

RECLAMATION

Managing Water in the West

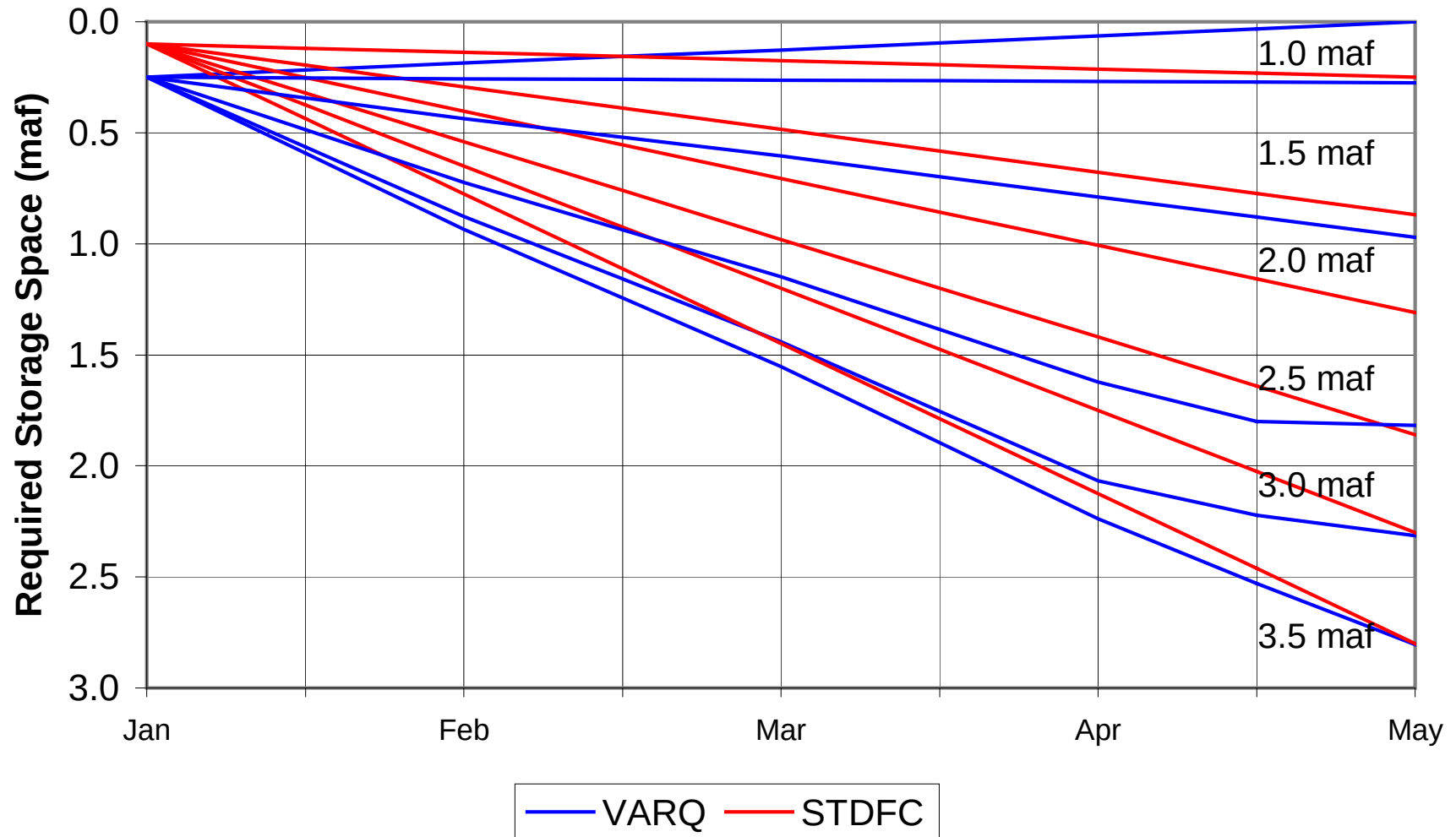
Yellowtail Dam & Bighorn Lake VARQ

Billings, MT
October 9, 2008

VARQ – What is it

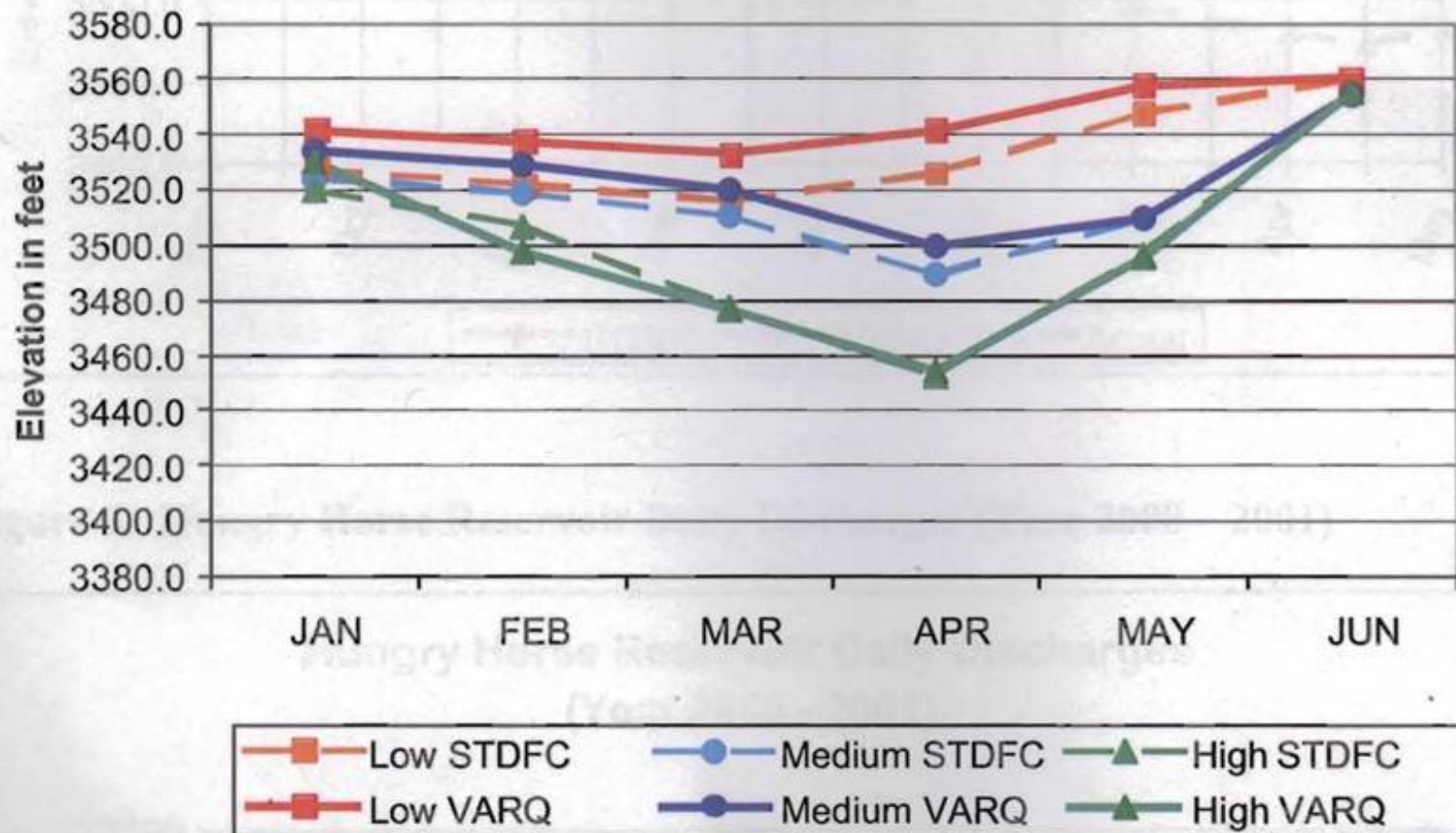
- **A series of Revised Flood Control Rule Curves Designed to:**
 - Reduce wintertime Reservoir drawdown compared to existing operations
 - Provides better assurance of reservoir refill in summer
 - Reduce probability of significant release reduction during spring refill season

Hungry Horse Reservoir Standard and VARQ Flood Control Storage Reservation Diagrams



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Modeled HGH End of Month Reservoir Elevations Low(1977), Medium(1975), High(1974) Water Years



