188,071 | 194,706 | 195,095 | 188,641 | 269,252 | 297,224 | 304,524 | 289,898 | 301,329 | 250,728 | 223,327 | 2,898,597 |
| **NorthWestern Energy Plants** | **174,557** | **167,887** | **171,576** | **173,698** | **167,500** | **233,753** | **258,118** | **263,468** | **262,642** | **267,978** | **225,185** | **196,442** | **2,562,804** |
| **Difference (MWh)**<br>**Modeled - Historical** | | | | | | | | | | | | | |
| | **2013** | | | **2014** | | | | | | | | | |
| **2014 WY** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Total** |
| **Madison** | 113 | 71 | 165 | 184 | 253 | 546 | 290 | 635 | 589 | 719 | 751 | 203 | 4,519 |
| **Canyon Ferry** | -397 | -686 | -41 | -80 | -343 | 2,249 | 408 | 4,055 | -2,225 | 233 | -1,100 | 487 | 2,560 |
| **Hauser** | 246 | 224 | 291 | 332 | 94 | 328 | 154 | 274 | -238 | -163 | -234 | 36 | 1,344 |
| **Holter** | 1,305 | 303 | 741 | 383 | -857 | 212 | -615 | -1,445 | -347 | 949 | 345 | 626 | 1,600 |
| **Black Eagle** | 1,187 | 1,276 | 1,639 | 429 | 1,087 | -784 | -522 | -1,153 | -1,015 | -18 | -150 | -136 | 1,840 |
| **Rainbow** | 1,226 | 1,403 | 1,336 | 729 | 3,431 | -718 | 1,993 | 2,286 | 3,038 | 1,114 | 1,100 | 569 | 17,507 |
| **Cochrane** | 1,114 | 1,403 | 1,199 | 515 | 2,240 | -492 | 1,830 | -951 | 2,681 | 1,606 | 728 | 144 | 12,017 |
| **Ryan** | 1,609 | 1,899 | 680 | 2,994 | 3,531 | 773 | 937 | -1,149 | 225 | 1,089 | 2,361 | 996 | 15,945 |
| **Morony** | 472 | 543 | 874 | 1,195 | 1,100 | -31 | 470 | -3,875 | -2,196 | 1,118 | 900 | 558 | 1,128 |
| **Thompson Falls** | 1,625 | 3,037 | 3,353 | 3,169 | 2,776 | 2,604 | -736 | 3,160 | 2,490 | -432 | 3,638 | 1,801 | 26,485 |
| **Mystic** | 217 | -48 | 436 | 315 | -2 | 15 | 262 | 25 | -135 | -68 | 117 | 16 | 1,150 |
| **System Total** | 8,717 | 9,425 | 10,673 | 10,165 | 13,310 | 4,702 | 4,471 | 1,862 | 2,867 | 6,147 | 8,456 | 5,300 | 86,095 |
| **NorthWestern Energy Plants** | **9,114** | **10,111** | **10,714** | **10,245** | **13,653** | **2,453** | **4,063** | **-2,193** | **5,092** | **5,914** | **9,556** | **4,813** | **83,535** |
| **Percent Difference (%)**<br>**Difference/Historical** | | | | | | | | | | | | | |
| | **2013** | | | **2014** | | | | | | | | | |
| **2014 WY** | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Total** |
| **Madison** | 2.5% | 1.7% | 3.7% | 3.6% | 5.8% | 10.2% | 5.8% | 12.2% | 12.1% | 13.8% | 14.3% | 4.4% | 7.8% |
| **Canyon Ferry** | -1.8% | -3.3% | -0.2% | -0.4% | -1.6% | 6.8% | 1.1% | 11.0% | -7.5% | 0.7% | -4.1% | 1.8% | 0.8% |
| **Hauser** | 2.8% | 2.6% | 3.1% | 3.9% | 1.1% | 2.8% | 1.5% | 3.8% | -2.1% | -1.4% | -1.9% | 0.3% | 1.1% |
| **Holter** | 8.0% | 1.8% | 4.1% | 2.2% | -4.9% | 0.8% | -2.4% | -4.9% | -1.4% | 3.5% | 1.5% | 2.9% | 0.6% |
| **Black Eagle** | 12.7% | 14.5% | 24.2% | 5.7% | 17.1% | -5.8% | -3.6% | -7.6% | -6.9% | -0.2% | -1.4% | -1.3% | 1.4% |
| **Rainbow** | 5.1% | 6.1% | 5.7% | 3.3% | 15.8% | -1.9% | 4.6% | 5.1% | 7.2% | 2.9% | 3.4% | 1.9% | 4.5% |
| **Cochrane** | 6.9% | 9.1% | 7.5% | 3.3% | 14.6% | -1.7% | 5.1% | -2.4% | 8.1% | 6.3% | 3.1% | 0.8% | 4.2% |
| **Ryan** | 5.5% | 6.7% | 2.4% | 10.9% | 13.2% | 1.9% | 2.4% | -2.5% | 0.5% | 2.6% | 6.0% | 2.6% | 3.7% |
| **Morony** | 2.7% | 3.2% | 5.3% | 7.4% | 7.3% | -0.2% | 2.7% | -21.9% | -11.5% | 3.8% | 3.7% | 2.4% | 0.5% |
| **Thompson Falls** | 4.8% | 9.3% | 10.5% | 8.2% | 8.2% | 5.8% | -1.2% | 5.7% | 4.6% | -0.7% | 10.1% | 7.0% | 5.2% |
| **Mystic** | 3.8% | -1.4% | 7.9% | 6.3% | -0.1% | 0.5% | 14.6% | 0.6% | -1.7% | -0.8% | 1.3% | 0.2% | 1.8% |
| **System Total** | 4.7% | 5.3% | 5.8% | 5.5% | 7.6% | 1.8% | 1.5% | 0.6% | 1.0% | 2.1% | 3.5% | 2.4% | 3.1% |
| **NorthWestern Energy Plants** | **5.5%** | **6.4%** | **6.7%** | **6.3%** | **8.9%** | **1.1%** | **1.6%** | **-0.8%** | **2.0%** | **2.3%** | **4.4%** | **2.5%** | **3.4%** |

As previously noted, the actual reservoir operations were simulated in the V_2014WY scenario to mimic actual reservoir operations. Figures 4-1 through 4-13 show modeled elevations and flows along with historical elevations and flows for each reservoir. As shown in these figures, the model will not discretionarily spill; modeled spill will only occur once the reservoir reaches the defined spill elevation. As an example, during May 2014 the model simulates Rainbow filling up to full pool elevation, whereas historically discretionary/precautionary spills during this time held the pool at a much lower elevation. Overall, the model follows the trends of the historical elevations and discharges very closely for each of the reservoirs, with minor deviations due to actual operations.

**FIGURE 4-1**
**V_2014 WY AND HISTORICAL HEBGEN OPERATIONS**

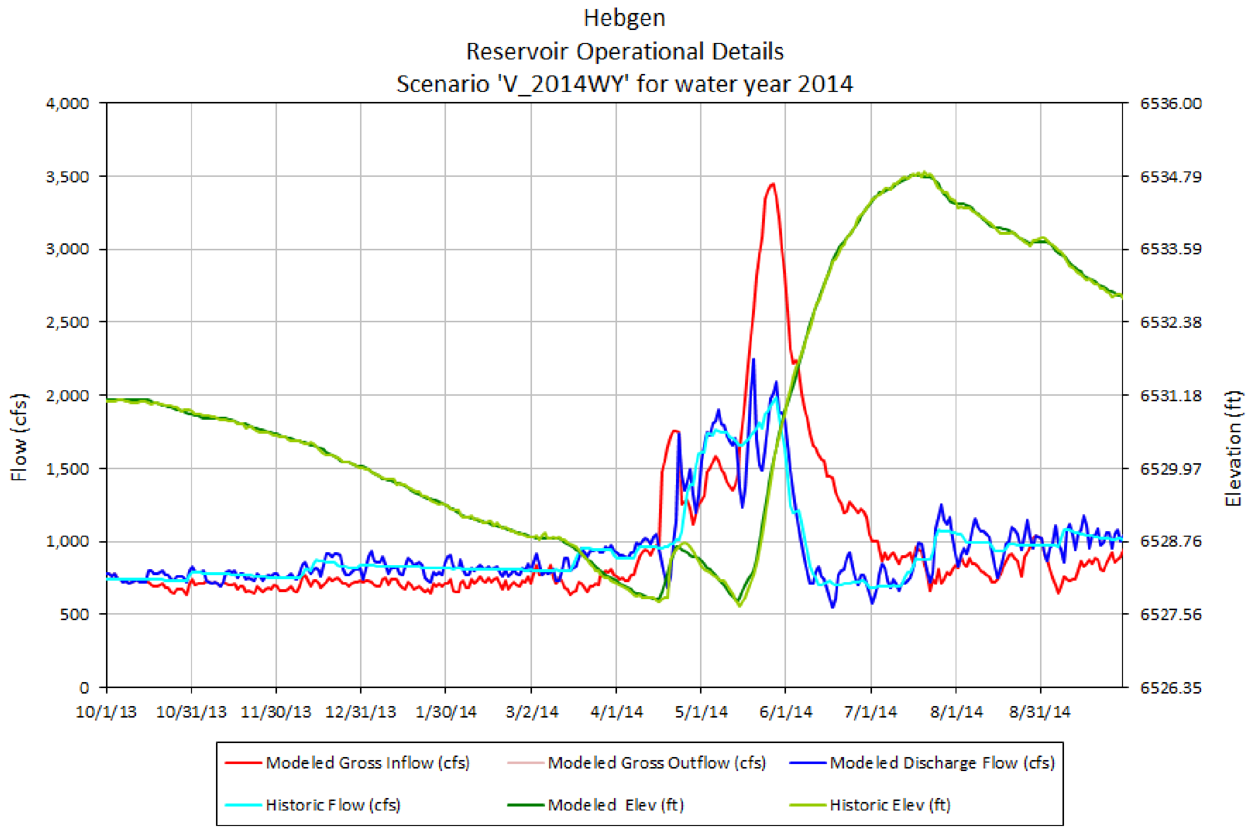
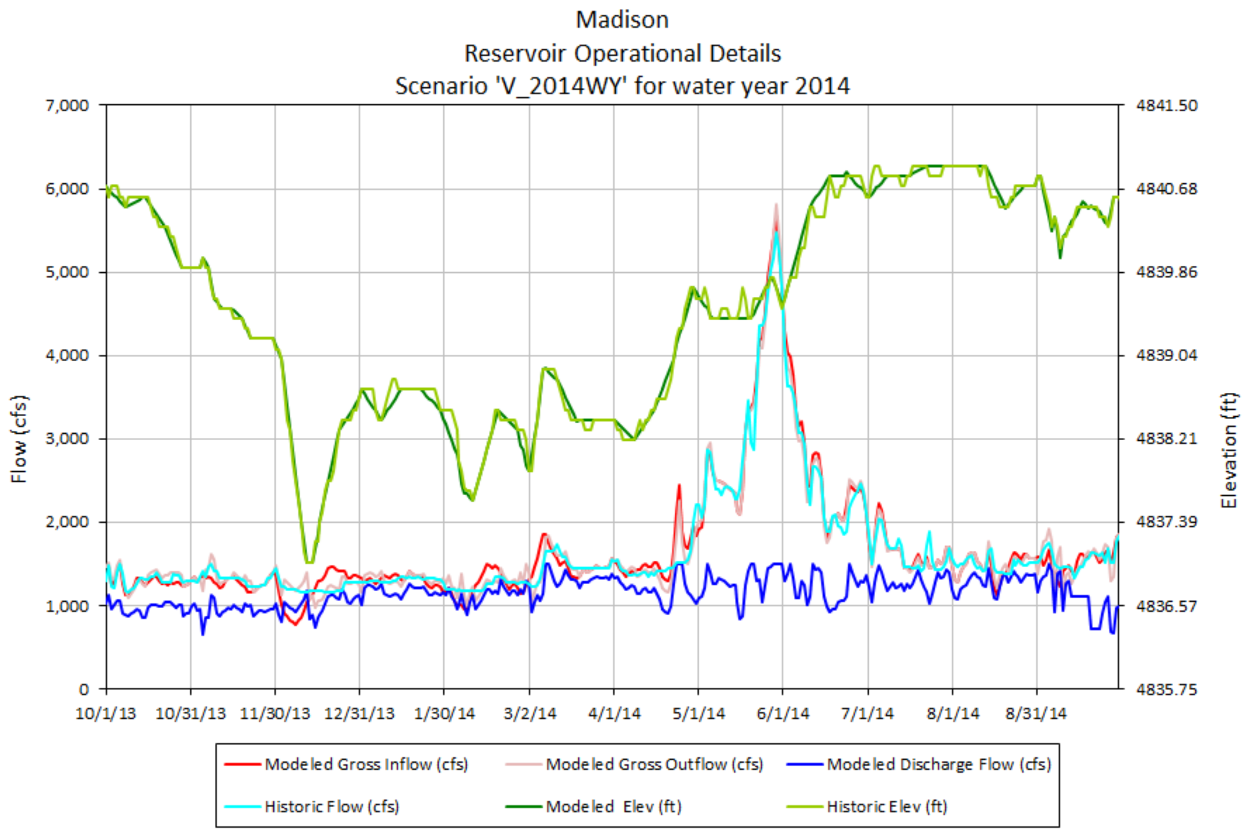


**FIGURE 4-2**
**V_2014 WY AND HISTORICAL MADISON OPERATIONS**



# FIGURE 4-3
# V_2014 WY AND HISTORICAL CANYON FERRY OPERATIONS

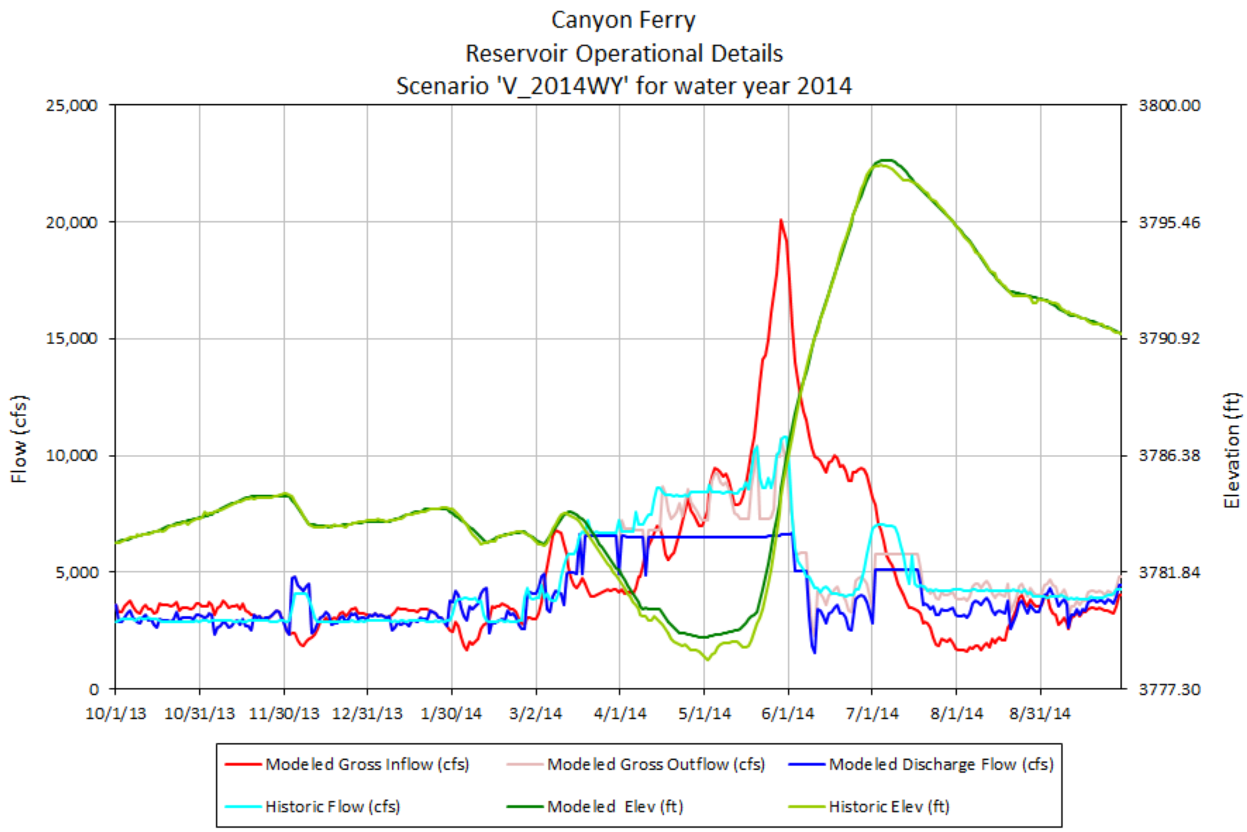
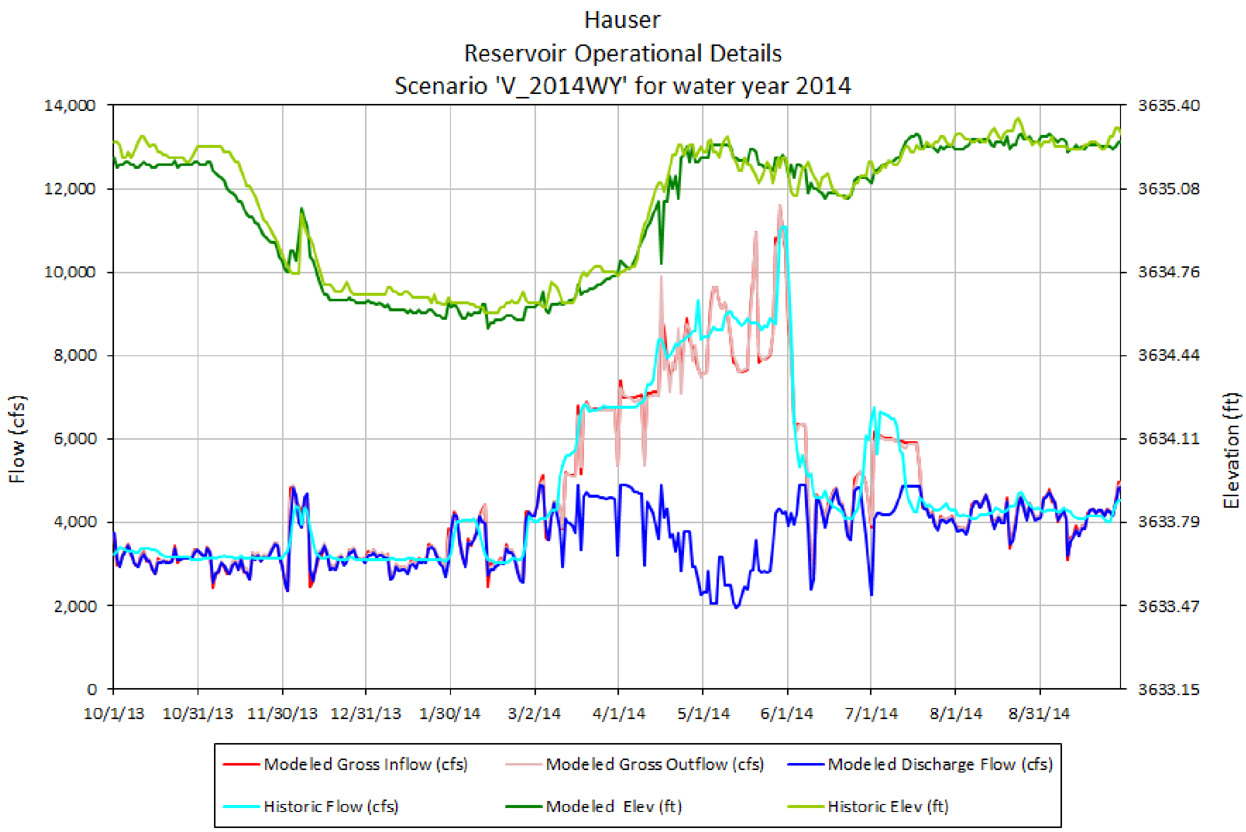


**FIGURE 4-4**
**V_2014 WY AND HISTORICAL HAUSER OPERATIONS**



# FIGURE 4-5
# V_2014 WY AND HISTORICAL HOLTER OPERATIONS

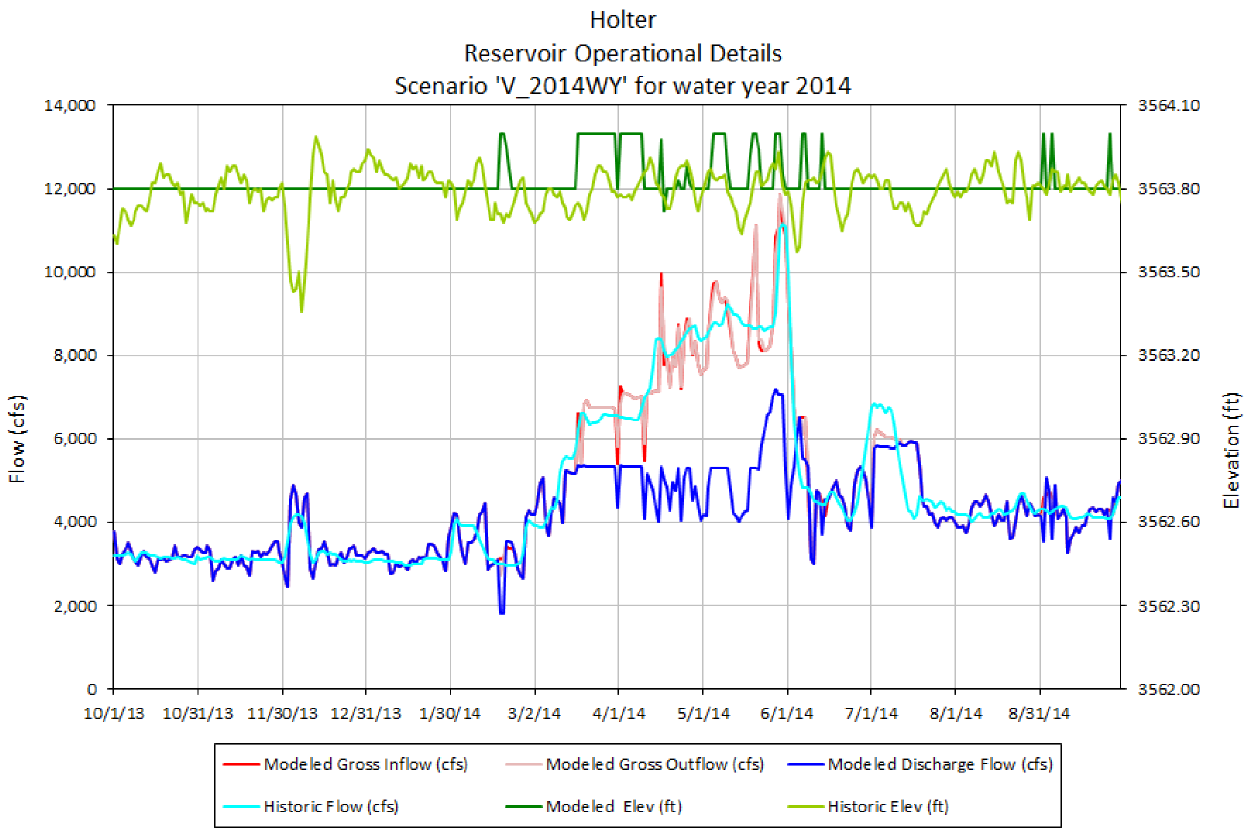
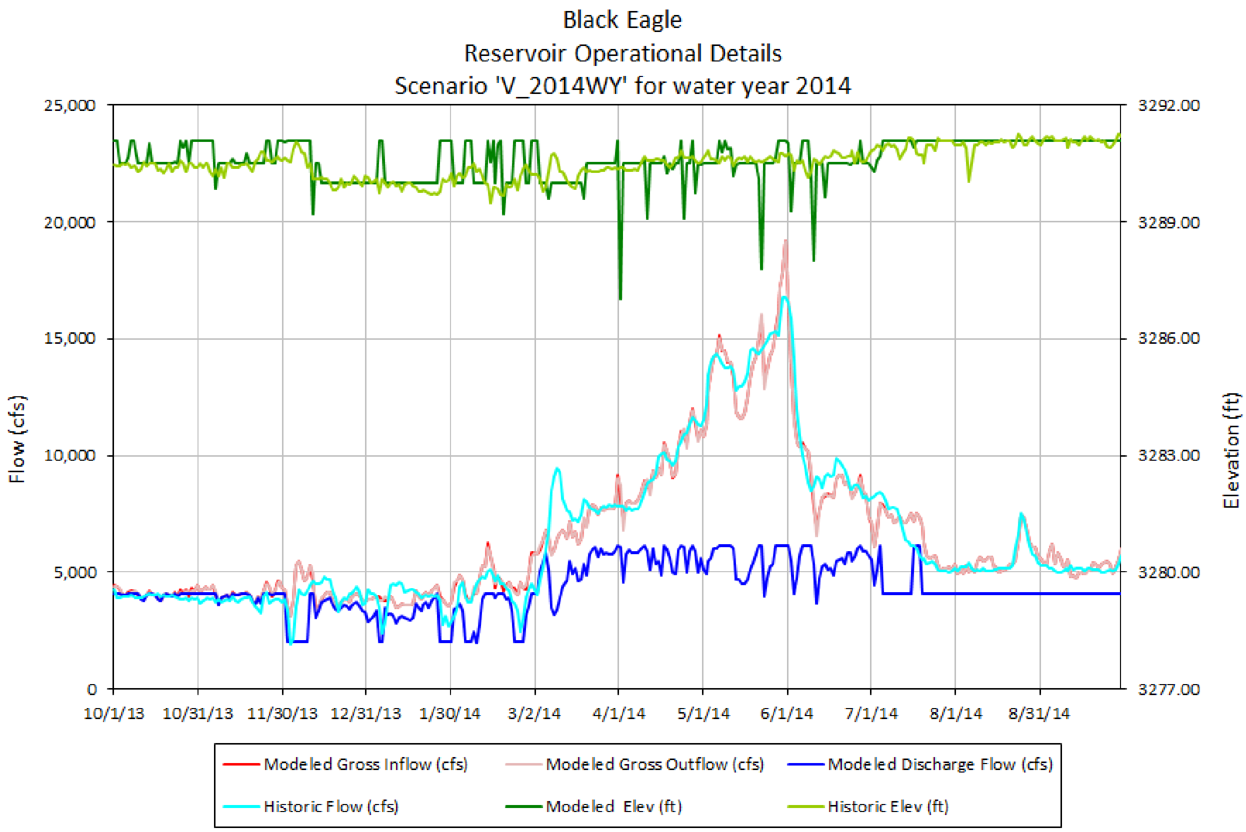
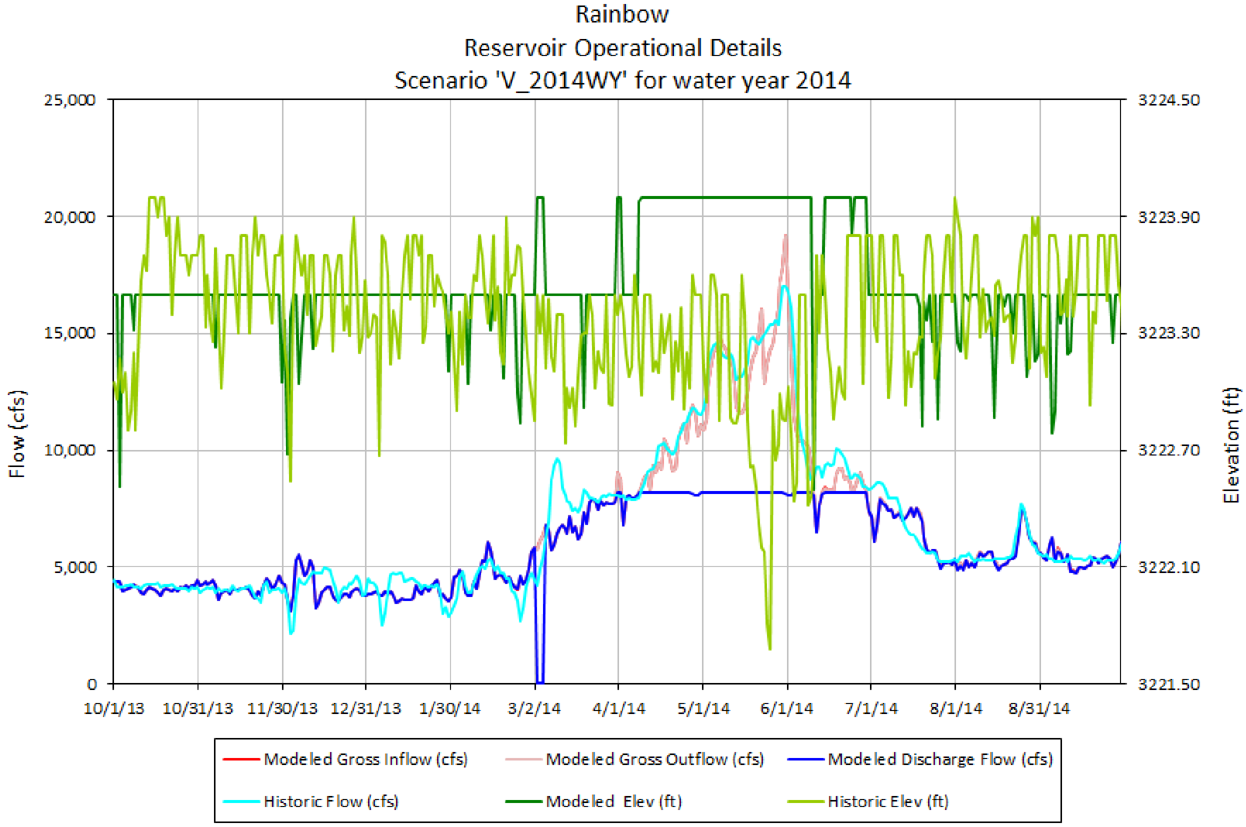


**FIGURE 4-6**
**V_2014 WY AND HISTORICAL BLACK EAGLE OPERATIONS**



# FIGURE 4-7
# V_2014 WY AND HISTORICAL RAINBOW OPERATIONS



# FIGURE 4-8
# V_2014 WY AND HISTORICAL COCHRANE OPERATIONS

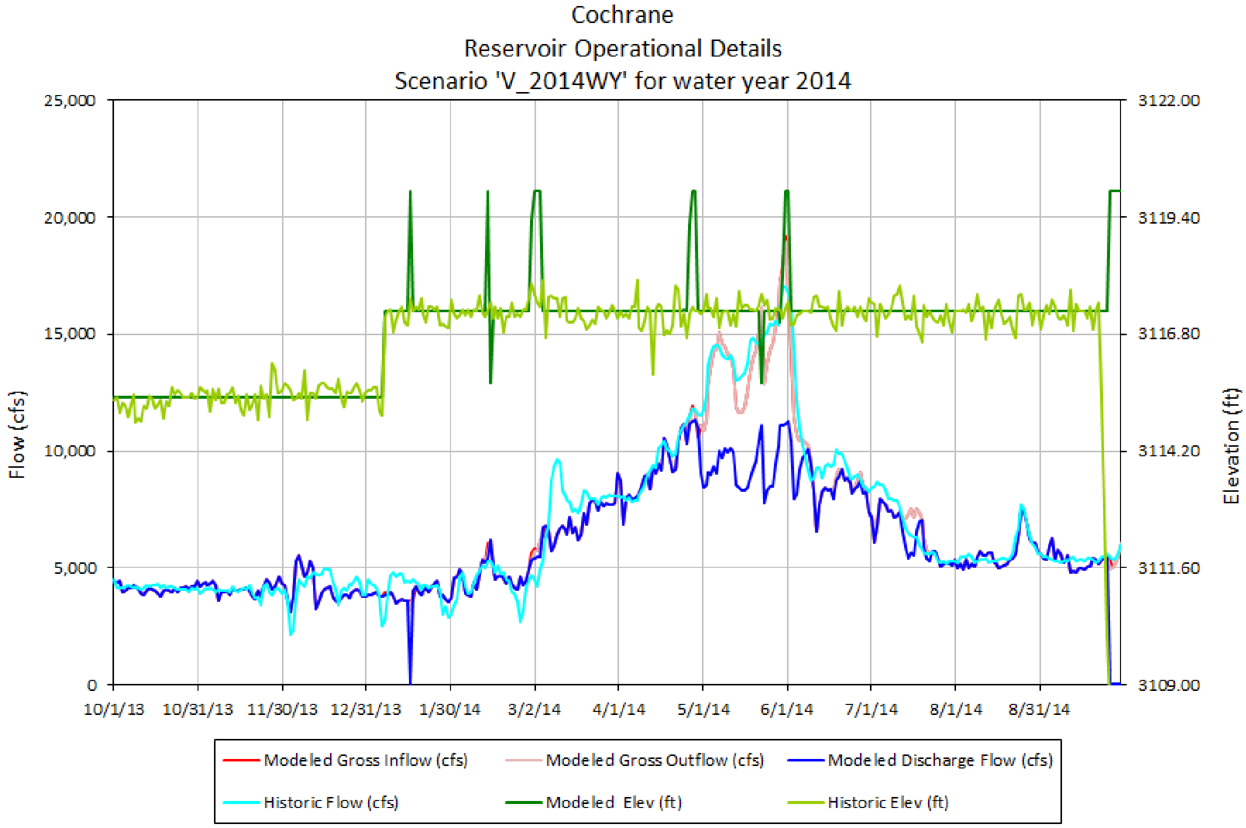
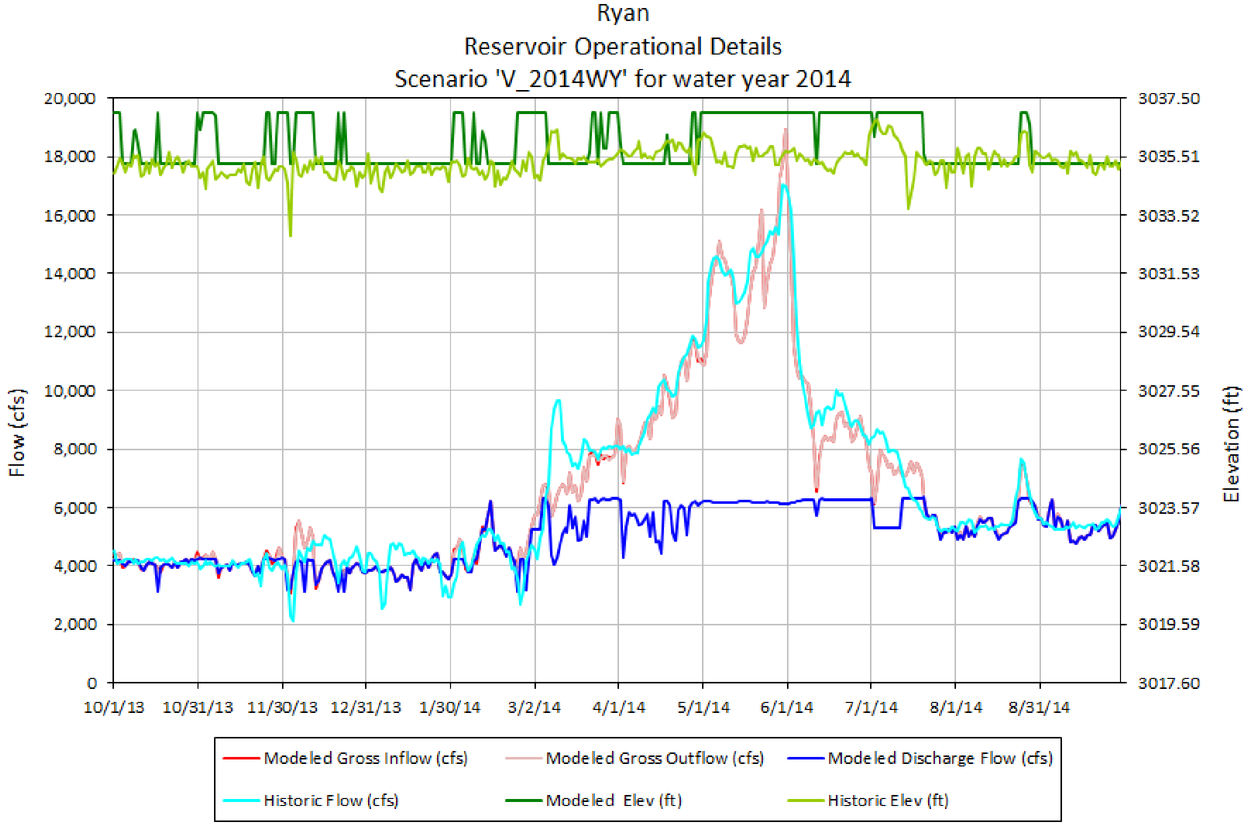
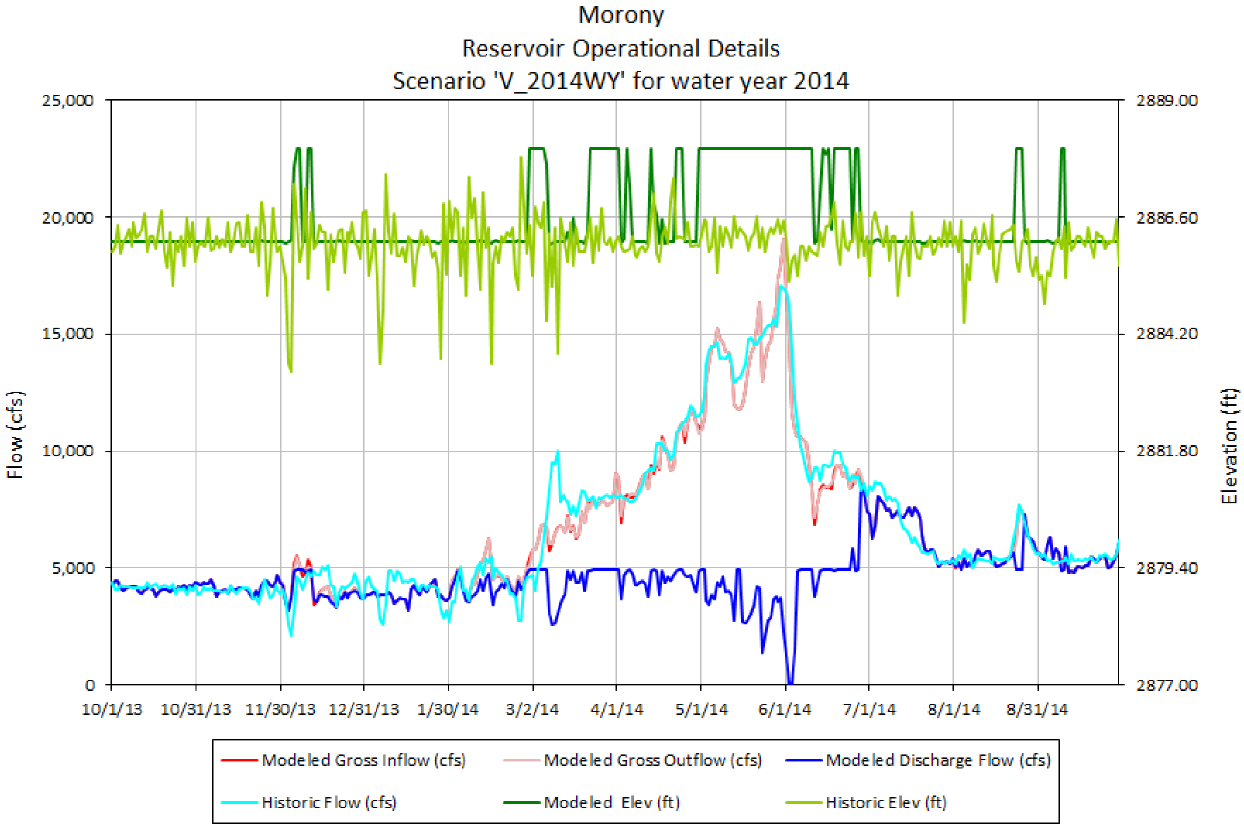


