BUREAU OF RECLAMATION

Yellowtail Dam Operating Criteria

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The Bighorn Lake/Bighorn River Operating Criteria (Operating Criteria) was first implemented in Water Year (WY) 2010 and was updated in WY2012 and WY2015 and serves as the basic operational framework for Yellowtail Dam. The Operating Criteria is based upon meeting various end of month reservoir storage levels and desired river releases for authorized project purposes. Reservoir and river operations require a careful balance between meeting these needs over a large range of inflow scenarios. Neither the lake level targets nor the fishery flow targets are mandatory but rather are goals for establishing a balanced operating plan. A timeline regarding changes made to the Operating Criteria is included in Appendix A.

For more detailed information and analysis, please visit Reclamation's Bighorn River System Issues Group at https://www.usbr.gov/gp/mtao/yellowtail/bighorn_longterm.html

Operating Targets:

Reservoir elevation targets were established to provide desired lake elevations for flood control, irrigation, power generation, recreation, lake fishery and water supply for the river fishery. Based on the streamflows noted below and the need for adequate storage space in the spring for flood control, the following reservoir target elevations, for October 31, March 31 and July 31 have been established:

Date	Reservoir Elevation Target (feet)
October 31	3635-3640
March 31	3617 (for establishing winter release)
April through July Rule Curve*	3591.5-3617 (minimum elevation)
July 31	3640

*Discussed under Operating Guidelines, April-July

The Optimum, Standard and Minimum instream flows are also identified in the *Streamflow and Lake Level Management Plan, Bighorn River and Bighorn Lake* which is tied to the Crow Tribe water rights settlement.:

Optimum Fishery Flow	2,500 cfs
Standard Fishery Flow	2,000 cfs
Minimum Fishery Flow	1,500 cfs
Absolute Minimum Fishery Flow	1,000 cfs

Reducing the river release below 1,500 cfs should not be considered unless it becomes necessary in extreme drought conditions. It is a priority to release all water through the Yellowtail Powerplant, which has a maximum capacity of 7,500 to 8,200 cfs when all four units are available. The maximum powerplant release varies with power generation availability and power transmission reserve and regulation requirements set by Western Area Power Administration.

As described in the U.S. Army Corps of Engineers' (USACE) *Report on Reservoir Regulations for Flood Control, Yellowtail Dam and Bighorn Lake* (Water Control Manual), reservoir operations should be planned to avoid releases that would cause flows in the Bighorn River to exceed 20,000 cfs at St. Xavier, 25,000 cfs at Bighorn, and 65,000 cfs in the Yellowstone River at Miles City. These levels were determined by the USACE when the project was originally planned and reflects what was identified as the safe channel capacity at the time and was used for the sizing of the flood pool. Current rule curves are built with a maximum estimated release below USACE flood safe channel capacities (see Table 1 for estimated maximum releases based on ideal conditions). This was done to provide operational flexibility for

unanticipated weather events resulting in streamflow's exceeding forecast (both above and below the dam) to provide a safety factor for operations.

Meeting the above reservoir elevations and river flow targets is dependent on the actual available water supply and inflow timing. In years with limited or excessive water supply, some targets may not be met. In these years, a careful balance between meeting reservoir elevation and river flow needs is necessary.

A description of the Operating Criteria by specific periods of the year is provided below.

Operating Criteria

November-December

Following the irrigation season and in advance of winter conditions, it is desirable to establish a stable winter release for the late fall and winter. This supports the health of the river fishery and helps to prevent potential disruption to downstream ice conditions.

The Yellowtail release rate is set near November 1 to achieve a March 31 reservoir elevation of 3617 feet and is calculated based on the actual end of October Bighorn Lake storage level, the planned November-March release from Buffalo Bill and Boysen Dams, and forecasted November through March river system gains between Buffalo Bill and Boysen Dams and Yellowtail Dam.

The forecasted November through March gains are based on actual April through October gains. The relationship between the actual April through October gains and the forecasted November through March gains are defined by a linear regression equation developed from historical data. The equation is modified as needed to include the latest data and provide the best fit.

Releases from Yellowtail Dam are adjusted as needed during November and December to stay on track with the March 31 elevation target of 3617 feet. Adjustments may be required due to actual inflows being higher or lower than forecasted, release changes from Boysen and Buffalo Bill Dams, or changes to forecasted gains. The frequency and magnitude of changes are dependent on conditions.