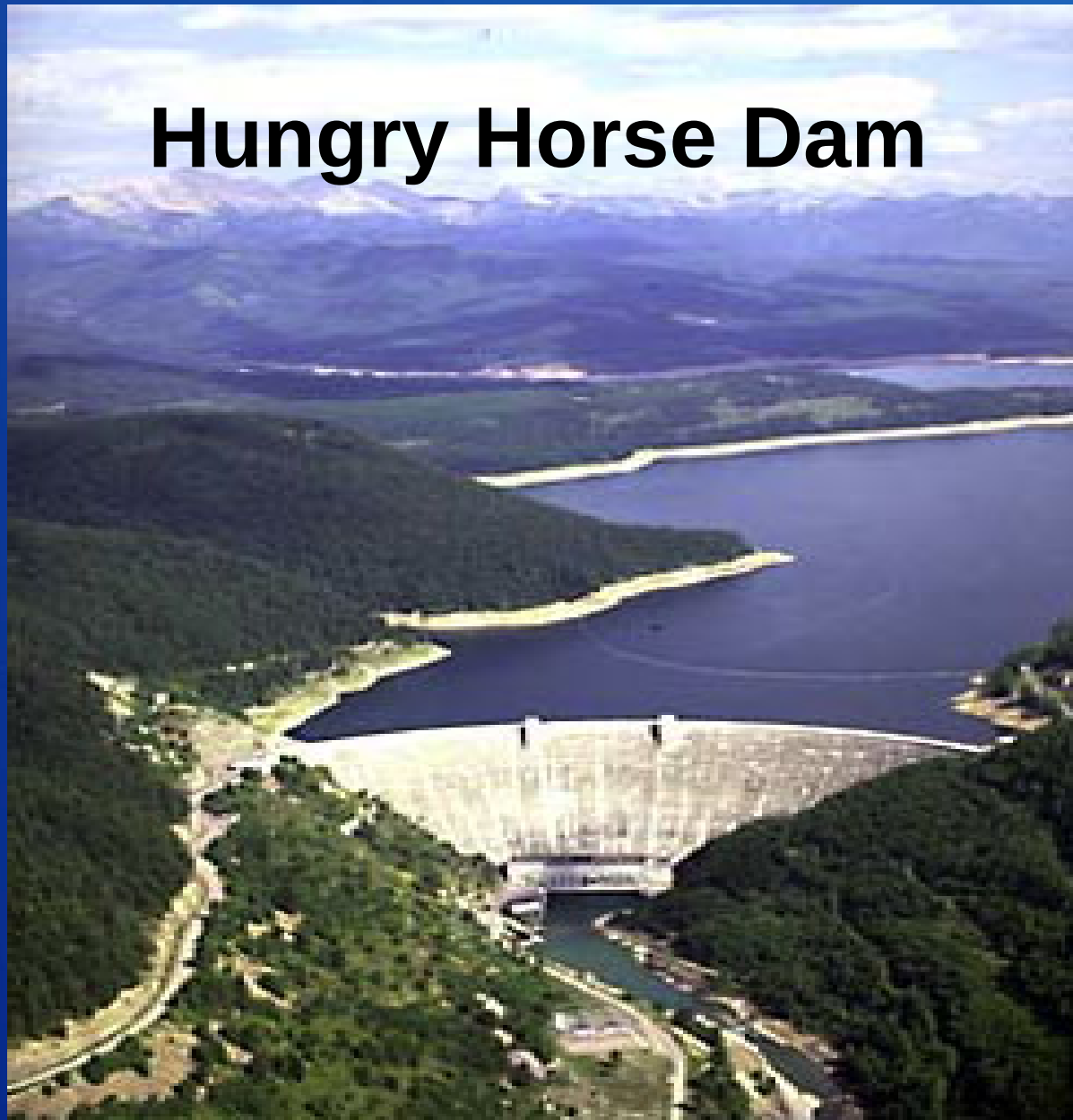
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Differences between River Basins

- **Hungry Horse Dam (South Fork Flathead River)**
 - No upstream development
 - 100% Mountain drainage
 - Bob Marshall Wilderness
 - Natural Hydrograph
 - Reservoir Capacity 3.5 maf, Drainage Basin 1,640 sq mi
- **Yellowtail Dam (Bighorn River)**
 - Significant upstream irrigation development
 - Two large & several smaller upstream reservoirs
 - River is both Mountain and plains feed
 - Hydrograph significantly altered by upstream development
 - Reservoir Capacity 1.1 maf, Drainage Basin 19,650 sq mi

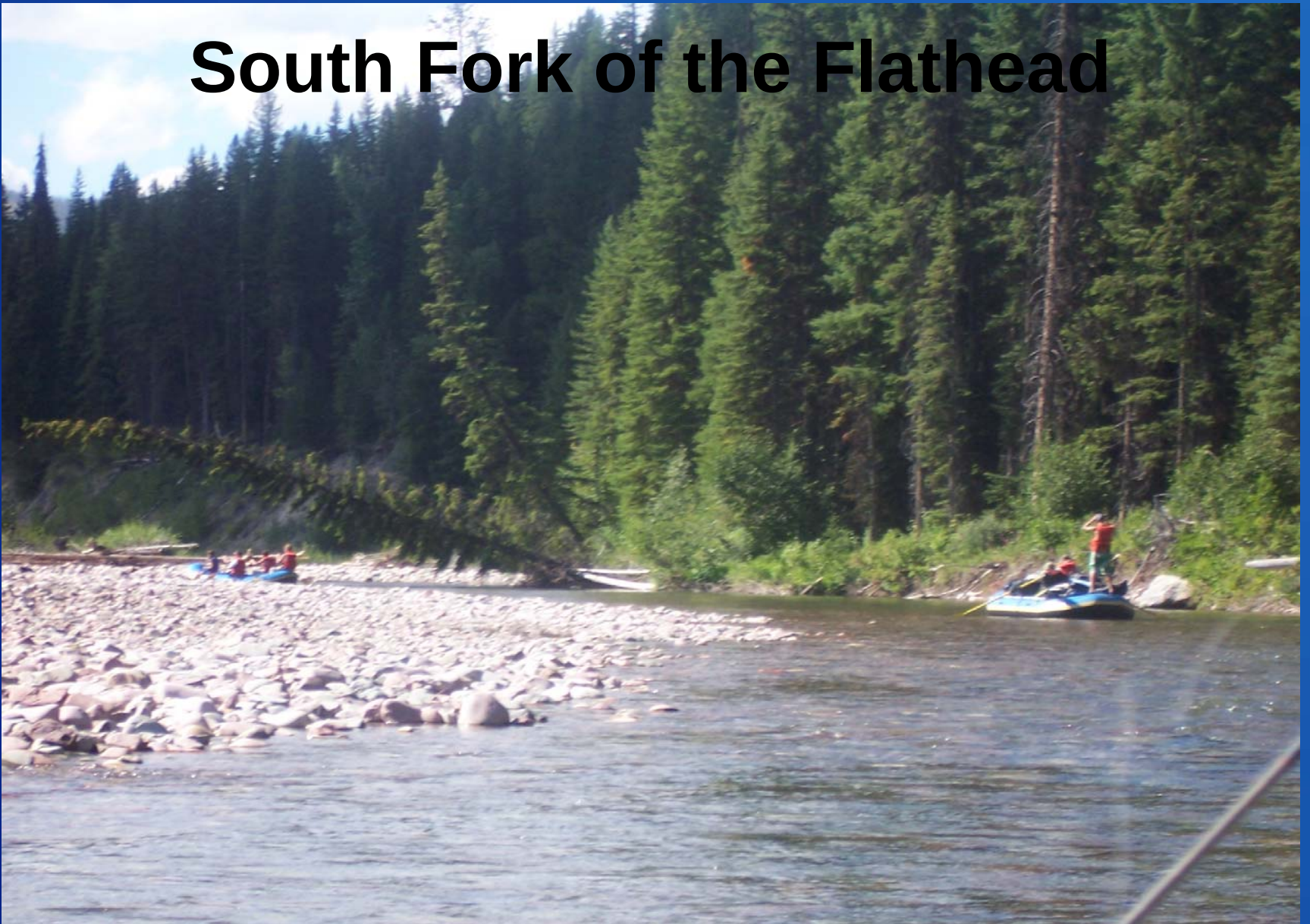
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Hungry Horse Dam



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South Fork of the Flathead



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South Fork of the Flathead



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South Fork of the Flathead



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Yellowtail Dam



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A wide-angle photograph of the Boysen Dam and Reservoir. The dam is a long, low concrete structure spanning a deep canyon. Behind the dam is a large reservoir of dark blue water. In the foreground, there are steep, rocky hillsides with some green trees and shrubs. A small concrete structure, likely part of the dam's spillway or powerhouse, is visible on the left side of the dam. The sky is blue with some white clouds.

Boysen

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Buffalo Bill



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Bull Lake



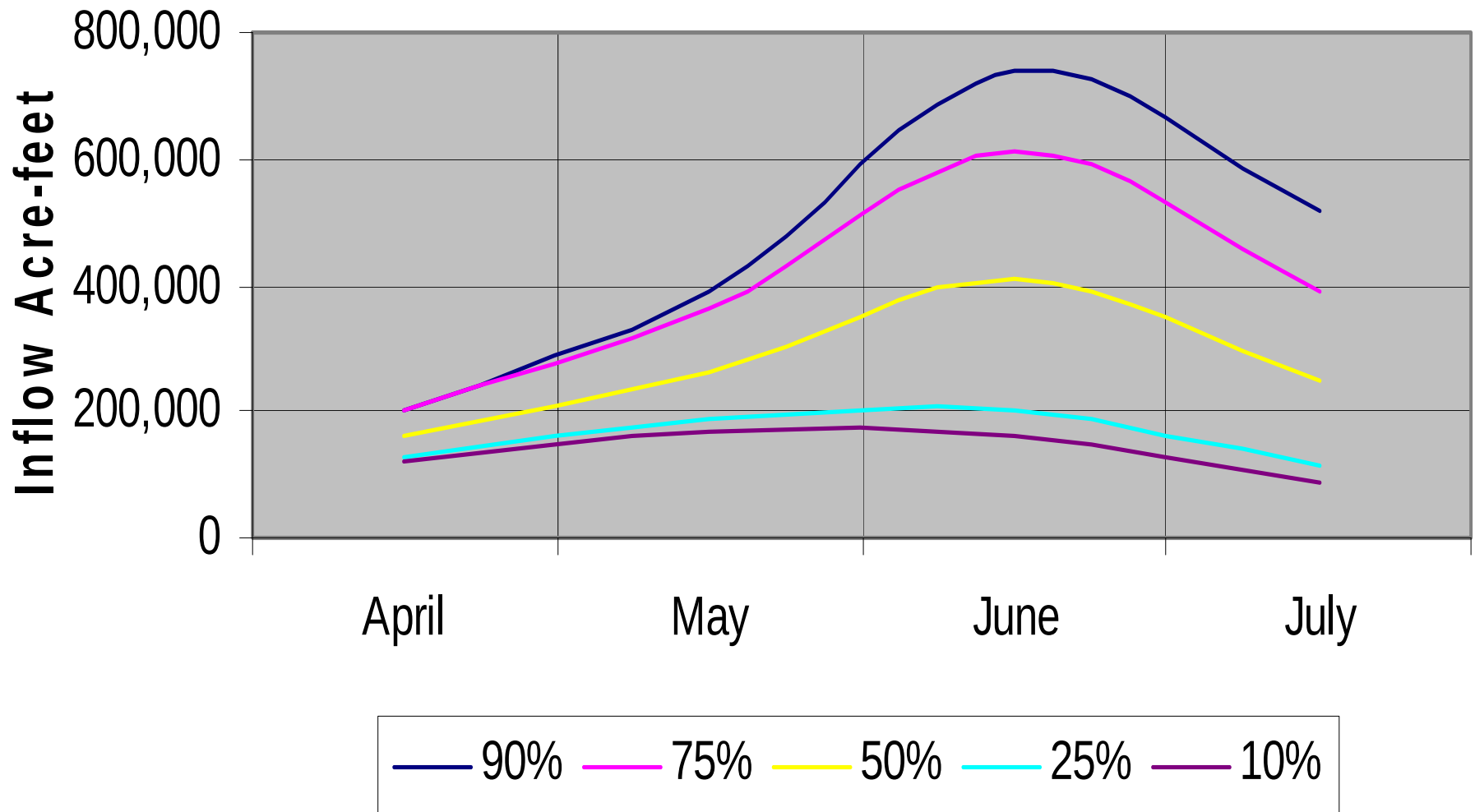
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Bighorn Lake Inflow Percentiles