**FIGURE 4-9**
**V_2014 WY AND HISTORICAL RYAN OPERATIONS**



# FIGURE 4-10
# V_2014 WY AND HISTORICAL MORONY OPERATIONS



# FIGURE 4-11
# V_2014 WY AND HISTORICAL THOMPSON FALLS OPERATIONS

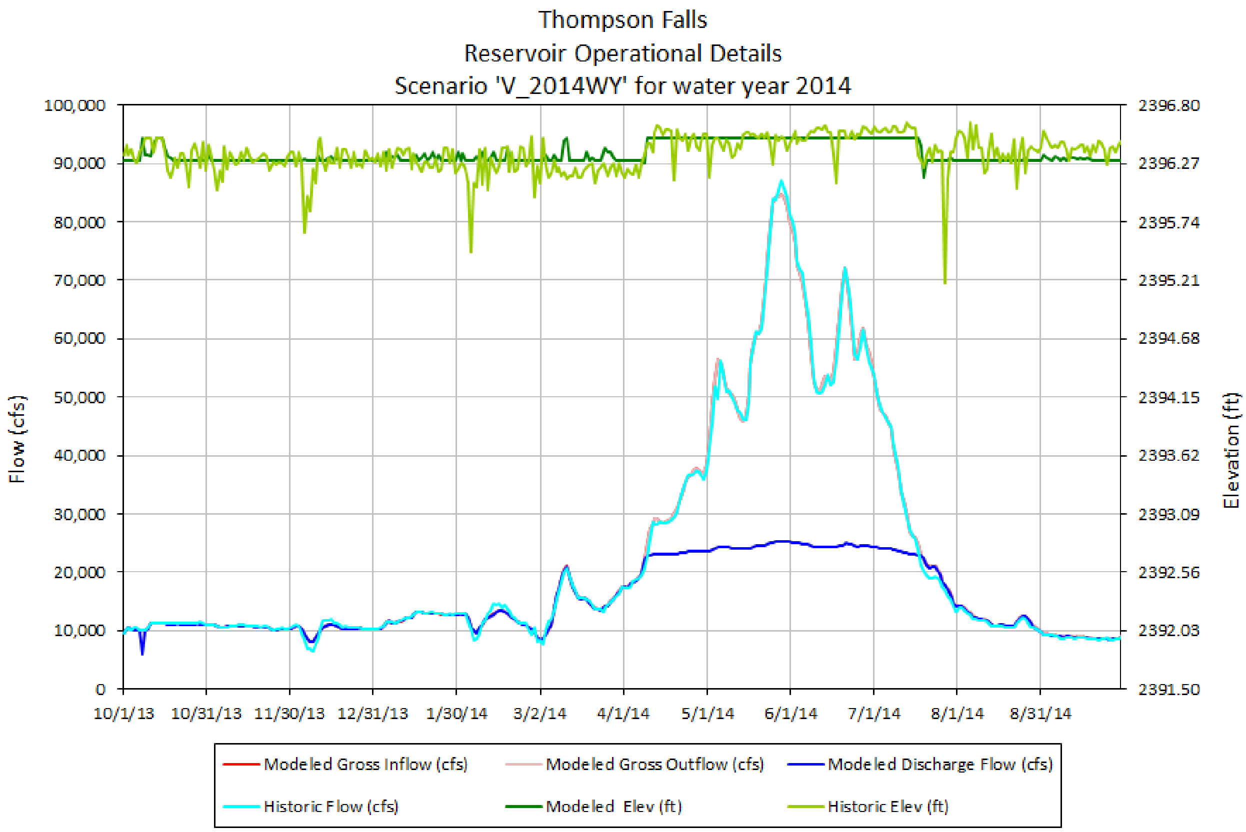
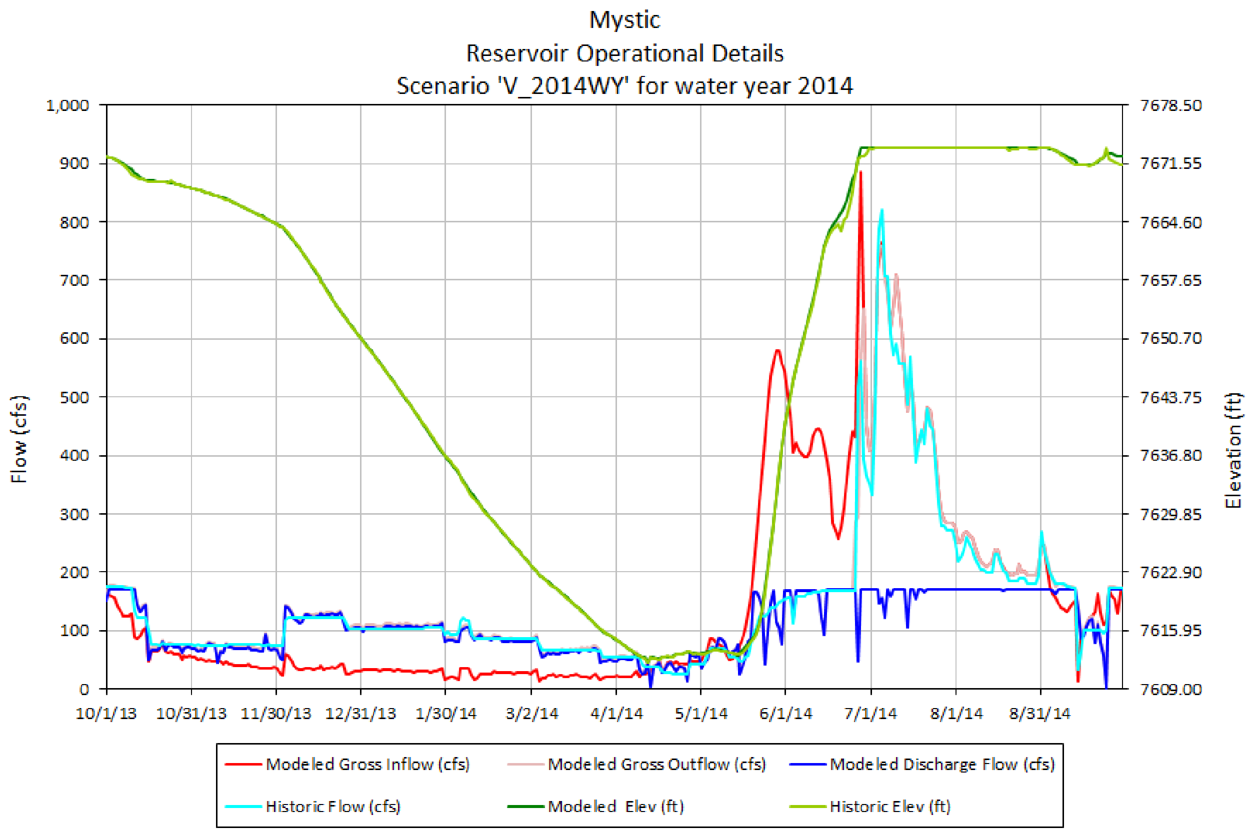
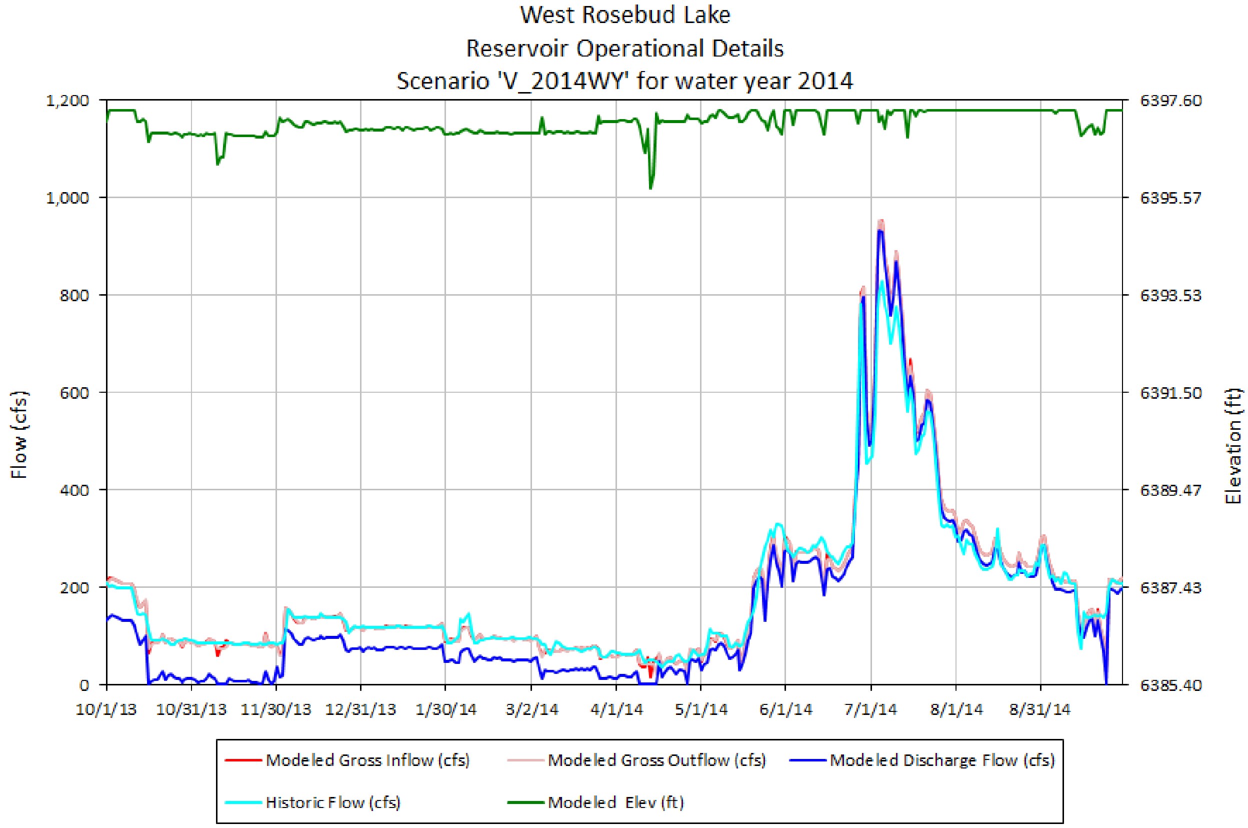


**FIGURE 4-12**
**V_2014 WY AND HISTORICAL MYSTIC LAKE OPERATIONS**



# FIGURE 4-13
# V_2014 WY AND HISTORICAL WEST ROSEBUD LAKE OPERATIONS



Section 5
# Summary and Conclusions

## 5.1 Summary

The purpose of this operations/verification report is to document inputs and assumptions used in the development of the NWE CHEOPS Model, to demonstrate the model reasonably characterizes operations of the modeled system, and to demonstrate that the model is adequate for use in evaluating the effects of alternative operating scenarios. The CHEOPS software and this NWE CHEOPS Model are tools that, as this report demonstrates, can be successfully used to evaluate the relative sensitivity and response of the Hydros to changing operational constraints. The model is a tool and does not predict future conditions or outcomes. The model results must be analyzed and interpreted based on knowledge of hydrologic and hydraulic principles and understanding of results viewed in a relative, rather than an absolute, context.

## 5.2 Conclusions

As discussed in Section 4, the model verification process includes comparisons between modeled output and historical data. The goal of this process is to obtain no more than 5 percent variance when comparing modeled results to historical data for generation on an annual basis. The modeled release from the project is compared to historical data to show whether the model provides a reasonable representation of project operations throughout the year (e.g., the timing, magnitude, and duration of operations).

As shown in Table 4-2, there are significant swings between modeled and historical generation. However, there are many factors inherent in the model data and setup that can contribute to output discrepancies (i.e., deviations) when compared to historical data. In many cases, several of these factors may be involved simultaneously, which makes it difficult to isolate individual sources of difference. Four examples of potential sources of deviations from historical data are the standardized spilling rules, hydrology, minimum flow requirements, and historical unit outages and discrepancies in unit performance:

- Spill Operations – The model follows a set of defined rules for spilling below the spill elevation, and it is seen in the historical records that operations vary greatly from year to year, month to month, and even day to day. This is one of the greatest sources of deviation and swings in the generation comparison and why the goal of this summary is to compare long-term trends rather than monthly values.
- Hydrology – The model uses reconstructed unimpaired flow data as the input for daily inflow water to the system. The unimpaired hydrology was synthesized based on gage data and plant records, both of which have a certain amount of inherent error especially when multiple locations and data sources are involved. The overall hydrologic data set appears to be a good representation of daily inflows and is acceptable for use in future water management planning.
- Minimum Streamflow Requirements – The model is set up to account for minimum streamflow requirements automatically. As a result, the model is proactive in automatically addressing minimum streamflow requirements rather than reactive in providing excess flow to avoid potential violations, as the case may be in actual operations.
- Unit Outages and Performance – The model has been set up with post upgrade/rehabilitation unit performance information in the verification scenario *V_2014WY*, which takes into account only the outages noted in "*Raw_EventData.CSV*" or that could be discerned from the PI data supplied by NorthWestern Energy.

In interpreting the information provided in this model operations/verification report, it is important to reflect on the purpose of the model: to reasonably characterize development operations. Comparing model results with historical data confirms use of the model as a tool for simulating "real" operations. It is not possible with reasonable time to account for every outside influence or condition to match historical operations and hydrology.

Small changes in input data or model logic can often result in large swings in output. This is due to a number of reasons including (but not limited to) runoff characteristics, reliance on coordinated operations, and numerous/variable flow requirements. Each of these elements individually contributes to the sensitivity of the system. Combined, they multiply that sensitivity exponentially. The input data and logic in the historical base scenario is an attempt to consolidate the effects of these variables to achieve an approximation of “characteristic operations.”

Most importantly, it must always be foremost in model discussions that the model should always be used to assess the relative impacts between scenarios. What this means is model verification is really the only time it is appropriate to compare model results with historical data. As previously stated, verification is intended to validate the model input data and model logic so the “Base Case” becomes the baseline for all subsequent analyses. The Verification scenario represents the Base Case scenario with the addition of forced elevations, approximations of historical spills, and unit outages to simulate actual historical operations.

In the opinion of HDR, verification results show the model compares favorably to historical data, reasonably characterizes study area operations, and is appropriate for use in evaluating the effects of alternative operating scenarios. However, appropriate use of the results is cautioned. As with any model, accuracy is highly dependent on input data; consequently, model results should be viewed in a relative, rather than absolute, context. This model is a tool that, as this report demonstrates, can be successfully used to evaluate the relative sensitivity and response of the Hydros to changing operational constraints.