January-February

Starting in January of each year and concluding in June, Reclamation, USACE, and Natural Resources Conservation Service (NRCS) forecast April through July inflow on a monthly basis. These forecasts are generally based on mountain snowpack, precipitation data, antecedent conditions and historic inflows. In years when actual inflows are considerably higher or lower than median forecasted inflow, it may be beneficial to deviate from end of March elevation target of 3617 feet and adjust the winter release rate prior to March 1 to conserve or draft storage. If a decision is made to adjust the river release rate, changes during periods of cold weather should be gradual to minimize the risk of flooding due to possible ice jams on either the Bighorn or Yellowstone Rivers. Since early forecast accuracy is limited, adjustments should only be made to protect against high flood discharge later in the spring or water shortages.

If forecasts are near normal, increases or decreases to release rate are made, as necessary, to keep on track to reach elevation 3617 feet by March 31.

March
The April through July inflow forecasts are used with the rule curves (discussed in the next section) to establish the minimum required drawdown for anticipated inflow. If the April through July forecast is greater than the minimum fill volume of 727,000 acre-feet, releases are set to target April 30 drawdown elevation starting when the March forecast and monthly plan is finalized. Changes may be gradual depending on downstream ice conditions. The higher the April through July inflow forecast, the lower the drawdown elevation target. Table 1 includes rule curve drawdown targets based on April through July inflow volumes.

April-July
April through July runoff season utilizes a rule curve as a guide for determining desired reservoir elevations for flood control purposes. The rule curve is determined by using the April through July inflow forecast as an input and is updated once a month with each new inflow forecast. The minimum rule curve is designed to allow the reservoir to fill with a river release of 2,000 cfs under an April-July inflow volume of 727,000 acre-feet. The maximum rule curve under an April through July inflow volume of 2,500,000 acre-feet draws the reservoir down to a minimum elevation of 3591.5 feet.

It may be necessary to reduce the river release to 2,000 cfs or less to adequately conserve storage for long term operations in years with forecasted runoff of less than 727,000 acre-feet. The primary goal in low water years is to conserve storage to provide a stable river release rate of between 1,500 cfs to 2,000 cfs while allowing storage to stay near the desired elevation of 3617 feet by March 31 of the following year.

The rule curves are based on hydrology from the historical record that allow for filling of the reservoir to the top of joint use pool (elevation 3640) while providing sufficient storage space to control high spring runoff events with releases below flood control targets. Changes in temperature and precipitation amounts can significantly affect the quantity and timing of rainfall and snowmelt entering the streams. Dry conditions result in significant river depletion due to upstream irrigation, while wet conditions can eliminate these irrigation depletions. Recognizing this, the rule curve is not an absolute rule but rather a tool to assist decision making through spring runoff.

Table 1 shows the minimum reservoir elevations and anticipated maximum releases based on the rule curve for several different April through July runoff volumes. The estimated maximum release assumes ideal runoff conditions. The actual peak releases may be higher (+/- 20 percent) due to natural variability during spring runoff. Temperatures fluctuations, snowpack conditions, significant rain events, and the potential for more runoff than forecasted are all factors that could result in the actual peak release exceeding the estimated release.

Table 1: Rule Curve Drawdown

Percentile Rank	Percent of Average	April-July Inflow Forecast (acre-feet)	Rule Curve Minimum Elevation (feet)	Date of Minimum Elevation	Estimated Maximum Release	Estimated Duration of Release > 8,000 cfs
27	61%	727,000	3617.0	1-Apr	2,000	
35	84%	950,000	3616.0	1-Apr	3,400	
50	99%	1,121,800	3613.5	3-May	4,500	
60	116%	1,310,000	3611.5	13-May	5,700	
75	140%	1,584,000	3607.7	15-May	7,500	
90	163%	1,850,000	3603.7	18-May	9,500	30 days
95	173%	1,957,300	3600.5	17-May	10,000	41 days
98	204%	2,310,000	3594.5	14-May	12,000	58 days
Max (99+)	221%	2,500,000	3591.5	14-May	13,000	66 days

End of month and minimum drawdown elevation targets are used from the rule curve. These targets along with the current storage level are used to calculate the forecasted release rate for each month. For example, the April 1 forecast of April through July inflow is used to define the rule curve and the end of April, May, and June elevations are used from the rule curve along with the minimum elevation of the rule curve as elevation targets. The May 1 forecast of May through July inflow is used to define another rule curve and the end of May and June elevations are used from the rule curve along with the minimum rule curve elevation as elevation targets. This same routine is done in June except the minimum elevation has passed for the season.