	1,000 acre-feet				
	Apr	May	June	July	Total
Percentile					
90%	203.6	388.8	740.6	518.4	1,851.6
75%	204.4	361.7	613.3	393.2	1,572.7
50%	162.8	260.5	412.5	249.7	1,085.6
25%	126.3	189.4	202.1	113.7	631.5
10%	117.7	171.2	160.5	85.6	534.9

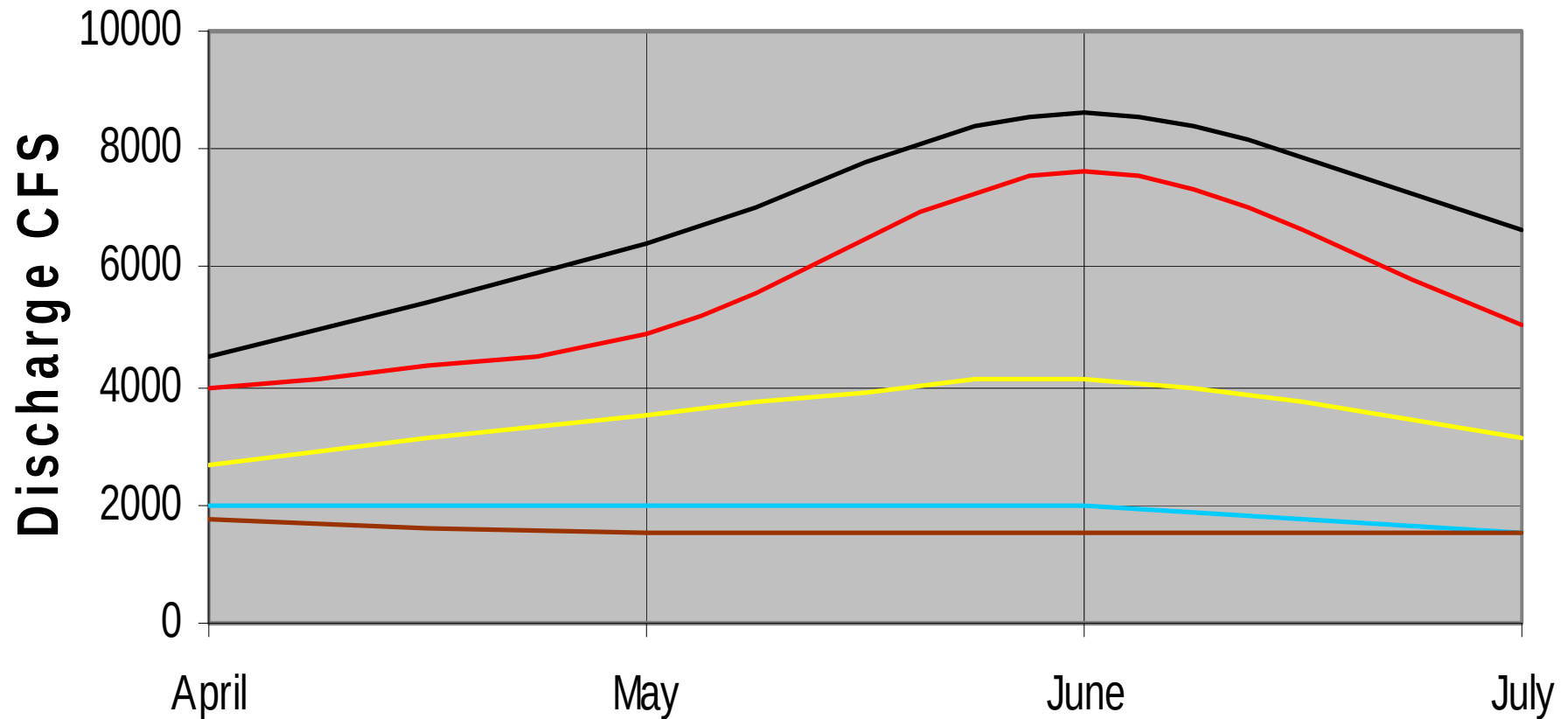
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Bighorn Lake Inflow



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Bighorn Lake Storage Reservation Release Curves

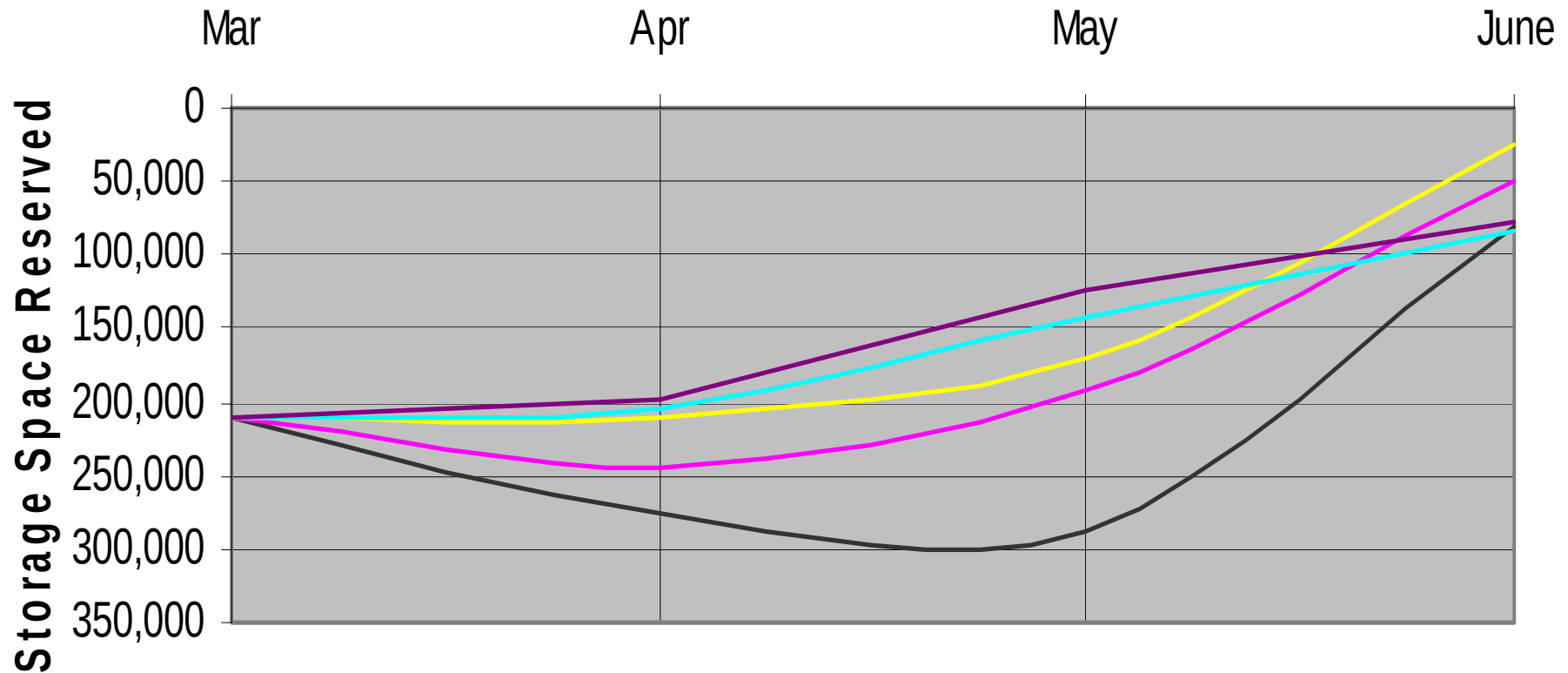


— 90 Percentile — 75 percentile — 50 percentile — 25 Percentile — 10 Percentile

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Bighorn Lake Storage Reservation Curves