# APPENDIX A

# PERIOD OF RECORD HYDROLOGY COMPARISON

FIGURE A-1
MODELED AND HISTORICAL HEBGEN DISCHARGE COMPARISON

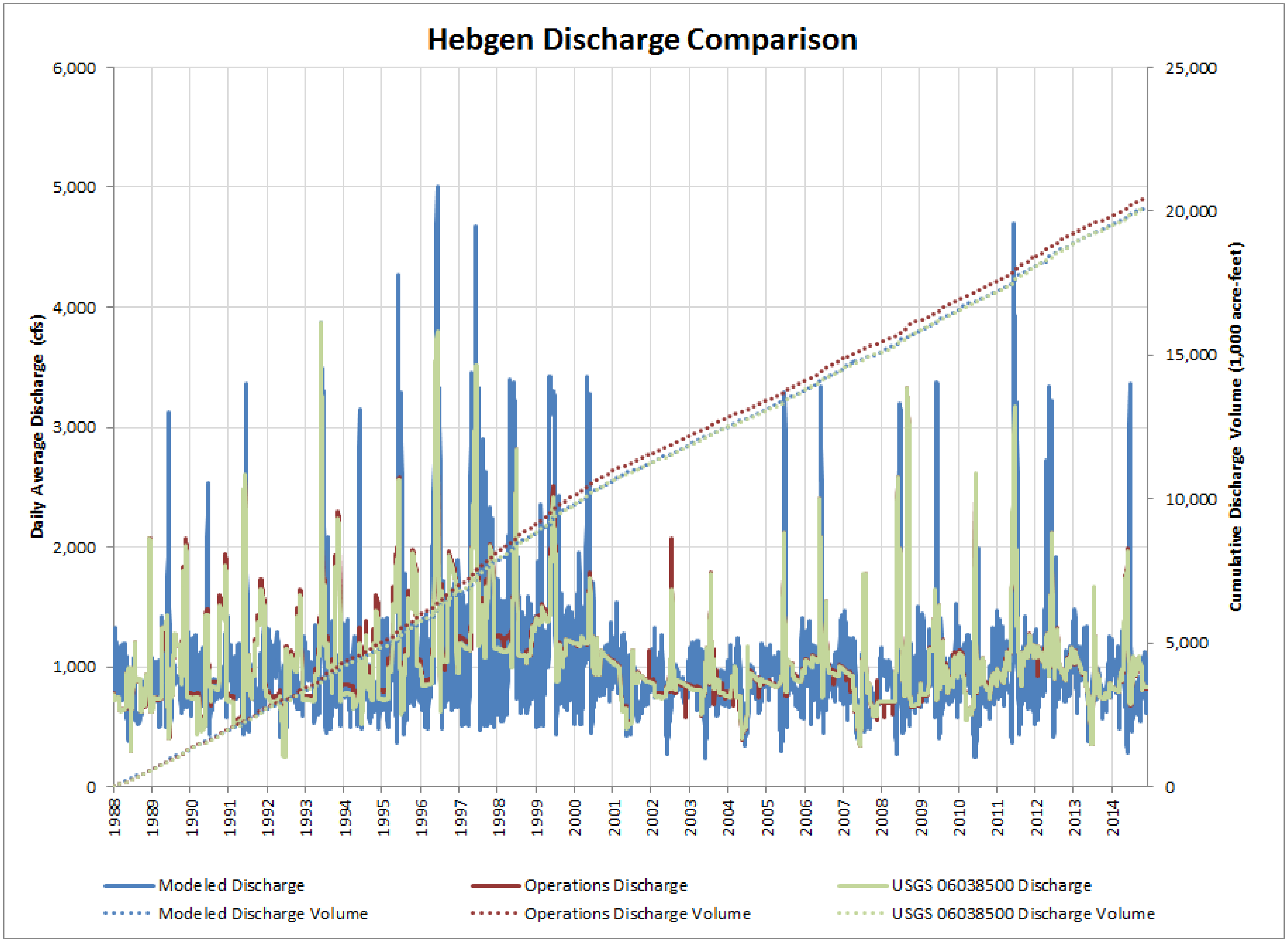


**FIGURE A-2**
**MODELED AND HISTORICAL MADISON DISCHARGE COMPARISON**

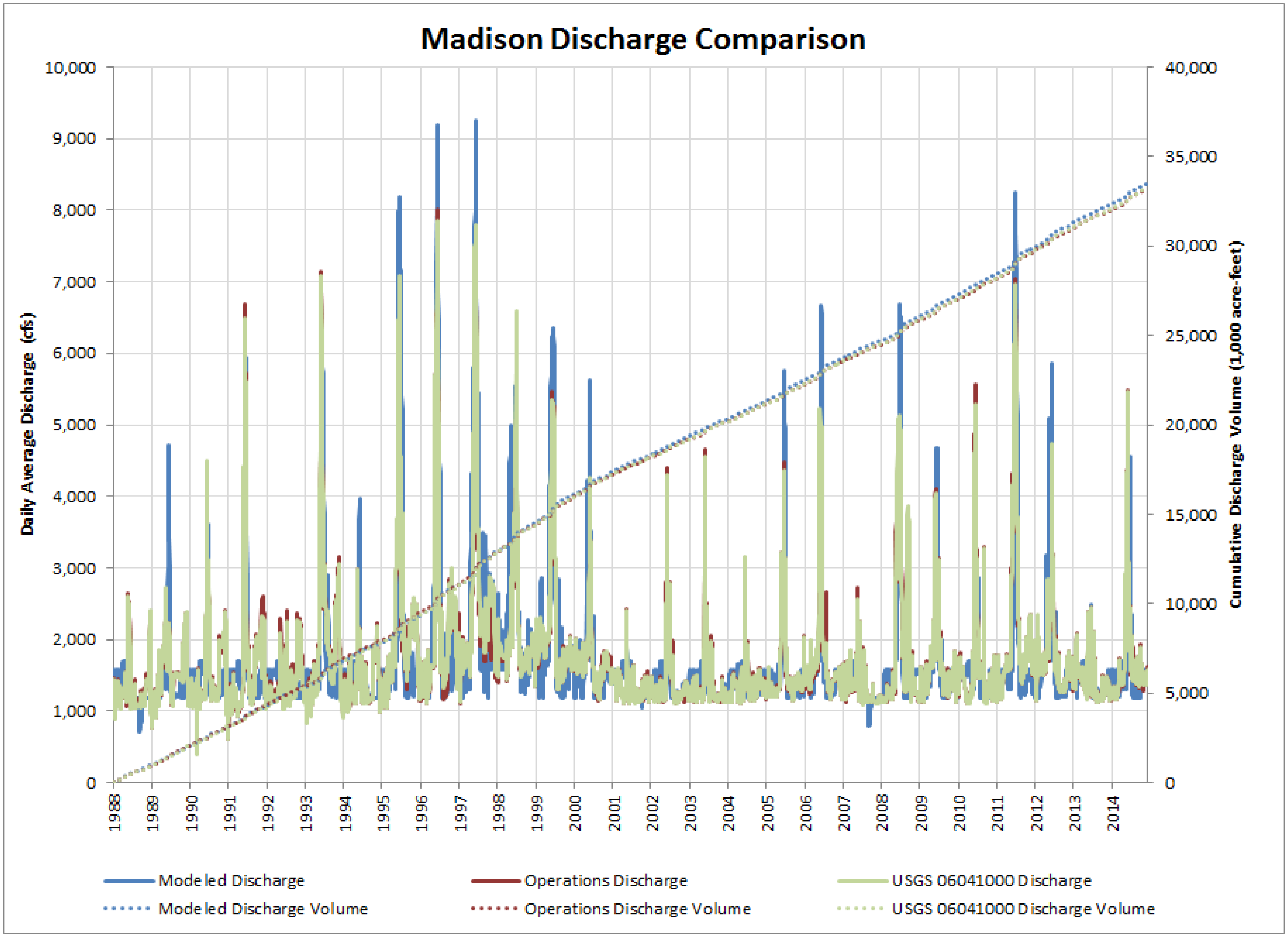


**FIGURE A-3**
**MODELED AND HISTORICAL CANYON FERRY DISCHARGE COMPARISON**

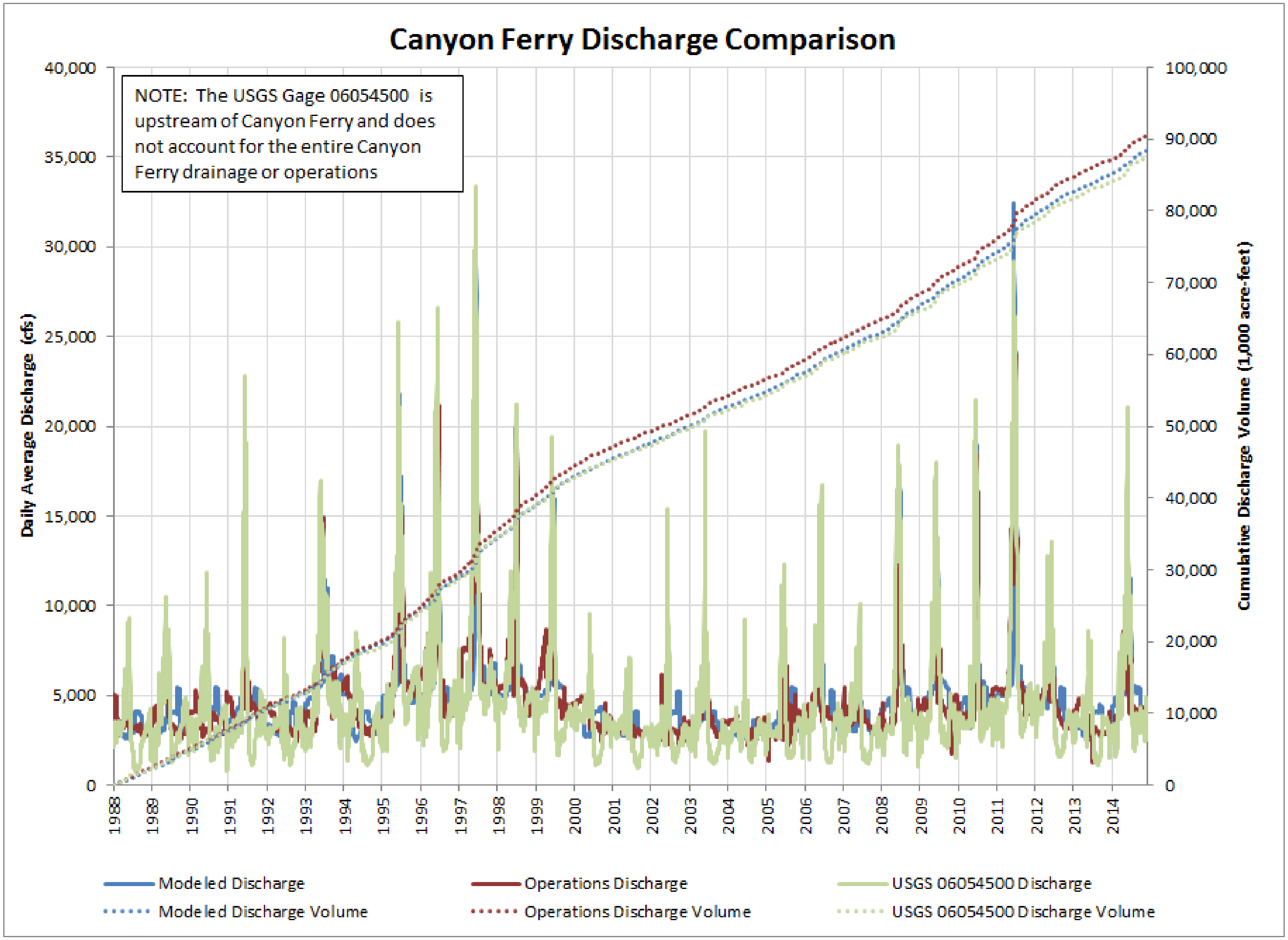


**FIGURE A-4**
**MODELED AND HISTORICAL HAUSER DISCHARGE COMPARISON**

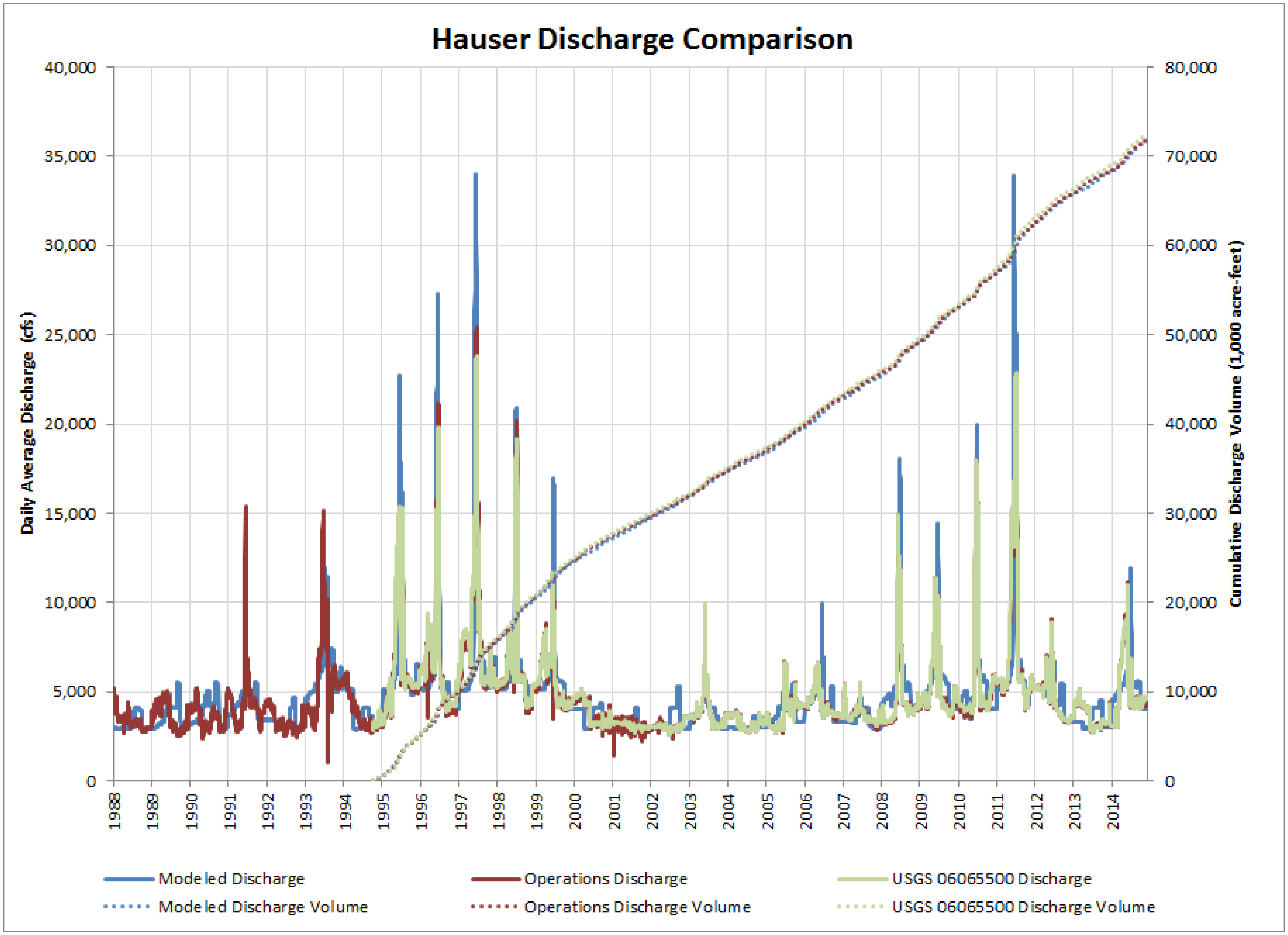


**FIGURE A-5**
**MODELED AND HISTORICAL HOLTER DISCHARGE COMPARISON**

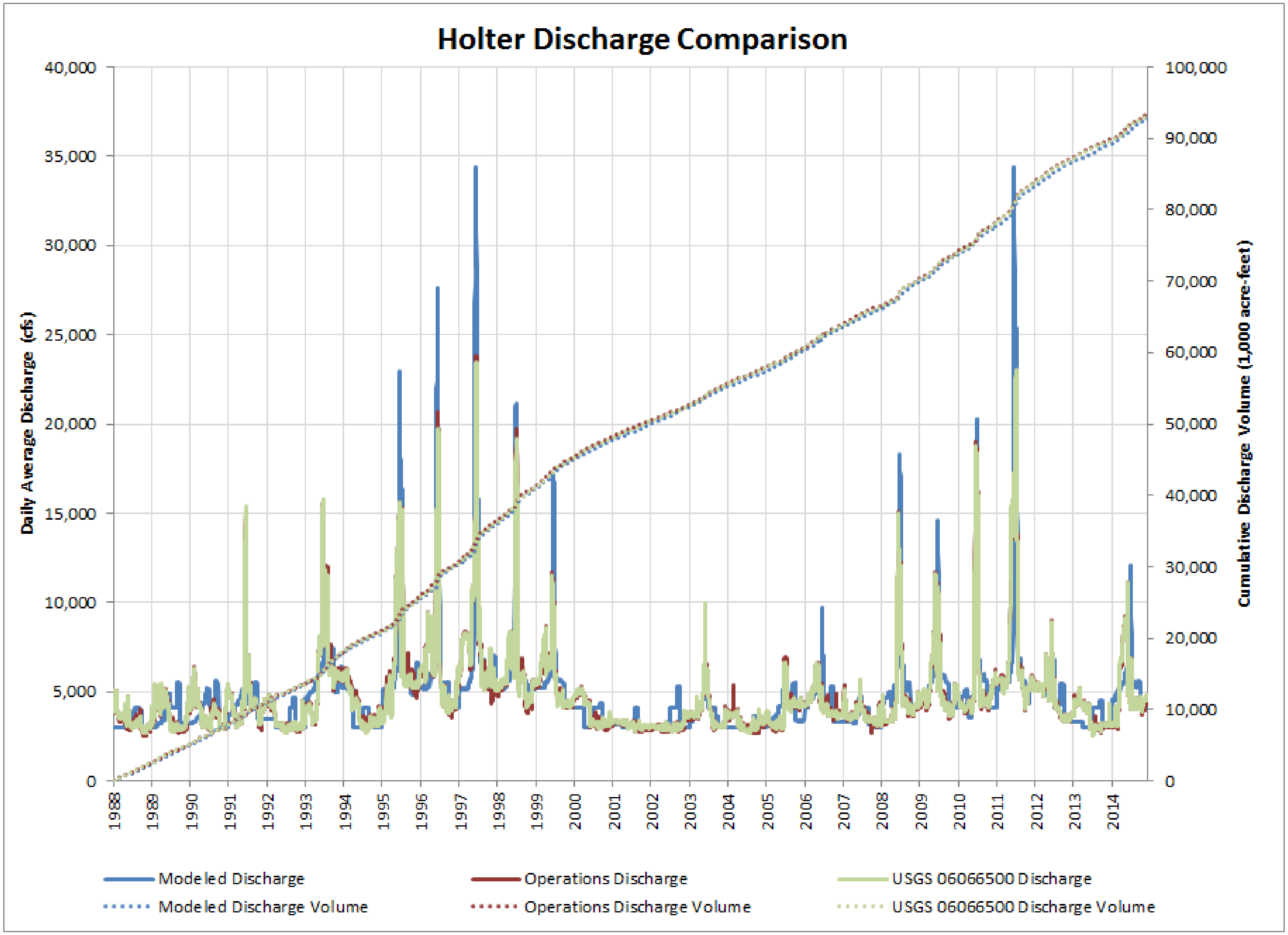


**FIGURE A-6**
**MODELED AND HISTORICAL BLACK EAGLE DISCHARGE COMPARISON**

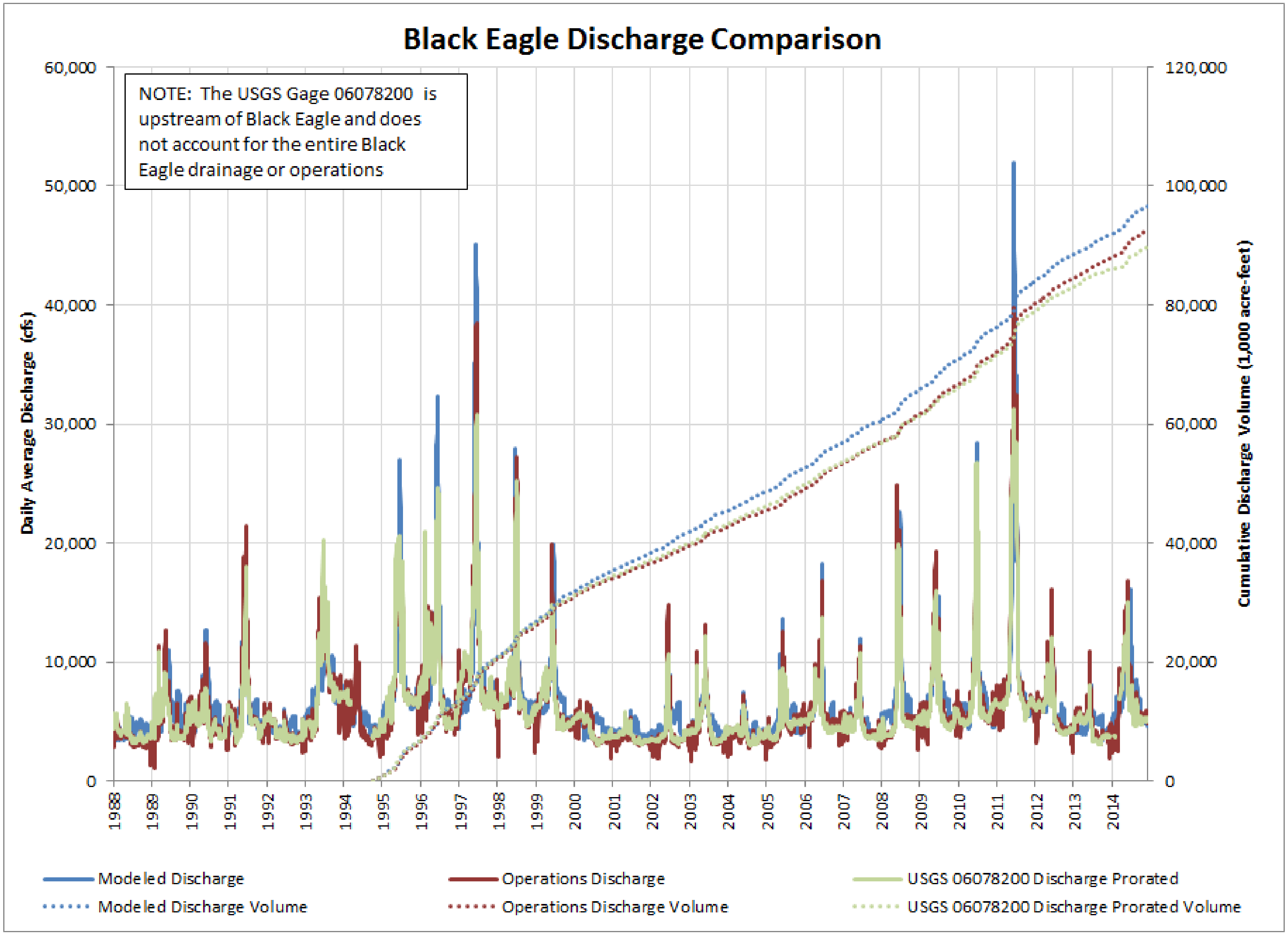


**FIGURE A-7**
**MODELED AND HISTORICAL RAINBOW DISCHARGE COMPARISON**

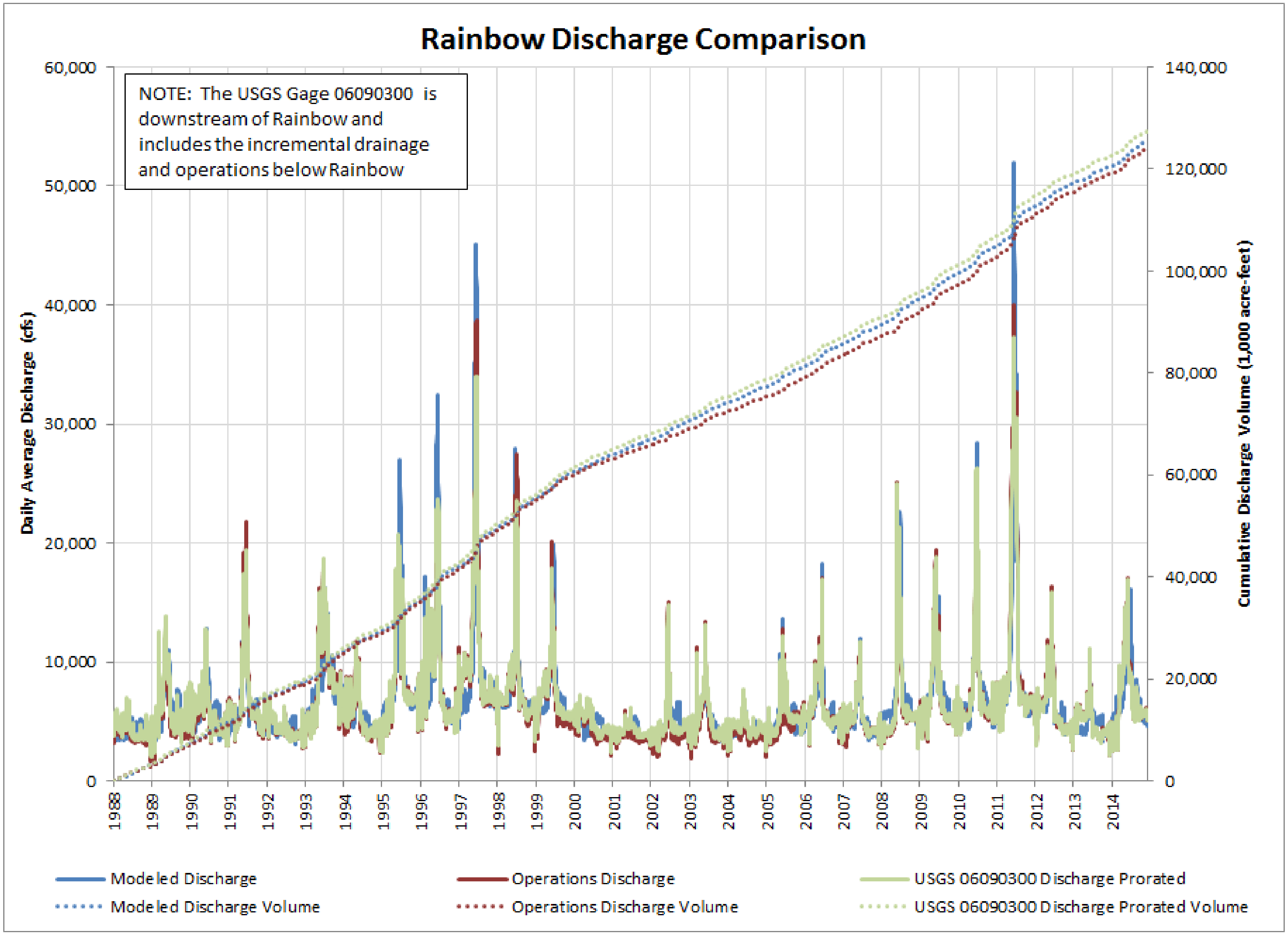


**FIGURE A-8**
**MODELED AND HISTORICAL COCHRANE DISCHARGE COMPARISON**

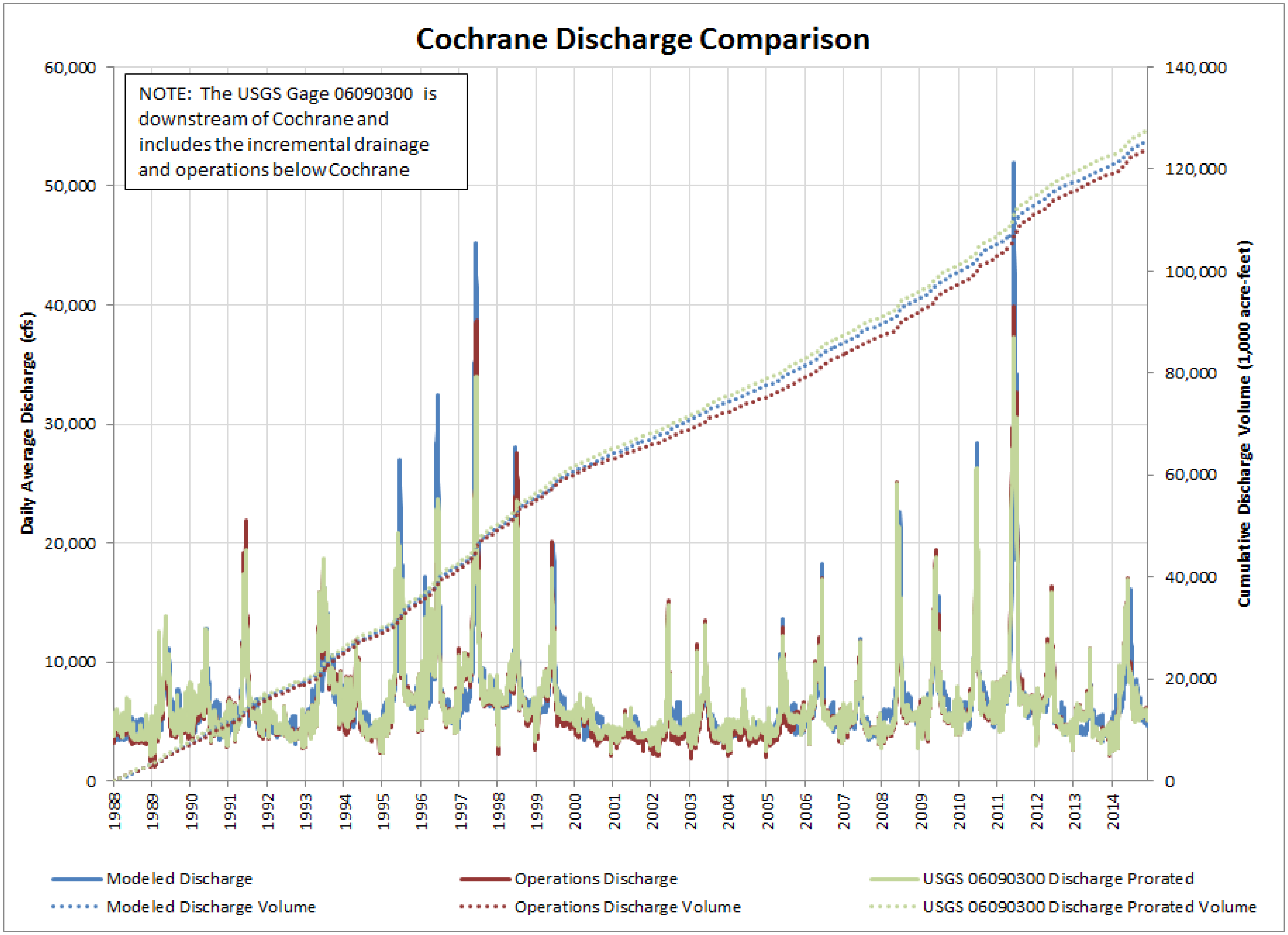


**FIGURE A-9**
**MODELED AND HISTORICAL RYAN DISCHARGE COMPARISON**

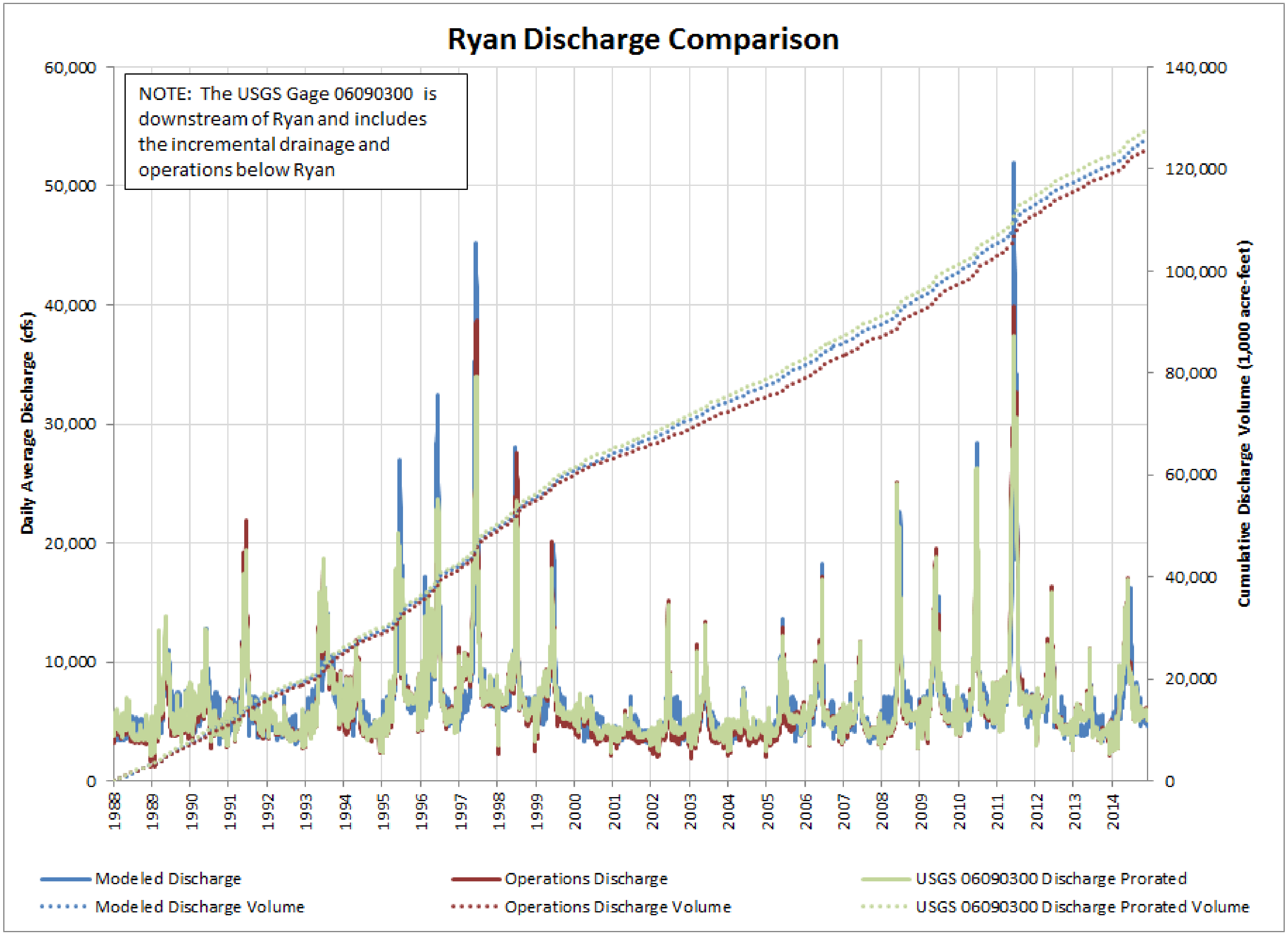


**FIGURE A-10**
**MODELED AND HISTORICAL MORONY DISCHARGE COMPARISON**

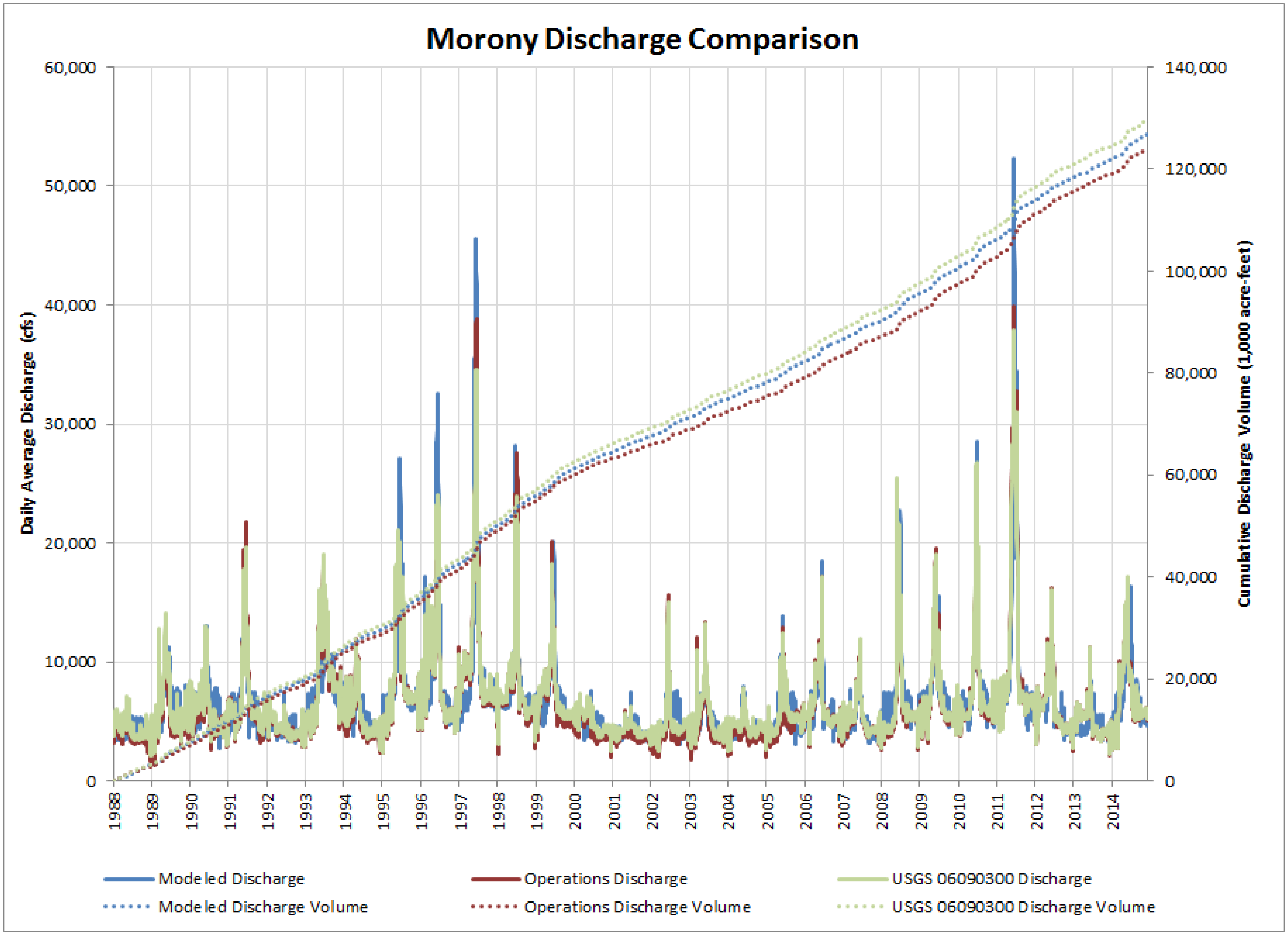


**FIGURE A-11**
**MODELED AND HISTORICAL THOMPSON FALLS DISCHARGE COMPARISON**

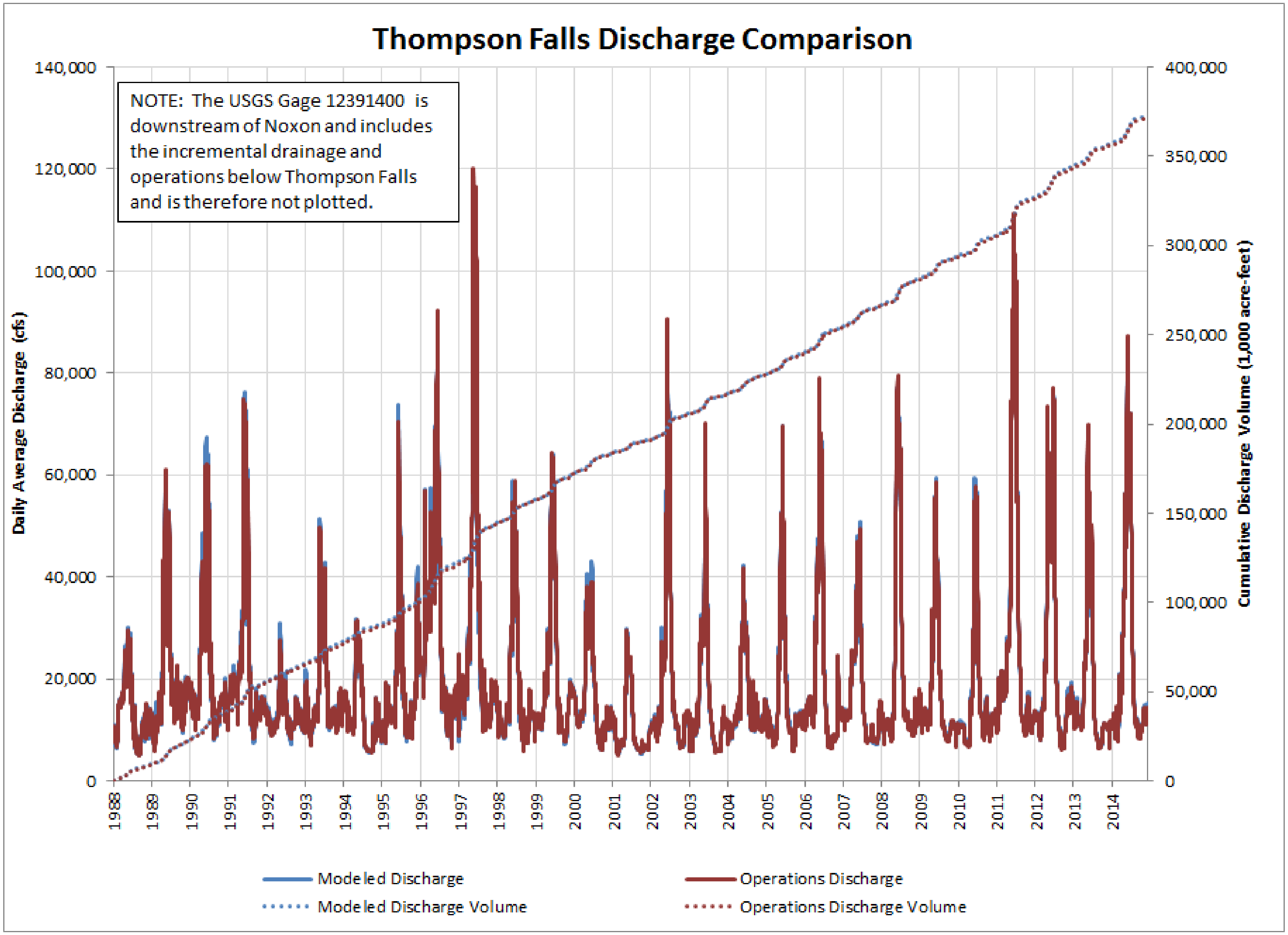


**FIGURE A-12**
**MODELED AND HISTORICAL MYSTIC LAKE DISCHARGE COMPARISON**

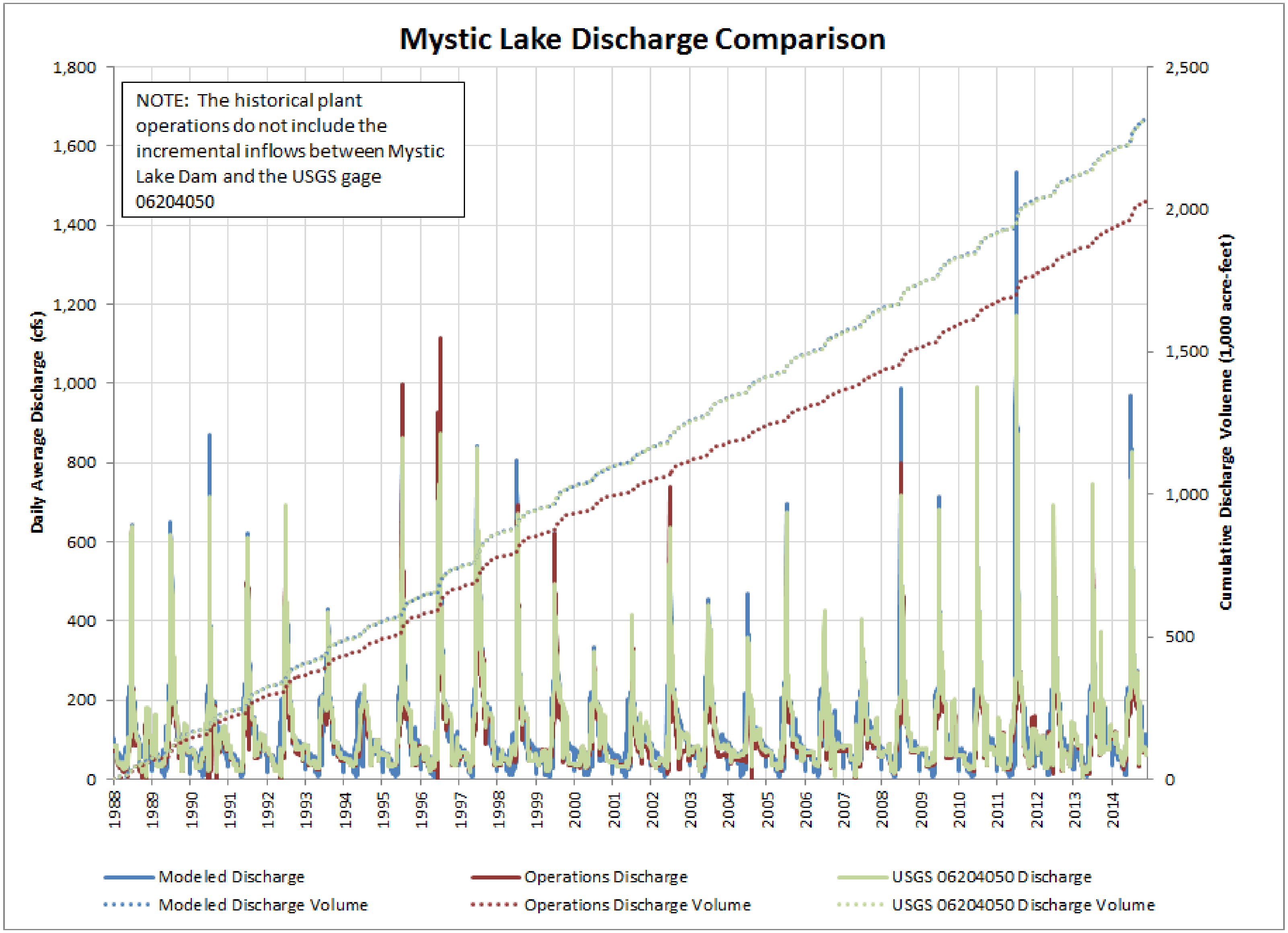
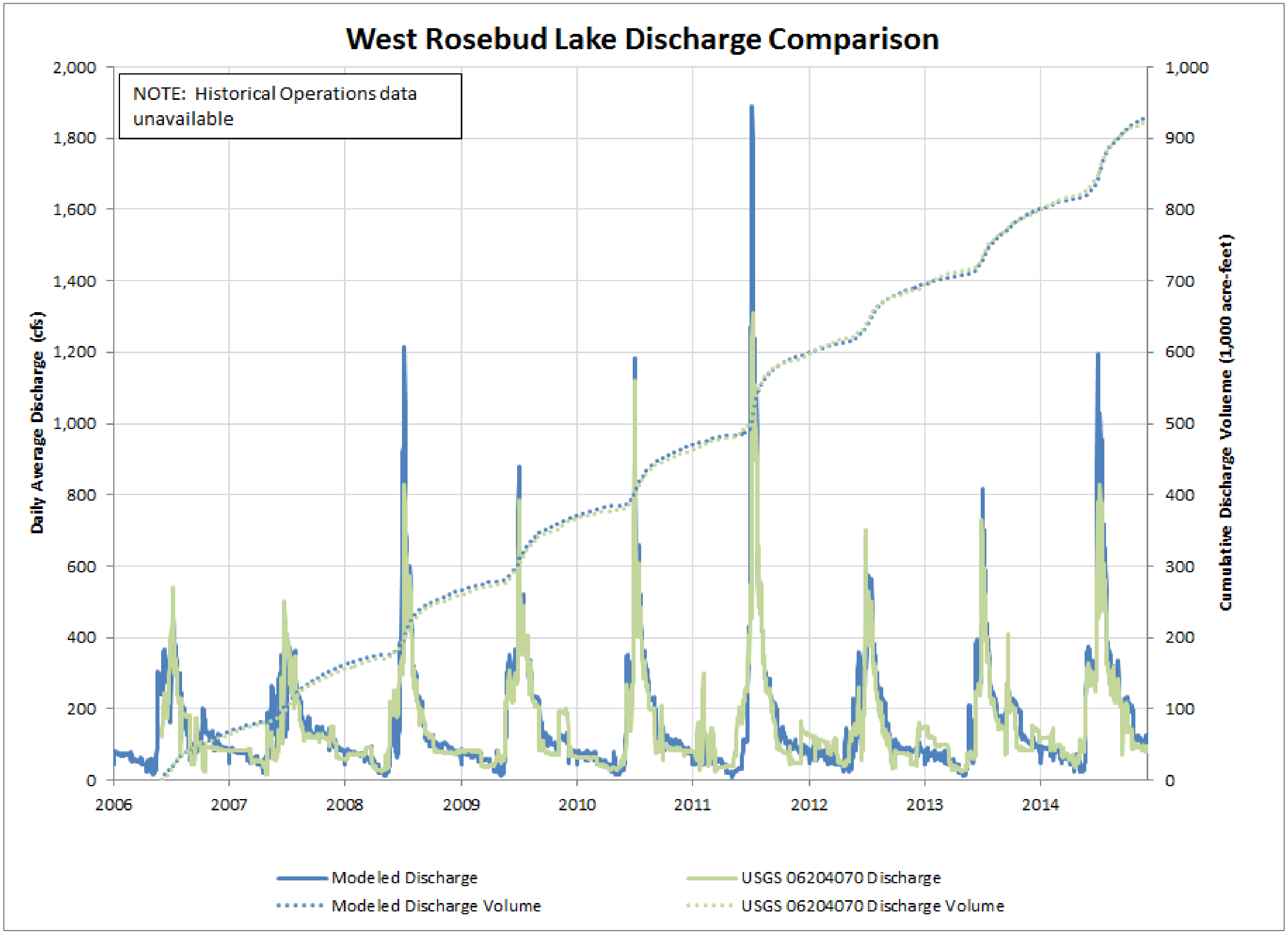


**FIGURE A-13**
**MODELED AND HISTORICAL WEST ROSEBUD LAKE DISCHARGE COMPARISON**



# APPENDIX B

# BASE CASE SCENARIO DEFINITION

Complete Scenario Data for Scenario - Base Case

Written on 2/12/2015 2:37:56 PM

********************************************
Scenario
Name: Base Case
Description: "Operational requirements and unit configuration as of Fall 2013.Peaking only at Canyon Ferry, Thompson Falls and Mystic."
Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked. KADAMEC 2015/2/12 Checked again
System Settings: Base

********************************************
System Settings
Name: Base
Description: "Base with Hydrology dataset computed for 1988 through Nov 2014. Station service of 0.32 percent included based on sheet ""Aux Loads"" from ""Generator info - JCummings.xlsx""."

Notes: BKROLAK 2015/2/3. ASCANGAS 2015/2/5 checked.

| Loadshape | Hydrology Set | Elevation Carry-Over | Forecast Days | Forecast Accuracy | Metering Loss | Enable CNF Agreement Logic |
|---|---|---|---|---|---|---|
| 6x16_Generic | Inflows_19880101-20141130Final.xls | TRUE | 1 | 1 | 0.0032 | TRUE |

********************************************
Loadshape
Name: 6x16_Generic
Description: Generic 6x16
Notes: BKROLAK 2014/12/16. ASCANGAS 2015/2/5 checked.

| Month | Period | Duration (hrs) | Price ($) |
|---|---|---|---|
| Jan | 1 | 6 | 50 |
| Jan | 2 | 0 | 70 |
| Jan | 3 | 8 | 100 |
| Jan | 4 | 0 | 70 |
| Jan | 5 | 8 | 100 |
| Jan | 6 | 0 | 70 |
| Jan | 7 | 2 | 50 |
| Jan | 8 | 6 | 40 |
| Jan | 9 | 8 | 75 |
| Jan | 10 | 0 | 40 |
| Jan | 11 | 8 | 75 |
| Jan | 12 | 2 | 40 |
| Feb | 1 | 6 | 50 |
| Feb | 2 | 0 | 70 |
| Feb | 3 | 8 | 100 |
| Feb | 4 | 0 | 70 |
| Feb | 5 | 8 | 100 |
| Feb | 6 | 0 | 70 |
| Feb | 7 | 2 | 50 |
| Feb | 8 | 6 | 40 |
| Feb | 9 | 8 | 75 |
| Feb | 10 | 0 | 40 |
| Feb | 11 | 8 | 75 |
| Feb | 12 | 2 | 40 |
| Mar | 1 | 6 | 50 |

| | | | |
|---|---|---|---|
| Mar | 2 | 0 | 70 |
| Mar | 3 | 8 | 100 |
| Mar | 4 | 0 | 70 |
| Mar | 5 | 8 | 100 |
| Mar | 6 | 0 | 70 |
| Mar | 7 | 2 | 50 |
| Mar | 8 | 6 | 40 |
| Mar | 9 | 8 | 75 |
| Mar | 10 | 0 | 40 |
| Mar | 11 | 8 | 75 |
| Mar | 12 | 2 | 40 |
| Apr | 1 | 6 | 50 |
| Apr | 2 | 0 | 70 |
| Apr | 3 | 8 | 100 |
| Apr | 4 | 0 | 70 |
| Apr | 5 | 8 | 100 |
| Apr | 6 | 0 | 70 |
| Apr | 7 | 2 | 50 |
| Apr | 8 | 6 | 40 |
| Apr | 9 | 8 | 75 |
| Apr | 10 | 0 | 40 |
| Apr | 11 | 8 | 75 |
| Apr | 12 | 2 | 40 |
| May | 1 | 6 | 50 |
| May | 2 | 0 | 70 |
| May | 3 | 8 | 100 |
| May | 4 | 0 | 70 |
| May | 5 | 8 | 100 |
| May | 6 | 0 | 70 |
| May | 7 | 2 | 50 |
| May | 8 | 6 | 40 |
| May | 9 | 8 | 75 |
| May | 10 | 0 | 40 |
| May | 11 | 8 | 75 |
| May | 12 | 2 | 40 |
| Jun | 1 | 6 | 50 |
| Jun | 2 | 0 | 70 |
| Jun | 3 | 8 | 100 |
| Jun | 4 | 0 | 70 |
| Jun | 5 | 8 | 100 |
| Jun | 6 | 0 | 70 |
| Jun | 7 | 2 | 50 |
| Jun | 8 | 6 | 40 |
| Jun | 9 | 8 | 75 |
| Jun | 10 | 0 | 40 |
| Jun | 11 | 8 | 75 |
| Jun | 12 | 2 | 40 |
| Jul | 1 | 6 | 50 |
| Jul | 2 | 0 | 70 |
| Jul | 3 | 8 | 100 |
| Jul | 4 | 0 | 70 |
| Jul | 5 | 8 | 100 |
| Jul | 6 | 0 | 70 |
| Jul | 7 | 2 | 50 |

| | | | |
|---|---|---|---|
| Jul | 8 | 6 | 40 |
| Jul | 9 | 8 | 75 |
| Jul | 10 | 0 | 40 |
| Jul | 11 | 8 | 75 |
| Jul | 12 | 2 | 40 |
| Aug | 1 | 6 | 50 |
| Aug | 2 | 0 | 70 |
| Aug | 3 | 8 | 100 |
| Aug | 4 | 0 | 70 |
| Aug | 5 | 8 | 100 |
| Aug | 6 | 0 | 70 |
| Aug | 7 | 2 | 50 |
| Aug | 8 | 6 | 40 |
| Aug | 9 | 8 | 75 |
| Aug | 10 | 0 | 40 |
| Aug | 11 | 8 | 75 |
| Aug | 12 | 2 | 40 |
| Sep | 1 | 6 | 50 |
| Sep | 2 | 0 | 70 |
| Sep | 3 | 8 | 100 |
| Sep | 4 | 0 | 70 |
| Sep | 5 | 8 | 100 |
| Sep | 6 | 0 | 70 |
| Sep | 7 | 2 | 50 |
| Sep | 8 | 6 | 40 |
| Sep | 9 | 8 | 75 |
| Sep | 10 | 0 | 40 |
| Sep | 11 | 8 | 75 |
| Sep | 12 | 2 | 40 |
| Oct | 1 | 6 | 50 |
| Oct | 2 | 0 | 70 |
| Oct | 3 | 8 | 100 |
| Oct | 4 | 0 | 70 |
| Oct | 5 | 8 | 100 |
| Oct | 6 | 0 | 70 |
| Oct | 7 | 2 | 50 |
| Oct | 8 | 6 | 40 |
| Oct | 9 | 8 | 75 |
| Oct | 10 | 0 | 40 |
| Oct | 11 | 8 | 75 |
| Oct | 12 | 2 | 40 |
| Nov | 1 | 6 | 50 |
| Nov | 2 | 0 | 70 |
| Nov | 3 | 8 | 100 |
| Nov | 4 | 0 | 70 |
| Nov | 5 | 8 | 100 |
| Nov | 6 | 0 | 70 |
| Nov | 7 | 2 | 50 |
| Nov | 8 | 6 | 40 |
| Nov | 9 | 8 | 75 |
| Nov | 10 | 0 | 40 |
| Nov | 11 | 8 | 75 |
| Nov | 12 | 2 | 40 |
| Dec | 1 | 6 | 50 |

| | | | |
|---|---|---|---|
| Dec | 2 | 0 | 70 |
| Dec | 3 | 8 | 100 |
| Dec | 4 | 0 | 70 |
| Dec | 5 | 8 | 100 |
| Dec | 6 | 0 | 70 |
| Dec | 7 | 2 | 50 |
| Dec | 8 | 6 | 40 |
| Dec | 9 | 8 | 75 |
| Dec | 10 | 0 | 40 |
| Dec | 11 | 8 | 75 |
| Dec | 12 | 2 | 40 |

Scenario Information for Hebgen

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Hebgen | Base_Stor | Base | |

*********************************************

Physical Settings

Plant: Hebgen
Name: Base_Stor
Description: Base Storage.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked. KADAMEC 2015/2/12 Checked again
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Base
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_Storage

*********************************************

Reservoir Storage

Plant: Hebgen
Name: Base
Description: "Elevations from file ""\CD_from_Client\3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 6470 | 3967 |
| 6471 | 4959 |
| 6472 | 6149 |
| 6473 | 7339 |
| 6474 | 8529 |
| 6475 | 9918 |
| 6476 | 11306 |
| 6477 | 12694 |
| 6478 | 14281 |

| | |
|---|---|
| 6479 | 15868 |
| 6480 | 17653 |
| 6481 | 19438 |
| 6482 | 21422 |
| 6483 | 23405 |
| 6484 | 25587 |
| 6485 | 27769 |
| 6486 | 30149 |
| 6487 | 32728 |
| 6488 | 35505 |
| 6489 | 38480 |
| 6490 | 41654 |
| 6491 | 45025 |
| 6492 | 48397 |
| 6493 | 51968 |
| 6494 | 55538 |
| 6495 | 59307 |
| 6496 | 63075 |
| 6497 | 67042 |
| 6498 | 71208 |
| 6499 | 75571 |
| 6500 | 80133 |
| 6501 | 84894 |
| 6502 | 89853 |
| 6503 | 94811 |
| 6504 | 99968 |
| 6505 | 105324 |
| 6506 | 110878 |
| 6507 | 116828 |
| 6508 | 123175 |
| 6509 | 129919 |
| 6510 | 136862 |
| 6511 | 144002 |
| 6512 | 151341 |
| 6513 | 158878 |
| 6514 | 166614 |
| 6515 | 174548 |
| 6516 | 182680 |
| 6517 | 191209 |
| 6518 | 200135 |
| 6519 | 209458 |
| 6520 | 219177 |
| 6521 | 229094 |
| 6522 | 239210 |
| 6523 | 249524 |
| 6524 | 260037 |
| 6525 | 270748 |
| 6526 | 281459 |
| 6527 | 292368 |
| 6528 | 303277 |
| 6529 | 314385 |
| 6530 | 325691 |
| 6531 | 337393 |
| 6532 | 349493 |

| | |
|---|---|
| 6533 | 361989 |
| 6534 | 374882 |
| 6534.9 | 386184 |
| 6535 | 387873 |

*********************************************

Tailwater Curve

Plant: Hebgen

Name: Base

Description: "From ""CD_from_Client\5 - Tailwater Rating Curves\HEBTWR.xls"""

Notes: BKROLAK 2015/1/19. ASCANGAS 2015/1/19 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 6455 | 0 |
| 6456.5 | 100 |
| 6457.3 | 200 |
| 6457.7 | 300 |
| 6458 | 400 |
| 6458.2 | 500 |
| 6458.4 | 700 |
| 6458.5 | 800 |
| 6458.6 | 900 |
| 6458.7 | 1000 |
| 6458.8 | 1100 |
| 6458.9 | 1200 |
| 6459 | 1370 |
| 6459.1 | 1500 |
| 6459.5 | 2000 |

*********************************************

Spillway Curve

Plant: Hebgen

Name: Base

Description: "From ""CD_from_Client\4 - Spillway discharge rating curves\HEB_Spillway Rating dwg 11143-A.xls"" with values multiplied for 6 gates."

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 6525.26 | 0 |
| 6525.5 | 24 |
| 6526 | 102 |
| 6526.12 | 120 |
| 6526.44 | 180 |
| 6526.5 | 192 |
| 6526.76 | 240 |
| 6527 | 288 |
| 6527.03 | 300 |
| 6527.65 | 450 |
| 6528 | 546 |
| 6528.23 | 600 |
| 6528.62 | 720.84 |
| 6528.93 | 816.6 |
| 6529 | 839.04 |
| 6529.19 | 900 |

| | |
|---|---|
| 6529.5 | 1007.4 |
| 6530 | 1174.8 |
| 6530.05 | 1200 |
| 6530.33 | 1311 |
| 6530.83 | 1500 |
| 6531.2 | 1650 |
| 6531.67 | 1860 |
| 6532.33 | 2170.2 |
| 6533 | 2490 |
| 6533.33 | 2666.25 |
| 6534.01 | 3000 |
| 6534.87 | 3462 |
| 6535 | 3559.8 |
| 6536.07 | 4200 |
| 6537 | 4750.2 |
| 6538 | 5265 |
| 6538.32 | 5400 |
| 6539 | 5679.6 |
| 6539.97 | 5985.6 |
| 6541 | 6289.2 |
| 6542 | 6540 |
| 6543 | 6762.6 |
| 6544 | 6949.8 |
| 6545 | 7128 |

********************************************

Plant Options

Plant: Hebgen

Name: Base_Storage

Description: Storage Reservoir.

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 0 | FALSE | TRUE | 0 | 6534.87 |

********************************************

Operation Settings

Plant: Hebgen

Name: Base

Description: Base conditions.

Notes: ASCANGAS 2015/1/26. KADAMEC 2015/2/12 Checked. BKROLAK 2015/2/12 Ramping rate added. ASCANGAS 2015/2/12 checked.