Once new elevation targets are defined by the rule curve, releases are set to target the current end of month elevation or minimum elevation depending on the time of the year. Additionally, daily inflow forecasts from the National Weather Service are used during runoff to forecast runoff from forecasted precipitation and snowmelt runoff in real time. Releases, end of month elevation targets, and minimum elevation targets will change based on actual inflows and revised inflow forecasts.

After the reservoir has filled to the top of joint use pool or reached its peak elevation for the year and inflows begin to recede, river releases are adjusted with the goal of meeting an end of July reservoir target elevation of 3640 feet while also providing a fishery flow of 2,500 cfs or more.

August-October

Following April through July runoff, the river release should be established at 2,500 cfs or more if forecasted inflows can meet an end-of-October reservoir elevation target between 3635 and 3640 feet. The end of October elevation target range is established to provide an overwinter water supply for making late fall and winter releases to the river and support reservoir waterfowl hunting.

In lower inflow years when a river release of 2,500 cfs cannot be met without drafting the reservoir below elevation 3635 by the end of October, planned operations should meet an end-of-March target elevation of elevation 3617 feet with a uniform release throughout the late summer, fall, and winter seasons. This release rate is calculated using estimated August through October reservoir gains, the forecasted November through March gains and planned August through March releases from Buffalo Bill and Boysen Reservoirs.

Reservoir and River Real-Time Operation Considerations

Development of the Operating Criteria, first utilized in water year 2010, includes lake level targets, river fishery targets, a method for calculating gains, a procedure for establishing a November through March river release rate and spring runoff rule curves. The Operating Criteria provided a more transparent method for establishing major operational decisions through each annual operating cycle and are intended to be a guideline to operational decision making. There will always be real-time considerations that may not allow for exact adherence to the Operating Criteria. Inflow events, drought conditions, USACE flood control orders, infrastructure maintenance, and inflow timing will continue to have a significant effect on operations.

References

Final Draft Report (April 2012 - Reclamation). Draft Yellowtail Unit Operating Criteria Evaluation Study and Report. Available at https://www.usbr.gov/gp/mtao/yellowtail/bighorn_longterm.html.

Changes for the 2012 Water Year (November 2011 – Reclamation). Draft Bighorn Lake Operating Criteria. Available at https://www.usbr.gov/gp/mtao/yellowtail/bighorn_longterm.html

Draft Report (September 2010 - Reclamation). Draft Yellowtail Unit Operating Criteria Evaluation Study and Report. Available at https://www.usbr.gov/gp/mtao/yellowtail/bighorn_longterm.html.

Report on Reservoir Regulations for Flood Control, Yellowtail Dam and Bighorn Lake (January 1974 – USACE). Yellowtail Dam and Bighorn Lake Report on Reservoir Regulations for Flood Control.

Appendix A

Timeline of Changes to the Operating Criteria

October 2010: Operating Criteria Implemented

October 2011: Changes Implemented for Water Year 2012

- The end of October target was changed to 3635 to 3640 feet from 3638 to 3640 feet.
- The end of March target was changed to 3615 to 3619 feet from 3616.7 to 3620.6 feet
- The equation used to forecast November through March gains was changed.
- Refinements to the rule curves were made.
    - The distribution of inflows during April and May were refined.
    - 2010 and 2011 Water Years were added to the years that go into creating the rule curves. The rule curves were refined and expanded to cover inflow forecasts up to 2,500,000 acre-feet. The minimum lake level elevation was changed to 3591.5 feet for the highest inflow April through July forecast of 2,500,000 acre-feet.

No changes to the Operating Criteria were made for Water Years 2013, 2014, or 2015.

April 2015: Change Implemented for Water Year 2016

- The equation used to forecast November through March gains was updated using new data.

November 2015: Changes Implemented for Water Year 2016

- The end of March target was changed to 3617 feet from 3615 to 3619 feet.
- The release can be adjusted during November through February to stay on the end of March target of 3617 feet but maintain the flexibility of changing the end of March target when snowpack or inflow forecasts are abnormally high or low.
- The release will be adjusted in March and April based on end of April elevation target. The end of April elevation target is dependent on the rule curve defined by the April through July inflow forecast.