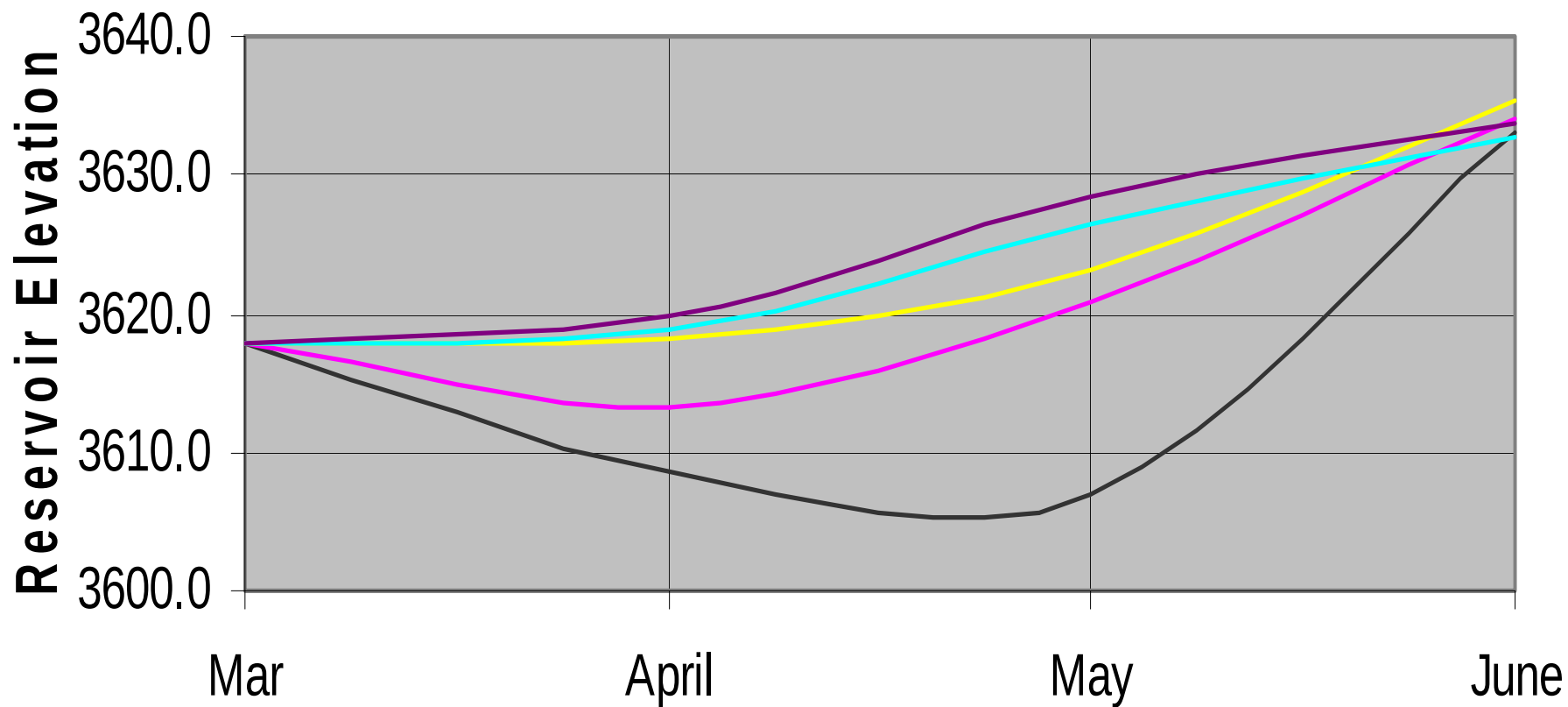
End of Month Values



— 90 Percentile — 75 Percentile — 50 Percentile — 25 Percentile — 10 percentile

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Bighorn Lake Storage Reservation Curves



— 90 Percentile — 75 Percentile — 50 Percentile — 25 Percentile — 10 percentile

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Rule Curve Evaluation

Three Sample Year Evaluated to Test Results

- 1973 Medium Year
- 2000 Lower Quartile Year
- 2008 Recent Year, 61 Percentile Year (120% of Medium Year)

Bighorn Lake Inflow Percentiles 1973

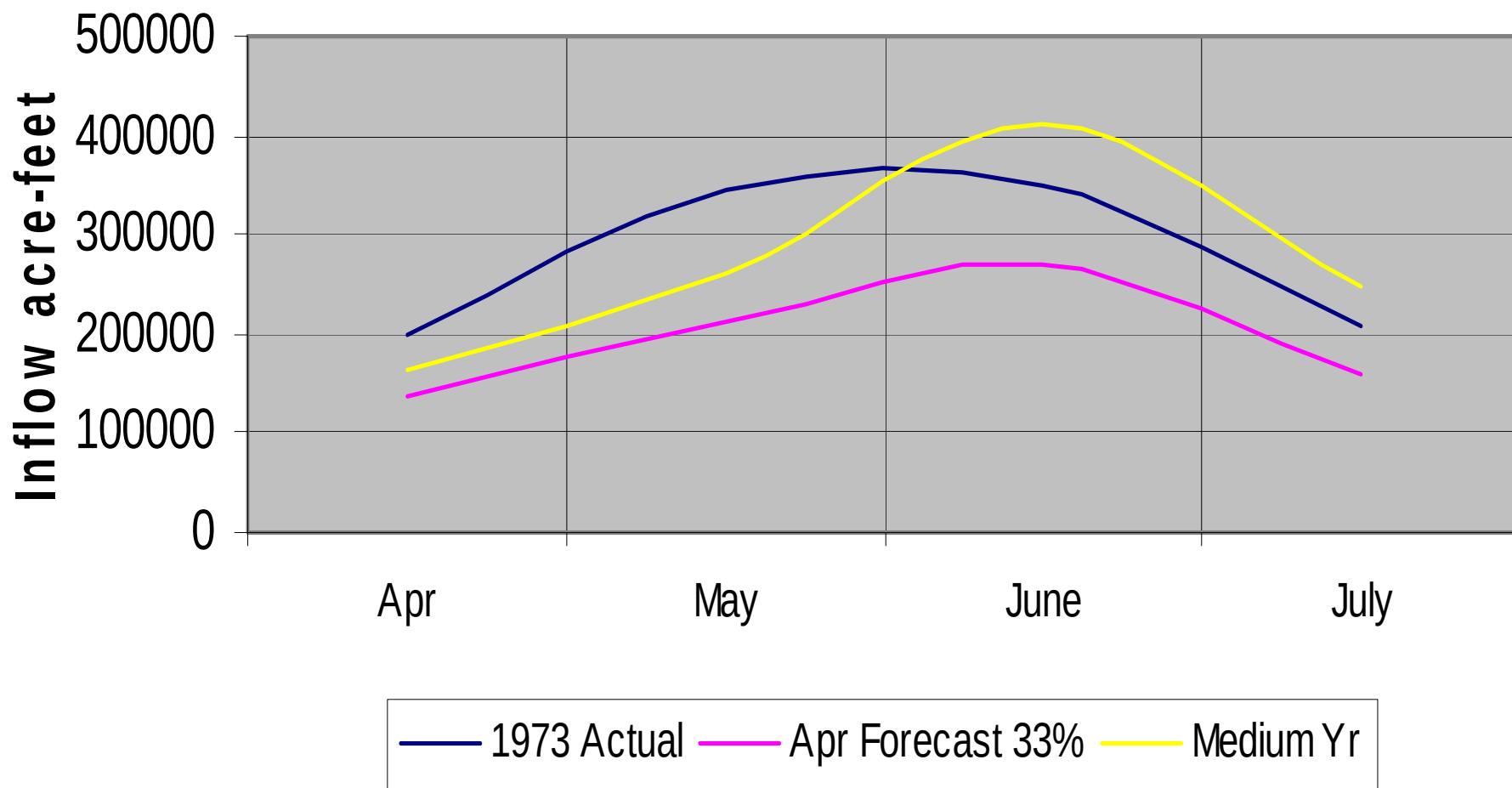
1,000 acre-feet

Percentile	Apr	May	June	July	Total
90%	203.6	388.8	740.6	518.4	1,841.6
75%	204.4	361.7	613.3	393.2	1,572.7
50%	162.8	260.5	412.5	249.7	1,085.6
33% Forecast	138.0	212.2	269.4	157.2	776.8
25%	126.3	189.4	202.1	113.7	631.5
10%	117.7	171.2	160.5	85.6	534.9