Spill Elevations: 6534.87

Target Elevations: Figure1.2-1

Minimum Elevations: 6530.26

Weekly Drawdown:

Water Withdrawals:

Reservoir Fluctuation Limits:

Reservoir Fluctuation Rates:

Tailwater Ramping Rates: Base

Minimum Instantaneous Flow: 150cfs

Minimum Daily Average Flow:

Recreation Flows: 600cfsKirby

Bypass Flow:

Maximum Flow: 3500
Max Flow from Elev:
Flashboards:

********************************************
Spill Elevations
Plant: Hebgen
Name: 6534.87
Description: "From ""CD_from_Client\3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls""."
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 6534.87 |
| 31-Dec | 6534.87 |

********************************************
Target Elevations
Plant: Hebgen
Name: Figure1.2-1
Description: "License Exhibit B Evaluation ""Ex B-1 P-2188 Liceense Hebgen.pdf""."
Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/12 Checked. BKROLAK 2015/2/12 Checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 6528.7 |
| 1-Apr | 6524 |
| 1-May | 6524 |
| 1-Jul | 6534.87 |
| 1-Sep | 6534.87 |
| 31-Dec | 6528.8 |

********************************************
Minimum Elevations
Plant: Hebgen
Name: 6530.26
Description: "From ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" for summer limit and dates (cells A89:A90). Max drawdown from ""PPL Agrmt 14-06-600-476A"" PDF page 29."

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/20 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 6477 |
| 20-Jun | 6530.26 |
| 1-Oct | 6530.26 |
| 31-Dec | 6477 |

********************************************
Tailwater Ramping Rates
Plant: Hebgen
Name: Base
Description: "Per ""NWEhydrooperationsplan.docx"". 3) 10pct diff from previous day""s flow."
Notes: BKROLAK 2015/2/12. ASCANGAS 2015/2/12 checked.

Constrained by Stage Calendar Day Hourly Rate Up (units/hr) Daily Rate Up (units/day) Hourly Rate Down (units/hr) Daily Rate Down (units/day) Use Hrly Min/Max Houly Min/Max Difference Reference Plant

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FALSE | 1 | 0 | 0.1 | 0 | 0.1 | FALSE | 0 | 2 |

*********************************************
Minimum Instantaneous Flow
Plant: Hebgen
Name: 150cfs
Description: "Base condition per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/12 Checked

| Calendar Day | | Flow (cfs) Or Inflow |
|---|---|---|
| 1-Jan | 150 | FALSE |
| 31-Dec | 150 | FALSE |

*********************************************
Recreation Flows
Plant: Hebgen
Name: 600cfsKirby
Description: "600 cfs at Kirby Ranch per ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"". Checking of the ""Use Custom Schedule"" checkbox will toggle the logic to use incremental accretions between Hebgen and Kirby in performing the required release calcs from Hebgen."
Notes: BKROLAK 2015/1/20. ASCANGAS 2015/1/20 checked.

| Calendar Day | | Day of Week | | Flow (cfs) | Start Hour | End Hour | Use Plant Discharge Only When PH Off | Use Custom Schedule |
|---|---|---|---|---|---|---|---|---|
| 1-Jan | 0 | 600 | 1 | 24 | TRUE | FALSE | TRUE | |
| 31-Dec | 0 | 600 | 1 | 24 | TRUE | FALSE | TRUE | |

*********************************************
Maximum Flow
Plant: Hebgen
Name: 3500
Description: "Max Quake Lake limits, ""Hydro Operations Requirements Summary from Licenses & Agreements with Agencies by JHJ 2014-11-12.pdf"""

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Calendar Day | | Day of Week | | Flow (cfs) | Start Hour | End Hour |
|---|---|---|---|---|---|---|
| 1-Jan | 0 | 3500 | 1 | 24 | | |
| 31-Dec | 0 | 3500 | 1 | 24 | | |

Scenario Information for Madison

| Plant/Node | | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|---|
| Madison | Base_RORDA | Base | Base | |

*********************************************
Physical Settings
Plant: Madison
Name: Base_RORDA
Description: Base Run of River Daily Average.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked. KADAMEC 2015/2/12 Checked again
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Base
Spillway Curve: Base

Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_RORDA

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Reservoir Storage

Plant: Madison
Name: Base
Description: "Elevations from file ""\CD_from_Client\3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 4826 | 2803 |
| 4827 | 3215 |
| 4828 | 4247 |
| 4829 | 5671 |
| 4830 | 7464 |
| 4831 | 9609 |
| 4832 | 12070 |
| 4832.7 | 13983 |
| 4833 | 14803 |
| 4834 | 17749 |
| 4835 | 20862 |
| 4836 | 24116 |
| 4837 | 27477 |
| 4838 | 30939 |
| 4839 | 34499 |
| 4840 | 38159 |
| 4841 | 41917 |
| 4841.5 | 43964 |
| 4842 | 46013 |

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Tailwater Curve

Plant: Madison
Name: Base
Description: "From ""5 - Tailwater Rating Curves\MADTW.xls""."
Notes: BKROLAK 2015/1/19. ASCANGAS 2015/1/19 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 4716 | 0 |
| 4719.2 | 200 |
| 4720.4 | 400 |
| 4721.1 | 600 |
| 4721.8 | 800 |
| 4722.2 | 1000 |
| 4722.7 | 1200 |
| 4723.1 | 1400 |
| 4723.5 | 1600 |
| 4723.8 | 1800 |
| 4724.1 | 2000 |

| | |
|---|---|
| 4724.8 | 2600 |
| 4725.3 | 3000 |
| 4725.8 | 3600 |
| 4726.1 | 4000 |
| 4726.7 | 5000 |
| 4727.1 | 6000 |
| 4727.3 | 7000 |
| 4727.4 | 8000 |
| 4727.5 | 10000 |

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Spillway Curve

Plant: Madison

Name: Base

Description: "From ""4 - Spillway discharge rating curves\MAD_SpillTable R1.xls""."

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 4832.7 | 0 |
| 4833 | 59.84 |
| 4833.5 | 260.6 |
| 4834 | 539.82 |
| 4834.5 | 879.51 |
| 4835 | 1270.35 |
| 4835.5 | 1706.35 |
| 4836 | 2183.24 |
| 4836.5 | 2697.78 |
| 4837 | 3247.39 |
| 4837.5 | 3829.95 |
| 4838 | 4443.7 |
| 4838.5 | 5087.13 |
| 4839 | 5758.93 |
| 4839.5 | 6457.95 |
| 4840 | 7183.16 |
| 4840.5 | 7933.65 |
| 4841 | 8708.6 |
| 4841.5 | 9507.26 |
| 4842 | 10328.94 |
| 4843 | 12038.91 |
| 4844 | 13834.04 |
| 4844.5 | 14762.31 |
| 4845 | 15710.46 |
| 4846 | 17664.8 |
| 4846.5 | 18670.24 |
| 4847 | 19694.06 |
| 4848 | 21795.58 |
| 4850 | 32892.15 |
| 4852 | 37254.13 |
| 4854 | 42072.25 |
| 4856 | 47278.62 |
| 4858 | 52830.35 |
| 4859 | 55725.97 |
| 4860 | 58697.28 |
| 4860.5 | 60210.49 |

| | |
|---|---|
| 4860.75 | 60973.84 |
| 4861 | 61741.65 |
| 4862 | 64856.73 |
| 4864 | 71290.79 |
| 4866 | 77984.86 |
| 4868 | 84926.7 |
| 4870 | 92105.83 |
| 4872 | 99513.16 |

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Plant Options

Plant: Madison
Name: Base_RORDA
Description: Base Run of River Daily Average.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|---|
| 0 | 5 | FALSE | TRUE | 0 | 4841 | |

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Operation Settings

Plant: Madison
Name: Base
Description: Base conditions.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/20 checked. KADAMEC 2015/2/12 Checked again
Spill Elevations: 4841
Target Elevations: WinterDrawdown
Minimum Elevations: 4831.5
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow: 1100
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow: 200cfsApr-Jun
Maximum Flow:
Max Flow from Elev:
Flashboards:

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Spill Elevations

Plant: Madison
Name: 4841
Description: "Full Pond From ""1 - Drawings\2_Madison\P-2188-1005, F-81, Madison Spillway Plan & Details, 09-27-2000.TIF""."
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 4841 |
| 31-Dec | 4841 |

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Target Elevations

Plant: Madison
Name: WinterDrawdown
Description: "Winter drawdown per ""Regulatory Constraints.pdf"". Roughly ""Elev 4840 to 4841 when no ice. 4839 early Dec to Early April""."
Notes: BKROLAK 2015/1/8. KADAMEC 2015/1/19 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 4839 |
| 1-Apr | 4839 |
| 1-Jun | 4840.5 |
| 1-Nov | 4840.5 |
| 1-Dec | 4839 |
| 31-Dec | 4839 |

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Minimum Elevations

Plant: Madison
Name: 4831.5
Description: "From ""PPL Agrmt 14-06-600-476A.pdf"""
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 4831.5 |
| 31-Dec | 4831.5 |

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Minimum Instantaneous Flow

Plant: Madison
Name: 1100
Description: "Based on License Article 403 Operations outlined in ""Regulatory Constraints.pdf"""
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/19 checked.

| Calendar Day | Flow (cfs) | Or Inflow |
|---|---|---|
| 1-Jan | 1100 | FALSE |
| 31-Dec | 1100 | FALSE |

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Bypass Flow

Plant: Madison
Name: 200cfsApr-Jun
Description: "200 cfs Apr1 to Jun30, 80 cfs otherwise. Per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/19 checked.

| Calendar Day | Flow (cfs) | Or Inflow | Destination Node |
|---|---|---|---|
| 1-Jan | 80 | FALSE | 3 |
| 31-Mar | 80 | FALSE | 3 |
| 1-Apr | 200 | FALSE | 3 |
| 30-Jun | 200 | FALSE | 3 |
| 1-Jul | 80 | FALSE | 3 |
| 31-Dec | 80 | FALSE | 3 |

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Generation Settings

Plant: Madison

Name: Base
Description: Base conditions. Upper head extended on input curves to cuver full range of operational head.
Notes: BKROLAK 2015/1/14. BKROLAK 2015/1/22. KADAMEC 2015/2/10 Checked
Powerhouse Setup: BaseHD
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

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Powerhouse Setup
Plant: Madison
Name: BaseHD
Description: "Base powerhouse setup. U2 flow limited per ""Perf Verif Data mMDS.xls"" 2.0-2.2 MW max generation @ approx. 70% gate & < 350 cfs. Using unit combined (total unit) efficiency. Reduced efficiency curves to represent maximum historical operations, reviewed both PI and daily operations records."
Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked. ASCANGAS 2015/1/22 limited to historical maximum output based on available PI data. KADAMEC 2015/2/6 Checked

Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 4units | "U1,3,4_Total_Unit_HD" | "U1,3_2.2_Limited_1.0Eff" | 0 |
| 2 | 4units | U2_70PctGate_Total_Unit_HD | U2_2.3_Limited_1.0Eff | 0 |
| 3 | 4units | "U1,3,4_Total_Unit_HD" | "U1,3_2.2_Limited_1.0Eff" | 0 |
| 4 | 4units | "U1,3,4_Total_Unit_HD" | U4_2.5_1.0_Limited | 0 |

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Turbine Efficiency Curves
Plant: Madison
Name: "U1,3,4_Total_Unit_HD"
Description: "Madison U1, 3, 4. All have same turbine. From ""Perf Verif Data mMDS.xls"" 2.3-2.5 MW max generation @ 100% gate & about 350 cfs. Used total unit performance and reduced performance to limit maximum output to maxiumum reported in ""CD_from_Client\2 - Historical Ops Data\PI Avg Hourly Data"""
Notes: ASCANGAS 2015/1/26. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 100 | 103 | 0.4133 |
| 100 | 165 | 0.5558 |
| 100 | 230 | 0.6102 |
| 100 | 297 | 0.6353 |
| 100 | 367 | 0.6445 |
| 100 | 440 | 0.6452 |
| 102.5 | 101 | 0.416 |
| 102.5 | 162 | 0.5538 |
| 102.5 | 225 | 0.6103 |
| 102.5 | 290 | 0.6351 |
| 102.5 | 359 | 0.6439 |
| 102.5 | 429 | 0.6472 |
| 105 | 98 | 0.4139 |
| 105 | 158 | 0.5519 |
| 105 | 219 | 0.6104 |
| 105 | 283 | 0.6349 |
| 105 | 350 | 0.6434 |
| 105 | 417 | 0.6492 |

| | | |
|---|---|---|
| 110 | 93 | 0.4172 |
| 110 | 150 | 0.5558 |
| 110 | 209 | 0.6106 |
| 110 | 270 | 0.6353 |
| 110 | 334 | 0.6436 |
| 110 | 399 | 0.6472 |
| 113 | 90 | 0.4172 |
| 113 | 145 | 0.5558 |
| 113 | 203 | 0.6106 |
| 113 | 262 | 0.6353 |
| 113 | 324 | 0.6436 |
| 113 | 388 | 0.6472 |

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Turbine Efficiency Curves

Plant: Madison

Name: U2_70PctGate_Total_Unit_HD

Description: "Madison U2. From ""Perf Verif Data mMDS.xls"" 2.0-2.2 MW max generation @ approx. 70% gate & < 350 cfs. Last row of turbine flow performance removed compared to U2 turbine input. Used total unit performance and reduced performance to limit maximum output to maxiumum reported in ""CD_from_Client\2 - Historical Ops Data\PI Avg Hourly Data"""

Notes: ASCANGAS 2015/1/26. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 100 | 89 | 0.5835 |
| 100 | 154 | 0.6869 |
| 100 | 226 | 0.7038 |
| 100 | 299 | 0.71 |
| 100 | 372 | 0.7137 |
| 102.5 | 87 | 0.5865 |
| 102.5 | 151 | 0.686 |
| 102.5 | 221 | 0.7042 |
| 102.5 | 292 | 0.711 |
| 102.5 | 364 | 0.7129 |
| 105 | 84 | 0.5895 |
| 105 | 147 | 0.6851 |
| 105 | 215 | 0.7047 |
| 105 | 284 | 0.7121 |
| 105 | 355 | 0.7121 |
| 110 | 81 | 0.5827 |
| 110 | 140 | 0.6869 |
| 110 | 205 | 0.7056 |
| 110 | 272 | 0.7094 |
| 110 | 339 | 0.7118 |
| 113 | 79 | 0.5827 |
| 113 | 136 | 0.6869 |
| 113 | 199 | 0.7056 |
| 113 | 265 | 0.7094 |
| 113 | 329 | 0.7118 |

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Generator Efficiency Curves

Plant: Madison

Name: "U1,3_2.2_Limited_1.0Eff"

Description: 1.0 efficiency as turbine efficiency inputs include generator efficiency. Limited to the maximum output of the available PI data

Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/6 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 2.2 | 0 | 1 |
| 2.2 | 2.2 | 1 |

*********************************************

Generator Efficiency Curves
Plant: Madison
Name: U2_2.3_Limited_1.0Eff
Description: 1.0 efficiency as turbine efficiency inputs include generator efficiency. Limited to the maximum output of the available PI data
Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/6 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 2.3 | 0 | 1 |
| 2.3 | 2.3 | 1 |

*********************************************

Generator Efficiency Curves
Plant: Madison
Name: U4_2.5_1.0_Limited
Description: 1.0 efficiency as turbine efficiency inputs include generator efficiency.
Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked. ASCANGAS 2015/1/22 limited to historical maximum output based on available PI data. KADAMEC 2015/2/6 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 2.5 | 0 | 1 |
| 2.5 | 0.5 | 1 |
| 2.5 | 0.9 | 1 |
| 2.5 | 1.4 | 1 |
| 2.5 | 1.8 | 1 |
| 2.5 | 2.5 | 1 |

*********************************************

Plant Flow Type
Plant: Madison
Name: MaxCap
Description: Max Capacity plant.
Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/6 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Canyon Ferry

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Canyon Ferry | Base_Peak | Base | Base |

*********************************************

Physical Settings
Plant: Canyon Ferry
Name: Base_Peak
Description: Base Peaking with estimated Spillway capacity.

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked. KADAMEC 2015/2/12 Checked again
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: 3650.6
Spillway Curve: Estimate
Low Level Outlet:
Alt. Spillway: RiverOutlets
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_Peak

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Reservoir Storage
Plant: Canyon Ferry
Name: Base
Description: "Base data from NWE provided data table in \3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls, which appears to be higher by about 50kaf from the BurRec raw elevation/storage curve data shown in ""ReferenceData\CanyonFerry Data\Canyon Ferry Tabular Data.xlsm"". This is presumed to be the total storage."
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3650 | 50000 |
| 3740 | 586901 |
| 3750 | 739500 |
| 3760 | 924700 |
| 3770 | 1147501 |
| 3780 | 1410200 |
| 3781 | 1438832 |
| 3782 | 1467864 |
| 3783 | 1497211 |
| 3784 | 1527102 |
| 3785 | 1557295 |
| 3786 | 1587860 |
| 3787 | 1618788 |
| 3788 | 1650077 |
| 3789 | 1681718 |
| 3790 | 1713701 |
| 3791 | 1746022 |
| 3792 | 1778672 |
| 3793 | 1811647 |
| 3794 | 1844936 |
| 3795 | 1878532 |
| 3796 | 1912431 |
| 3797 | 1946624 |
| 3798 | 1981107 |
| 3799 | 2015867 |
| 3800 | 2050901 |

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Tailwater Curve
Plant: Canyon Ferry
Name: 3650.6
Description: Median TW elevation from BurRec Arc50 data series.

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3650.6 | 0 |

********************************************
Spillway Curve

Plant: Canyon Ferry
Name: Estimate
Description: Estimated flow capacity based on generic weir discharge.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3766 | 0 |
| 3767 | 756 |
| 3770 | 6048 |
| 3774 | 17106.3272 |
| 3778 | 31426.3298 |
| 3782 | 48384 |
| 3786 | 67618.6956 |
| 3790 | 88887.0838 |
| 3794 | 112010.5275 |
| 3797 | 130486.1256 |
| 3800 | 149878.7875 |
| 3803 | 170147.0335 |

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Alt. Spillway

Plant: Canyon Ferry
Name: RiverOutlets
Description: "Four Low level ""River Outlets"" of 9500 cfs each. http://www.usbr.gov/projects/Facility.jsp?fac_Name=Canyon+Ferry+Dam&groupName=Dimensions"

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 0 | 38000 |

********************************************
Plant Options

Plant: Canyon Ferry
Name: Base_Peak
Description: Base Peaking. Full pond elevation is top of joint use pool.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 1 | FALSE | TRUE | 0 | 3797 |

********************************************
Operation Settings

Plant: Canyon Ferry
Name: Base
Description: Base conditions. Seasonal target is more representative of the minimim elevation at those date.
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/20 checked. KADAMEC 2015/2/12 Checked again
Spill Elevations: Seasonal

Target Elevations: Seasonal
Minimum Elevations: 3650_DeadStorage
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow: MonthlyMedian
Maximum Flow: 15000
Max Flow from Elev: 3750ElevLimit
Flashboards:

********************************************
Spill Elevations
Plant: Canyon Ferry
Name: Seasonal
Description: Seasonal forcing of spill at certain elevations to folllow historical operations from Bureau of Reclamations Arc50 database.
Notes: BKROLAK 2015/1/8. KADAMEC 2015/2/6 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3794 |
| 31-Mar | 3794 |
| 1-May | 3800 |
| 1-Nov | 3800 |
| 30-Nov | 3794 |
| 31-Dec | 3794 |

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Target Elevations
Plant: Canyon Ferry
Name: Seasonal
Description: "Built from general description of elevation requirements, ""Operating Guidelines PPL & BOR Agreement"" & ""PPL Agreement 14-06-600-476A""."

Notes: BKROLAK 2015/1/8. KADAMEC 2015/1/19 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3783 |
| 31-Mar | 3775 |
| 1-May | 3785 |
| 30-Jun | 3797 |
| 31-Aug | 3785 |
| 30-Sep | 3783 |
| 31-Dec | 3783 |

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Minimum Elevations
Plant: Canyon Ferry
Name: 3650_DeadStorage
Description: "Dead storage. per ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls""."
Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3650 |
| 31-Dec | 3650 |

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Bypass Flow

Plant: Canyon Ferry

Name: MonthlyMedian

Description: Median monthly values based on historical operations from 1988 - 2014 from the Bureau of Reclamations Arc50 database.

Notes: ASCANGAS 2015/1/20. KADAMEC 2015/1/21 Checked

| Calendar Day | Flow (cfs) | Or Inflow | Destination Node |
|---|---|---|---|
| 1-Jan | 0 | FALSE | 4 |
| 1-Feb | 0 | FALSE | 4 |
| 1-Mar | 0 | FALSE | 4 |
| 1-Apr | 325 | FALSE | 4 |
| 1-May | 600 | FALSE | 4 |
| 1-Jun | 647 | FALSE | 4 |
| 1-Jul | 699 | FALSE | 4 |
| 1-Aug | 692 | FALSE | 4 |
| 1-Sep | 375 | FALSE | 4 |
| 1-Oct | 0 | FALSE | 4 |
| 1-Nov | 0 | FALSE | 4 |
| 1-Dec | 0 | FALSE | 4 |

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Maximum Flow

Plant: Canyon Ferry

Name: 15000

Description: "Max flow for Missouri river flood abatement. ""Operating Guidelines PPL & BOR Agrmt.pdf"""

Notes: BKROLAK 2015/1/8. ASCANGAS 2015/1/19 checked.

| Calendar Day | Day of Week | Flow (cfs) | Start Hour | End Hour |
|---|---|---|---|---|
| 1-Jan | 0 | 15000 | 1 | 24 |
| 31-Dec | 0 | 15000 | 1 | 24 |

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Max Flow from Elev

Plant: Canyon Ferry

Name: 3750ElevLimit

Description: "Limit to 2800 cfs if below 3750 per ""Operating Guidelines PPL & BOR Agrmt.pdf""."

Notes: BKROLAK 2015/1/8.. ASCANGAS 2015/1/19 checked.

| Elev (ft) | Flow (cfs) |
|---|---|
| 3749 | 2800 |
| 3750 | 100000 |

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Generation Settings

Plant: Canyon Ferry

Name: Base

Description: Base estimated conditions. Upper head extended on input curves to cuver full range of operational head.

Notes: BKROLAK 2015/1/19. BKROLAK 2015/1/22. KADAMEC 2015/2/6 Checked

Powerhouse Setup: Base_HD
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: PeakCap
Limit Off Peak Gen:

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Powerhouse Setup

Plant: Canyon Ferry
Name: Base_HD
Description: Base condition estimated performance.
Notes: BKROLAK 2015/1/19. KADAMEC 2015/1/21 Checked. BKROLAK 2015/1/22 Heads extended. KADAMEC 2015/2/6 Checked
Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 3units | U1-2-3_HD | "U1,2,3_20" | 0 |
| 2 | 3units | U1-2-3_HD | "U1,2,3_20" | 0 |
| 3 | 3units | U1-2-3_HD | "U1,2,3_20" | 0 |

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Turbine Efficiency Curves

Plant: Canyon Ferry
Name: U1-2-3_HD
Description: (Description)
Notes: BKROLAK 2015/1/22. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 100 | 707.15 | 0.7378 |
| 100 | 952.45 | 0.8039 |
| 100 | 1188.95 | 0.8468 |
| 100 | 1320.14 | 0.8774 |
| 100 | 1428.67 | 0.8919 |
| 100 | 1501.71 | 0.8846 |
| 100 | 1575.66 | 0.8756 |
| 100 | 1649.12 | 0.8703 |
| 100 | 1703.33 | 0.8619 |
| 100 | 1816.85 | 0.8386 |
| 100 | 1900.66 | 0.8183 |
| 112.5 | 750.05 | 0.7378 |
| 112.5 | 1010.23 | 0.8039 |
| 112.5 | 1261.07 | 0.8468 |
| 112.5 | 1400.22 | 0.8774 |
| 112.5 | 1515.33 | 0.8919 |
| 112.5 | 1592.81 | 0.8846 |
| 112.5 | 1671.24 | 0.8756 |
| 112.5 | 1749.16 | 0.8703 |
| 112.5 | 1806.65 | 0.8619 |
| 112.5 | 1927.06 | 0.8386 |
| 112.5 | 2015.95 | 0.8183 |
| 125 | 790.62 | 0.7378 |
| 125 | 1064.87 | 0.8039 |
| 125 | 1329.29 | 0.8468 |

| | | |
|---|---|---|
| 125 | 1475.96 | 0.8774 |
| 125 | 1597.3 | 0.8919 |
| 125 | 1678.96 | 0.8846 |
| 125 | 1761.64 | 0.8756 |
| 125 | 1843.77 | 0.8703 |
| 125 | 1904.38 | 0.8619 |
| 125 | 2031.3 | 0.8386 |
| 125 | 2125 | 0.8183 |
| 133.5 | 817.06 | 0.7378 |
| 133.5 | 1100.48 | 0.8039 |
| 133.5 | 1373.74 | 0.8468 |
| 133.5 | 1525.32 | 0.8774 |
| 133.5 | 1650.71 | 0.8919 |
| 133.5 | 1735.11 | 0.8846 |
| 133.5 | 1820.55 | 0.8756 |
| 133.5 | 1905.43 | 0.8703 |
| 133.5 | 1968.06 | 0.8619 |
| 133.5 | 2099.23 | 0.8386 |
| 133.5 | 2196.06 | 0.8183 |
| 142 | 842.67 | 0.7378 |
| 142 | 1134.98 | 0.8039 |
| 142 | 1416.8 | 0.8468 |
| 142 | 1573.13 | 0.8774 |
| 142 | 1702.45 | 0.8919 |
| 142 | 1789.5 | 0.8846 |
| 142 | 1877.61 | 0.8756 |
| 142 | 1965.15 | 0.8703 |
| 142 | 2029.75 | 0.8619 |
| 142 | 2165.03 | 0.8386 |
| 142 | 2264.9 | 0.8183 |

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Generator Efficiency Curves

Plant: Canyon Ferry
Name: "U1,2,3_20"
Description: "Flat 95% efficiency based on turbine ratings of 17,531 kw and generators at 16,667 kw."
Notes: BKROLAK 2015/1/19

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 20 | 0 | 0.95 |
| 20 | 20 | 0.95 |

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Plant Flow Type

Plant: Canyon Ferry
Name: PeakCap
Description: Peak plant option.
Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/6 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | TRUE |
| 31-Dec | TRUE |

Scenario Information for Hauser

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Hauser | Base_ReReg | Base | Base |

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Physical Settings

Plant: Hauser

Name: Base_ReReg

Description: Base Re Regulating with tailwater curve based on historical data.

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.. KADAMEC 2015/1/21. BKROLAK 2015/1/22 Checked TW. KADAMEC 2015/2/10 Checked

Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Historical
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_ReReg

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Reservoir Storage

Plant: Hauser

Name: Base

Description: "Hauser plus Lake Helena storage capacity. From ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."

Notes: BKROLAK 2015/1/16. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3617 | 46810 |
| 3618 | 48893 |
| 3619 | 51075 |
| 3620 | 53336 |
| 3621 | 55676 |
| 3622 | 58096 |
| 3623 | 60615 |
| 3624 | 63253 |
| 3625 | 66129 |
| 3626 | 69352 |
| 3627 | 73022 |
| 3628 | 77108 |
| 3629 | 81597 |
| 3630 | 86617 |
| 3631 | 92071 |
| 3632 | 97982 |
| 3633 | 104446 |
| 3634 | 111478 |
| 3635 | 119132 |
| 3636 | 127352 |

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Tailwater Curve

Plant: Hauser

Name: Historical

Description: "Elevation raised by 0.35"" for the same flows from ""5 - Tailwater Rating Curves\HAUTWR.xls"" to align with hstorical readings reported in ""HAU PI Avg Hourly.xlsx""."

Notes: KADAMEC 2015/1/21. BKROLAK 2015/1/22 Checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3567.35 | 0 |
| 3568.55 | 2000 |
| 3569.55 | 4000 |
| 3570.45 | 6000 |
| 3571.25 | 8000 |
| 3571.95 | 10000 |
| 3572.55 | 12000 |
| 3573.15 | 14000 |
| 3573.65 | 16000 |
| 3574.15 | 18000 |
| 3574.65 | 20000 |
| 3575.55 | 25000 |
| 3576.45 | 30000 |
| 3577.05 | 35000 |
| 3577.45 | 40000 |

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Spillway Curve

Plant: Hauser

Name: Base

Description: "Base from ""4 - Spillway discharge rating curves\HAU MAXIMUM SPILL RATING.xls""."

Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/6 Checked

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3621 | 0 |
| 3623.05 | 5000 |
| 3624.5 | 10000 |
| 3625.62 | 15000 |
| 3626.55 | 20000 |
| 3627.4 | 25000 |
| 3628.2 | 30000 |
| 3628.88 | 35000 |
| 3629.63 | 40000 |
| 3631 | 50000 |
| 3632.3 | 60000 |
| 3633.7 | 70000 |
| 3634.9 | 80000 |
| 3635.9 | 90000 |
| 3636.4 | 95000 |
| 3636.9 | 100000 |
| 3637.4 | 105000 |
| 3638 | 110000 |
| 3638.6 | 113000 |
| 3639.1 | 114250 |
| 3639.3 | 113000 |

| | |
|---|---|
| 3639.4 | 111750 |
| 3640.2 | 115000 |
| 3640.8 | 120000 |
| 3641.8 | 130000 |
| 3642.9 | 140000 |
| 3643.8 | 150000 |
| 3644.59 | 160000 |
| 3644.9 | 165000 |
| 3646.8 | 188400 |

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Plant Options

Plant: Hauser

Name: Base_ReReg

Description: Base with Re-Reg option to all for ramping rates.

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 3635.4 | |

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Operation Settings

Plant: Hauser

Name: Base

Description: Base conditions.

Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/10 Checked. BKROLAK 2015/2/12 Ramping rates added. ASCANGAS 2015/2/12 checked.

Spill Elevations: 3635.4
Target Elevations: 3635.2
Minimum Elevations: 3634.4
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates: Base
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow:
Maximum Flow:
Max Flow from Elev:
Flashboards:

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Spill Elevations

Plant: Hauser

Name: 3635.4

Description: "Normal water level. ""1 - Drawings\4_Hauser\P-2188-1174, F-71, Hauser General Arrangement Plan, 03-11-2011.TIF""."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3635.4 |

31-Dec 3635.4

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Target Elevations
Plant: Hauser
Name: 3635.2
Description: "Estimated of end of day elevation. Operate between 3634.4 and 3635.4 per ""Regulatory Constraints.pdf"" and From ""HDB HAU 198801 to 201411.xlsx"" 50th percentile elevation."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3635.2 |
| 31-Dec | 3635.2 |

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Minimum Elevations
Plant: Hauser
Name: 3634.4
Description: "License article 403 Maintain elevation between 3634.4 and 3635.4, ""Hydro Operations Requirements Summary from Licenses & Agreements with Agencies by JHJ 2014-11-12.pdf""."

Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/10 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3634.4 |
| 31-Dec | 3634.4 |

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Tailwater Ramping Rates
Plant: Hauser
Name: Base
Description: "Per ""NWEhydrooperationsplan.docx"". 3) 10pct diff from inflow to Hauser. 4) Highest hourly to lowest hourly is no more than sum of 10pct of previous day""s average flow and increase or decrease from CNF for yesterday or today. 5) hourly average flow change no more than 5pct."
Notes: BKROLAK 2015/2/12. ASCANGAS 2015/2/12 checked.

| Constrained by Stage | Calendar Day | Hourly Rate Up (units/hr) | Daily Rate Up (units/day) | Hourly Rate Down (units/hr) | Daily Rate Down (units/day) | Use Hrly Min/Max | Houly Min/Max Difference | Reference Plant |
|---|---|---|---|---|---|---|---|---|
| FALSE | 1 | 0.05 | 0.1 | 0.05 | 0.1 | TRUE | 0.1 | 3 |

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Generation Settings
Plant: Hauser
Name: Base
Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". Using unit combined efficiency"

Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/6 Checked
Powerhouse Setup: Base
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

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Powerhouse Setup

Plant: Hauser

Name: Base

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". Using unit combined efficiency"

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 6units | U1_Total_Unit | "U1,2,3,4,5_1.0_eff" | 0 |
| 2 | 6units | U2_Total_Unit | "U1,2,3,4,5_1.0_eff" | 0 |
| 3 | 6units | U3_Total_Unit | "U1,2,3,4,5_1.0_eff" | 0 |
| 4 | 6units | U4_Total_Unit | "U1,2,3,4,5_1.0_eff" | 0 |
| 5 | 6units | U5_Total_Unit | "U1,2,3,4,5_1.0_eff" | 0 |
| 6 | 6units | U6_Total_Unit | U6_1.0_eff | 0 |

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Turbine Efficiency Curves

Plant: Hauser

Name: U1_Total_Unit

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\Hauser_U1.xlsm. Used total unit performance."

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 57 | 280 | 0.37 |
| 57 | 402 | 0.5154 |
| 57 | 492 | 0.6317 |
| 57 | 596 | 0.6953 |
| 57 | 663 | 0.7813 |
| 57 | 698 | 0.8905 |
| 58.5 | 277.5 | 0.364 |
| 58.5 | 398.5 | 0.5068 |
| 58.5 | 494.5 | 0.6129 |
| 58.5 | 587 | 0.6882 |
| 58.5 | 658.5 | 0.7668 |
| 58.5 | 691.5 | 0.8762 |
| 60 | 275 | 0.3579 |
| 60 | 395 | 0.4983 |
| 60 | 497 | 0.5941 |
| 60 | 578 | 0.6811 |
| 60 | 654 | 0.7524 |
| 60 | 685 | 0.862 |
| 65 | 255 | 0.3563 |
| 65 | 383 | 0.4744 |
| 65 | 490 | 0.5562 |
| 65 | 550 | 0.6607 |
| 65 | 650 | 0.6988 |
| 65 | 700 | 0.7787 |
| 66 | 252 | 0.355 |
| 66 | 380 | 0.4709 |
| 66 | 485 | 0.5534 |
| 66 | 546 | 0.6555 |
| 66 | 642 | 0.6968 |

| | | |
|---|---|---|
| 66 | 690 | 0.778 |

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Turbine Efficiency Curves

Plant: Hauser

Name: U2_Total_Unit

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\Hauser_U2.xlsm. Used total unit performance."

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 57 | 270 | 0.3837 |
| 57 | 360 | 0.5755 |
| 57 | 455 | 0.6831 |
| 57 | 577 | 0.7182 |
| 57 | 645 | 0.8031 |
| 57 | 678 | 0.9168 |
| 58.5 | 270 | 0.3741 |
| 58.5 | 358 | 0.5642 |
| 58.5 | 450.5 | 0.6726 |
| 58.5 | 561.5 | 0.7196 |
| 58.5 | 641 | 0.7878 |
| 58.5 | 674 | 0.899 |
| 60 | 270 | 0.3645 |
| 60 | 356 | 0.5529 |
| 60 | 446 | 0.662 |
| 60 | 546 | 0.721 |
| 60 | 637 | 0.7725 |
| 60 | 670 | 0.8813 |
| 65 | 269 | 0.3377 |
| 65 | 350 | 0.5191 |
| 65 | 421 | 0.6474 |
| 65 | 518 | 0.7015 |
| 65 | 624 | 0.7279 |
| 65 | 679 | 0.8028 |
| 66 | 269 | 0.3326 |
| 66 | 348 | 0.5142 |
| 66 | 429 | 0.6257 |
| 66 | 513 | 0.6976 |
| 66 | 622 | 0.7192 |
| 66 | 684 | 0.7848 |

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Turbine Efficiency Curves

Plant: Hauser

Name: U3_Total_Unit

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\Hauser_U3.xlsm. Used total unit performance."

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 57 | 270 | 0.3837 |
| 57 | 360 | 0.5755 |
| 57 | 455 | 0.6831 |

| | | |
|---|---|---|
| 57 | 577 | 0.7182 |
| 57 | 645 | 0.8031 |
| 57 | 678 | 0.9168 |
| 58.5 | 270 | 0.3741 |
| 58.5 | 358 | 0.5642 |
| 58.5 | 450.5 | 0.6726 |
| 58.5 | 561.5 | 0.7196 |
| 58.5 | 641 | 0.7878 |
| 58.5 | 674 | 0.899 |
| 60 | 270 | 0.3645 |
| 60 | 356 | 0.5529 |
| 60 | 446 | 0.662 |
| 60 | 546 | 0.721 |
| 60 | 637 | 0.7725 |
| 60 | 670 | 0.8813 |
| 65 | 269 | 0.3377 |
| 65 | 350 | 0.5191 |
| 65 | 421 | 0.6474 |
| 65 | 518 | 0.7015 |
| 65 | 624 | 0.7279 |
| 65 | 679 | 0.8028 |
| 66 | 269 | 0.3326 |
| 66 | 348 | 0.5142 |
| 66 | 429 | 0.6257 |
| 66 | 513 | 0.6976 |
| 66 | 622 | 0.7192 |
| 66 | 684 | 0.7848 |

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Turbine Efficiency Curves

Plant: Hauser

Name: U4_Total_Unit

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\Hauser_U4.xlsm. Used total unit performance."

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 57 | 241 | 0.4299 |
| 57 | 363 | 0.5708 |
| 57 | 499 | 0.6228 |
| 57 | 651 | 0.6365 |
| 57 | 814 | 0.6367 |
| 57 | 976 | 0.6369 |
| 58.5 | 240 | 0.4208 |
| 58.5 | 358 | 0.5642 |
| 58.5 | 489.5 | 0.619 |
| 58.5 | 635 | 0.6362 |
| 58.5 | 793.5 | 0.6367 |
| 58.5 | 951.5 | 0.637 |
| 60 | 239 | 0.4118 |
| 60 | 353 | 0.5576 |
| 60 | 480 | 0.6151 |
| 60 | 619 | 0.636 |
| 60 | 773 | 0.6366 |

| | | |
|---|---|---|
| 60 | 927 | 0.637 |
| 65 | 236 | 0.3849 |
| 65 | 340 | 0.5344 |
| 65 | 453 | 0.6016 |
| 65 | 577 | 0.6298 |
| 65 | 714 | 0.6362 |
| 65 | 856 | 0.6368 |
| 66 | 235 | 0.3807 |
| 66 | 335 | 0.5341 |
| 66 | 444 | 0.6045 |
| 66 | 563 | 0.6357 |
| 66 | 693 | 0.6455 |
| 66 | 827 | 0.6491 |

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Turbine Efficiency Curves

Plant: Hauser

Name: U5_Total_Unit

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\Hauser_U5.xlsm. Used total unit performance."