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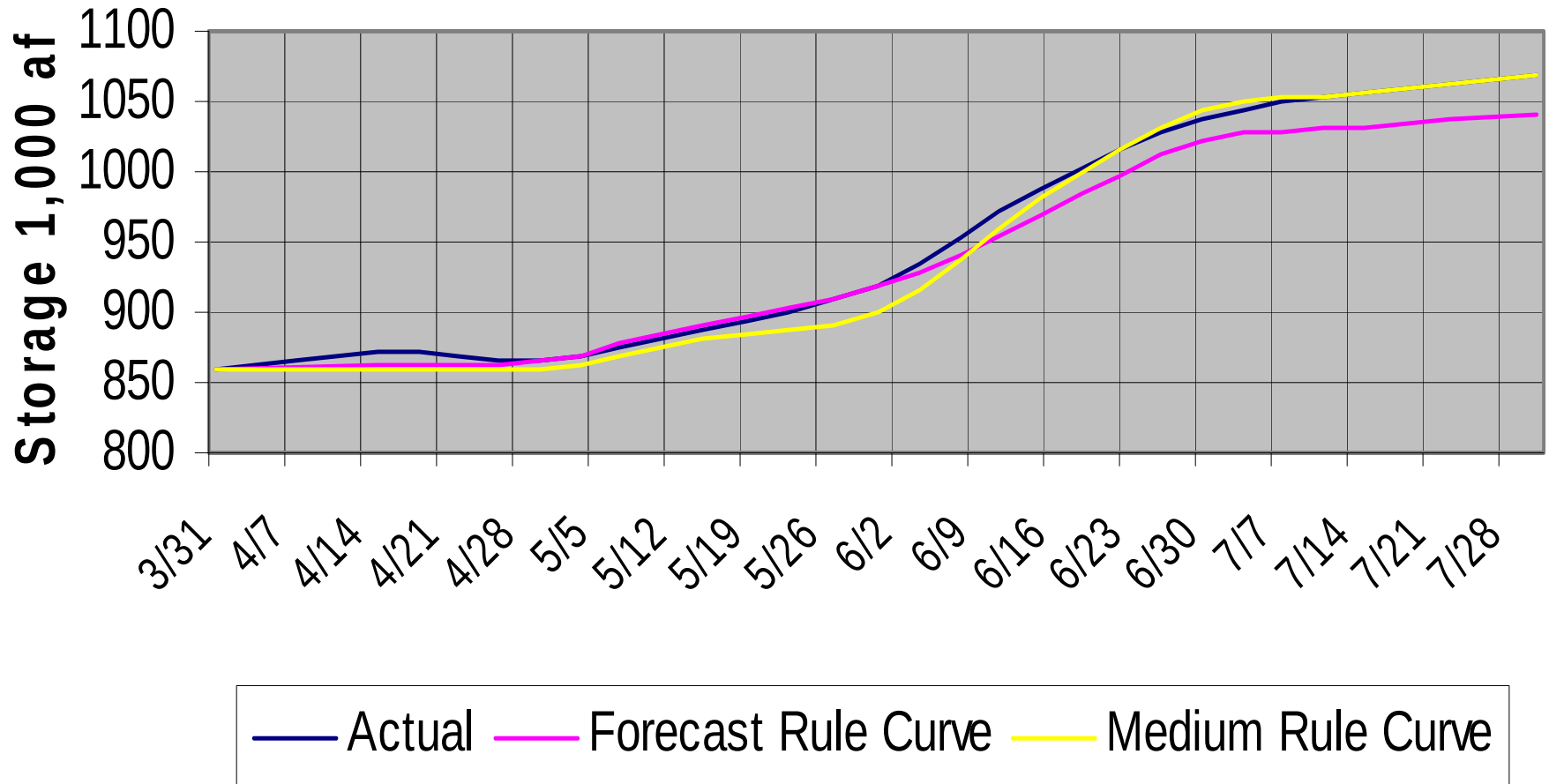
Bighorn Lake Inflow 1973

Medium Year

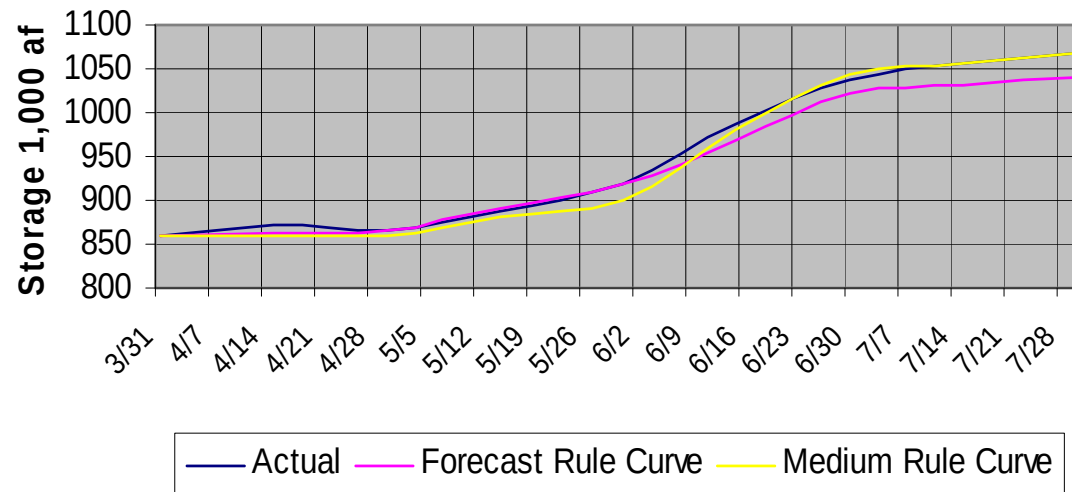


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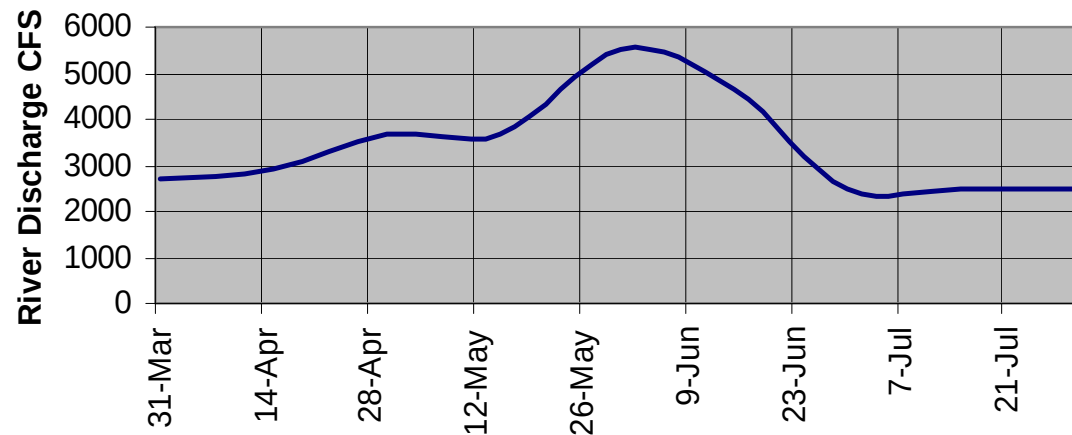
Bighorn Lake Storage 1973



Bighorn Lake Storage 1973



Bighorn Lake River Release 1973



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Bighorn Lake Inflow Percentiles 2000

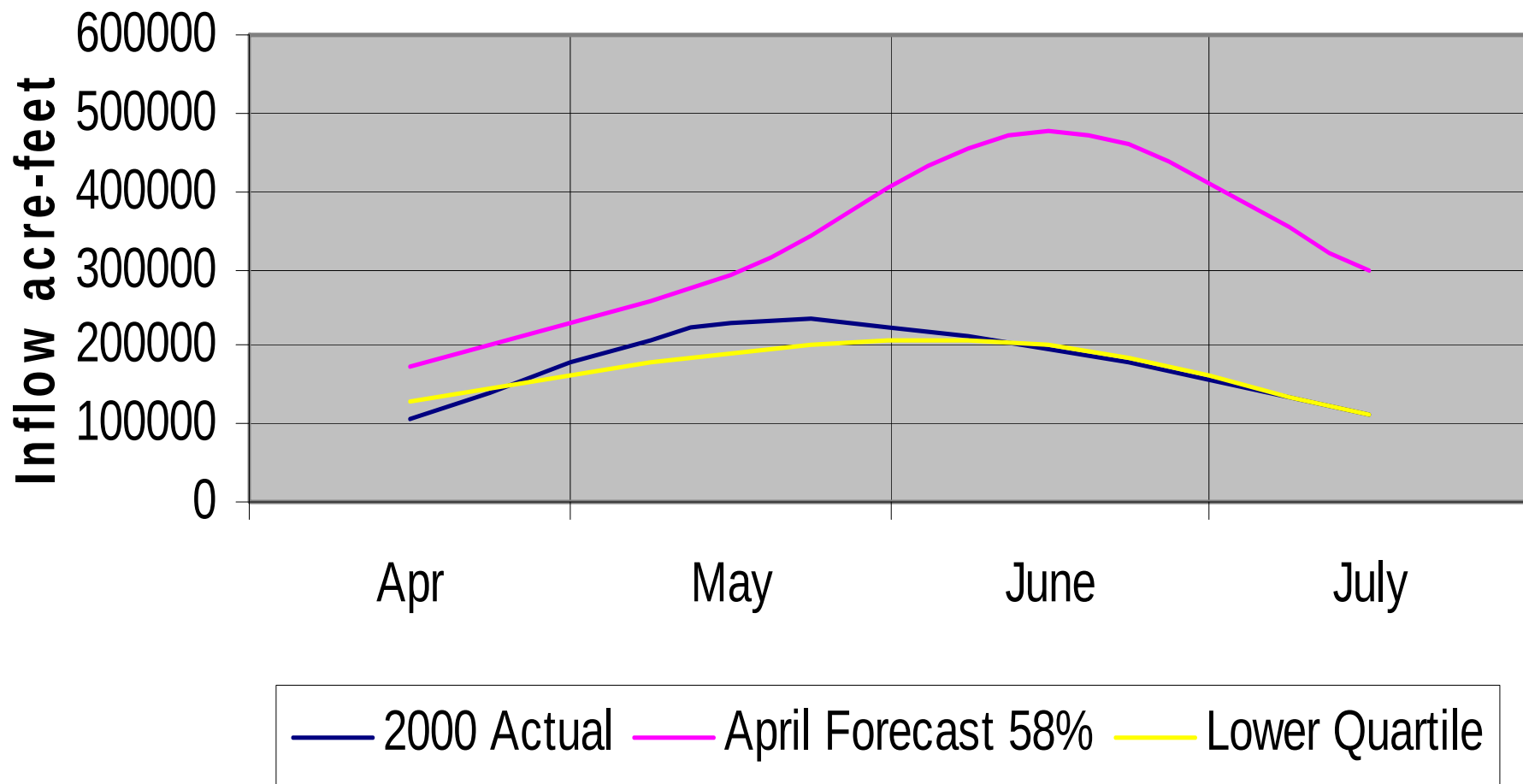
1,000 acre-feet

Percentile	Apr	May	June	July	Total
90%	203.6	388.8	740.6	518.4	1,841.6
75%	204.4	361.7	613.3	393.2	1,572.7
58% Forecast	175.8	292.9	476.8	295.6	1,241.1
50%	162.8	260.5	412.5	249.7	1,085.6
25%	126.3	189.4	202.1	113.7	631.5
10%	117.7	171.2	160.5	85.6	534.9

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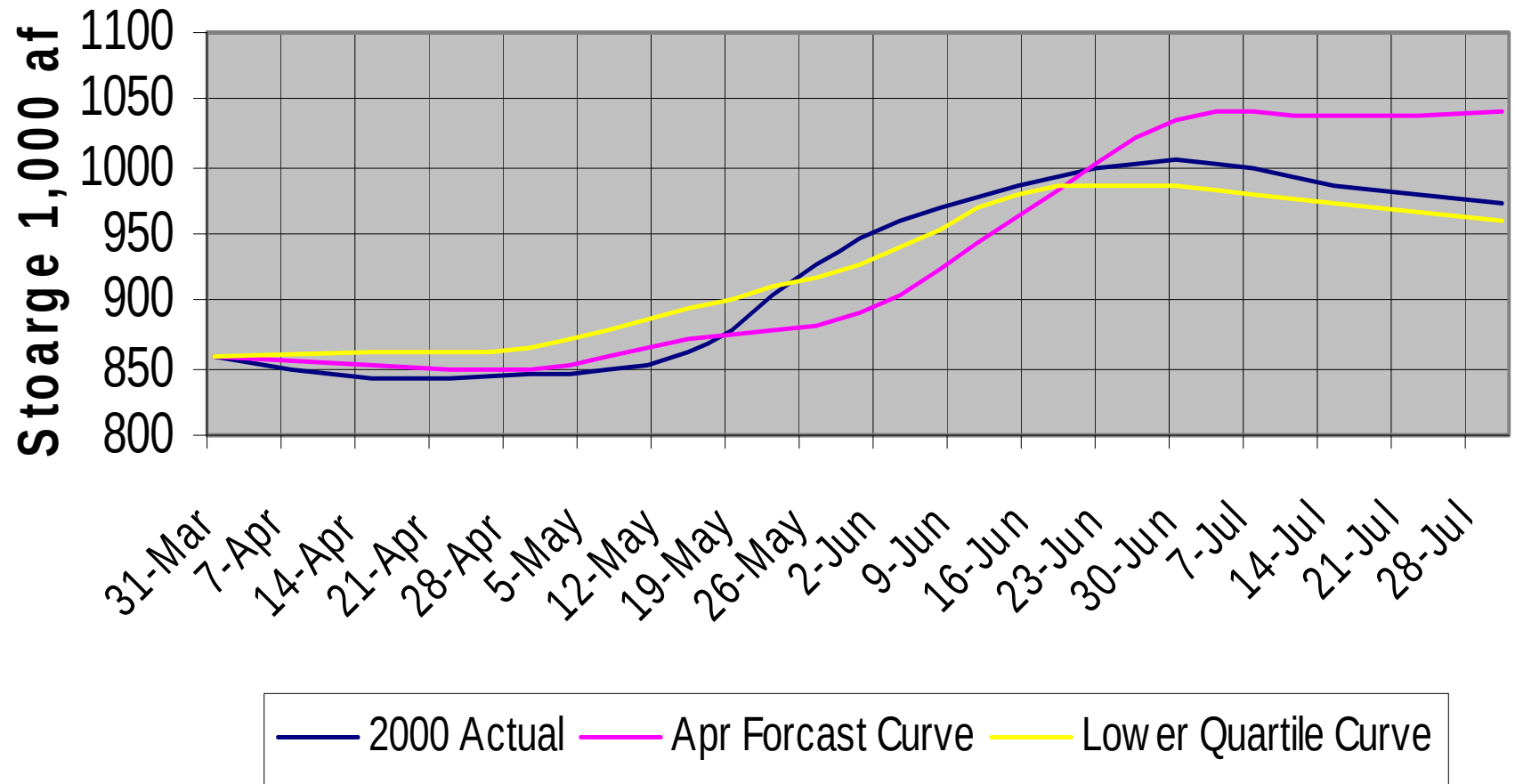
Bighorn Lake Inflow 2000

Lower Quartile Year

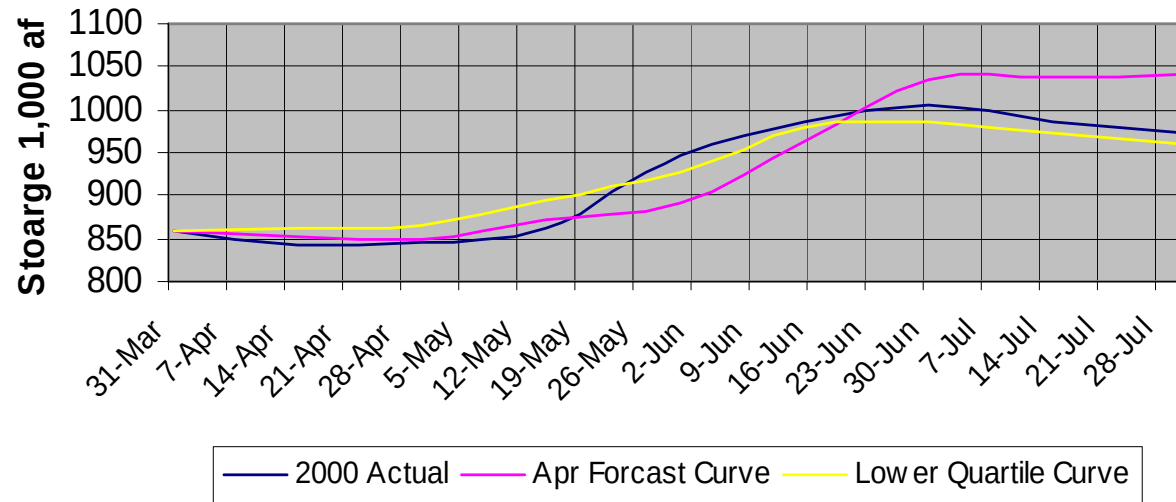


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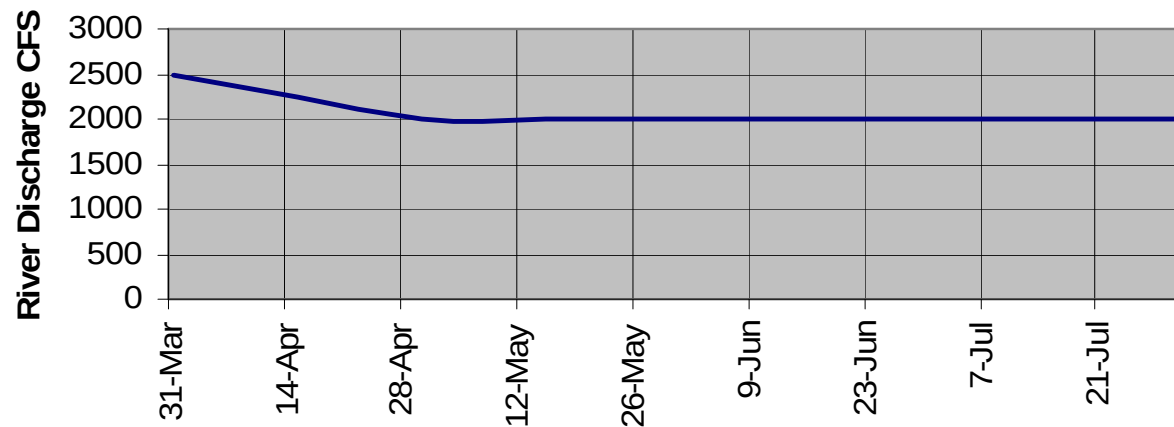
Bighorn Lake Storage vs Rule Curves 2000