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 57 | 401 | 0.2583 |
| 57 | 453 | 0.4574 |
| 57 | 510 | 0.6094 |
| 57 | 569 | 0.7283 |
| 57 | 767 | 0.6753 |
| 57 | 921 | 0.6749 |
| 58.5 | 404 | 0.25 |
| 58.5 | 455 | 0.444 |
| 58.5 | 510 | 0.5942 |
| 58.5 | 567.5 | 0.7119 |
| 58.5 | 748 | 0.6752 |
| 58.5 | 898 | 0.6749 |
| 60 | 407 | 0.2418 |
| 60 | 457 | 0.4307 |
| 60 | 510 | 0.5789 |
| 60 | 566 | 0.6955 |
| 60 | 729 | 0.675 |
| 60 | 875 | 0.6749 |
| 65 | 418 | 0.2173 |
| 65 | 464 | 0.3916 |
| 65 | 511 | 0.5333 |
| 65 | 562 | 0.6466 |
| 65 | 616 | 0.7374 |
| 65 | 864 | 0.6309 |
| 66 | 421 | 0.2125 |
| 66 | 465 | 0.3848 |
| 66 | 512 | 0.5242 |
| 66 | 561 | 0.6379 |
| 66 | 614 | 0.7286 |
| 66 | 844 | 0.636 |

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Turbine Efficiency Curves

Plant: Hauser

Name: U6_Total_Unit

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\Hauser_U6.xlsm. Used total unit performance."

Notes: CDOE 2015/1/20. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 57 | 159 | 0.6515 |
| 57 | 318 | 0.6516 |
| 57 | 436 | 0.7128 |
| 57 | 553 | 0.7493 |
| 57 | 649 | 0.7981 |
| 57 | 747 | 0.8321 |
| 57 | 883 | 0.8213 |
| 57 | 1101 | 0.7527 |
| 57 | 1239 | 0.7525 |
| 58.5 | 160 | 0.6314 |
| 58.5 | 320 | 0.6314 |
| 58.5 | 431.5 | 0.7022 |
| 58.5 | 542 | 0.7454 |
| 58.5 | 640 | 0.789 |
| 58.5 | 733.5 | 0.8261 |
| 58.5 | 852 | 0.8302 |
| 58.5 | 1073.5 | 0.7527 |
| 58.5 | 1208 | 0.7525 |
| 60 | 161 | 0.6112 |
| 60 | 322 | 0.6113 |
| 60 | 427 | 0.6915 |
| 60 | 531 | 0.7414 |
| 60 | 631 | 0.7798 |
| 60 | 720 | 0.8201 |
| 60 | 821 | 0.8391 |
| 60 | 1046 | 0.7527 |
| 60 | 1177 | 0.7525 |
| 65 | 166 | 0.5472 |
| 65 | 332 | 0.5473 |
| 65 | 416 | 0.6551 |
| 65 | 499 | 0.7282 |
| 65 | 603 | 0.7533 |
| 65 | 686 | 0.7946 |
| 65 | 770 | 0.8259 |
| 65 | 867 | 0.8383 |
| 65 | 1086 | 0.7529 |
| 66 | 168 | 0.5325 |
| 66 | 336 | 0.5326 |
| 66 | 412 | 0.6515 |
| 66 | 487 | 0.7349 |
| 66 | 589 | 0.7595 |
| 66 | 675 | 0.7953 |
| 66 | 754 | 0.8306 |
| 66 | 842 | 0.8501 |
| 66 | 973 | 0.8276 |

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Generator Efficiency Curves

Plant: Hauser

Name: "U1,2,3,4,5_1.0_eff"

Description: "Units 1-5 per ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"".  1.0 efficiency as turbine efficiency inputs include generator efficiency."

Notes: CDOE 2015/1/20.  KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 2.5 | 0 | 1 |
| 2.5 | 0.5 | 1 |
| 2.5 | 1 | 1 |
| 2.5 | 1.5 | 1 |
| 2.5 | 2 | 1 |
| 2.5 | 2.5 | 1 |

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Generator Efficiency Curves

Plant: Hauser

Name: U6_1.0_eff

Description: "U6 generator limited per ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"".  1.0 efficiency as turbine efficiency inputs include generator efficiency."

Notes: CDOE 2015/1/20.  KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 4.3 | 0 | 1 |
| 4.3 | 0.9 | 1 |
| 4.3 | 1.7 | 1 |
| 4.3 | 2.6 | 1 |
| 4.3 | 3.4 | 1 |
| 4.3 | 4.3 | 1 |

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Plant Flow Type

Plant: Hauser

Name: MaxCap

Description: Max flow plant.

Notes: BKROLAK 2015/1/14.  KADAMEC 2015/2/6 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Holter

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Holter | Base_ReReg | Base | Base |

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Physical Settings

Plant: Holter

Name: Base_ReReg

Description: Base Re Regulating with tailwater curve based on historical data.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked. KADAMEC 2015/1/21. BKROLAK 2015/1/22 TW Checked. KADAMEC 2015/2/10 Checked

Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Historical
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_ReReg

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Reservoir Storage
Plant: Holter
Name: Base
Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3543 | 158000 |
| 3544 | 162000 |
| 3545 | 165000 |
| 3546 | 168000 |
| 3547 | 172000 |
| 3548 | 175000 |
| 3549 | 179000 |
| 3550 | 182000 |
| 3551 | 186000 |
| 3552 | 189000 |
| 3553 | 193000 |
| 3554 | 197000 |
| 3555 | 201000 |
| 3556 | 205000 |
| 3557 | 209000 |
| 3558 | 213000 |
| 3559 | 218000 |
| 3560 | 222000 |
| 3561 | 227000 |
| 3562 | 231000 |
| 3563 | 236000 |
| 3564 | 240000 |
| 3570 | 268001 |

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Tailwater Curve
Plant: Holter
Name: Historical
Description: "Updated from ""5 - Tailwater Rating Curves\HOLTLWR.xls"" revised curve to align with historic data from ""HLT PI Avg Hourly.xlsx""."

Notes: KADAMEC 2015/1/21. BKROLAK 2015/1/22 Checked

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3450 | 0 |
| 3450.25 | 400 |
| 3451.05 | 800 |
| 3451.6 | 1200 |
| 3451.96 | 2425.57 |
| 3452.85 | 4954.4 |
| 3453.57 | 6228.13 |
| 3455.18 | 6519.32 |
| 3455.55 | 7200 |
| 3455.9 | 8000 |
| 3456.7 | 10000 |
| 3457.5 | 12000 |
| 3458.2 | 14000 |
| 3458.8 | 16000 |
| 3459.45 | 18000 |
| 3460 | 20000 |
| 3460.6 | 22000 |
| 3461.2 | 24000 |
| 3461.65 | 26000 |
| 3462.2 | 28000 |

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Spillway Curve

Plant: Holter

Name: Base

Description: "Total Flow Spillway, Overtopping, less powerhouse flow from ""4 - Spillway discharge rating curves\HLT MAXIMUM SPILL RATING.xls""."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3562 | 93500 |
| 3563 | 103700 |
| 3564 | 114300 |
| 3565 | 125200 |
| 3566 | 136400 |
| 3567 | 147600 |
| 3568 | 150000 |
| 3569 | 159600 |
| 3570 | 170900 |
| 3571 | 182700 |
| 3572 | 195100 |
| 3573 | 208000 |
| 3574 | 221400 |
| 3575 | 235400 |
| 3576 | 249600 |

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Plant Options

Plant: Holter

Name: Base_ReReg

Description: Base with Re-Reg option to all for ramping rates.

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 3564 | |

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Operation Settings
Plant: Holter
Name: Base
Description: Base conditions.
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked. BKROLAK 2015/1/23 Modified MinInst.. ASCANGAS 2015/1/25 modified minimum elevation. KADAMEC 2015/2/10 Checked. BKROLAK 2015/2/12 Ramping rates added. ASCANGAS 2015/2/12 checked.
Spill Elevations: 3564
Target Elevations: 3563.8
Minimum Elevations: 3563
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates: Base
Minimum Instantaneous Flow: 3000
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow:
Maximum Flow:
Max Flow from Elev:
Flashboards:

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Spill Elevations
Plant: Holter
Name: 3564
Description: "From ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3564 |
| 31-Dec | 3564 |

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Target Elevations
Plant: Holter
Name: 3563.8
Description: "From ""HDB HLT 198801 to 201411.xlsx"" 50th percentile elevation."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3563.8 |
| 31-Dec | 3563.8 |

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Minimum Elevations
Plant: Holter
Name: 3563

Description: "License article 403 Maintain elevation between 3563 and 3564, ""Hydro Operations Requirements Summary from Licenses & Agreements with Agencies by JHJ 2014-11-12.pdf""."

Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/6 Checked

| Calendar Day | | Elevation (ft) |
|---|---|---|
| 1-Jan | 3563 | |
| 31-Dec | 3563 | |

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Tailwater Ramping Rates

Plant: Holter

Name: Base

Description: "Per ""NWEhydrooperationsplan.docx"". 3) 10pct diff from inflow to Holter. 4) Highest hourly to lowest hourly is no more than sum of 10pct of previous day""s average flow and increase or decrease from CNF for yesterday or today. 5) hourly average flow change no more than 5pct."

Notes: BKROLAK 2015/2/12. ASCANGAS 2015/2/12 checked.

Constrained by Stage Calendar Day Hourly Rate Up (units/hr) Daily Rate Up (units/day) Hourly Rate Down (units/hr) Daily Rate Down (units/day) Use Hrly Min/Max Houly Min/Max Difference Reference Plant

FALSE 1 0.05 0.1 0.05 0.1 TRUE 0.1 3

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Minimum Instantaneous Flow

Plant: Holter

Name: 3000

Description: "3000 cfs per ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls""."

Notes: BKROLAK 2015/1/23. KADAMEC 2015/2/12 Checked

| Calendar Day | | Flow (cfs) Or Inflow |
|---|---|---|
| 1-Jan | 3000 | FALSE |
| 31-Dec | 3000 | FALSE |

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Generation Settings

Plant: Holter

Name: Base

Description: "Lower head extended on input curves to cuver full range of operational head. From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". Using unit combined efficiency"

Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/6 Checked

Powerhouse Setup: BaseHD

Powerhouse Weekend Ops:

Maintenance Schedule:

Minimum Flow Unit:

Plant Flow Type: MaxCap

Limit Off Peak Gen:

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Powerhouse Setup

Plant: Holter

Name: BaseHD

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". Using unit combined efficiency and limiting flow based on PI data."

Notes: ASCANGAS 2015/2/5. KADAMEC 2015/2/6 Checked

Dispatched: FALSE

| Unit Number | | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|---|
| 1 | 4units | U1_Total_UnitHD_Rev1 | | "U1,2,3,4_1.0_eff" | 0 |
| 2 | 4units | U2_Total_UnitHD_Rev1 | | "U1,2,3,4_1.0_eff" | 0 |
| 3 | 4units | U3_Total_UnitHD_Rev1 | | "U1,2,3,4_1.0_eff" | 0 |
| 4 | 4units | U4_Total_UnitHD_Rev1 | | "U1,2,3,4_1.0_eff" | 0 |

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Turbine Efficiency Curves

Plant: Holter

Name: U1_Total_UnitHD_Rev1

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\5Holter_U1.xlsm. Used total unit performance. Total Unit performance extended for full head range and limited based on PI data."

Notes: ASCANGAS 2015/2/5. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 91 | 377.22 | 0.268 |
| 91 | 515.23 | 0.3924 |
| 91 | 616.44 | 0.4919 |
| 91 | 717.65 | 0.5634 |
| 91 | 828.05 | 0.6103 |
| 91 | 920.06 | 0.6592 |
| 91 | 1012.07 | 0.6991 |
| 91 | 1104.07 | 0.7324 |
| 91 | 1196.08 | 0.7606 |
| 91 | 1288.08 | 0.7847 |
| 91 | 1380.09 | 0.8056 |
| 91 | 1518.1 | 0.799 |
| 91 | 1656.11 | 0.7934 |
| 99.25 | 393.95 | 0.268 |
| 99.25 | 538.08 | 0.3924 |
| 99.25 | 643.78 | 0.4919 |
| 99.25 | 749.47 | 0.5634 |
| 99.25 | 864.78 | 0.6103 |
| 99.25 | 960.86 | 0.6592 |
| 99.25 | 1056.95 | 0.6991 |
| 99.25 | 1153.03 | 0.7324 |
| 99.25 | 1249.12 | 0.7606 |
| 99.25 | 1345.21 | 0.7847 |
| 99.25 | 1441.29 | 0.8056 |
| 99.25 | 1585.42 | 0.799 |
| 99.25 | 1729.55 | 0.7934 |
| 107.5 | 410 | 0.268 |
| 107.5 | 560 | 0.3924 |
| 107.5 | 670 | 0.4919 |
| 107.5 | 780 | 0.5634 |
| 107.5 | 900 | 0.6103 |
| 107.5 | 1000 | 0.6592 |
| 107.5 | 1100 | 0.6991 |
| 107.5 | 1200 | 0.7324 |
| 107.5 | 1300 | 0.7606 |
| 107.5 | 1400 | 0.7847 |
| 107.5 | 1500 | 0.8056 |
| 107.5 | 1650 | 0.799 |

| | | |
|---|---|---|
| 107.5 | 1800 | 0.7934 |
| 108.5 | 411.9 | 0.268 |
| 108.5 | 562.6 | 0.3924 |
| 108.5 | 673.11 | 0.4919 |
| 108.5 | 783.62 | 0.5634 |
| 108.5 | 904.18 | 0.6103 |
| 108.5 | 1004.64 | 0.6592 |
| 108.5 | 1105.1 | 0.6991 |
| 108.5 | 1205.57 | 0.7324 |
| 108.5 | 1306.03 | 0.7606 |
| 108.5 | 1406.5 | 0.7847 |
| 108.5 | 1506.96 | 0.8056 |
| 108.5 | 1657.66 | 0.799 |
| 108.5 | 1808.35 | 0.7934 |
| 109.5 | 413.8 | 0.268 |
| 109.5 | 565.19 | 0.3924 |
| 109.5 | 676.2 | 0.4919 |
| 109.5 | 787.22 | 0.5634 |
| 109.5 | 908.33 | 0.6103 |
| 109.5 | 1009.26 | 0.6592 |
| 109.5 | 1110.19 | 0.6991 |
| 109.5 | 1211.11 | 0.7324 |
| 109.5 | 1312.04 | 0.7606 |
| 109.5 | 1412.96 | 0.7847 |
| 109.5 | 1513.89 | 0.8056 |
| 109.5 | 1665.28 | 0.799 |
| 109.5 | 1816.67 | 0.7934 |

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Turbine Efficiency Curves

Plant: Holter

Name: U2_Total_UnitHD_Rev1

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\5Holter_U2.xlsm. Used total unit performance. Total Unit performance extended for full head range and limited based on PI data."

Notes: ASCANGAS 2015/2/5. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 91 | 377.22 | 0.268 |
| 91 | 478.43 | 0.4225 |
| 91 | 579.64 | 0.5231 |
| 91 | 680.84 | 0.5938 |
| 91 | 782.05 | 0.6462 |
| 91 | 874.06 | 0.6939 |
| 91 | 966.06 | 0.7324 |
| 91 | 1058.07 | 0.7642 |
| 91 | 1173.08 | 0.7755 |
| 91 | 1265.08 | 0.799 |
| 91 | 1380.09 | 0.8056 |
| 91 | 1472.1 | 0.824 |
| 91 | 1610.11 | 0.8222 |
| 91 | 1725.11 | 0.8203 |
| 99.25 | 393.95 | 0.268 |
| 99.25 | 499.65 | 0.4225 |
| 99.25 | 605.34 | 0.5231 |

| | | |
|---|---|---|
| 99.25 | 711.04 | 0.5938 |
| 99.25 | 816.73 | 0.6462 |
| 99.25 | 912.82 | 0.6939 |
| 99.25 | 1008.91 | 0.7324 |
| 99.25 | 1104.99 | 0.7642 |
| 99.25 | 1225.1 | 0.7755 |
| 99.25 | 1321.19 | 0.799 |
| 99.25 | 1441.29 | 0.8056 |
| 99.25 | 1537.38 | 0.824 |
| 99.25 | 1681.51 | 0.8222 |
| 99.25 | 1801.62 | 0.8203 |
| 107.5 | 410 | 0.268 |
| 107.5 | 520 | 0.4225 |
| 107.5 | 630 | 0.5231 |
| 107.5 | 740 | 0.5938 |
| 107.5 | 850 | 0.6462 |
| 107.5 | 950 | 0.6939 |
| 107.5 | 1050 | 0.7324 |
| 107.5 | 1150 | 0.7642 |
| 107.5 | 1275 | 0.7755 |
| 107.5 | 1375 | 0.799 |
| 107.5 | 1500 | 0.8056 |
| 107.5 | 1600 | 0.824 |
| 107.5 | 1750 | 0.8222 |
| 107.5 | 1875 | 0.8203 |
| 108.5 | 411.9 | 0.268 |
| 108.5 | 522.41 | 0.4225 |
| 108.5 | 632.92 | 0.5231 |
| 108.5 | 743.43 | 0.5938 |
| 108.5 | 853.94 | 0.6462 |
| 108.5 | 954.41 | 0.6939 |
| 108.5 | 1054.87 | 0.7324 |
| 108.5 | 1155.34 | 0.7642 |
| 108.5 | 1280.92 | 0.7755 |
| 108.5 | 1381.38 | 0.799 |
| 108.5 | 1506.96 | 0.8056 |
| 108.5 | 1607.42 | 0.824 |
| 108.5 | 1758.12 | 0.8222 |
| 108.5 | 1883.7 | 0.8203 |
| 109.5 | 413.8 | 0.268 |
| 109.5 | 524.81 | 0.4225 |
| 109.5 | 635.83 | 0.5231 |
| 109.5 | 746.85 | 0.5938 |
| 109.5 | 857.87 | 0.6462 |
| 109.5 | 958.8 | 0.6939 |
| 109.5 | 1059.72 | 0.7324 |
| 109.5 | 1160.65 | 0.7642 |
| 109.5 | 1286.81 | 0.7755 |
| 109.5 | 1387.73 | 0.799 |
| 109.5 | 1513.89 | 0.8056 |
| 109.5 | 1614.82 | 0.824 |
| 109.5 | 1766.2 | 0.8222 |
| 109.5 | 1892.36 | 0.8203 |

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Turbine Efficiency Curves

Plant: Holter

Name: U3_Total_UnitHD_Rev1

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\5Holter_U3.xlsm. Used total unit performance. Total Unit performance extended for full head range and limited based on PI data."

Notes: ASCANGAS 2015/2/5. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 91 | 361.58 | 0.2795 |
| 91 | 462.79 | 0.4368 |
| 91 | 564 | 0.5377 |
| 91 | 665.2 | 0.6078 |
| 91 | 766.41 | 0.6594 |
| 91 | 858.42 | 0.7065 |
| 91 | 966.06 | 0.7324 |
| 91 | 1058.07 | 0.7642 |
| 91 | 1165.72 | 0.7804 |
| 91 | 1257.72 | 0.8037 |
| 91 | 1364.45 | 0.8149 |
| 91 | 1472.1 | 0.824 |
| 91 | 1564.1 | 0.8401 |
| 99.25 | 377.62 | 0.2795 |
| 99.25 | 483.31 | 0.4368 |
| 99.25 | 589.01 | 0.5377 |
| 99.25 | 694.7 | 0.6078 |
| 99.25 | 800.4 | 0.6594 |
| 99.25 | 896.48 | 0.7065 |
| 99.25 | 1008.91 | 0.7324 |
| 99.25 | 1104.99 | 0.7642 |
| 99.25 | 1217.41 | 0.7804 |
| 99.25 | 1313.5 | 0.8037 |
| 99.25 | 1424.96 | 0.8149 |
| 99.25 | 1537.38 | 0.824 |
| 99.25 | 1633.47 | 0.8401 |
| 107.5 | 393 | 0.2795 |
| 107.5 | 503 | 0.4368 |
| 107.5 | 613 | 0.5377 |
| 107.5 | 723 | 0.6078 |
| 107.5 | 833 | 0.6594 |
| 107.5 | 933 | 0.7065 |
| 107.5 | 1050 | 0.7324 |
| 107.5 | 1150 | 0.7642 |
| 107.5 | 1267 | 0.7804 |
| 107.5 | 1367 | 0.8037 |
| 107.5 | 1483 | 0.8149 |
| 107.5 | 1600 | 0.824 |
| 107.5 | 1700 | 0.8401 |
| 108.5 | 394.82 | 0.2795 |
| 108.5 | 505.33 | 0.4368 |
| 108.5 | 615.84 | 0.5377 |
| 108.5 | 726.36 | 0.6078 |
| 108.5 | 836.87 | 0.6594 |
| 108.5 | 937.33 | 0.7065 |

| | | |
|---|---|---|
| 108.5 | 1054.87 | 0.7324 |
| 108.5 | 1155.34 | 0.7642 |
| 108.5 | 1272.88 | 0.7804 |
| 108.5 | 1373.34 | 0.8037 |
| 108.5 | 1489.88 | 0.8149 |
| 108.5 | 1607.42 | 0.824 |
| 108.5 | 1707.89 | 0.8401 |
| 109.5 | 396.64 | 0.2795 |
| 109.5 | 507.66 | 0.4368 |
| 109.5 | 618.68 | 0.5377 |
| 109.5 | 729.69 | 0.6078 |
| 109.5 | 840.71 | 0.6594 |
| 109.5 | 941.64 | 0.7065 |
| 109.5 | 1059.72 | 0.7324 |
| 109.5 | 1160.65 | 0.7642 |
| 109.5 | 1278.73 | 0.7804 |
| 109.5 | 1379.66 | 0.8037 |
| 109.5 | 1496.73 | 0.8149 |
| 109.5 | 1614.82 | 0.824 |
| 109.5 | 1715.74 | 0.8401 |

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Turbine Efficiency Curves

Plant: Holter

Name: U4_Total_UnitHD_Rev1

Description: "From PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"", source file \ExcelFiles\5Holter_U4.xlsm. Used total unit performance. Total Unit performance extended for full head range and limited based on PI data."

Notes: ASCANGAS 2015/2/5. KADAMEC 2015/2/6 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 91 | 354.22 | 0.2854 |
| 91 | 455.43 | 0.4439 |
| 91 | 556.64 | 0.5448 |
| 91 | 657.84 | 0.6146 |
| 91 | 759.05 | 0.6658 |
| 91 | 863.02 | 0.7027 |
| 91 | 966.06 | 0.7324 |
| 91 | 1058.07 | 0.7642 |
| 91 | 1150.08 | 0.791 |
| 91 | 1254.04 | 0.806 |
| 91 | 1357.09 | 0.8193 |
| 91 | 1472.1 | 0.824 |
| 91 | 1564.1 | 0.8401 |
| 91 | 1656.11 | 0.8545 |
| 99.25 | 369.93 | 0.2854 |
| 99.25 | 475.63 | 0.4439 |
| 99.25 | 581.32 | 0.5448 |
| 99.25 | 687.02 | 0.6146 |
| 99.25 | 792.71 | 0.6658 |
| 99.25 | 901.29 | 0.7027 |
| 99.25 | 1008.91 | 0.7324 |
| 99.25 | 1104.99 | 0.7642 |
| 99.25 | 1201.08 | 0.791 |
| 99.25 | 1309.65 | 0.806 |

| | | |
|---|---|---|
| 99.25 | 1417.27 | 0.8193 |
| 99.25 | 1537.38 | 0.824 |
| 99.25 | 1633.47 | 0.8401 |
| 99.25 | 1729.55 | 0.8545 |
| 107.5 | 385 | 0.2854 |
| 107.5 | 495 | 0.4439 |
| 107.5 | 605 | 0.5448 |
| 107.5 | 715 | 0.6146 |
| 107.5 | 825 | 0.6658 |
| 107.5 | 938 | 0.7027 |
| 107.5 | 1050 | 0.7324 |
| 107.5 | 1150 | 0.7642 |
| 107.5 | 1250 | 0.791 |
| 107.5 | 1363 | 0.806 |
| 107.5 | 1475 | 0.8193 |
| 107.5 | 1600 | 0.824 |
| 107.5 | 1700 | 0.8401 |
| 107.5 | 1800 | 0.8545 |
| 108.5 | 386.79 | 0.2854 |
| 108.5 | 497.3 | 0.4439 |
| 108.5 | 607.81 | 0.5448 |
| 108.5 | 718.32 | 0.6146 |
| 108.5 | 828.83 | 0.6658 |
| 108.5 | 942.35 | 0.7027 |
| 108.5 | 1054.87 | 0.7324 |
| 108.5 | 1155.34 | 0.7642 |
| 108.5 | 1255.8 | 0.791 |
| 108.5 | 1369.32 | 0.806 |
| 108.5 | 1481.84 | 0.8193 |
| 108.5 | 1607.42 | 0.824 |
| 108.5 | 1707.89 | 0.8401 |
| 108.5 | 1808.35 | 0.8545 |
| 109.5 | 388.56 | 0.2854 |
| 109.5 | 499.58 | 0.4439 |
| 109.5 | 610.6 | 0.5448 |
| 109.5 | 721.62 | 0.6146 |
| 109.5 | 832.64 | 0.6658 |
| 109.5 | 946.69 | 0.7027 |
| 109.5 | 1059.72 | 0.7324 |
| 109.5 | 1160.65 | 0.7642 |
| 109.5 | 1261.57 | 0.791 |
| 109.5 | 1375.62 | 0.806 |
| 109.5 | 1488.66 | 0.8193 |
| 109.5 | 1614.82 | 0.824 |
| 109.5 | 1715.74 | 0.8401 |
| 109.5 | 1816.67 | 0.8545 |

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Generator Efficiency Curves

Plant: Holter

Name: "U1,2,3,4_1.0_eff"

Description: "Generator limited per ""Generator info - JCummings.xlsx"". Note: the Holter turbines are good for 14.5 MW. 1 MW row entry manually added. Changed to 1.0 eff as turbine efficiency now includes gen eff"

Notes: BKROLAK 2015/1/14. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 12 | 0 | 1 |
| 12 | 1 | 1 |
| 12 | 2.4 | 1 |
| 12 | 4.8 | 1 |
| 12 | 7.2 | 1 |
| 12 | 9.6 | 1 |
| 12 | 12 | 1 |

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Plant Flow Type
Plant: Holter
Name: MaxCap
Description: (Description)
Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/6 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Black Eagle

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Black Eagle | Base_ReReg | Base | Base |

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Physical Settings
Plant: Black Eagle
Name: Base_ReReg
Description: Base with Re Regulating option to all for ramping rates.
Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Base
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_ReReg

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Reservoir Storage
Plant: Black Eagle
Name: Base
Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3276 | 0 |

| | |
|---|---|
| 3277 | 18 |
| 3278 | 59 |
| 3279 | 107 |
| 3280 | 168 |
| 3281 | 238 |
| 3282 | 323 |
| 3283 | 415 |
| 3284 | 515 |
| 3285 | 629 |
| 3286 | 772 |
| 3287 | 953 |
| 3288 | 1184 |
| 3289 | 1469 |
| 3290 | 1819 |

*********************************************

Tailwater Curve

Plant: Black Eagle

Name: Base

Description: "Base from ""5 - Tailwater Rating Curves\BLE Powerhouse Tailwater.xls"".  Second entry for 3238.5 and 3243.34 feet were removed from source data set to prevent duplicate flow entries."

Notes: BKROLAK 2015/1/19. ASCANGAS 2015/1/19 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3230 | 0 |
| 3234 | 750 |
| 3234.4 | 1000 |
| 3235.7 | 2000 |
| 3236.8 | 3000 |
| 3237.8 | 4000 |
| 3238.5 | 5000 |
| 3238.85 | 10000 |
| 3239.2 | 12000 |
| 3239.45 | 14000 |
| 3239.75 | 16000 |
| 3240 | 18000 |
| 3240.3 | 20000 |
| 3240.55 | 22000 |
| 3240.8 | 24000 |
| 3241 | 26000 |
| 3241.25 | 28000 |
| 3241.5 | 30000 |
| 3241.75 | 32000 |
| 3241.95 | 34000 |
| 3242.1 | 36000 |
| 3242.24 | 38000 |
| 3242.37 | 40000 |
| 3242.5 | 42000 |
| 3242.62 | 44000 |
| 3242.74 | 46000 |
| 3242.85 | 48000 |
| 3242.95 | 50000 |
| 3243.05 | 52000 |
| 3243.15 | 54000 |

| | |
|---|---|
| 3243.25 | 56000 |
| 3243.42 | 60000 |
| 3243.51 | 62000 |
| 3243.59 | 64000 |
| 3243.67 | 66000 |
| 3243.75 | 68000 |
| 3243.82 | 70000 |
| 3243.9 | 72000 |

********************************************

Spillway Curve

Plant: Black Eagle

Name: Base

Description: "Base from ""4 - Spillway discharge rating curves\BLE DISCHARGE CAPABILITY.xls"". Added waste gate crest elevation as 0 flow point."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked. BKROLAK 2015/2/4. ASCANGAS 2015/2/5 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3267 | 0 |
| 3279 | 12712 |
| 3280 | 16102 |
| 3281 | 20339 |
| 3282 | 25424 |
| 3283 | 32203 |
| 3284 | 38983 |
| 3285 | 47458 |
| 3286 | 56780 |
| 3287 | 65763 |
| 3288 | 76271 |
| 3289 | 86780 |
| 3290 | 99153 |
| 3291 | 111017 |
| 3292 | 125085 |
| 3293 | 137288 |
| 3294 | 153390 |
| 3295 | 168644 |
| 3296 | 185000 |
| 3297 | 205172 |
| 3298 | 225862 |
| 3299 | 247782 |
| 3300 | 272034 |
| 3301 | 295763 |
| 3302 | 317797 |
| 3303 | 338136 |
| 3304 | 359322 |
| 3305 | 378448 |

********************************************

Plant Options

Plant: Black Eagle

Name: Base_ReReg

Description: Base with Re-Reg option to all for ramping rates.

Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 3290 |

*********************************************
Operation Settings
Plant: Black Eagle
Name: Base
Description: Base conditions.
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked. KADAMEC 2015/2/12 Checked again
Spill Elevations: 3290
Target Elevations: 3289.9
Minimum Elevations: 3278
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows: 200Falls
Bypass Flow:
Maximum Flow:
Max Flow from Elev:
Flashboards:

*********************************************
Spill Elevations
Plant: Black Eagle
Name: 3290
Description: "Base from ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/12. KADAMEC 2015/2/12 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3290 |
| 31-Dec | 3290 |

*********************************************
Target Elevations
Plant: Black Eagle
Name: 3289.9
Description: "Base from ""Regulatory Constraints.pdf"". 0.1 ft below normal full pool."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3289.9 |
| 31-Dec | 3289.9 |

*********************************************
Minimum Elevations
Plant: Black Eagle
Name: 3278
Description: "Lowest observed end of day elevation 1988 to 2014, from ""HDB BLK 198801 to 201411.xla.xlsx"""
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3278 |
| 31-Dec | 3278 |

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Recreation Flows
Plant: Black Eagle
Name: 200Falls
Description: "Spill min 200cfs 9am-8pm on weekends/holidays Mem day to Labor day, except when Apr-Jun runoff into Canyon Ferr < 900 kaf (50% of 1961 to 1990 average) per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/20 checked.

| Calendar Day | Day of Week | Flow (cfs) | Start Hour | End Hour | Use Plant Discharge | Only When PH Off | Use Custom Schedule |
|---|---|---|---|---|---|---|---|
| 1-Jan | 0 | 0 | 1 | 24 | FALSE | FALSE | FALSE |
| 24-May | 1 | 200 | 9 | 20 | FALSE | FALSE | FALSE |
| 24-May | 7 | 200 | 9 | 20 | FALSE | FALSE | FALSE |
| 10-Sep | 0 | 0 | 1 | 24 | FALSE | FALSE | FALSE |

********************************************

Generation Settings
Plant: Black Eagle
Name: Base
Description: Base with calculated common and estimated unit headlosses. Turbine data from Index test Aug 2004 with shape from original Hill Curves.

Notes: BKROLAK 2015/1/15. KADAMEC 2015/2/10 Checked
Powerhouse Setup: Base_HillCurve
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

********************************************

Powerhouse Setup
Plant: Black Eagle
Name: Base_HillCurve
Description: Hill curves used for shaping. Gross head inputs. GenEffs used.
Notes: BKROLAK 2015/2/4. KADAMEC 2015/2/9 Checked
Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | ZeroHL | U1-2-3_HillCurveAdjust_11pct | "U1,2_7.25" | 0 |
| 2 | ZeroHL | U1-2-3_HillCurveAdjust_11pct | "U1,2_7.25" | 0 |
| 3 | ZeroHL | U1-2-3_HillCurveAdjust_11pct | U3_7.25 | 0 |

********************************************

Turbine Efficiency Curves
Plant: Black Eagle
Name: U1-2-3_HillCurveAdjust_11pct
Description: "Shape of ""SMorganSmith Turbine Curves BE 1.pdf"" adjusted to historical PI limits and daily operations data."
Notes: BKROLAK 2015/2/5. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 47 | 795.02 | 0.775 |
| 47 | 1114.97 | 0.8 |
| 47 | 1454.3 | 0.815 |
| 47 | 1653.06 | 0.815 |
| 47 | 1803.34 | 0.804 |
| 47 | 1987.55 | 0.7991 |
| 48.5 | 807.61 | 0.775 |
| 48.5 | 1132.62 | 0.8 |
| 48.5 | 1477.33 | 0.815 |
| 48.5 | 1679.23 | 0.815 |
| 48.5 | 1831.89 | 0.804 |
| 48.5 | 2019.02 | 0.7991 |
| 50 | 820 | 0.775 |
| 50 | 1150 | 0.8 |
| 50 | 1500 | 0.815 |
| 50 | 1705 | 0.815 |
| 50 | 1860 | 0.804 |
| 50 | 2050 | 0.7991 |
| 51.5 | 832.21 | 0.775 |
| 51.5 | 1167.12 | 0.8 |
| 51.5 | 1522.33 | 0.815 |
| 51.5 | 1730.39 | 0.815 |
| 51.5 | 1887.69 | 0.804 |
| 51.5 | 2050 | 0.8 |
| 53 | 844.24 | 0.775 |
| 53 | 1184 | 0.8 |
| 53 | 1544.34 | 0.815 |
| 53 | 1755.4 | 0.815 |
| 53 | 1914.99 | 0.804 |
| 53 | 2050 | 0.801 |

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Generator Efficiency Curves

Plant: Black Eagle

Name: "U1,2_7.25"

Description: "Gen 3 from ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx""."

Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/9 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 7.25 | 0 | 0 |
| 7.25 | 1.5 | 0.9439 |
| 7.25 | 2.9 | 0.9696 |
| 7.25 | 4.4 | 0.9773 |
| 7.25 | 5.8 | 0.9805 |
| 7.25 | 7.25 | 0.9819 |

********************************************

Generator Efficiency Curves

Plant: Black Eagle

Name: U3_7.25

Description: "Gen 3 from ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx""."

Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/9 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 7.25 | 0 | 0 |
| 7.25 | 1.5 | 0.9403 |
| 7.25 | 2.9 | 0.9676 |
| 7.25 | 4.4 | 0.9757 |
| 7.25 | 5.8 | 0.9792 |
| 7.25 | 7.25 | 0.9806 |

********************************************

Plant Flow Type
Plant: Black Eagle
Name: MaxCap
Description: Max Cap.
Notes: BKROLAK 2015/2/4. KADAMEC 2015/2/9 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Rainbow

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Rainbow | Base_ReReg | Base | Base_Post2013 |

********************************************

Physical Settings
Plant: Rainbow
Name: Base_ReReg
Description: Base with Re Regulating option to all for ramping rates.
Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Base
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_ReReg

********************************************

Reservoir Storage
Plant: Rainbow
Name: Base
Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3212 | 67 |
| 3213 | 116 |
| 3214 | 178 |

| | |
|---|---|
| 3215 | 265 |
| 3216 | 357 |
| 3217 | 452 |
| 3218 | 549 |
| 3219 | 648 |
| 3220 | 752 |
| 3221 | 866 |
| 3222 | 987 |
| 3223 | 1111 |
| 3224 | 1237 |
| 3225 | 1369 |

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Tailwater Curve

Plant: Rainbow

Name: Base

Description: Temp holding table for tailwater. Dependent upon downstream Cochrane. Using median elevation of 3116 table entry for this input.

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3114 | 0 |
| 3116.02 | 3000 |
| 3116.03 | 3500 |
| 3116.04 | 4000 |
| 3116.05 | 4200 |
| 3116.05 | 4400 |
| 3116.05 | 4600 |
| 3116.06 | 4800 |
| 3116.06 | 5000 |
| 3116.07 | 5200 |
| 3116.08 | 5400 |
| 3116.13 | 7000 |
| 3116.17 | 8000 |
| 3116.26 | 10000 |
| 3116.37 | 12000 |
| 3116.57 | 15000 |
| 3116.77 | 17600 |
| 3116.98 | 20000 |
| 3117.46 | 25000 |
| 3117.99 | 30000 |
| 3118.56 | 35000 |
| 3119.15 | 40000 |

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Spillway Curve

Plant: Rainbow

Name: Base

Description: "Spillway and waste gates from ""4 - Spillway discharge rating curves\RAI Discharge Capability.xls""."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3191 | 0 |
| 3214 | 13846 |

| | |
|---|---|
| 3215 | 19615 |
| 3216 | 26923 |
| 3217 | 36538 |
| 3218 | 46923 |
| 3219 | 59615 |
| 3220 | 73077 |
| 3222 | 102308 |
| 3224 | 136154 |
| 3226 | 170000 |
| 3228 | 212308 |
| 3230 | 262692 |
| 3232 | 317308 |

********************************************
Plant Options
Plant: Rainbow
Name: Base_ReReg
Description: Base with Re-Reg option to all for ramping rates.
Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 3224 |

********************************************
Operation Settings
Plant: Rainbow
Name: Base
Description: Base conditions.
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/20 checked. KADAMEC 2015/2/12 Checked again
Spill Elevations: 3224
Target Elevations: 3223.9
Minimum Elevations: 3199
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows: 200Falls
Bypass Flow:
Maximum Flow: 8000cfsWaterRights
Max Flow from Elev:
Flashboards:

********************************************
Spill Elevations
Plant: Rainbow
Name: 3224
Description: "Base from ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

Calendar Day Elevation (ft)

| | |
|---|---|
| 1-Jan | 3224 |
| 31-Dec | 3224 |

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Target Elevations

Plant: Rainbow
Name: 3223.9
Description: Estimate for usable storage.
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3223.9 |
| 31-Dec | 3223.9 |

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Minimum Elevations

Plant: Rainbow
Name: 3199
Description: "Lowest observed historical end of day elevation 1988 to 2014, from ""HDB RNB 198801 to 201411.xlsx""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3199 |
| 31-Dec | 3199 |

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Recreation Flows

Plant: Rainbow
Name: 200Falls
Description: "Spill min 200cfs 9am-8pm on weekends/holidays Mem day to Labor day, except when Apr-Jun runoff into Canyon Ferr < 900 kaf (50% of 1961 to 1990 average) per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/20 checked.

| Calendar Day | | Day of Week | | Flow (cfs) | Start Hour | End Hour | Use Plant Discharge Only When PH Off | Use Custom Schedule |
|---|---|---|---|---|---|---|---|---|
| 1-Jan | 0 | 0 | 1 | 24 | FALSE | FALSE | FALSE | |
| 24-May | 1 | 200 | 9 | 20 | FALSE | FALSE | FALSE | |
| 24-May | 7 | 200 | 9 | 20 | FALSE | FALSE | FALSE | |
| 10-Sep | 0 | 0 | 1 | 24 | FALSE | FALSE | FALSE | |

********************************************

Maximum Flow

Plant: Rainbow
Name: 8000cfsWaterRights
Description: "Per cell comment in cell U9 of ""8 - Power Plant Eq Performance Data\Hydro Capacity-Limits Rev 9.xlsx"", sheet ""Generator"". Water rights limit confirmed in conference call and textual response from NWE found in email from Carrie Harris 1/22/2015 6:25pm (EST)."
Notes: BKROLAK 2015/1/15. BKROLAK 2015/2/12 Updated description. KADAMEC 2015/2/12 Checked

| Calendar Day | | Day of Week | | Flow (cfs) | Start Hour | End Hour |
|---|---|---|---|---|---|---|
| 1-Jan | 0 | 8000 | 1 | 24 | | |
| 31-Dec | 0 | 8000 | 1 | 24 | | |

********************************************

Generation Settings

Plant: Rainbow

Name: Base_Post2013
Description: U9 online Mar 2013. PI data reduction for U9.
Notes: BKROLAK 2015/1/23. KADAMEC 2015/2/10 Checked
Powerhouse Setup: U9_PI
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

********************************************

Powerhouse Setup
Plant: Rainbow
Name: U9_PI
Description: Unit online March 2013. From PI data reduction.
Notes: BKROLAK 2015/1/23. KADAMEC 2015/2/9 Checked
Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 1unit_Post2013 | U9_PI | U9_Extended | 0 |

********************************************

Turbine Efficiency Curves
Plant: Rainbow
Name: U9_PI
Description: "PI data reduction from hourly power and flow, from ""RNB PI Avg Hourly.xlsx""."
Notes: BKROLAK 2015/1/23. ASCANGAS 2015/2/5 checked.