Bighorn Lake Storage vs Rule Curves 2000



Bighorn Lake River Release 2000



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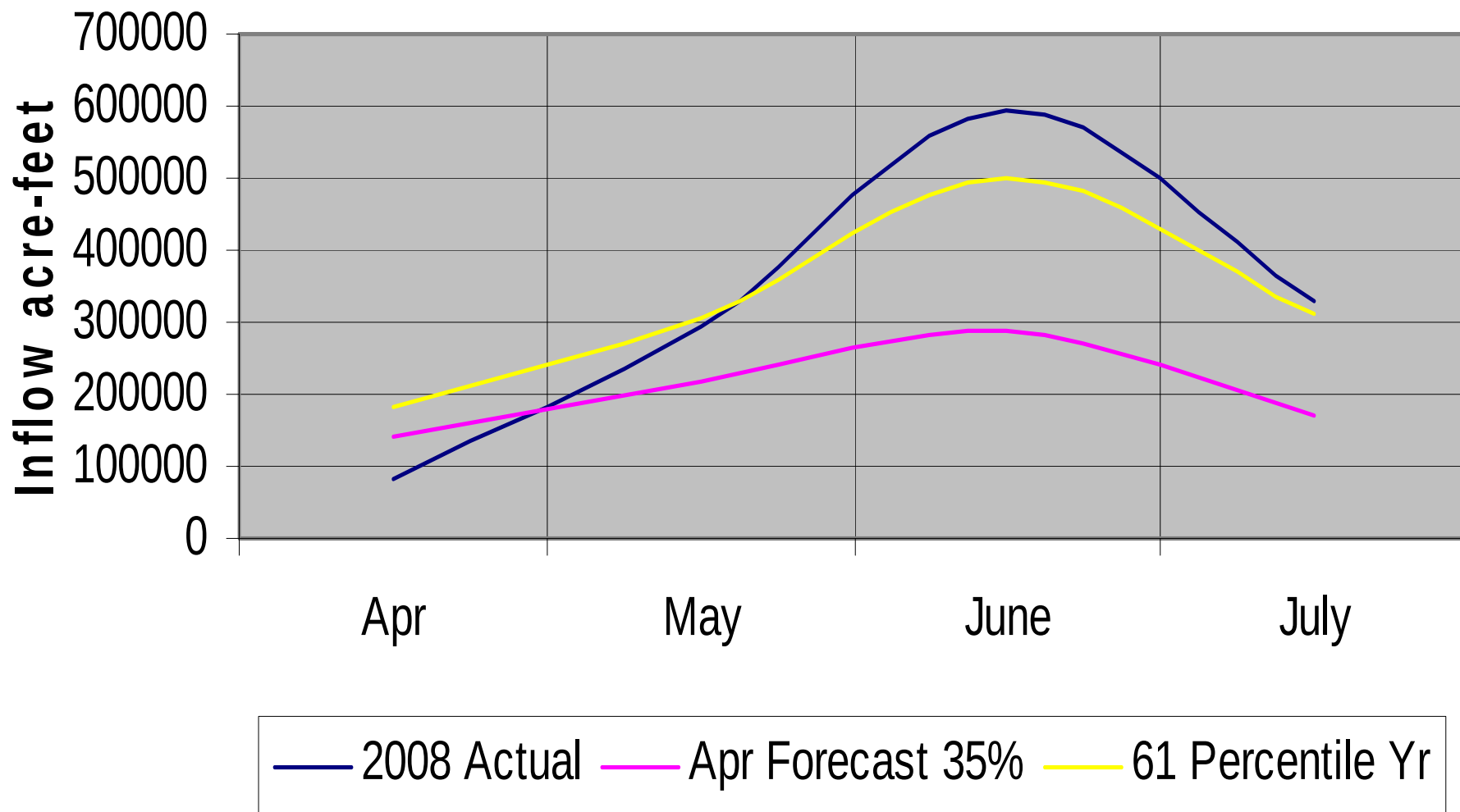
Bighorn Lake Inflow Percentiles 2008

1,000 acre-feet

Percentile	Apr	May	June	July	Total
90%	203.6	388.8	740.6	518.4	1,841.6
75%	204.4	361.7	613.3	393.2	1,572.7
61% Actual	80.6	291.6	595.1	330.7	1,298.0
50%	162.8	260.5	412.5	249.7	1,085.6
35% Forecast	141.5	219.0	289.6	170.6	820.7
25%	126.3	189.4	202.1	113.7	631.5
10%	117.7	171.2	160.5	85.6	534.9

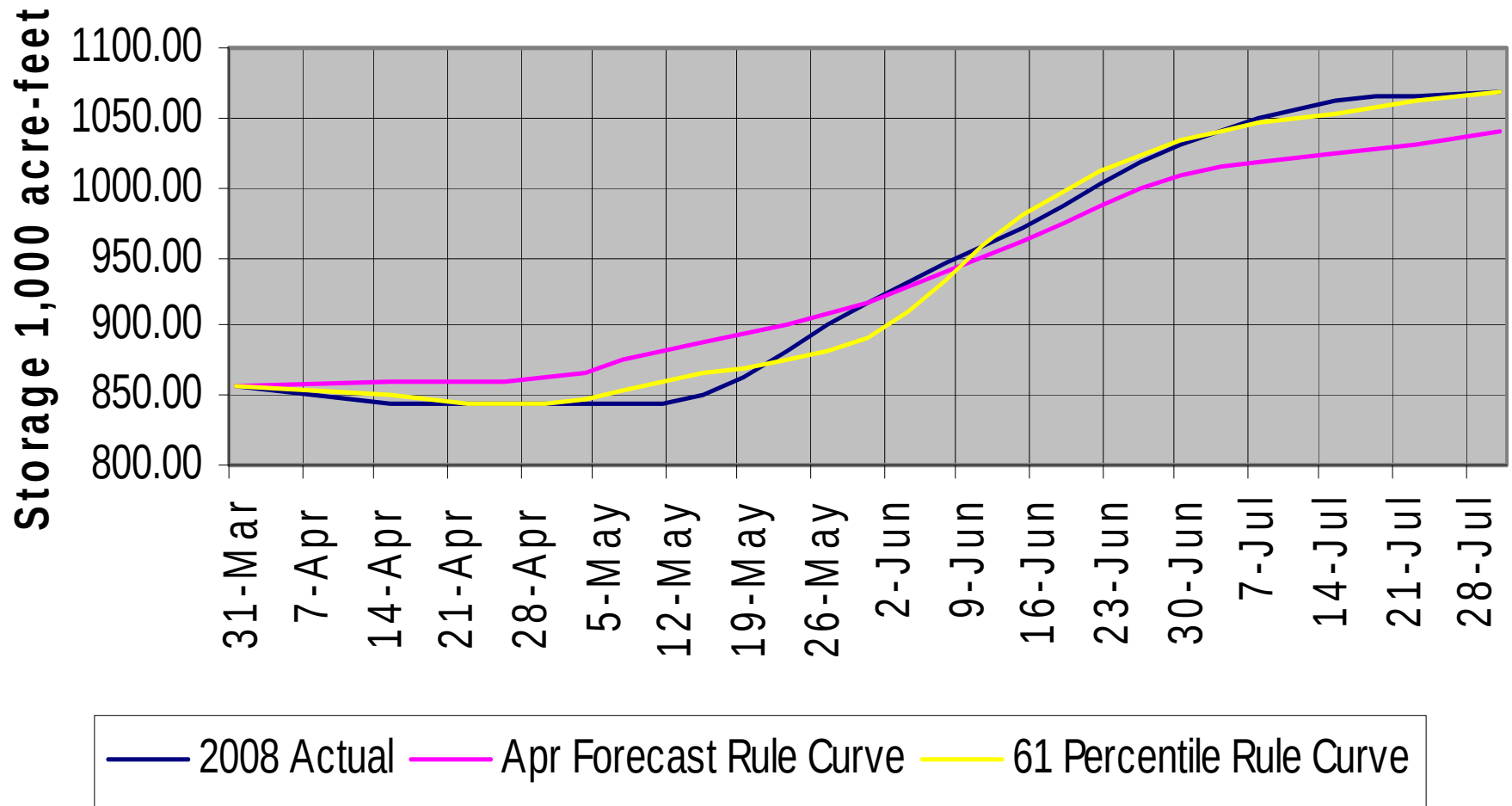
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Bighorn Lake 2008 Inflow



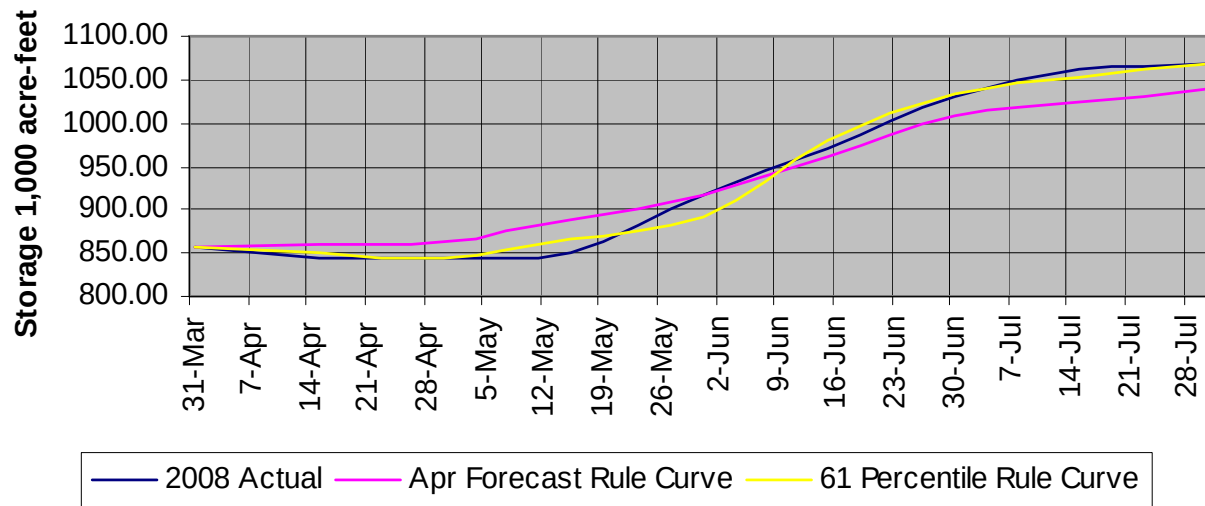
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Bighorn Lake Storage vs Rule Curves 2008

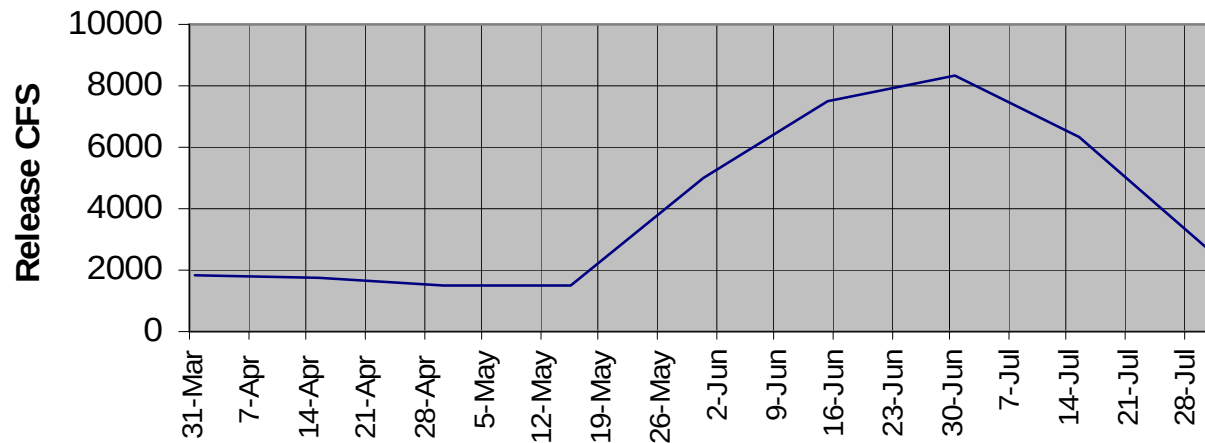


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Bighorn Lake Storage vs Rule Curves 2008



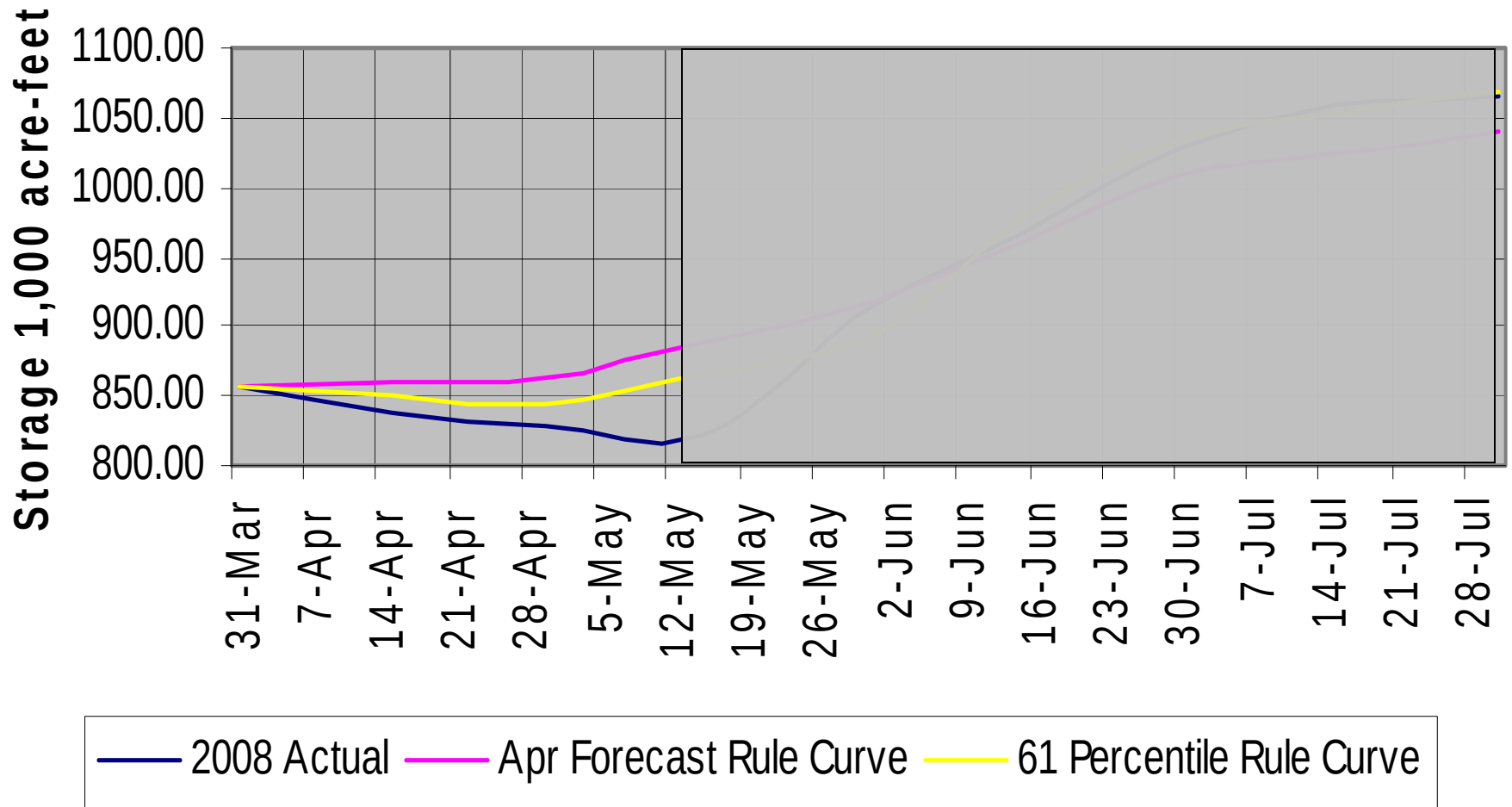
Bighorn Lake River Release 2008



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Bighorn Lake Storage vs Rule Curves

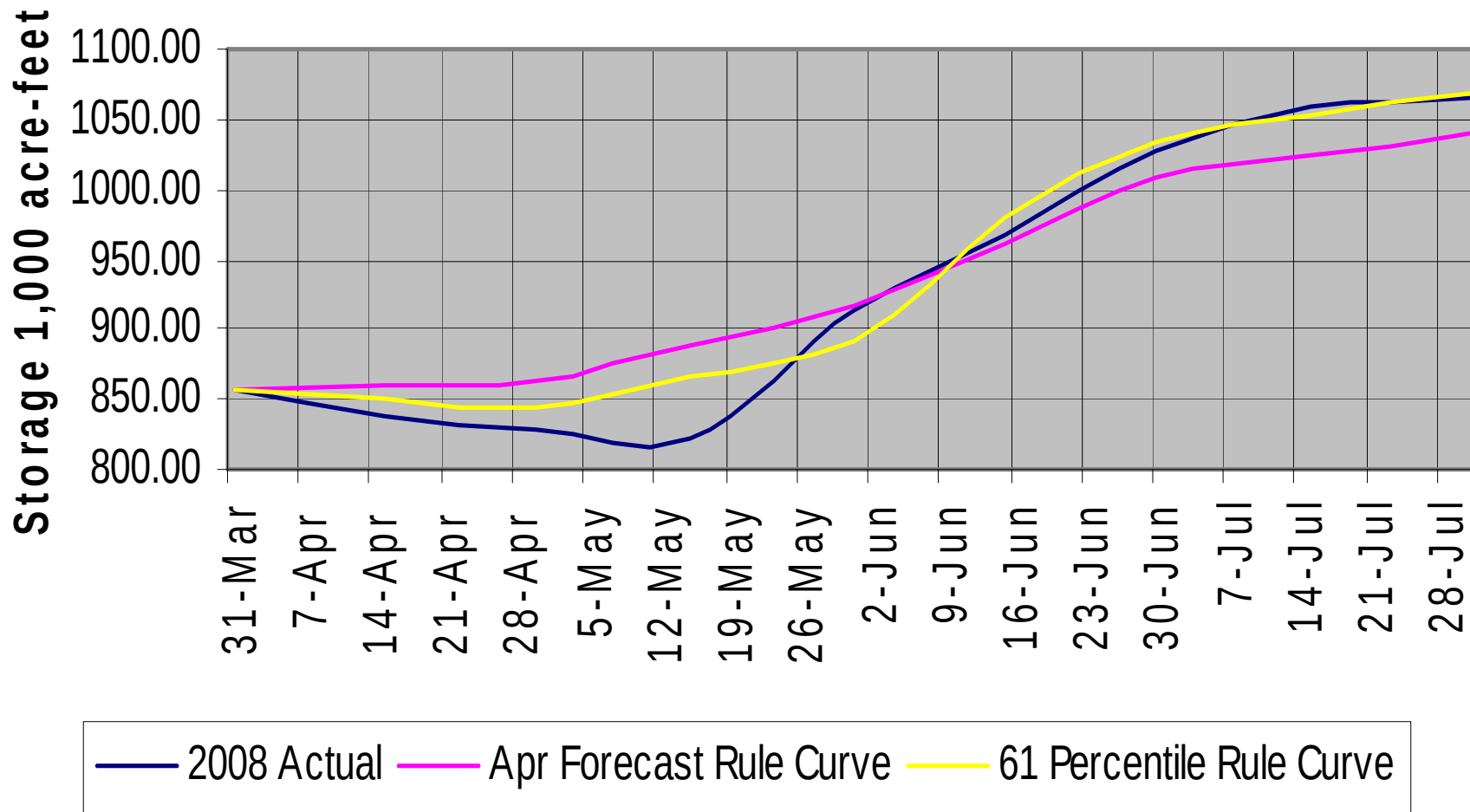
2008 with 1900 cfs min Release



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Bighorn Lake Storage vs Rule Curves

2008 with 1900 cfs min Release



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Discussion & Questions

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GorQ – Fall/Winter River Release Rate

- Parameters for calculating Release Rate based on March 31 Reservoir Level Target of Elev. 3618.0
 - Bighorn Lake Apr-Oct Gain = 238,200 af
 - Bighorn Lake Oct 31 Storage = 1,062,900 af
 - Buffalo Bill Nov-Mar Planned Release = 350 cfs
 - Boysen Nov-Mar Planned Release = 700 cfs
 - Calculated Fall/Winter Release Rate 2,535 cfs