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 101 | 2384.98 | 0.8773 |
| 101 | 2931.16 | 0.8983 |
| 101 | 3908.21 | 0.9272 |
| 101 | 4885.26 | 0.9332 |
| 101 | 5862.31 | 0.9281 |
| 101 | 6839.37 | 0.9088 |
| 101 | 7816.42 | 0.8943 |
| 101 | 7962.98 | 0.894 |
| 103.4 | 2413.15 | 0.8773 |
| 103.4 | 2965.78 | 0.8983 |
| 103.4 | 3954.37 | 0.9272 |
| 103.4 | 4942.96 | 0.9332 |
| 103.4 | 5931.56 | 0.9281 |
| 103.4 | 6920.15 | 0.9088 |
| 103.4 | 7908.74 | 0.8943 |
| 103.4 | 8057.03 | 0.894 |
| 105.8 | 2441 | 0.8773 |
| 105.8 | 3000 | 0.8983 |
| 105.8 | 4000 | 0.9272 |
| 105.8 | 5000 | 0.9332 |
| 105.8 | 6000 | 0.9281 |
| 105.8 | 7000 | 0.9088 |
| 105.8 | 8000 | 0.8943 |
| 105.8 | 8150 | 0.894 |

| | | |
|---|---|---|
| 108.4 | 2470.81 | 0.8773 |
| 108.4 | 3036.64 | 0.8983 |
| 108.4 | 4048.85 | 0.9272 |
| 108.4 | 5061.06 | 0.9332 |
| 108.4 | 6073.28 | 0.9281 |
| 108.4 | 7085.49 | 0.9088 |
| 108.4 | 8097.7 | 0.8943 |
| 108.4 | 8249.53 | 0.894 |
| 111 | 2500.27 | 0.8773 |
| 111 | 3072.84 | 0.8983 |
| 111 | 4097.12 | 0.9272 |
| 111 | 5121.4 | 0.9332 |
| 111 | 6145.68 | 0.9281 |
| 111 | 7169.96 | 0.9088 |
| 111 | 8194.24 | 0.8943 |
| 111 | 8347.88 | 0.894 |

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Generator Efficiency Curves

Plant: Rainbow

Name: U9_Extended

Description: "U9 following the Andritz data from ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx""."

Notes: BKROLAK 2015/1/15. CDOE 2015/1/20. KADAMEC 2015/1/21 Checked. ASCANGAS 2015/1/22 extended to historical maximum output based on available PI data. KADAMEC 2015/2/9 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 64.16 | 0 | 0 |
| 64.16 | 11.79 | 0.954 |
| 64.16 | 23.58 | 0.9739 |
| 64.16 | 35.37 | 0.9799 |
| 64.16 | 47.16 | 0.9824 |
| 64.16 | 58.95 | 0.9833 |
| 64.16 | 64.16 | 0.9833 |

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Plant Flow Type

Plant: Rainbow

Name: MaxCap

Description: (Description)

Notes: BKROLAK 2015/1/15. KADAMEC 2015/2/9 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Cochrane

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Cochrane | Base_ReReg | Base | Base |

********************************************

Physical Settings

Plant: Cochrane

Name: Base_ReReg
Description: Base with Re Regulating option to all for ramping rates and with tailwater curve based on historical data.
Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Historical
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_ReReg

********************************************

Reservoir Storage
Plant: Cochrane
Name: Base
Description: "Base with 3116 entry removed for increasing volume with increasing elevation. From ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."

Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3090 | 3961 |
| 3091 | 4118 |
| 3092 | 4274 |
| 3093 | 4431 |
| 3094 | 4588 |
| 3094.8 | 4707 |
| 3095 | 4746 |
| 3096 | 4905 |
| 3097 | 5064 |
| 3098 | 5224 |
| 3099 | 5385 |
| 3100 | 5546 |
| 3101 | 5712 |
| 3102 | 5877 |
| 3103 | 6044 |
| 3104 | 6214 |
| 3105 | 6389 |
| 3106 | 6569 |
| 3107 | 6756 |
| 3108 | 6948 |
| 3109 | 7146 |
| 3110 | 7351 |
| 3111 | 7561 |
| 3112 | 7777 |
| 3113 | 7999 |
| 3114 | 8228 |
| 3115 | 8464 |
| 3115.8 | 8777 |
| 3117 | 8793 |
| 3118 | 9053 |

| | |
|---|---|
| 3119 | 9320 |
| 3120 | 9671 |

********************************************

Tailwater Curve

Plant: Cochrane

Name: Historical

Description: "Revised from Base from ""5 - Tailwater Rating Curves\COC TW EVALUATION.xls"" to align with historical data from ""CCH PI Avg Hourly.xlsx""."

Notes: KADAMEC 2015/1/21. BKROLAK 2015/1/22 Checked

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3032 | 0 |
| 3032.39 | 1156.13 |
| 3034 | 1850 |
| 3036 | 5000 |
| 3037 | 10000 |
| 3037.4 | 15669.56 |
| 3037.85 | 40000 |
| 3038.07 | 60000 |

********************************************

Spillway Curve

Plant: Cochrane

Name: Base

Description: "Base from ""4 - Spillway discharge rating curves\CCH DISCHARGE CAPABILITY.xls"". Flow capacity capped at 190,000 cfs, prior to changeover to orifice flow."

Notes: BKROLAK 2015/1/12. KADAMEC 2015/2/10 Checked

| Elevation (ft) | Flow (cfs) |
|---|---|
| 3094.75 | 0 |
| 3100 | 11000 |
| 3105 | 31000 |
| 3108.6 | 50000 |
| 3110 | 59000 |
| 3110.2 | 60000 |
| 3112.31 | 75000 |
| 3115 | 96154 |
| 3115.48 | 100000 |
| 3118.4 | 125000 |
| 3120 | 140000 |
| 3121.1 | 150000 |
| 3123.85 | 175000 |
| 3125 | 185577 |
| 3126 | 190000 |

********************************************

Plant Options

Plant: Cochrane

Name: Base_ReReg

Description: Base with Re-Reg option to all for ramping rates.

Notes: ASCANGAS 2015/2/10. KADAMEC 2015/2/10 Checked

| Min Powerhouse Flow | Plant Operation TypeDelinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 3120 |

*********************************************

Operation Settings

Plant: Cochrane
Name: Base
Description: Base condition post Rainbow upgrade.
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/20 checked. KADAMEC 2015/2/12 Checked again
Spill Elevations: 3120
Target Elevations: 3119.8
Minimum Elevations: 3110
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow:
Maximum Flow:
Max Flow from Elev:
Flashboards:

*********************************************

Spill Elevations

Plant: Cochrane
Name: 3120
Description: "Base from ""1 - Drawings\8_Cochrane\P-2188-1060, F-27, Cochrane Spillway Sections & Rating Curve, 09-27-2000.TIF""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3120 |
| 31-Dec | 3120 |

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Target Elevations

Plant: Cochrane
Name: 3119.8
Description: Near full pond 3120 for peaking post Rainbow upgrade.
Notes: BKROLAK 2015/1/12. KADAMEC 2015/2/12 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3119.8 |
| 31-Dec | 3119.8 |

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Minimum Elevations

Plant: Cochrane
Name: 3110
Description: "10 foot peaking pool from ""Cochrane License Application Exhibit B Excerpt.pdf""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3110 |
| 31-Dec | 3110 |

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Generation Settings

Plant: Cochrane
Name: Base
Description: "Unit performance from index tests conducted in 2005, and extended for full operational head range."
Notes: BKROLAK 2015/1/15. KADAMEC 2015/2/10 Checked
Powerhouse Setup: Base_HD_Final
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

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Powerhouse Setup

Plant: Cochrane
Name: Base_HD_Final
Description: "Unit performance from index tests conducted in 2005, Lower bound of turbine inputs extended. Rev2 turbines added 2015-02-03."
Notes: BKROLAK 2015/1/15. KADAMEC 2015/1/21 Checked. BKROLAK 2015/1/22. KADAMEC 2015/2/9 Checked
Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 2units | U1_HD_Rev1 | "U1,2" | 0 |
| 2 | 2units | U2_HD_Rev1 | "U1,2" | 0 |

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Turbine Efficiency Curves

Plant: Cochrane
Name: U1_HD_Rev1
Description: "From ""Cochrane Index testing\Index Test Report.pdf"" with performance calibrated to hisotircal PI and daily records."
Notes: BKROLAK 2015/2/3. ASCANGAS 2015/2/5. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 73 | 1820.32 | 0.836 |
| 73 | 2217.61 | 0.858 |
| 73 | 2992.22 | 0.87 |
| 73 | 3707.51 | 0.868 |
| 73 | 4513.17 | 0.853 |
| 73 | 5152.13 | 0.822 |
| 76.5 | 1863.45 | 0.836 |
| 76.5 | 2270.15 | 0.858 |
| 76.5 | 3063.11 | 0.87 |
| 76.5 | 3795.35 | 0.868 |
| 76.5 | 4620.09 | 0.853 |
| 76.5 | 5274.2 | 0.822 |
| 80 | 1905.6 | 0.836 |
| 80 | 2321.5 | 0.858 |
| 80 | 3132.4 | 0.87 |
| 80 | 3881.2 | 0.868 |

| | | |
|---|---|---|
| 80 | 4724.6 | 0.853 |
| 80 | 5393.5 | 0.822 |
| 81 | 1917.47 | 0.836 |
| 81 | 2335.96 | 0.858 |
| 81 | 3151.92 | 0.87 |
| 81 | 3905.38 | 0.868 |
| 81 | 4754.04 | 0.853 |
| 81 | 5427.1 | 0.822 |
| 82 | 1929.27 | 0.836 |
| 82 | 2350.34 | 0.858 |
| 82 | 3171.31 | 0.87 |
| 82 | 3929.42 | 0.868 |
| 82 | 4783.29 | 0.853 |
| 82 | 5460.5 | 0.822 |

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Turbine Efficiency Curves
Plant: Cochrane
Name: U2_HD_Rev1
Description: "From ""Cochrane Index testing\Index Test Report.pdf"" with performance calibrated to hisotircal PI and daily records."
Notes: BKROLAK 2015/2/3. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 73 | 1390.75 | 0.801 |
| 73 | 1844.2 | 0.873 |
| 73 | 2470.85 | 0.88 |
| 73 | 3292.84 | 0.8745 |
| 73 | 4026.37 | 0.869 |
| 73 | 4863.84 | 0.838 |
| 73 | 5560.69 | 0.784 |
| 76.5 | 1423.7 | 0.801 |
| 76.5 | 1887.9 | 0.873 |
| 76.5 | 2529.39 | 0.88 |
| 76.5 | 3370.85 | 0.8745 |
| 76.5 | 4121.77 | 0.869 |
| 76.5 | 4979.07 | 0.838 |
| 76.5 | 5692.44 | 0.784 |
| 80 | 1455.9 | 0.801 |
| 80 | 1930.6 | 0.873 |
| 80 | 2586.6 | 0.88 |
| 80 | 3447.1 | 0.8745 |
| 80 | 4215 | 0.869 |
| 80 | 5091.7 | 0.838 |
| 80 | 5821.2 | 0.784 |
| 81 | 1464.97 | 0.801 |
| 81 | 1942.63 | 0.873 |
| 81 | 2602.72 | 0.88 |
| 81 | 3468.58 | 0.8745 |
| 81 | 4241.26 | 0.869 |
| 81 | 5123.42 | 0.838 |
| 81 | 5857.47 | 0.784 |
| 82 | 1473.99 | 0.801 |
| 82 | 1954.58 | 0.873 |
| 82 | 2618.73 | 0.88 |

| | | |
|---|---|---|
| 82 | 3489.92 | 0.8745 |
| 82 | 4267.36 | 0.869 |
| 82 | 5154.95 | 0.838 |
| 82 | 5893.52 | 0.784 |

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Generator Efficiency Curves

Plant: Cochrane

Name: "U1,2"

Description: "From ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx""."

Notes: BKROLAK 2015/1/15. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 35.5 | 0 | 0 |
| 35.5 | 7.1 | 0.9539 |
| 35.5 | 14.2 | 0.9747 |
| 35.5 | 21.3 | 0.9809 |
| 35.5 | 28.4 | 0.9836 |
| 35.5 | 35.5 | 0.9847 |

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Plant Flow Type

Plant: Cochrane

Name: MaxCap

Description: (Description)

Notes: BKROLAK 2015/1/22. KADAMEC 2015/2/9 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Ryan

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Ryan | Base_ReReg | Base | Base_Post2013 |

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Physical Settings

Plant: Ryan

Name: Base_ReReg

Description: Base with Re Regulating option to all for ramping rates.

Notes: BKROLAK 2015/1/13. KADAMEC 2015/2/10 Checked

Reservoir Storage: Base

Reservoir Area:

Monthly Evaporation:

Tailwater Curve: Base

Spillway Curve: Base

Low Level Outlet:

Alt. Spillway:

Alt. Tailwater Curve:

Ramp Rating Curve:

Plant Options: Base_ReReg

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Reservoir Storage

Plant: Ryan

Name: Base

Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."

Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 3020 | 1213 |
| 3021 | 1338 |
| 3022 | 1465 |
| 3023 | 1594 |
| 3024 | 1723 |
| 3025 | 1854 |
| 3026 | 1985 |
| 3027 | 2123 |
| 3028 | 2262 |
| 3029 | 2403 |
| 3030 | 2548 |
| 3031 | 2697 |
| 3032 | 2847 |
| 3033 | 3000 |
| 3034 | 3157 |
| 3035 | 3317 |
| 3036 | 3484 |
| 3037 | 3653 |
| 3038 | 3825 |
| 3039 | 4004 |
| 3040 | 4243 |

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Tailwater Curve

Plant: Ryan

Name: Base

Description: "Base from ""5 - Tailwater Rating Curves\RYN Powerhouse Tailwater.xls""."

Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2883.7 | 400 |
| 2884.2 | 800 |
| 2884.8 | 1200 |
| 2885.1 | 1600 |
| 2885.6 | 2000 |
| 2886.1 | 2400 |
| 2886.5 | 2800 |
| 2887 | 3200 |
| 2887.4 | 3600 |
| 2888 | 4000 |
| 2888.3 | 4400 |
| 2888.8 | 4800 |
| 2889.2 | 5200 |
| 2889.6 | 5600 |
| 2890 | 6000 |

| | |
|---|---|
| 2890.3 | 6400 |
| 2891.2 | 7200 |
| 2891.9 | 8000 |
| 2893.1 | 9200 |
| 2893.8 | 10000 |
| 2894 | 10400 |
| 2895.1 | 11600 |
| 2895.4 | 12000 |
| 2896.1 | 12800 |
| 2897 | 14000 |
| 2897.9 | 15200 |
| 2898.5 | 16000 |
| 2899.05 | 16800 |
| 2899.9 | 18000 |
| 2900.1 | 18400 |
| 2900.3 | 18800 |
| 2900.9 | 19600 |
| 2901.1 | 20000 |
| 2901.9 | 21200 |
| 2902.1 | 21600 |
| 2902.3 | 22000 |
| 2903.05 | 23200 |
| 2903.5 | 24000 |
| 2904 | 24800 |
| 2904.6 | 26000 |
| 2905 | 26800 |
| 2905.6 | 28000 |
| 2906.05 | 28800 |
| 2906.6 | 30000 |
| 2907.6 | 32000 |
| 2908.4 | 34000 |
| 2909.09 | 36000 |
| 2909.74 | 38000 |
| 2910.36 | 40000 |
| 2910.95 | 42000 |
| 2911.51 | 44000 |
| 2912.05 | 46000 |
| 2912.56 | 48000 |
| 2913.06 | 50000 |
| 2913.53 | 52000 |
| 2913.99 | 54000 |
| 2914.43 | 56000 |
| 2914.85 | 58000 |
| 2915.26 | 60000 |
| 2915.66 | 62000 |
| 2916.04 | 64000 |
| 2916.42 | 66000 |
| 2916.78 | 68000 |
| 2917.13 | 70000 |
| 2917.47 | 72000 |

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Spillway Curve

Plant: Ryan

Name: Base
Description: "Base with low level outlet, waste gates and spillways from ""4 - Spillway discharge rating curves\RYN DISCHARGE CAPABILITY.xls"" with plant flow removed and 0 flow value set at centerline of low level outlet per ""1 - Drawings\9_Ryan\P-2188-1070, F-14, Ryan Waste Gate Plan, Section. Detail & Rating Curve, 09-27-2000.TIF""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2971 | 0 |
| 3023 | 14100 |
| 3024 | 18385.71 |
| 3025 | 19100 |
| 3026 | 26957.14 |
| 3027 | 28385.71 |
| 3028 | 35528.57 |
| 3029 | 38385.71 |
| 3030 | 44528.57 |
| 3031 | 51242.86 |
| 3033 | 55528.57 |
| 3034 | 64100 |
| 3035 | 66957.14 |
| 3036 | 77671.43 |
| 3037 | 79814.29 |
| 3038 | 92671.43 |
| 3039 | 93385.71 |
| 3040 | 107480.28 |
| 3041 | 122973.24 |
| 3041.6 | 124381.69 |
| 3042 | 140578.87 |
| 3043 | 142691.55 |

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Plant Options

Plant: Ryan
Name: Base_ReReg
Description: Base with Re-Reg option to all for ramping rates.
Notes: BKROLAK 2015/2/10. KADAMEC 2015/2/10 Checked

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 3037 |

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Operation Settings

Plant: Ryan
Name: Base
Description: Base conditions.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.
Spill Elevations: 3037
Target Elevations: 3036.8
Minimum Elevations: 3018.6
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:

Minimum Daily Average Flow:
Recreation Flows: 200Falls
Bypass Flow:
Maximum Flow:
Max Flow from Elev:
Flashboards:

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Spill Elevations
Plant: Ryan
Name: 3037
Description: "Top of flashboards per ""1 - Drawings\9_Ryan\P-2188-1067, F-11, Ryan Spillway Plan, Section & Details, Rating Curve, 09-27-2000.PDF""."

Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3037 |
| 31-Dec | 3037 |

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Target Elevations
Plant: Ryan
Name: 3036.8
Description: Two tenths of a foot below full pool.
Notes: ASCANGAS 2015/1/25. KADAMEC 2015/2/12 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3036.8 |
| 31-Dec | 3036.8 |

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Minimum Elevations
Plant: Ryan
Name: 3018.6
Description: "Lowest observed 1988 to 2014 from ""HDB RYN 198801 to 201411.xlsx""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 3018.6 |
| 31-Dec | 3018.6 |

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Recreation Flows
Plant: Ryan
Name: 200Falls
Description: "Spill min 200cfs 9am-8pm on weekends/holidays Mem day to Labor day, except when Apr-Jun runoff into Canyon Ferr < 900 kaf (50% of 1961 to 1990 average) per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/12. ASCANGAS 2015/1/20 checked.

| Calendar Day | Day of Week | Flow (cfs) | Start Hour | End Hour | Use Plant Discharge | Only When PH Off | Use Custom Schedule |
|---|---|---|---|---|---|---|---|
| 1-Jan | 0 | 0 | 1 | 24 | FALSE | FALSE | FALSE |
| 24-May | 1 | 200 | 9 | 20 | FALSE | FALSE | FALSE |
| 24-May | 7 | 200 | 9 | 20 | FALSE | FALSE | FALSE |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10-Sep | 0 | 0 | 1 | 24 | FALSE | FALSE | FALSE |

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Generation Settings

Plant: Ryan

Name: Base_Post2013

Description: "Turbines are generator limited. Post upgrade of units 2, 4, 5."

Notes: BKROLAK 2015/1/16. ASCANGAS 2015/1/22. KADAMEC 2015/2/10 Checked

Powerhouse Setup: Base_Post2013_Rev1

Powerhouse Weekend Ops:

Maintenance Schedule:

Minimum Flow Unit:

Plant Flow Type: MaxCap

Limit Off Peak Gen:

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Powerhouse Setup

Plant: Ryan

Name: Base_Post2013_Rev1

Description: "6 unit powerhouse. No headloss component. Ryan runner upgrades - #2 in 12/2012, #4 in 3/2012, #5 in 12/2013. Comments from assessments state gate leakage exists. Older unit efficiencies reduced to calibrate to historical PI and daily operations data."

Notes: ASCANGAS 2015/2/5. KADAMEC 2015/2/9 Checked

Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 6units | "U1,6_Rev1" | "U1,3,6_10.2" | 0 |
| 2 | 6units | "U2,4,5_Rev1" | "U2,4,5_12" | 0 |
| 3 | 6units | U3_Rev1 | "U1,3,6_10.2" | 0 |
| 4 | 6units | "U2,4,5_Rev1" | "U2,4,5_12" | 0 |
| 5 | 6units | "U2,4,5_Rev1" | "U2,4,5_12" | 0 |
| 6 | 6units | "U1,6_Rev1" | "U1,3,6_10.2" | 0 |

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Turbine Efficiency Curves

Plant: Ryan

Name: "U1,6_Rev1"

Description: "Units 1, 6. Representing 13,500 (U3, 6) and 15,000 (U1) HP turbines. Data computed from PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". U 3 has same turbine but is limited operation below 9MW due to vibration per ""8 - Power Plant Eq Performance Data\Performance Verification Data\Important Operational Information on Ryan #3.msg"". Efficiency reduced to calibrate to historic."

Notes: ASCANGAS 2015/2/6. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 135 | 231.48 | 0.3463 |
| 135 | 298.84 | 0.473 |
| 135 | 369.99 | 0.5745 |
| 135 | 443.04 | 0.6391 |
| 135 | 517.03 | 0.6858 |
| 135 | 591.98 | 0.7191 |
| 135 | 667.87 | 0.7443 |
| 135 | 743.77 | 0.7642 |
| 135 | 819.66 | 0.7807 |
| 135 | 896.51 | 0.7934 |
| 135 | 977.14 | 0.8011 |

| | | |
|---|---|---|
| 142.5 | 237.82 | 0.3463 |
| 142.5 | 307.02 | 0.473 |
| 142.5 | 380.12 | 0.5745 |
| 142.5 | 455.18 | 0.6391 |
| 142.5 | 531.2 | 0.6858 |
| 142.5 | 608.2 | 0.7191 |
| 142.5 | 686.17 | 0.7443 |
| 142.5 | 764.15 | 0.7642 |
| 142.5 | 842.12 | 0.7807 |
| 142.5 | 921.07 | 0.7934 |
| 142.5 | 1003.92 | 0.8011 |
| 150 | 244 | 0.3463 |
| 150 | 315 | 0.473 |
| 150 | 390 | 0.5745 |
| 150 | 467 | 0.6391 |
| 150 | 545 | 0.6858 |
| 150 | 624 | 0.7191 |
| 150 | 704 | 0.7443 |
| 150 | 784 | 0.7642 |
| 150 | 864 | 0.7807 |
| 150 | 945 | 0.7934 |
| 150 | 1030 | 0.8011 |
| 152.5 | 246.02 | 0.3463 |
| 152.5 | 317.61 | 0.473 |
| 152.5 | 393.24 | 0.5745 |
| 152.5 | 470.88 | 0.6391 |
| 152.5 | 549.52 | 0.6858 |
| 152.5 | 629.18 | 0.7191 |
| 152.5 | 709.84 | 0.7443 |
| 152.5 | 790.51 | 0.7642 |
| 152.5 | 871.17 | 0.7807 |
| 152.5 | 952.84 | 0.7934 |
| 152.5 | 1038.55 | 0.8011 |
| 155 | 248.03 | 0.3463 |
| 155 | 320.21 | 0.473 |
| 155 | 396.45 | 0.5745 |
| 155 | 474.72 | 0.6391 |
| 155 | 554.01 | 0.6858 |
| 155 | 634.31 | 0.7191 |
| 155 | 715.64 | 0.7443 |
| 155 | 796.96 | 0.7642 |
| 155 | 878.28 | 0.7807 |
| 155 | 960.62 | 0.7934 |
| 155 | 1047.03 | 0.8011 |

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Turbine Efficiency Curves

Plant: Ryan

Name: "U2,4,5_Rev1"

Description: "Unit 2, 4, 5. 17,800 HP units. Ryan runner upgrades - #2 in 12/2012, #4 in 3/2012, #5 in 12/2013. Per ""8 - Power Plant Eq Performance Data\Major operational upgrades.docx"". Computations from PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". Calibrated to historical PI and daily operations data."

Notes: ASCANGAS 2015/2/6. KADAMEC 2015/2/9 Checked

Head (ft) Flow (cfs) Efficiency

| | | |
|---|---|---|
| 135 | 265.63 | 0.2758 |
| 135 | 322.55 | 0.462 |
| 135 | 351.01 | 0.6103 |
| 135 | 398.45 | 0.7198 |
| 135 | 474.34 | 0.7532 |
| 135 | 550.24 | 0.7791 |
| 135 | 616.64 | 0.8113 |
| 135 | 692.54 | 0.8254 |
| 135 | 758.95 | 0.8478 |
| 135 | 891.76 | 0.8829 |
| 135 | 958.17 | 0.8968 |
| 135 | 1043.55 | 0.8918 |
| 142.5 | 272.91 | 0.2758 |
| 142.5 | 331.39 | 0.462 |
| 142.5 | 360.63 | 0.6103 |
| 142.5 | 409.37 | 0.7198 |
| 142.5 | 487.34 | 0.7532 |
| 142.5 | 565.31 | 0.7791 |
| 142.5 | 633.54 | 0.8113 |
| 142.5 | 711.52 | 0.8254 |
| 142.5 | 779.74 | 0.8478 |
| 142.5 | 916.2 | 0.8829 |
| 142.5 | 984.43 | 0.8968 |
| 142.5 | 1072.15 | 0.8918 |
| 150 | 280 | 0.2758 |
| 150 | 340 | 0.462 |
| 150 | 370 | 0.6103 |
| 150 | 420 | 0.7198 |
| 150 | 500 | 0.7532 |
| 150 | 580 | 0.7791 |
| 150 | 650 | 0.8113 |
| 150 | 730 | 0.8254 |
| 150 | 800 | 0.8478 |
| 150 | 940 | 0.8829 |
| 150 | 1010 | 0.8968 |
| 150 | 1100 | 0.8918 |
| 152.5 | 282.32 | 0.2758 |
| 152.5 | 342.82 | 0.462 |
| 152.5 | 373.07 | 0.6103 |
| 152.5 | 423.49 | 0.7198 |
| 152.5 | 504.15 | 0.7532 |
| 152.5 | 584.81 | 0.7791 |
| 152.5 | 655.39 | 0.8113 |
| 152.5 | 736.06 | 0.8254 |
| 152.5 | 806.64 | 0.8478 |
| 152.5 | 947.8 | 0.8829 |
| 152.5 | 1018.38 | 0.8968 |
| 152.5 | 1109.13 | 0.8918 |
| 155 | 284.63 | 0.2758 |
| 155 | 345.62 | 0.462 |
| 155 | 376.12 | 0.6103 |
| 155 | 426.94 | 0.7198 |
| 155 | 508.27 | 0.7532 |
| 155 | 589.59 | 0.7791 |

| | | |
|---|---|---|
| 155 | 660.74 | 0.8113 |
| 155 | 742.07 | 0.8254 |
| 155 | 813.22 | 0.8478 |
| 155 | 955.54 | 0.8829 |
| 155 | 1026.7 | 0.8968 |
| 155 | 1118.18 | 0.8918 |

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Turbine Efficiency Curves

Plant: Ryan

Name: U3_Rev1

Description: "Unit 3. Representing 13,500 (U3) HP turbine. Data computed from PCS curves in ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". U 3 has same turbine as U6 but is limited operation below 9MW due to vibration per ""8 - Power Plant Eq Performance Data\Performance Verification Data\Important Operational Information on Ryan #3.msg"". 916 cfs at rated head equals 9MW generator output. With Efficiency reduced to calibrate to historical operations data."

Notes: ASCANGAS 2015/2/6. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 135 | 869.45 | 0.789 |
| 135 | 896.51 | 0.7934 |
| 135 | 977.14 | 0.8011 |
| 142.5 | 893.28 | 0.789 |
| 142.5 | 921.07 | 0.7934 |
| 142.5 | 1003.92 | 0.8011 |
| 150 | 916 | 0.789 |
| 150 | 945 | 0.7934 |
| 150 | 1030 | 0.8011 |
| 152.5 | 924.09 | 0.789 |
| 152.5 | 952.84 | 0.7934 |
| 152.5 | 1038.55 | 0.8011 |
| 155 | 931.63 | 0.789 |
| 155 | 960.62 | 0.7934 |
| 155 | 1047.03 | 0.8011 |

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Generator Efficiency Curves

Plant: Ryan

Name: "U1,3,6_10.2"

Description: "From curves in ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"". 0.9MW entry added for smoothing turbine efficiencies."

Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 10.2 | 0 | 0 |
| 10.2 | 0.9 | 0.8 |
| 10.2 | 2 | 0.9614 |
| 10.2 | 4.1 | 0.9793 |
| 10.2 | 6.1 | 0.9846 |
| 10.2 | 8.2 | 0.9869 |
| 10.2 | 10.2 | 0.9879 |

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Generator Efficiency Curves

Plant: Ryan

Name: "U2,4,5_12"

Description: "From curves in ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"". U2 rewound 1989, U4 rewound 2009. Values for 0.9MW and 1.9MW added for turbine efficiency smoothing. Unit 5 simulated with this generator based on PI data."
Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 12 | 0 | 0 |
| 12 | 0.9 | 0.86 |
| 12 | 1.9 | 0.89 |
| 12 | 2.4 | 0.9625 |
| 12 | 4.8 | 0.9798 |
| 12 | 7.2 | 0.9849 |
| 12 | 9.6 | 0.9871 |
| 12 | 12 | 0.988 |

*********************************************
Plant Flow Type
Plant: Ryan
Name: MaxCap
Description: Max Capacity option.
Notes: BKROLAK 2015/1/16. KADAMEC 2015/2/9 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Morony

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Morony | Base_ReReg | Base | Base |

*********************************************
Physical Settings
Plant: Morony
Name: Base_ReReg
Description: Base conditions with ReRegulating option and with tailwater curve based on historical data.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked. KADAMEC 2015/1/21. BKROLAK 2015/1/22 TW Checked. KADAMEC 2015/2/10 Checked

Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Historical
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_ReReg

*********************************************
Reservoir Storage
Plant: Morony
Name: Base

Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 2861 | 6003 |
| 2862 | 6291 |
| 2863 | 6578 |
| 2864 | 6866 |
| 2865 | 7153 |
| 2866 | 7443 |
| 2867 | 7733 |
| 2868 | 8022 |
| 2869 | 8312 |
| 2870 | 8601 |
| 2871 | 8891 |
| 2872 | 9181 |
| 2873 | 9470 |
| 2874 | 9760 |
| 2875 | 10049 |
| 2876 | 10341 |
| 2877 | 10632 |
| 2878 | 10924 |
| 2879 | 11216 |
| 2880 | 11507 |
| 2881 | 11801 |
| 2882 | 12096 |
| 2883 | 12394 |
| 2884 | 12693 |
| 2885 | 12995 |
| 2886 | 13296 |
| 2887 | 13598 |
| 2888 | 13899 |
| 2889 | 14201 |
| 2890 | 14502 |

*********************************************

Tailwater Curve

Plant: Morony
Name: Historical
Description: "Elevation lowered by 2"" for the same flows from ""5 - Tailwater Rating Curves\MNY Powerhouse Tailwater.xls"" to align with historical data reported in ""MRN PI Avg Hourly.xlsx""."

Notes: KADAMEC 2015/1/21. BKROLAK 2015/1/22 Checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2799 | 0 |
| 2800.55 | 2000 |
| 2801.4 | 4000 |
| 2802 | 6000 |
| 2802.41 | 8000 |
| 2802.78 | 10000 |
| 2803.05 | 12000 |
| 2803.34 | 14000 |
| 2803.56 | 16000 |
| 2803.8 | 18000 |

| | |
|---|---|
| 2804 | 20000 |
| 2804.13 | 22000 |
| 2804.3 | 24000 |
| 2804.42 | 26000 |
| 2804.58 | 28000 |
| 2804.7 | 30000 |
| 2804.8 | 32000 |
| 2804.93 | 34000 |
| 2805.02 | 36000 |
| 2805.11 | 38000 |
| 2805.19 | 40000 |
| 2805.27 | 42000 |
| 2805.34 | 44000 |
| 2805.41 | 46000 |
| 2805.48 | 48000 |
| 2805.54 | 50000 |
| 2805.61 | 52000 |
| 2805.67 | 54000 |
| 2805.73 | 56000 |
| 2805.78 | 58000 |
| 2805.84 | 60000 |
| 2805.89 | 62000 |
| 2805.94 | 64000 |
| 2805.99 | 66000 |
| 2806.03 | 68000 |
| 2806.08 | 70000 |
| 2806.13 | 72000 |

*********************************************

Spillway Curve

Plant: Morony

Name: Base

Description: "Base condition computed from Trash Gate capacity and 9 radial gate capacities. From ""4 - Spillway discharge rating curves\MNY DISCHARGE CAPABILITY.xls"""

Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/10 Checked

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2864 | 0 |
| 2865 | 900 |
| 2866 | 2700 |
| 2868 | 9450 |
| 2870 | 18000 |
| 2872 | 28890 |
| 2874 | 41400 |
| 2876 | 54900 |
| 2878 | 70200 |
| 2880 | 87426 |
| 2887 | 150945 |
| 2888.55 | 160662 |
| 2890.35 | 169163 |
| 2892 | 177521 |

*********************************************

Plant Options

Plant: Morony
Name: Base_ReReg
Description: Reregulating plant.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 3 | FALSE | TRUE | 0 | 2888 |

*******************************************
Operation Settings
Plant: Morony
Name: Base
Description: Base operations with minimum elevation set at maximum drawdown during rereg operations.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked. BKROLAK 2015/2/12 Ramping rates added. ASCANGAS 2015/2/12 checked.

Spill Elevations: 2888
Target Elevations: 2886.2
Minimum Elevations: 2878
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates: Base
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow:
Maximum Flow:
Max Flow from Elev:
Flashboards:

*******************************************
Spill Elevations
Plant: Morony
Name: 2888
Description: "Maximum elevation during rereg and baseload operations per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 2888 |
| 31-Dec | 2888 |

*******************************************
Target Elevations
Plant: Morony
Name: 2886.2
Description: "50th percentile of historical 1988 to 2014 operations, ""HDB MRN 198801 to 201411.xlsx""."
Notes: BKROLAK 2015/1/13. Checked KADAMEC 2015/1/19

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 2886.2 |
| 31-Dec | 2886.2 |

*********************************************

Minimum Elevations

Plant: Morony
Name: 2878
Description: "Minimum drawdown during reregulating operations per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 2878 |
| 31-Dec | 2878 |

*********************************************

Tailwater Ramping Rates

Plant: Morony
Name: Base
Description: "Per ""NWEhydrooperationsplan.docx"". 6) 10pct diff from inflow to BLE (MRN outflow plus delta storage BLE, RNB, CCH, RYN, MRN). 7) Highest hourly flow to lowest hourly flow is no more than sum of 15pct of previous day""s average flow and difference between highest and lowest inflows to BLE for yesterday or today. 8) hourly average flow change no more than 7.5pct."

Notes: BKROLAK 2015/2/12. ASCANGAS 2015/2/12 checked.

| Constrained by Stage | Calendar Day | Hourly Rate Up (units/hr) | Daily Rate Up (units/day) | Hourly Rate Down (units/hr) | Daily Rate Down (units/day) | Use Hrly Min/Max | Houly Min/Max Difference | Reference Plant |
|---|---|---|---|---|---|---|---|---|
| FALSE | 1 | 0.075 | 0.1 | 0.075 | 0.1 | TRUE | 0.15 | 6 |

*********************************************

Generation Settings

Plant: Morony
Name: Base
Description: Base
Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/10 Checked
Powerhouse Setup: Base
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

*********************************************

Powerhouse Setup

Plant: Morony
Name: Base
Description: Base powerhouse.
Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked
Dispatched: TRUE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 2units | U1 | "U1,2_25" | 0 |
| 2 | 2units | U2 | "U1,2_25" | 0 |

*********************************************

Turbine Efficiency Curves

Plant: Morony
Name: U1

Description: "Unit 1 from PCS curves ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". From ""10Morony_U1.xlsm""."

Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 67 | 601.97 | 0.354 |
| 67 | 700.8 | 0.4865 |
| 67 | 799.63 | 0.5329 |
| 67 | 898.46 | 0.6181 |
| 67 | 998.19 | 0.6812 |
| 67 | 1111.39 | 0.7298 |
| 67 | 1233.58 | 0.7625 |
| 67 | 1355.77 | 0.7882 |
| 67 | 1483.36 | 0.8057 |
| 67 | 2191.34 | 0.8968 |
| 67 | 2318.92 | 0.9032 |
| 67 | 2443.81 | 0.9099 |
| 67 | 2577.68 | 0.9127 |
| 67 | 2720.53 | 0.9121 |
| 67 | 2875.07 | 0.908 |
| 67 | 3068.24 | 0.8931 |
| 67 | 3294.65 | 0.871 |
| 67 | 3517.47 | 0.8527 |
| 67 | 3799.58 | 0.8234 |
| 67 | 4357.53 | 0.7478 |
| 75 | 636.89 | 0.354 |
| 75 | 741.46 | 0.4865 |
| 75 | 846.02 | 0.5329 |
| 75 | 950.59 | 0.6181 |
| 75 | 1056.1 | 0.6812 |
| 75 | 1175.88 | 0.7298 |
| 75 | 1305.16 | 0.7625 |
| 75 | 1434.43 | 0.7882 |
| 75 | 1569.42 | 0.8057 |
| 75 | 2318.48 | 0.8968 |
| 75 | 2453.46 | 0.9032 |
| 75 | 2585.59 | 0.9099 |
| 75 | 2727.23 | 0.9127 |
| 75 | 2878.38 | 0.9121 |
| 75 | 3041.88 | 0.908 |
| 75 | 3246.25 | 0.8931 |
| 75 | 3485.8 | 0.871 |
| 75 | 3721.55 | 0.8527 |
| 75 | 4020.03 | 0.8234 |
| 75 | 4610.34 | 0.7478 |
| 83 | 670 | 0.354 |
| 83 | 780 | 0.4865 |
| 83 | 890 | 0.5329 |
| 83 | 1000 | 0.6181 |
| 83 | 1111 | 0.6812 |
| 83 | 1237 | 0.7298 |
| 83 | 1373 | 0.7625 |
| 83 | 1509 | 0.7882 |
| 83 | 1651 | 0.8057 |

| | | |
|---|---|---|
| 83 | 2439 | 0.8968 |
| 83 | 2581 | 0.9032 |
| 83 | 2720 | 0.9099 |
| 83 | 2869 | 0.9127 |
| 83 | 3028 | 0.9121 |
| 83 | 3200 | 0.908 |
| 83 | 3415 | 0.8931 |
| 83 | 3667 | 0.871 |
| 83 | 3915 | 0.8527 |
| 83 | 4229 | 0.8234 |
| 83 | 4850 | 0.7478 |
| 85.5 | 680.02 | 0.354 |
| 85.5 | 791.66 | 0.4865 |
| 85.5 | 903.3 | 0.5329 |
| 85.5 | 1014.95 | 0.6181 |
| 85.5 | 1127.61 | 0.6812 |
| 85.5 | 1255.49 | 0.7298 |
| 85.5 | 1393.52 | 0.7625 |
| 85.5 | 1531.56 | 0.7882 |
| 85.5 | 1675.68 | 0.8057 |
| 85.5 | 2475.46 | 0.8968 |
| 85.5 | 2619.58 | 0.9032 |
| 85.5 | 2760.66 | 0.9099 |
| 85.5 | 2911.89 | 0.9127 |
| 85.5 | 3073.26 | 0.9121 |
| 85.5 | 3247.84 | 0.908 |
| 85.5 | 3466.05 | 0.8931 |
| 85.5 | 3721.82 | 0.871 |
| 85.5 | 3973.52 | 0.8527 |
| 85.5 | 4292.22 | 0.8234 |
| 85.5 | 4922.5 | 0.7478 |
| 88 | 689.89 | 0.354 |
| 88 | 803.15 | 0.4865 |
| 88 | 916.42 | 0.5329 |
| 88 | 1029.68 | 0.6181 |
| 88 | 1143.97 | 0.6812 |
| 88 | 1273.71 | 0.7298 |
| 88 | 1413.75 | 0.7625 |
| 88 | 1553.79 | 0.7882 |
| 88 | 1700 | 0.8057 |
| 88 | 2511.39 | 0.8968 |
| 88 | 2657.6 | 0.9032 |
| 88 | 2800.73 | 0.9099 |
| 88 | 2954.15 | 0.9127 |
| 88 | 3117.87 | 0.9121 |
| 88 | 3294.98 | 0.908 |
| 88 | 3516.36 | 0.8931 |
| 88 | 3775.84 | 0.871 |
| 88 | 4031.2 | 0.8527 |
| 88 | 4354.52 | 0.8234 |
| 88 | 4993.95 | 0.7478 |

*********************************************

Turbine Efficiency Curves

Plant: Morony
Name: U2
Description: "Unit 2 from PCS curves ""8 - Power Plant Eq Performance Data\PCS_MW_vs_Flow_GUptmor.xlsx"". From ""10Morony_U2.xlsm""."

Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 67 | 601.97 | 0.354 |
| 67 | 700.8 | 0.4865 |
| 67 | 799.63 | 0.5329 |
| 67 | 898.46 | 0.6181 |
| 67 | 965.84 | 0.704 |
| 67 | 1072.76 | 0.756 |
| 67 | 1197.65 | 0.7854 |
| 67 | 1325.23 | 0.8063 |
| 67 | 1450.11 | 0.8241 |
| 67 | 2191.34 | 0.8968 |
| 67 | 2318.92 | 0.9032 |
| 67 | 2443.81 | 0.9099 |
| 67 | 2566.9 | 0.9165 |
| 67 | 2698.97 | 0.9194 |
| 67 | 2852.61 | 0.9151 |
| 67 | 3018.82 | 0.9077 |
| 67 | 3213.79 | 0.893 |
| 67 | 3458.17 | 0.8673 |
| 67 | 3766.34 | 0.8307 |
| 67 | 4357.53 | 0.7478 |
| 75 | 636.89 | 0.354 |
| 75 | 741.46 | 0.4865 |
| 75 | 846.02 | 0.5329 |
| 75 | 950.59 | 0.6181 |
| 75 | 1021.88 | 0.704 |
| 75 | 1135 | 0.756 |
| 75 | 1267.13 | 0.7854 |
| 75 | 1402.11 | 0.8063 |
| 75 | 1534.25 | 0.8241 |
| 75 | 2318.48 | 0.8968 |
| 75 | 2453.46 | 0.9032 |
| 75 | 2585.59 | 0.9099 |
| 75 | 2715.83 | 0.9165 |
| 75 | 2855.56 | 0.9194 |
| 75 | 3018.11 | 0.9151 |
| 75 | 3193.97 | 0.9077 |
| 75 | 3400.25 | 0.893 |
| 75 | 3658.81 | 0.8673 |
| 75 | 3984.86 | 0.8307 |
| 75 | 4610.34 | 0.7478 |
| 83 | 670 | 0.354 |
| 83 | 780 | 0.4865 |
| 83 | 890 | 0.5329 |
| 83 | 1000 | 0.6181 |
| 83 | 1075 | 0.704 |
| 83 | 1194 | 0.756 |
| 83 | 1333 | 0.7854 |

| | | |
|---|---|---|
| 83 | 1475 | 0.8063 |
| 83 | 1614 | 0.8241 |
| 83 | 2439 | 0.8968 |
| 83 | 2581 | 0.9032 |
| 83 | 2720 | 0.9099 |
| 83 | 2857 | 0.9165 |
| 83 | 3004 | 0.9194 |
| 83 | 3175 | 0.9151 |
| 83 | 3360 | 0.9077 |
| 83 | 3577 | 0.893 |
| 83 | 3849 | 0.8673 |
| 83 | 4192 | 0.8307 |
| 83 | 4850 | 0.7478 |
| 85.5 | 680.02 | 0.354 |
| 85.5 | 791.66 | 0.4865 |
| 85.5 | 903.3 | 0.5329 |
| 85.5 | 1014.95 | 0.6181 |
| 85.5 | 1091.07 | 0.704 |
| 85.5 | 1211.85 | 0.756 |
| 85.5 | 1352.93 | 0.7854 |
| 85.5 | 1497.05 | 0.8063 |
| 85.5 | 1638.13 | 0.8241 |
| 85.5 | 2475.46 | 0.8968 |
| 85.5 | 2619.58 | 0.9032 |
| 85.5 | 2760.66 | 0.9099 |
| 85.5 | 2899.71 | 0.9165 |
| 85.5 | 3048.91 | 0.9194 |
| 85.5 | 3222.46 | 0.9151 |
| 85.5 | 3410.23 | 0.9077 |
| 85.5 | 3630.47 | 0.893 |
| 85.5 | 3906.54 | 0.8673 |
| 85.5 | 4254.66 | 0.8307 |
| 85.5 | 4922.5 | 0.7478 |
| 88 | 689.89 | 0.354 |
| 88 | 803.15 | 0.4865 |
| 88 | 916.42 | 0.5329 |
| 88 | 1029.68 | 0.6181 |
| 88 | 1106.91 | 0.704 |
| 88 | 1229.44 | 0.756 |
| 88 | 1372.56 | 0.7854 |
| 88 | 1518.78 | 0.8063 |
| 88 | 1661.9 | 0.8241 |
| 88 | 2511.39 | 0.8968 |
| 88 | 2657.6 | 0.9032 |
| 88 | 2800.73 | 0.9099 |
| 88 | 2941.8 | 0.9165 |
| 88 | 3093.16 | 0.9194 |
| 88 | 3269.23 | 0.9151 |
| 88 | 3459.72 | 0.9077 |
| 88 | 3683.17 | 0.893 |
| 88 | 3963.24 | 0.8673 |
| 88 | 4316.42 | 0.8307 |
| 88 | 4993.95 | 0.7478 |

********************************************

Generator Efficiency Curves

Plant: Morony

Name: "U1,2_25"

Description: "Generators per ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"". Entries for 1MW and 3MW added for turbine efficiency smoothing. Extended to 25MW to correspond to PCS and PI limits."

Notes: ASCANGAS 2015/2/4. KADAMEC 2015/2/9 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 25 | 0 | 0 |
| 25 | 1 | 0.6 |
| 25 | 3 | 0.9 |
| 25 | 4.9 | 0.9395 |
| 25 | 9.8 | 0.9673 |
| 25 | 14.7 | 0.9756 |
| 25 | 19.6 | 0.9793 |
| 25 | 24.5 | 0.9808 |
| 25 | 25 | 0.9808 |

********************************************

Plant Flow Type

Plant: Morony

Name: MaxCap

Description: Max Capacity

Notes: BKROLAK 2015/1/16. KADAMEC 2015/2/9 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for Thompson Falls

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| Thompson Falls | Base_Peak | Base | Base |

********************************************

Physical Settings

Plant: Thompson Falls

Name: Base_Peak

Description: Base Peaking

Notes: BKROLAK 2015/1/19. ASCANGAS 2015/1/19 checked. BKROLAK 2015/1/30 Changed Alt_TW Curve to be U7_NoxDrafted. KADAMEC 2015/2/6 Checked

Reservoir Storage: Base

Reservoir Area:

Monthly Evaporation:

Tailwater Curve: U7TW_NoxNorm

Spillway Curve: Base

Low Level Outlet:

Alt. Spillway:

Alt. Tailwater Curve: U7_NoxDrafted

Ramp Rating Curve:

Plant Options: Base_Peak

*********************************************

Reservoir Storage

Plant: Thompson Falls

Name: Base

Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet."

Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 2380 | 0 |
| 2381 | 520 |
| 2382 | 1081 |
| 2383 | 1690 |
| 2384 | 2348 |
| 2385 | 3059 |
| 2386 | 3822 |
| 2387 | 4641 |
| 2388 | 5520 |
| 2389 | 6460 |
| 2390 | 7464 |
| 2391 | 8533 |
| 2392 | 9669 |
| 2393 | 10877 |
| 2394 | 12161 |
| 2395 | 13523 |
| 2396 | 14969 |
| 2396.5 | 15733 |
| 2397 | 16497 |

*********************************************

Tailwater Curve

Plant: Thompson Falls

Name: U7TW_NoxNorm

Description: "Unit 7 tailwater, with Noxon Normal elevation. From ""5 - Tailwater Rating Curves\THF Tailwater.xls""."

Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2334.38 | 0 |
| 2334.75 | 4000 |
| 2334.9 | 5000 |
| 2335 | 5500 |
| 2335.5 | 7000 |
| 2335.75 | 8000 |
| 2336.38 | 10000 |
| 2337.19 | 12000 |
| 2337.75 | 14000 |
| 2338.38 | 16000 |
| 2339 | 18000 |
| 2339.5 | 20000 |
| 2340.9 | 25000 |
| 2342.25 | 30000 |
| 2343.5 | 35000 |
| 2344.63 | 40000 |
| 2345.82 | 45000 |

| | |
|---|---|
| 2346.76 | 50000 |
| 2350.19 | 70000 |
| 2354 | 100000 |

********************************************

Spillway Curve

Plant: Thompson Falls
Name: Base
Description: "Base data digitized from PDF file ""4 - Spillway discharge rating curves\THO 2006 --Combined Spillway Discharge Curve.pdf""."
Notes: BKROLAK 2015/1/16. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2380 | 0 |
| 2381 | 2100 |
| 2382 | 6000 |
| 2383 | 14000 |
| 2384 | 22000 |
| 2385 | 34000 |
| 2388 | 70000 |
| 2390 | 100000 |
| 2395 | 202000 |
| 2398 | 274000 |
| 2398.5 | 291000 |
| 2400 | 315000 |
| 2401 | 332000 |
| 2403 | 380000 |
| 2405 | 440200 |

********************************************

Alt. Tailwater Curve

Plant: Thompson Falls
Name: U7_NoxDrafted
Description: "From ""5 - Tailwater Rating Curves\THF Tailwater.xls"". U7 Noxon Drafted."
Notes: BKROLAK 2015/1/30. KADAMEC 2015/2/6 Checked

| Elevation (ft) | Flow (cfs) |
|---|---|
| 2329.9 | 0 |
| 2330 | 5500 |
| 2331.29 | 7000 |
| 2332.41 | 8000 |
| 2334 | 10000 |
| 2335.33 | 12000 |
| 2336.47 | 14000 |
| 2337.5 | 16000 |
| 2338.33 | 18000 |
| 2339.11 | 20000 |
| 2340.67 | 25000 |
| 2342.24 | 30000 |
| 2343.5 | 35000 |
| 2344.63 | 40000 |
| 2345.82 | 45000 |
| 2346.76 | 50000 |
| 2350.19 | 70000 |
| 2354 | 100000 |

*********************************************

Plant Options

Plant: Thompson Falls
Name: Base_Peak
Description: Peaking operations.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 1 | FALSE | FALSE | 0 | 2396.5 |

*********************************************

Operation Settings

Plant: Thompson Falls
Name: Base
Description: Base conditions.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/20 checked.
Spill Elevations: 2396.5
Target Elevations: 2396
Minimum Elevations: 2392.5_PeakingLimit
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow: 6000cfsOrInflow
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow: FishLadder
Maximum Flow:
Max Flow from Elev:
Flashboards:

*********************************************

Spill Elevations

Plant: Thompson Falls
Name: 2396.5
Description: "Top of peaking pool. Top of flashboards. per ""RESERVOIR-CAPACITY.xls""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 2396.5 |
| 31-Dec | 2396.5 |

*********************************************

Target Elevations

Plant: Thompson Falls
Name: 2396
Description: "50th percentile (median) of historical elevations from ""HDB THF 198801 to 201411.xlsx""."
Notes: BKROLAK 2015/1/13. KADAMEC 2015/1/19 Checked as normal water elevation

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 2396 |

| | |
|---|---|
| 31-Dec | 2396 |

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Minimum Elevations

Plant: Thompson Falls
Name: 2392.5_PeakingLimit
Description: "Bottom of Peaking band 2396.5 to 2392.5 from ""Regulatory Constraints.pdf"". (4 ft below full pool elevation of 2396.5 ft)"
Notes: BKROLAK 2015/1/13. KADAMEC 2015/2/9 Checked

| Calendar Day | | Elevation (ft) |
|---|---|---|
| 1-Jan | 2392.5 | |
| 31-Dec | 2392.5 | |

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Minimum Instantaneous Flow

Plant: Thompson Falls
Name: 6000cfsOrInflow
Description: "Per ""Regulatory Constraints.pdf""."
Notes: BKROLAK 2015/1/13. KADAMEC 2015/2/9 Checked

| Calendar Day | | Flow (cfs) | Or Inflow |
|---|---|---|---|
| 1-Jan | 6000 | TRUE | |
| 31-Dec | 6000 | TRUE | |

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Bypass Flow

Plant: Thompson Falls
Name: FishLadder
Description: "From operations plan ""The U.S. Fish and Wildlife Service and Commission Approved Thompson Falls Fish Ladder operates annually from mid-March to late October depending on weather (shuts down when freeze conditions are imminent). Fish ladder flows range from 11 cfs to 81 cfs, but typically run at the high end (80 cfs) of this range. In addition to these flows through the ladder itself, NWE seasonally or when warranted by other factors, opens one spill gate near the fish ladder to provide an additional fish attractant flow of 25 cfs to 100 cfs. The spill flow rate (in this range) is variable as experimental and other factors warrant it."""
Notes: BKROLAK 2015/2/4. ASCANGAS 2015/2/4 checked.

| Calendar Day | | Flow (cfs) | Or Inflow | Destination Node |
|---|---|---|---|---|
| 1-Jan | 0 | FALSE | 999 | |
| 15-Mar | 80 | FALSE | 999 | |
| 25-Oct | 80 | FALSE | 999 | |
| 26-Oct | 0 | FALSE | 999 | |
| 31-Dec | 0 | FALSE | 999 | |

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Generation Settings

Plant: Thompson Falls
Name: Base
Description: Base 7 unit powerhouse combinations post-1995.
Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/10 Checked
Powerhouse Setup: BaseHD_Final
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

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Powerhouse Setup

Plant: Thompson Falls

Name: BaseHD_Final

Description: "Using unit combined efficiency for Units 2-6. Lowered input heads. Manual editing of U1,3 and U7. Extended generator capacity for U1,3. Updated U2,4,5,6 turb curve for smoothed performance. U2,4,5,6 Gen Eff extended to 7.5 MW to prevent generator limiting."

Notes: BKROLAK 2015/1/29. ASCANGAS 2015/2/5. KADAMEC 2015/2/9 Checked

Dispatched: FALSE

| Unit Number | | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|---|
| 1 | 7units | "U1,3_HD_R2" | "U1,3_8.9" | 0 | |
| 2 | 7units | "U2,4,5,6_Total_Unit_HD_R2" | "U2,4,5,6_7.5_1.0_eff" | | 0 |
| 3 | 7units | "U1,3_HD_R2" | "U1,3_8.9" | 0 | |
| 4 | 7units | "U2,4,5,6_Total_Unit_HD_R2" | "U2,4,5,6_7.5_1.0_eff" | | 0 |
| 5 | 7units | "U2,4,5,6_Total_Unit_HD_R2" | "U2,4,5,6_7.5_1.0_eff" | | 0 |
| 6 | 7units | "U2,4,5,6_Total_Unit_HD_R2" | "U2,4,5,6_7.5_1.0_eff" | | 0 |
| 7 | 7units | U7_B_HD_ManualEditLimited | U7_59 | 0 | |

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Turbine Efficiency Curves

Plant: Thompson Falls

Name: "U1,3_HD_R2"

Description: "U1 and 3. 9350 HP turbines. 5-60% gate is the lowest flow in this table. Data from U3 index test March 2002 in ""8 - Power Plant Eq Performance Data\TFalls\Turbine Runner Replacement (RS662)\Unit No 3\Unit 3 Performance.xls"". and extended to cover the full range of operational heads and limited flow to maximum flow reported in the PI data and approximate 60% gate limitation of 1350 cfs."

Notes: ASCANGAS 2015/2/4. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 43 | 1258.38 | 0.7991 |
| 43 | 1430.06 | 0.838 |
| 43 | 1550.25 | 0.8694 |
| 43 | 1687.49 | 0.831 |
| 54 | 1323.37 | 0.839 |
| 54 | 1503.92 | 0.8807 |
| 54 | 1630.32 | 0.9137 |
| 54 | 1774.64 | 0.8739 |
| 57.2 | 1342.28 | 0.8506 |
| 57.2 | 1525.4 | 0.8932 |
| 57.2 | 1653.61 | 0.9266 |
| 57.2 | 1799.99 | 0.8863 |
| 58.4 | 1356.28 | 0.8588 |
| 58.4 | 1541.32 | 0.9019 |
| 58.4 | 1670.87 | 0.9359 |
| 58.4 | 1818.78 | 0.8951 |
| 59.5 | 1369 | 0.8669 |
| 59.5 | 1555.77 | 0.9106 |
| 59.5 | 1686.53 | 0.9451 |
| 59.5 | 1835.82 | 0.904 |

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Turbine Efficiency Curves

Plant: Thompson Falls

Name: "U2,4,5,6_Total_Unit_HD_R2"

Description: "From U5 index test March 2002 in ""8 - Power Plant Eq Performance Data\TFalls\Turbine Runner Replacement (RS662)\Unit No 3\Unit 3 Performance.xls"". Used total unit performance and limited based on PI data."

Notes: ASCANGAS 2015/2/4. KADAMEC 2015/2/9 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 43 | 1154.03 | 0.6998 |
| 43 | 1310.33 | 0.7553 |
| 43 | 1503.31 | 0.7553 |
| 43 | 1696.22 | 0.7489 |
| 54 | 1213.64 | 0.6998 |
| 54 | 1378.01 | 0.7553 |
| 54 | 1580.95 | 0.7553 |
| 54 | 1783.82 | 0.7489 |
| 57.2 | 1230.97 | 0.6998 |
| 57.2 | 1397.69 | 0.7553 |
| 57.2 | 1603.54 | 0.7553 |
| 57.2 | 1809.31 | 0.7489 |
| 58.4 | 1243.82 | 0.6998 |
| 58.4 | 1412.28 | 0.7553 |
| 58.4 | 1620.27 | 0.7553 |
| 58.4 | 1828.19 | 0.7489 |
| 59.5 | 1255.48 | 0.6998 |
| 59.5 | 1425.52 | 0.7553 |
| 59.5 | 1635.46 | 0.7553 |
| 59.5 | 1845.33 | 0.7489 |

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Turbine Efficiency Curves

Plant: Thompson Falls

Name: U7_B_HD_ManualEditLimited

Description: "Input efficiencies and flows computed from PCS curves as documented in ""8 - Power Plant Eq Performance Data\Performance Verification Data\Thompson Falls PCS Water Curves.xls"". Extended to maximum flow reported in PI data and limited due to vibration limitations, approximately 10MW and resricted based on PI data."

Notes: BKROLAK 2015/2/4. ASCANGAS 2015/2/5. KADAMEC 2015/2/9 Checked. BKROLAK 2015/2/12 Documentation extended.

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 43 | 3349.3 | 0.8836 |
| 43 | 3598.9 | 0.8914 |
| 43 | 4177.5 | 0.9038 |
| 43 | 5222.8 | 0.9223 |
| 43 | 6774.5 | 0.9259 |
| 43 | 7612.5 | 0.9293 |
| 43 | 7856.9 | 0.9314 |
| 43 | 8333.7 | 0.9304 |
| 43 | 8948.3 | 0.9301 |
| 43 | 10795 | 0.9257 |
| 43 | 12367.1 | 0.9208 |
| 43 | 13537.9 | 0.9116 |
| 43 | 15260.2 | 0.9008 |
| 43 | 15432.4 | 0.8998 |
| 50 | 3028 | 0.8836 |
| 50 | 3251 | 0.8914 |
| 50 | 3768 | 0.9038 |
| 50 | 4702 | 0.9223 |
| 50 | 6078 | 0.9259 |

| | | |
|---|---|---|
| 50 | 6825 | 0.9293 |
| 50 | 7040 | 0.9314 |
| 50 | 7458 | 0.9304 |
| 50 | 7997 | 0.9301 |
| 50 | 9626 | 0.9257 |
| 50 | 11000 | 0.9208 |
| 50 | 12000 | 0.9116 |
| 50 | 13471 | 0.9008 |
| 50 | 13618 | 0.8998 |
| 60 | 2569 | 0.8679 |
| 60 | 2754 | 0.8769 |
| 60 | 3183 | 0.8916 |
| 60 | 3958 | 0.9131 |
| 60 | 5083 | 0.9227 |
| 60 | 5700 | 0.9273 |
| 60 | 5873 | 0.9304 |
| 60 | 6207 | 0.9316 |
| 60 | 6638 | 0.9338 |
| 60 | 7956 | 0.9334 |
| 60 | 9047 | 0.933 |
| 60 | 9803 | 0.9299 |
| 60 | 10915 | 0.9264 |
| 60 | 11026 | 0.9261 |
| 62.5 | 2483 | 0.8633 |
| 62.5 | 2660.5 | 0.8727 |
| 62.5 | 3072.5 | 0.888 |
| 62.5 | 3816 | 0.9106 |
| 62.5 | 4892.5 | 0.9217 |
| 62.5 | 5486.5 | 0.9262 |
| 62.5 | 5653 | 0.9294 |
| 62.5 | 5974.5 | 0.9305 |
| 62.5 | 6389 | 0.9328 |
| 62.5 | 7646 | 0.9339 |
| 62.5 | 8691 | 0.9339 |
| 62.5 | 9403.5 | 0.9322 |
| 62.5 | 10471 | 0.9286 |
| 62.5 | 10577.5 | 0.9284 |
| 65 | 2397 | 0.8587 |
| 65 | 2567 | 0.8684 |
| 65 | 2962 | 0.8844 |
| 65 | 3674 | 0.908 |
| 65 | 4702 | 0.9207 |
| 65 | 5273 | 0.9252 |
| 65 | 5433 | 0.9284 |
| 65 | 5742 | 0.9295 |
| 65 | 6140 | 0.9319 |
| 65 | 7336 | 0.9344 |
| 65 | 8335 | 0.9348 |
| 65 | 9004 | 0.9345 |
| 65 | 10027 | 0.9309 |
| 65 | 10129 | 0.9306 |

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Generator Efficiency Curves

Plant: Thompson Falls
Name: "U1,3_8.9"
Description: "From ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"". 8.9 MW output entered per PI data max output from U1 and U3 to keep from being enerator limited."

Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 8.9 | 0 | 0 |
| 8.9 | 1.4 | 0.9428 |
| 8.9 | 2.9 | 0.9692 |
| 8.9 | 4.3 | 0.9772 |
| 8.9 | 5.8 | 0.9806 |
| 8.9 | 7.2 | 0.9821 |
| 8.9 | 8.9 | 0.9821 |

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Generator Efficiency Curves
Plant: Thompson Falls
Name: "U2,4,5,6_7.5_1.0_eff"
Description: 1.0 eff as turbine efficiency includes generator efficiency. Extended to 7.5MW to prevent generator limiting.
Notes: BKROLAK 2015/1/29. KADAMEC 2015/2/9 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 7.5 | 0 | 1 |
| 7.5 | 1.2 | 1 |
| 7.5 | 2.5 | 1 |
| 7.5 | 3.7 | 1 |
| 7.5 | 5 | 1 |
| 7.5 | 7.5 | 1 |

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Generator Efficiency Curves
Plant: Thompson Falls
Name: U7_59
Description: "From ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx""."
Notes: BKROLAK 2015/1/16. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 59 | 0 | 0 |
| 59 | 11.8 | 0.9536 |
| 59 | 23.6 | 0.9744 |
| 59 | 35.4 | 0.9804 |
| 59 | 47.2 | 0.9828 |
| 59 | 59 | 0.9836 |

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Plant Flow Type
Plant: Thompson Falls
Name: MaxCap
Description: Max capacity use of units.
Notes: BKROLAK 2015/1/22. KADAMEC 2015/2/10 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |

31-Dec FALSE

Scenario Information for Mystic

| Plant/Node | | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|---|
| Mystic | Base_Peak | Base | Base_Post2008 | |

********************************************
Physical Settings
Plant: Mystic
Name: Base_Peak
Description: Base Peaking.
Notes: BKROLAK 2015/1/19. KADAMEC 2015/2/6 Checked
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Base
Spillway Curve: Base
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_Peak

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Reservoir Storage
Plant: Mystic
Name: Base
Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet. Lowest point in curve modified from 7612 at 0 volume to intake sill elevation 7608.75 feet per ""P-2301-1005, F-5, Mystic Intake Plan, Elev & Sections, 12-26-2007.TIF""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/16 checked. BKROLAK 2015/2/9. ASCANGAS 2015/2/12 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 7608.75 | 0 |
| 7613 | 280 |
| 7614 | 559 |
| 7615 | 841 |
| 7616 | 1140 |
| 7617 | 1440 |
| 7618 | 1740 |
| 7619 | 2039 |
| 7620 | 2339 |
| 7621 | 2638 |
| 7622 | 2938 |
| 7623 | 3237 |
| 7624 | 3537 |
| 7625 | 3836 |
| 7626 | 4136 |
| 7627 | 4437 |
| 7628 | 4739 |
| 7629 | 5040 |
| 7630 | 5341 |

| | |
|---|---|
| 7631 | 5645 |
| 7632 | 5950 |
| 7633 | 6258 |
| 7634 | 6567 |
| 7635 | 6879 |
| 7636 | 7192 |
| 7637 | 7507 |
| 7638 | 7825 |
| 7639 | 8144 |
| 7640 | 8465 |
| 7641 | 8789 |
| 7642 | 9114 |
| 7643 | 9441 |
| 7644 | 9771 |
| 7645 | 10102 |
| 7646 | 10435 |
| 7647 | 10770 |
| 7648 | 11107 |
| 7649 | 11447 |
| 7650 | 11790 |
| 7651 | 12137 |
| 7652 | 12488 |
| 7653 | 12843 |
| 7654 | 13202 |
| 7655 | 13565 |
| 7656 | 13932 |
| 7657 | 14303 |
| 7658 | 14678 |
| 7659 | 15057 |
| 7660 | 15439 |
| 7661 | 15826 |
| 7662 | 16217 |
| 7663 | 16612 |
| 7664 | 17010 |
| 7665 | 17413 |
| 7666 | 17820 |
| 7667 | 18230 |
| 7668 | 18645 |
| 7669 | 19063 |
| 7670 | 19486 |
| 7671 | 19912 |
| 7672 | 20342 |
| 7673 | 20777 |
| 7673.5 | 20997 |

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Tailwater Curve

Plant: Mystic
Name: Base
Description: "Centerline of discharge jet per ""1 - Drawings\12_Mystic\P-2301-1018, F-6, Mystic Flowline Plan, Profile & Details, 09-20-2011.tif""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/16 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 6545 | 1 |

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Spillway Curve

Plant: Mystic
Name: Base
Description: "Flashboards removed per ""4 - Spillway discharge rating curves\MYL DISCHARGE CAPABILITY.xls""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 7670 | 0 |
| 7670.5 | 328.99 |
| 7671 | 971.02 |
| 7671.5 | 1852.36 |
| 7672 | 2922.89 |
| 7672.5 | 4189.26 |
| 7673 | 5633.49 |
| 7673.5 | 7252.47 |
| 7674 | 9004.66 |

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Plant Options

Plant: Mystic
Name: Base_Peak
Description: Peaking operations.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 1 | FALSE | FALSE | 0 | 7673.5 |

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Operation Settings

Plant: Mystic
Name: Base
Description: Base conditions using average historical monthly starting elevations and minimum elevations requirement with summer limits.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/20 checked.
Spill Elevations: 7673.5
Target Elevations: HistAvg
Minimum Elevations: Seasonal
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow: Base
Maximum Flow:
Max Flow from Elev:
Flashboards:

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Spill Elevations

Plant: Mystic
Name: 7673.5
Description: "Normal Water Surface Elev per""1 - Drawings\12_Mystic\P-2301-1001, F-1, Mystic Dams, 12-26-2007.TIF""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 7673.5 |
| 31-Dec | 7673.5 |

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Target Elevations
Plant: Mystic
Name: HistAvg
Description: "Historical average month starting elevations from ""HDB MYL 198801 to 201411.xlsx""."
Notes: BKROLAK 2015/1/13. KADAMEC 2015/2/12 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 7639.86 |
| 1-Feb | 7630.46 |
| 1-Mar | 7622.05 |
| 1-Apr | 7615.21 |
| 1-May | 7613.79 |
| 1-Jun | 7632.79 |
| 1-Jul | 7669.93 |
| 1-Aug | 7672.95 |
| 1-Sep | 7669.66 |
| 1-Oct | 7665.12 |
| 1-Nov | 7658.1 |
| 1-Dec | 7648.77 |
| 31-Dec | 7639.86 |

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Minimum Elevations
Plant: Mystic
Name: Seasonal
Description: "Just below lowest observed elevation 1988 to 2014 during winter. Above 7663.5 Jul 10 to Sep 15 from ""HDB MYL 198801 to 201411.xlsx"""

Notes: BKROLAK 2015/1/13. KADAMEC 2015/2/6 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 7610 |
| 1-Jun | 7610 |
| 10-Jul | 7663.5 |
| 15-Sep | 7663.5 |
| 1-Oct | 7610 |
| 31-Dec | 7610 |

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Bypass Flow
Plant: Mystic
Name: Base
Description: "Base condition with 10 cfs Jun-Aug, 5 cfs otherwise."
Notes: BKROLAK 2015/1/13

| Calendar Day | | Flow (cfs) | Or Inflow | Destination Node |
|---|---|---|---|---|
| 1-Jan | 5 | FALSE | 13 | |
| 1-Jun | 10 | FALSE | 13 | |
| 31-Aug | 10 | FALSE | 13 | |
| 1-Sep | 5 | FALSE | 13 | |
| 31-Dec | 5 | FALSE | 13 | |

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Generation Settings

Plant: Mystic
Name: Base_Post2008
Description: Upgraded turbines post Apr 2008.
Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/10 Checked
Powerhouse Setup: 2008_Later
Powerhouse Weekend Ops:
Maintenance Schedule:
Minimum Flow Unit:
Plant Flow Type: MaxCap
Limit Off Peak Gen:

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Powerhouse Setup

Plant: Mystic
Name: 2008_Later
Description: Powerhouse setup with two upgraded turbines. Using unit combined efficiency. Modified Rev1 turbines to calibrate to historical PI and daily operations data.

Notes: BKROLAK 2015/1/29. KADAMEC 2015/2/6 Checked
Dispatched: FALSE

| Unit Number | Headloss | Turbine Efficiency | Generator Efficiency | Gate Leakage |
|---|---|---|---|---|
| 1 | 2Unit | U1-2_UG_R1 | U1-2_6MW_1.0_eff | 0 |
| 2 | 2Unit | U1-2_UG_R1 | U1-2_6MW_1.0_eff | 0 |

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Turbine Efficiency Curves

Plant: Mystic
Name: U1-2_UG_R1
Description: "Unit 1, upgraded Apr 2007. Unit 2 upgraded March 2008. This is total unit efficiency, from ""Mystic Unit 1 2 Comparison.xls"". Flow increased by 4 cfs at upper limit to calibrate to PI data."

Notes: BKROLAK 2015/1/13. CDOE 2015/1/21. KADAMEC 2015/1/21 Checked

| Head (ft) | Flow (cfs) | Efficiency |
|---|---|---|
| 903 | 3.77 | 0.084 |
| 903 | 12.26 | 0.6184 |
| 903 | 20.75 | 0.74 |
| 903 | 31.13 | 0.7914 |
| 903 | 38.67 | 0.8133 |
| 903 | 47.16 | 0.8303 |
| 903 | 54.71 | 0.8365 |
| 903 | 61.31 | 0.8388 |
| 903 | 70.74 | 0.8382 |
| 903 | 77.34 | 0.8379 |
| 903 | 82.29 | 0.837 |

| | | |
|---|---|---|
| 959 | 3.89 | 0.084 |
| 959 | 12.64 | 0.6184 |
| 959 | 21.38 | 0.74 |
| 959 | 32.08 | 0.7914 |
| 959 | 39.85 | 0.8133 |
| 959 | 48.6 | 0.8303 |
| 959 | 56.38 | 0.8365 |
| 959 | 63.18 | 0.8388 |
| 959 | 72.9 | 0.8382 |
| 959 | 79.71 | 0.8379 |
| 959 | 84.68 | 0.837 |
| 1015 | 4 | 0.084 |
| 1015 | 13 | 0.6184 |
| 1015 | 22 | 0.74 |
| 1015 | 33 | 0.7914 |
| 1015 | 41 | 0.8133 |
| 1015 | 50 | 0.8303 |
| 1015 | 58 | 0.8365 |
| 1015 | 65 | 0.8388 |
| 1015 | 75 | 0.8382 |
| 1015 | 82 | 0.8379 |
| 1015 | 86 | 0.837 |
| 1071.75 | 4.11 | 0.084 |
| 1071.75 | 13.36 | 0.6184 |
| 1071.75 | 22.61 | 0.74 |
| 1071.75 | 33.91 | 0.7914 |
| 1071.75 | 42.13 | 0.8133 |
| 1071.75 | 51.38 | 0.8303 |
| 1071.75 | 59.6 | 0.8365 |
| 1071.75 | 66.79 | 0.8388 |
| 1071.75 | 77.07 | 0.8382 |
| 1071.75 | 84.26 | 0.8379 |
| 1071.75 | 89.29 | 0.837 |
| 1128.5 | 4.22 | 0.084 |
| 1128.5 | 13.71 | 0.6184 |
| 1128.5 | 23.2 | 0.74 |
| 1128.5 | 34.8 | 0.7914 |
| 1128.5 | 43.23 | 0.8133 |
| 1128.5 | 52.72 | 0.8303 |
| 1128.5 | 61.16 | 0.8365 |
| 1128.5 | 68.54 | 0.8388 |
| 1128.5 | 79.08 | 0.8382 |
| 1128.5 | 86.46 | 0.8379 |
| 1128.5 | 91.52 | 0.837 |

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Generator Efficiency Curves

Plant: Mystic

Name: U1-2_6MW_1.0_eff

Description: "Eff from ""8 - Power Plant Eq Performance Data\Generator info - JCummings.xlsx"" with 0.8 PF. Estimated values for less thatn 1.2 MW from ""8 - Power Plant Eq Performance Data\Mystic turbine\Turbine Upgrade Unit #1 (RS318)\Mystic Unit 1 2 Comparison.xls"". 1.0 eff as turbine efficiency includes generator efficiency. Increased maximum capacity to 6.2 based on PI data."

Notes: CDOE 2015/1/21. KADAMEC 2015/1/21 Checked

| Max Generator Capacity | Generator Output (MW) | Efficiency |
|---|---|---|
| 6.2 | 0 | 1 |
| 6.2 | 6.2 | 1 |

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Plant Flow Type
Plant: Mystic
Name: MaxCap
Description: Max Capacity.
Notes: BKROLAK 2015/1/14. KADAMEC 2015/2/6 Checked

| Calendar Day | Run at Peak Efficiency |
|---|---|
| 1-Jan | FALSE |
| 31-Dec | FALSE |

Scenario Information for West Rosebud Lake

| Plant/Node | Physical Settings | Operation Settings | Generation Settings |
|---|---|---|---|
| West Rosebud Lake | Base_Stor | Base | |

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Physical Settings
Plant: West Rosebud Lake
Name: Base_Stor
Description: Base storage option.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked. BKROLAK 2015/1/21 Checked modified spillway curve. KADAMEC 2015/2/6 Checked
Reservoir Storage: Base
Reservoir Area:
Monthly Evaporation:
Tailwater Curve: Base
Spillway Curve: NoFlashboards
Low Level Outlet:
Alt. Spillway:
Alt. Tailwater Curve:
Ramp Rating Curve:
Plant Options: Base_Stor

********************************************

Reservoir Storage
Plant: West Rosebud Lake
Name: Base
Description: "Base from ""3 - Reservoir area & capacity curves\RESERVOIR-CAPACITY.xls"" converted to acre-feet. Zero volume was reduced from original curve value of 6387.4 to 6386.4 feet, which is the weir crest elevation. Weir crest from ""Reservoir-capacity.xls"""
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/16 checked.. BKROLAK 2015/1/22. ASCANGAS 2015/2/12 checked.

| Elevation (ft) | Volume (af) |
|---|---|
| 6386.4 | 0 |
| 6388.4 | 34 |
| 6389.4 | 60 |
| 6390.4 | 93 |
| 6391.4 | 131 |
| 6392.4 | 171 |

| | |
|---|---|
| 6393.4 | 210 |
| 6394.4 | 254 |
| 6395.4 | 298 |
| 6396.4 | 339 |
| 6397.4 | 389 |
| 6398.4 | 438 |
| 6399.4 | 482 |
| 6399.9 | 504 |

********************************************
Tailwater Curve
Plant: West Rosebud Lake
Name: Base
Description: "Base using energy diffuser crest: rel elev 77.4,  From ""1 - Drawings\12_Mystic\P-2301-1010, F-10, Mystic Reregulating Reservoir Dam, 12-26-2007.TIF"""

Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 6384.8 | 0 |

********************************************
Spillway Curve
Plant: West Rosebud Lake
Name: NoFlashboards
Description: "From P-2301-1010, F-10, Mystic Reregulating Reservoir Dam, 12-26-2007.TIF (End point duplicated from Weir crest (6386.4) to project boundary (6399.99) from ""Reservoir-Capacity.xls"" for an upper bound above the provided discharge curve)."
Notes: KADAMEC 2015/1/19. BKROLAK 2015/1/21 Checked.

| Elevation (ft) | Flow (cfs) |
|---|---|
| 6386.4 | 0 |
| 6387.8 | 200 |
| 6389.4 | 491 |
| 6390 | 642 |
| 6390.7 | 858 |
| 6391.9 | 1303 |
| 6394.1 | 2215 |
| 6396.9 | 3705 |
| 6399.8 | 5282 |
| 6401.4 | 24000 |

********************************************
Plant Options
Plant: West Rosebud Lake
Name: Base_Stor
Description: Storage Reservoir.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/17 checked.

| Min Powerhouse Flow | Plant Operation Type | Delinked - Owner | Delinked - System | Target Unit Power (MW) | Full Pond Elev (ft) |
|---|---|---|---|---|---|
| 0 | 0 | FALSE | FALSE | 0 | 6397.4 |

********************************************
Operation Settings
Plant: West Rosebud Lake
Name: Base

Description: Base conditions with fish spawning and egg recruitment flows.
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/20 checked. KADAMEC 2015/2/12 checked again
Spill Elevations: 6397.4
Target Elevations: 6397.4
Minimum Elevations: 6386.4
Weekly Drawdown:
Water Withdrawals:
Reservoir Fluctuation Limits:
Reservoir Fluctuation Rates:
Tailwater Ramping Rates:
Minimum Instantaneous Flow:
Minimum Daily Average Flow:
Recreation Flows:
Bypass Flow: SOP
Maximum Flow:
Max Flow from Elev:
Flashboards:

*********************************************
Spill Elevations
Plant: West Rosebud Lake
Name: 6397.4
Description: "Norm Reservori Water Level from ""Reservoir-Capacity.xls""."
Notes: BKROLAK 2015/1/13. KADAMEC 2015/2/12 Checked

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 6397.4 |
| 31-Dec | 6397.4 |

*********************************************
Target Elevations
Plant: West Rosebud Lake
Name: 6397.4
Description: "Norm Reservori Water Level from ""Reservoir-Capacity.xls""."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 6397.4 |
| 31-Dec | 6397.4 |

*********************************************
Minimum Elevations
Plant: West Rosebud Lake
Name: 6386.4
Description: "Weir crest from ""Reservoir-capacity.xls"""
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | Elevation (ft) |
|---|---|
| 1-Jan | 6386.4 |
| 31-Dec | 6386.4 |

*********************************************
Bypass Flow

Plant: West Rosebud Lake
Name: SOP
Description: "MFWP Approved SOP, includes increased flows Oct1-Nov30 for adult spawning flow and Dec1-Apr15 egg/fry recruitment."
Notes: BKROLAK 2015/1/13. ASCANGAS 2015/1/19 checked.

| Calendar Day | | Flow (cfs) | Or Inflow | Destination Node |
|---|---|---|---|---|
| 1-Jan | 43 | FALSE | 999 | |
| 15-Apr | 43 | FALSE | 999 | |
| 16-Apr | 20 | TRUE | 999 | |
| 30-Sep | 20 | TRUE | 999 | |
| 1-Oct | 75 | FALSE | 999 | |
| 30-Nov | 75 | FALSE | 999 | |
| 1-Dec | 43 | FALSE | 999 | |
| 31-Dec | 43 | FALSE | 999 | |

# APPENDIX C

# COMPARISONS OF THE 15-MINUTE MODEL SIMULATED, HOURLY HISTORICAL PI, AND HISTORICAL DAILY POWER VERSUS FLOW VALUES FOR EACH POWERHOUSE

**FIGURE C-1**

**MODELED AND HISTORICAL MADISON POWER VERSUS FLOW COMPARISON**

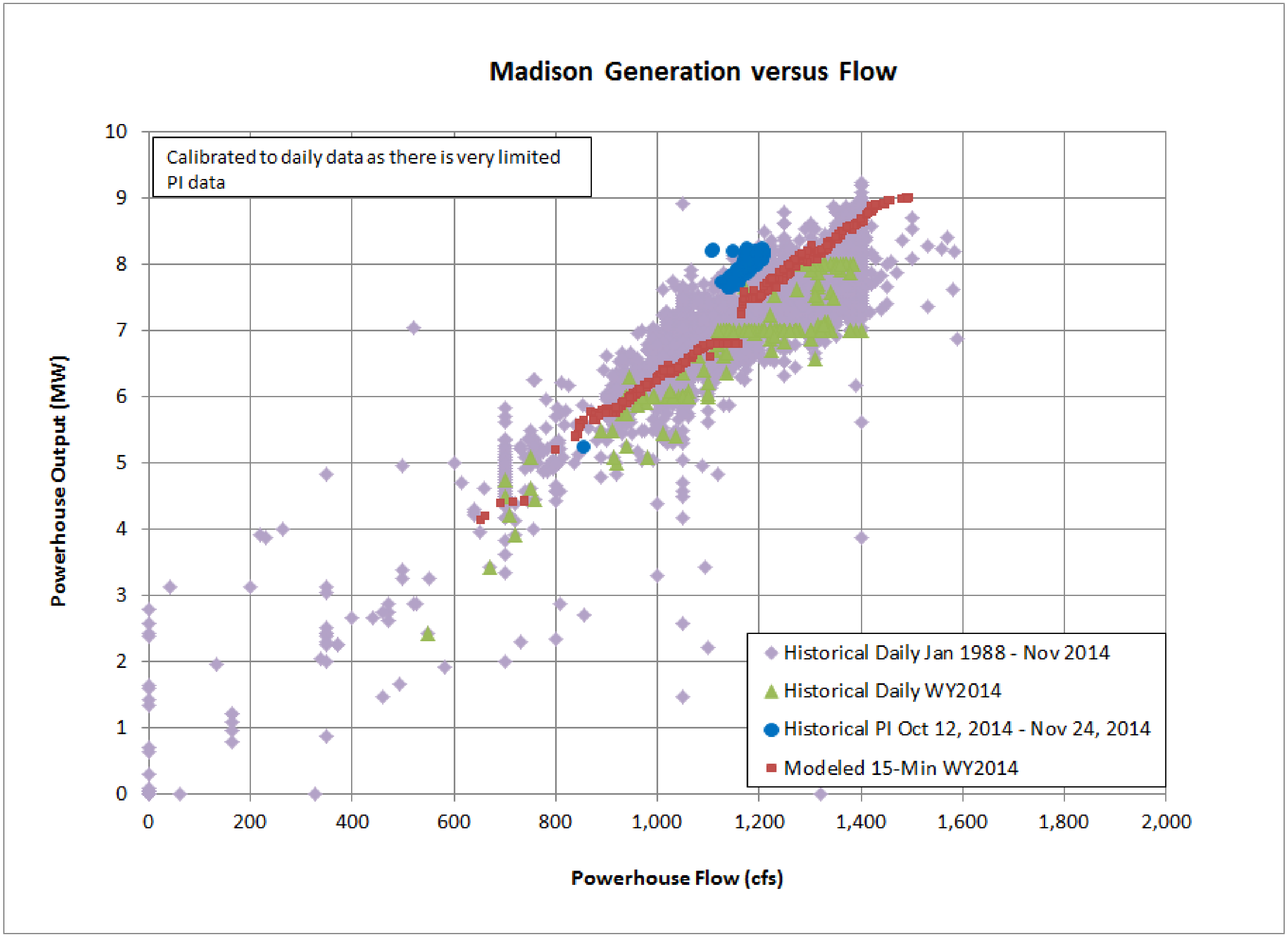

**FIGURE C-2**
**MODELED AND HISTORICAL HAUSER POWER VERSUS FLOW COMPARISON**

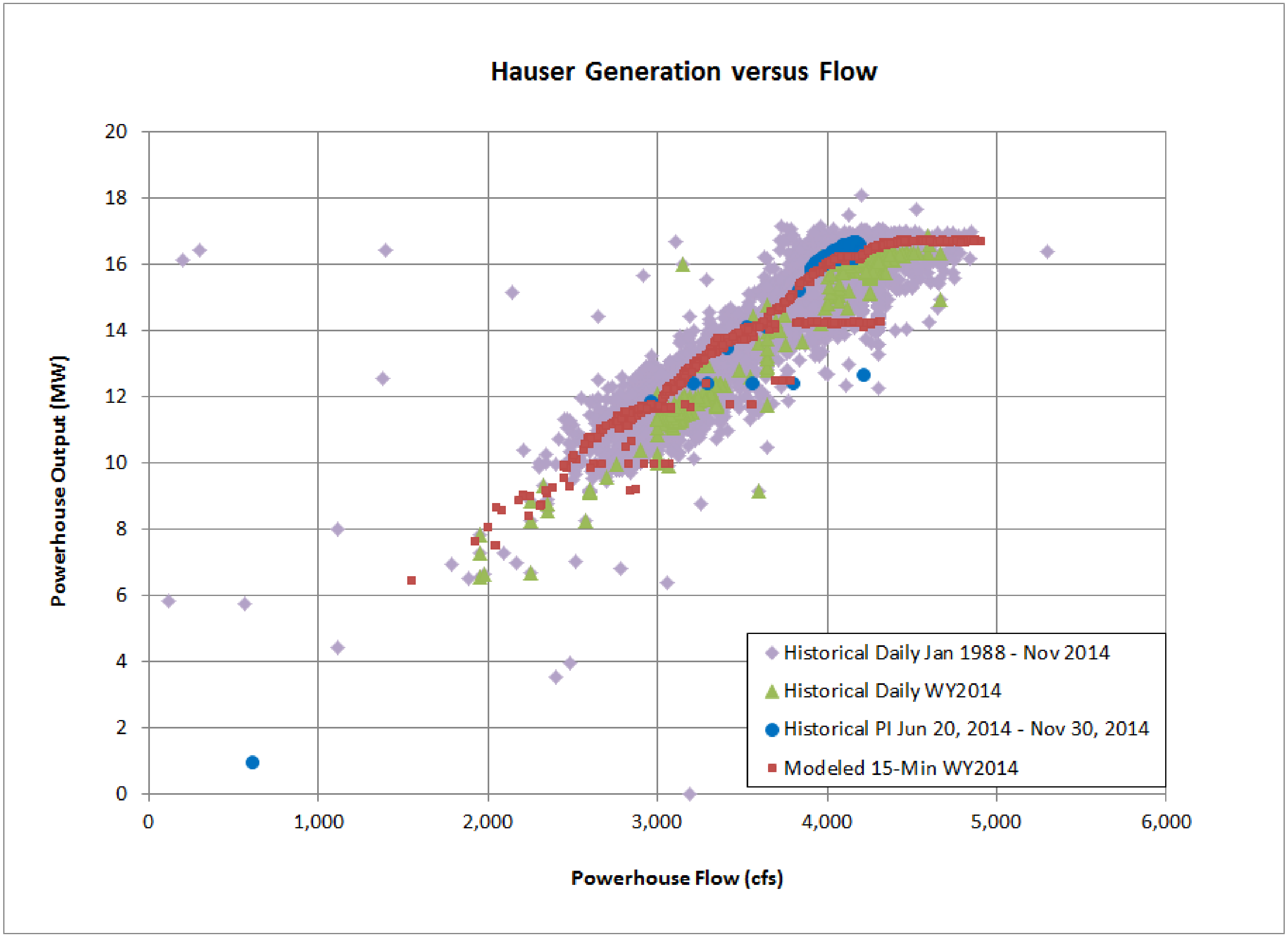

**FIGURE C-3**
**MODELED AND HISTORICAL HOLTER POWER VERSUS FLOW COMPARISON**

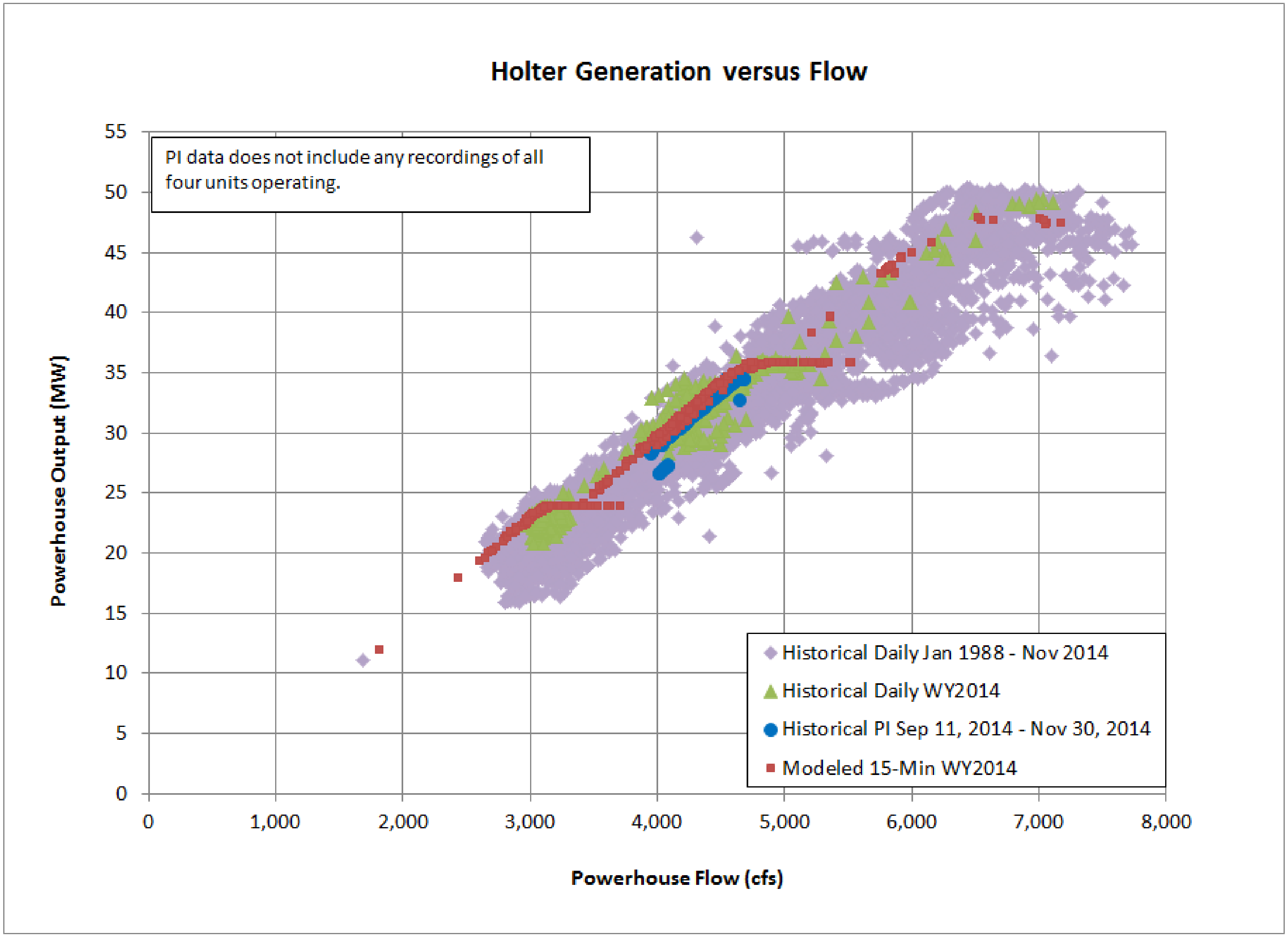

**FIGURE C-4**
**MODELED AND HISTORICAL BLACK EAGLE POWER VERSUS FLOW COMPARISON**

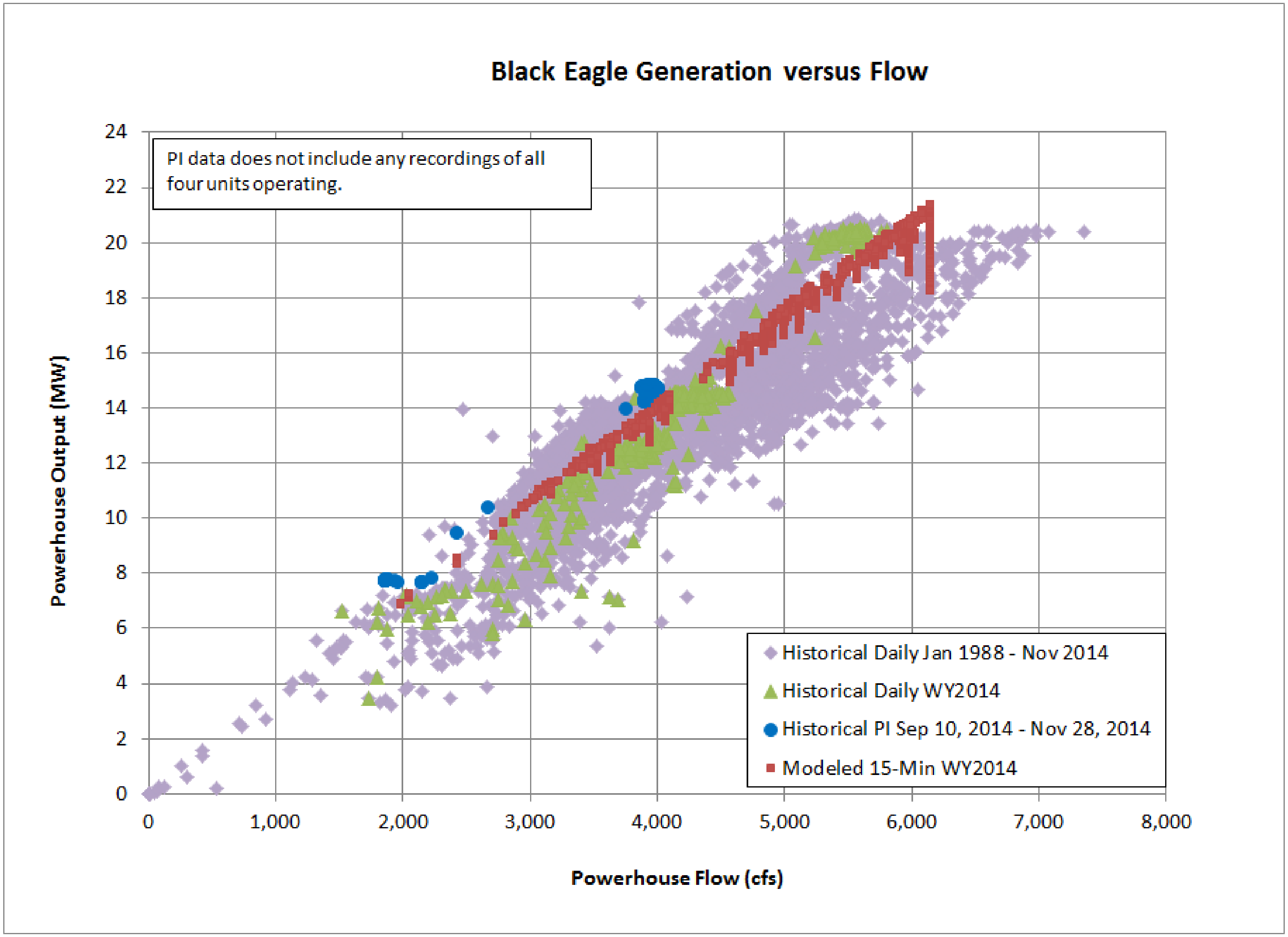

**FIGURE C-5**
**MODELED AND HISTORICAL RAINBOW POWER VERSUS FLOW COMPARISON**

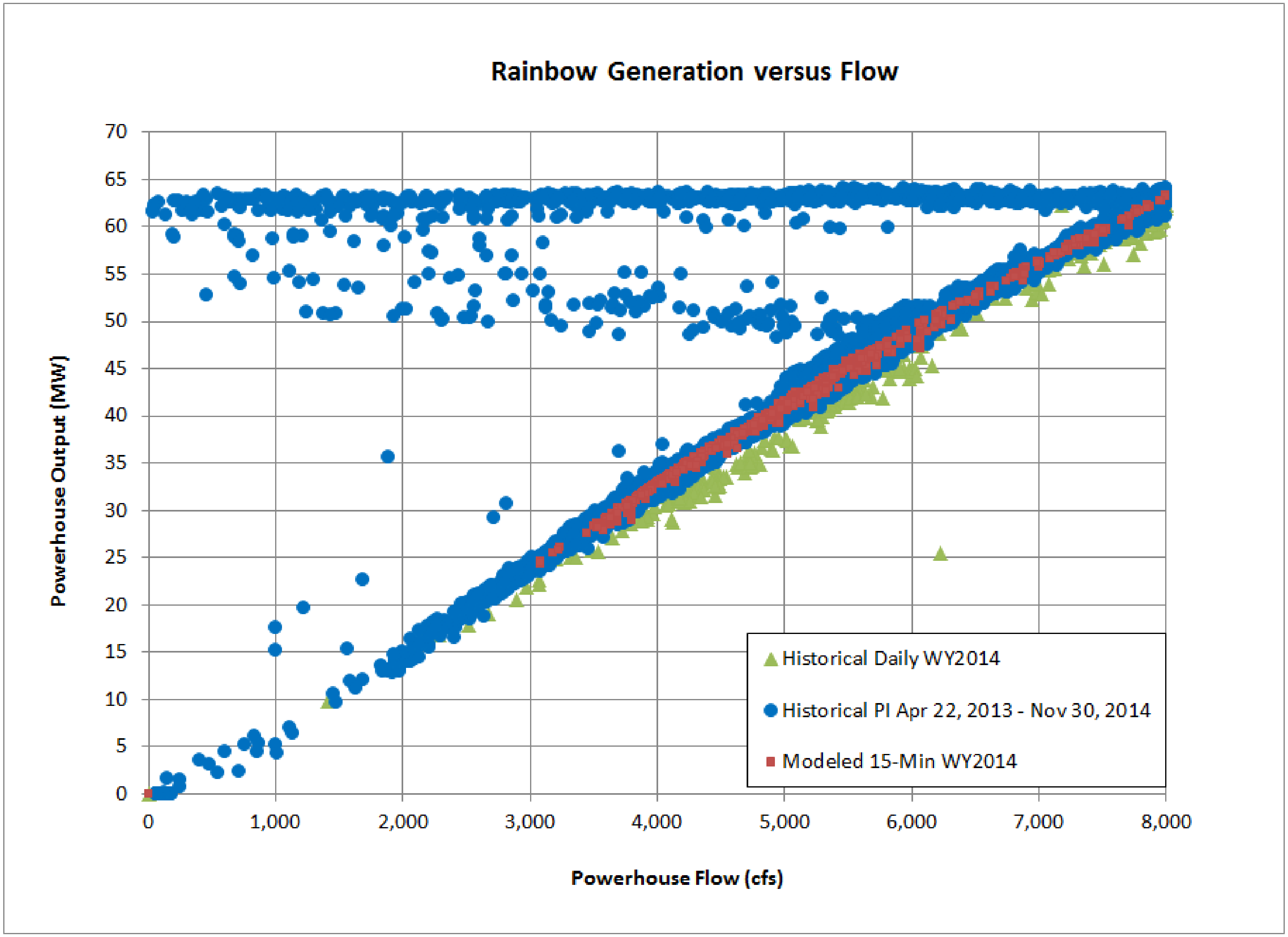

**FIGURE C-6**
**MODELED AND HISTORICAL COCHRANE POWER VERSUS FLOW COMPARISON**

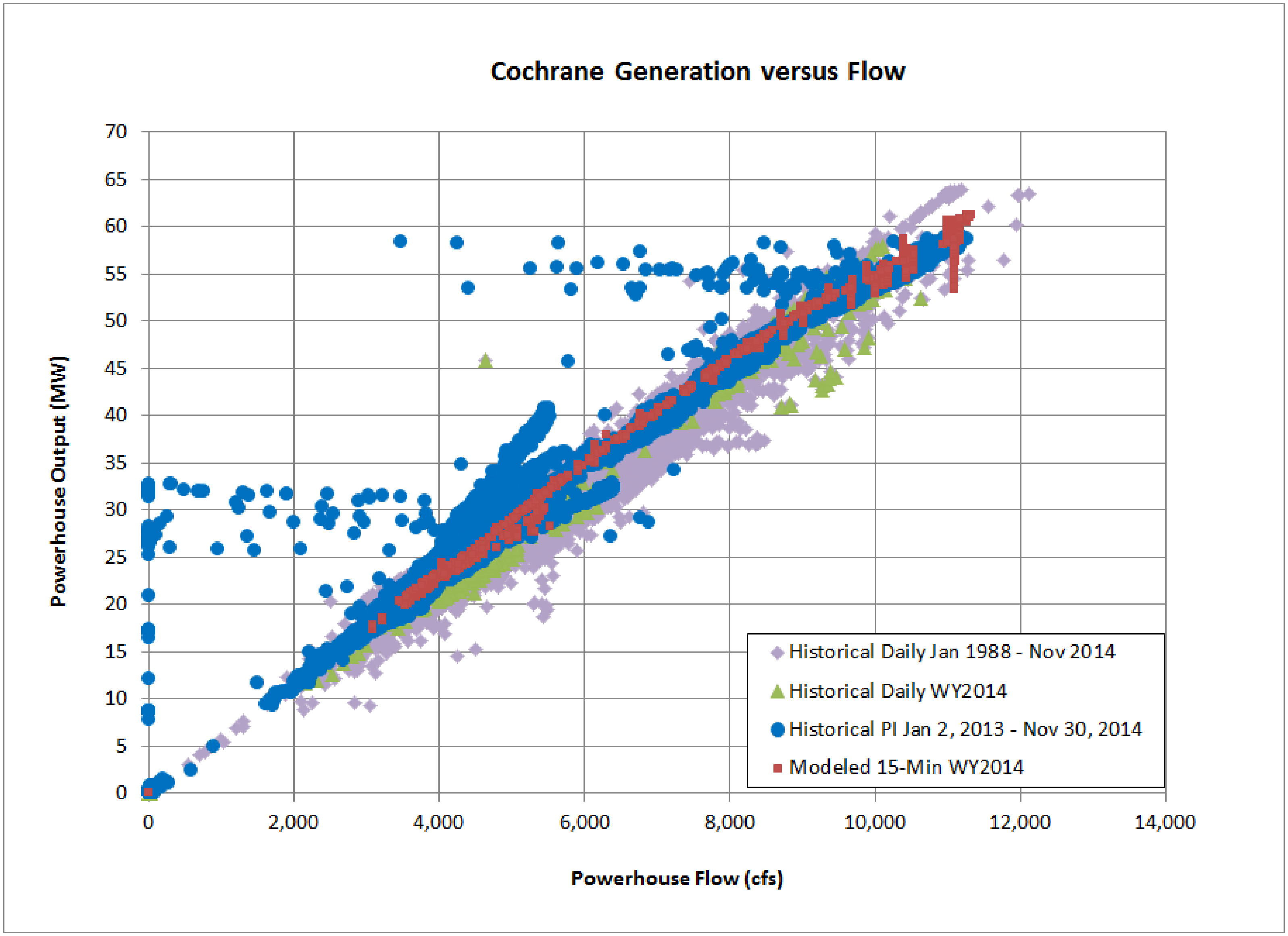

**FIGURE C-7**
**MODELED AND HISTORICAL RYAN POWER VERSUS FLOW COMPARISON**

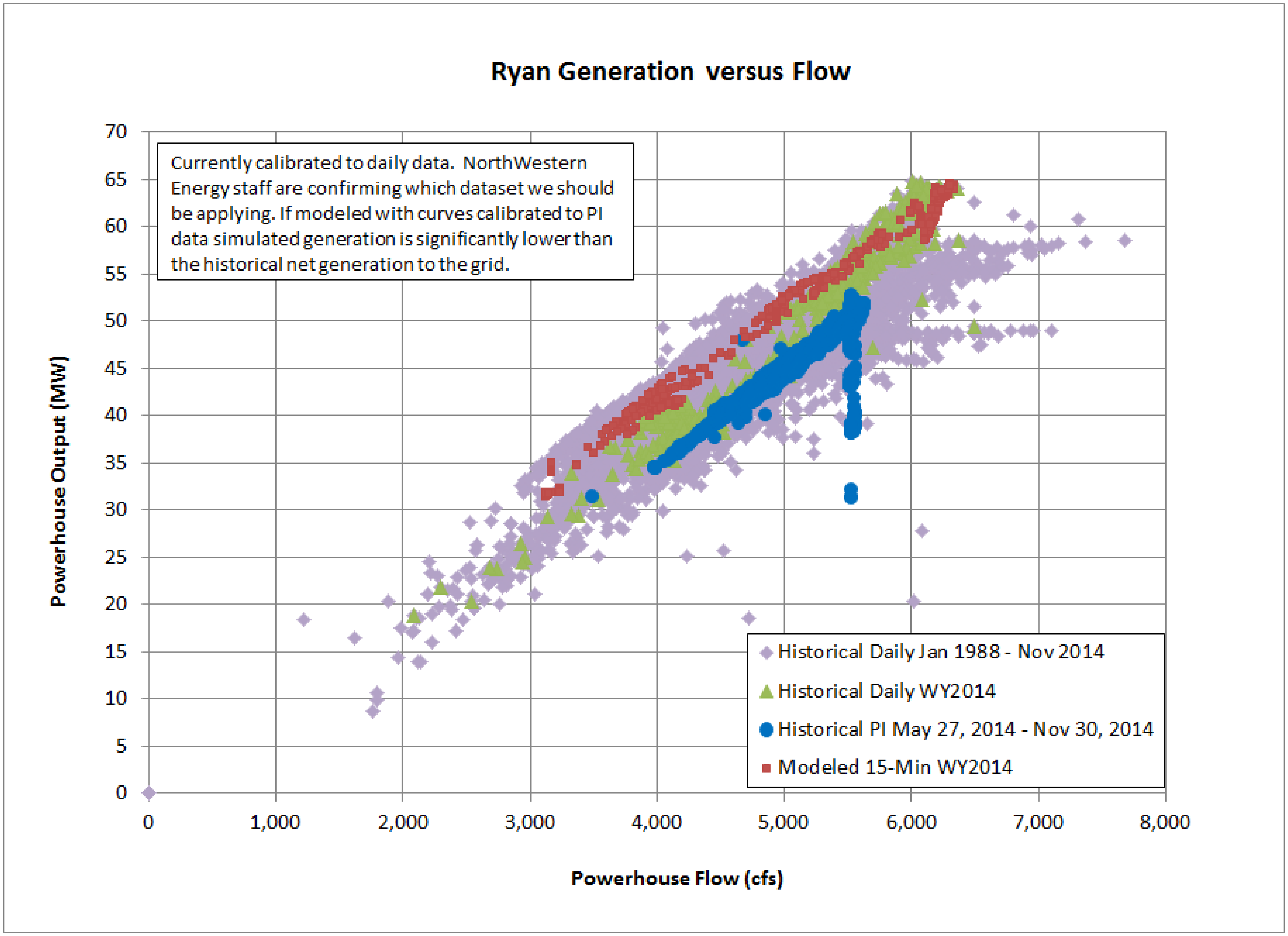

**FIGURE C-8**
**MODELED AND HISTORICAL MORONY POWER VERSUS FLOW COMPARISON**

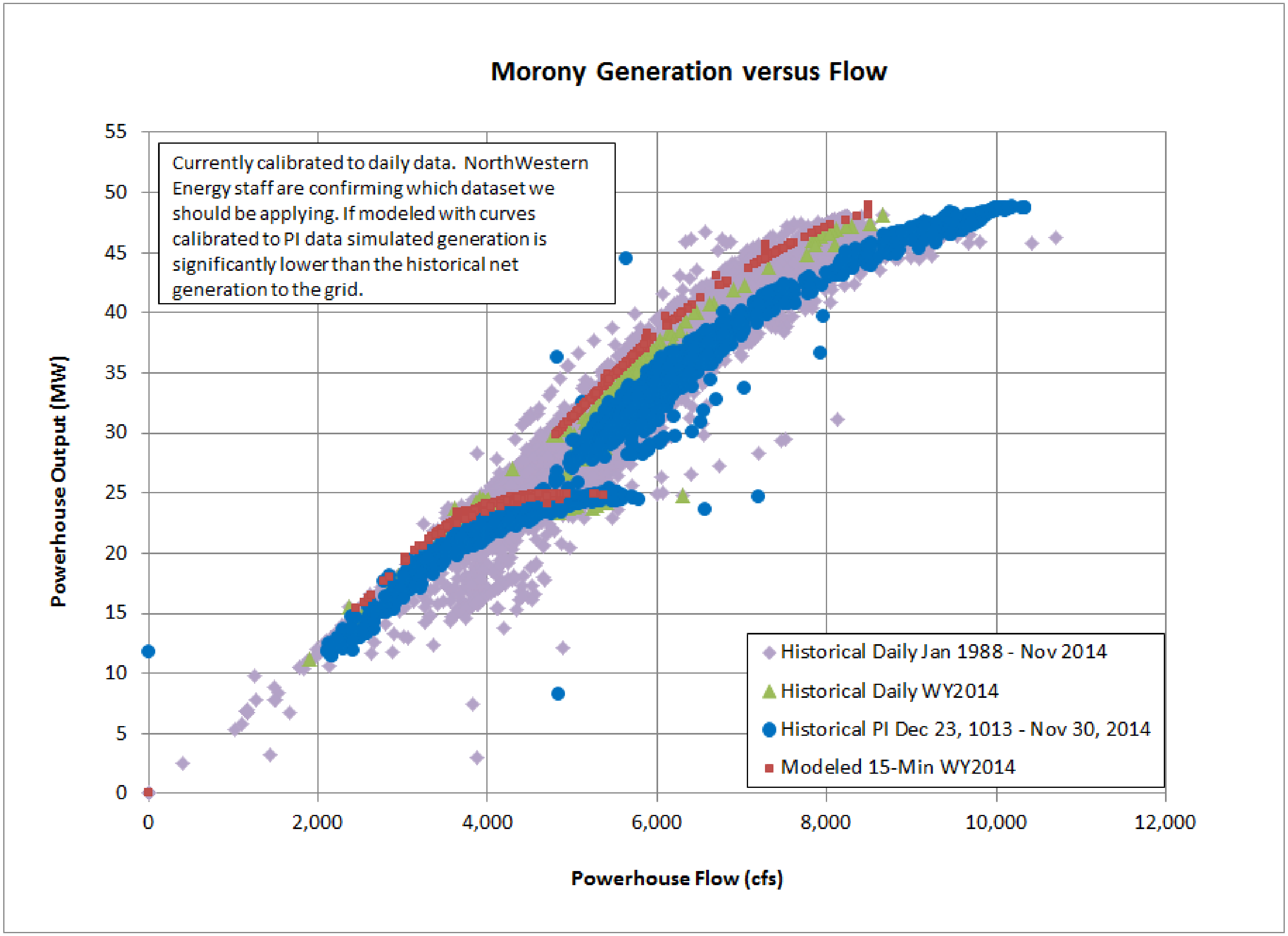

**FIGURE C-9**
**MODELED AND HISTORICAL THOMPSON FALLS POWER VERSUS FLOW COMPARISON**

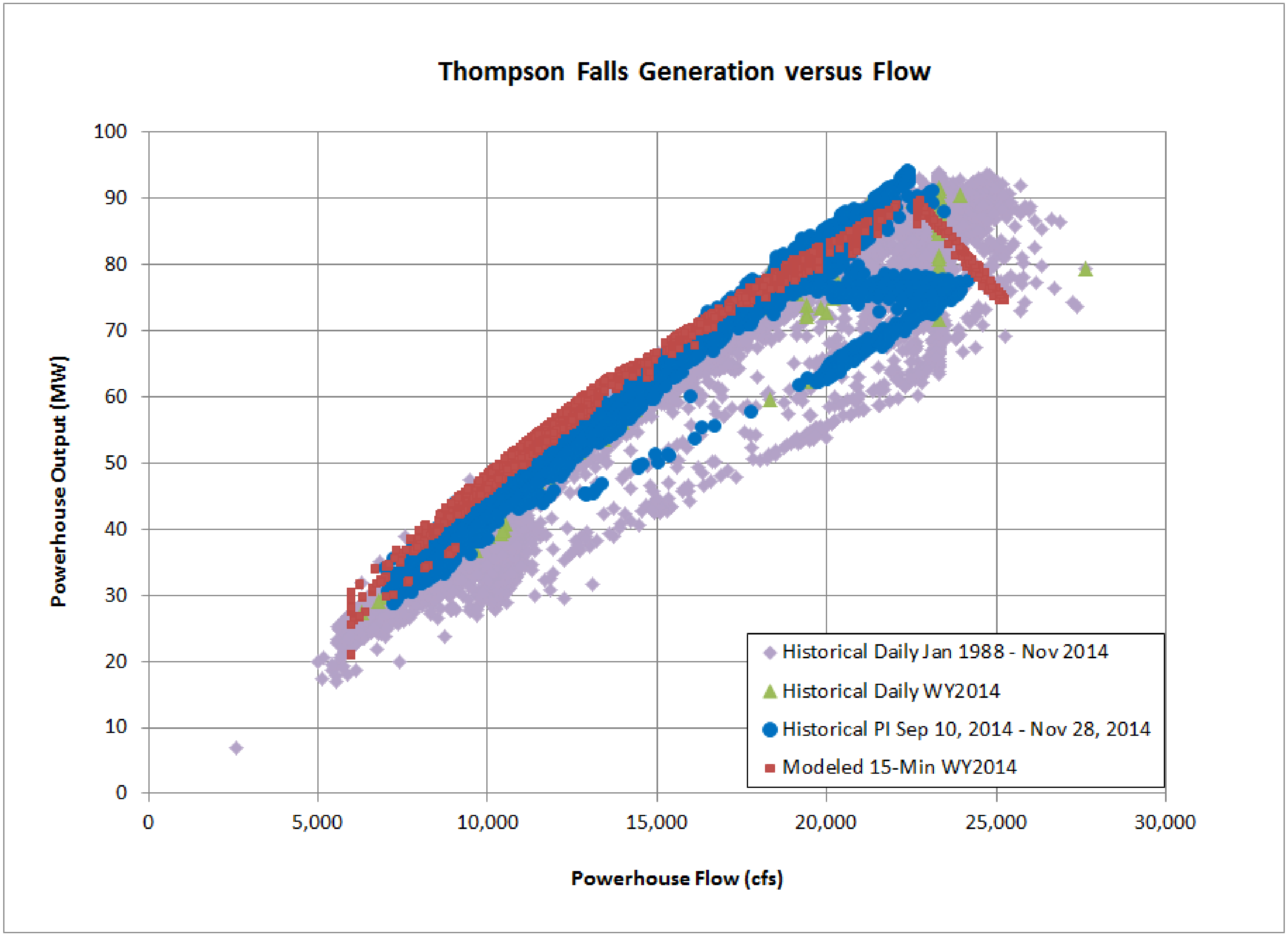

**FIGURE C-10**
**MODELED AND HISTORICAL MYSTIC LAKE POWER VERSUS FLOW COMPARISON**