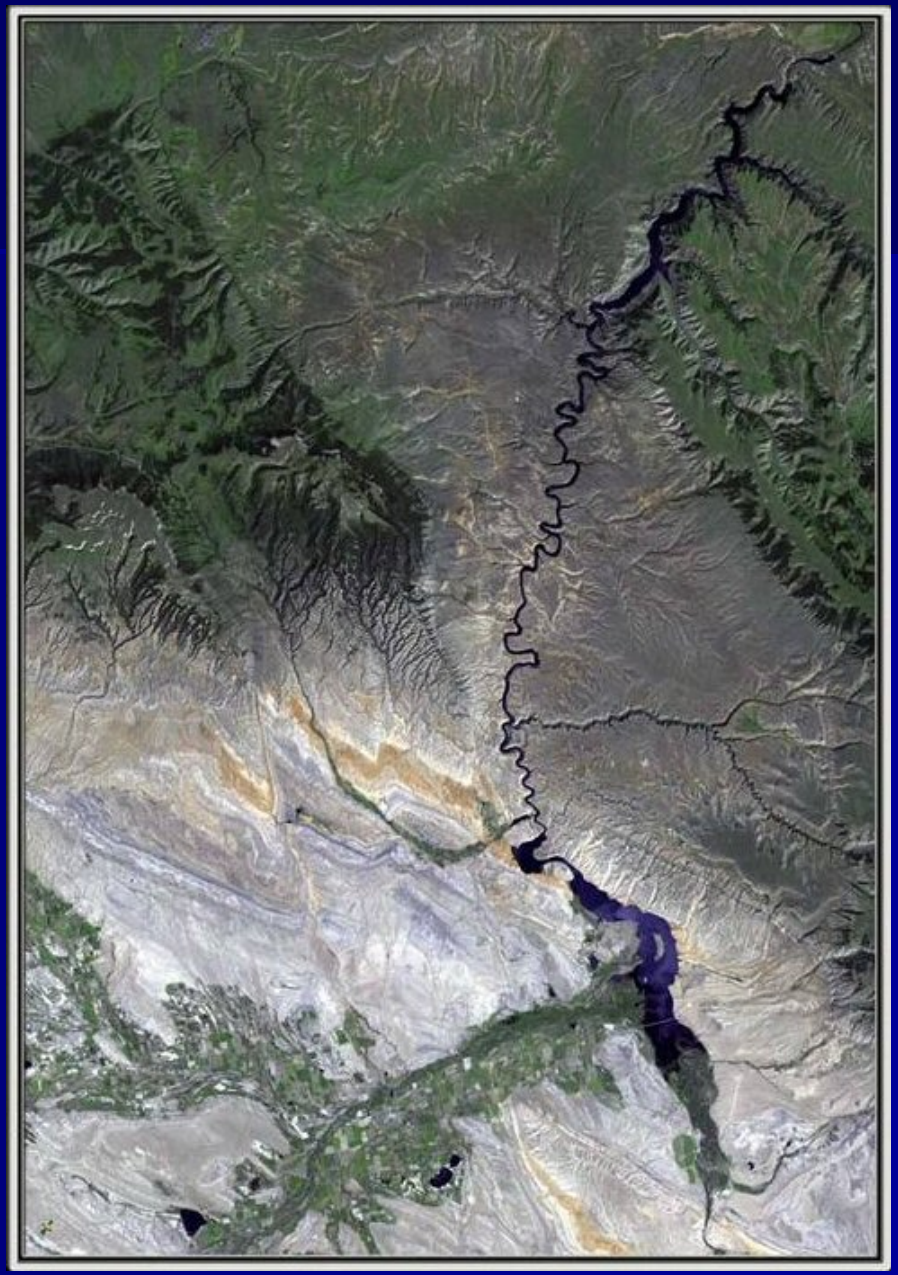
Friends of the Bighorn River

Reservoir Simulator



Doug Haacke
Spring 2009

bighornriver.org

Friends of the Bighorn River

Reservoir Simulator

Why do this?

Friends of the Bighorn River

Reservoir Simulator

Why do this?

Friends of the Bighorn River

Reservoir Simulator

Why do this?

1. Get a better understanding of the process.

Friends of the Bighorn River

Reservoir Simulator

Why do this?

1. Get a better understanding of the process.
2. Use any knowledge gained to become an asset to the process rather than a bystander.

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Reservoir Simulator

Why do this?

1. Get a better understanding of the process.
2. Use any knowledge gained to become an asset to the process rather than a bystander.
3. With luck, create something useful.

Friends of the Bighorn River

Getting started

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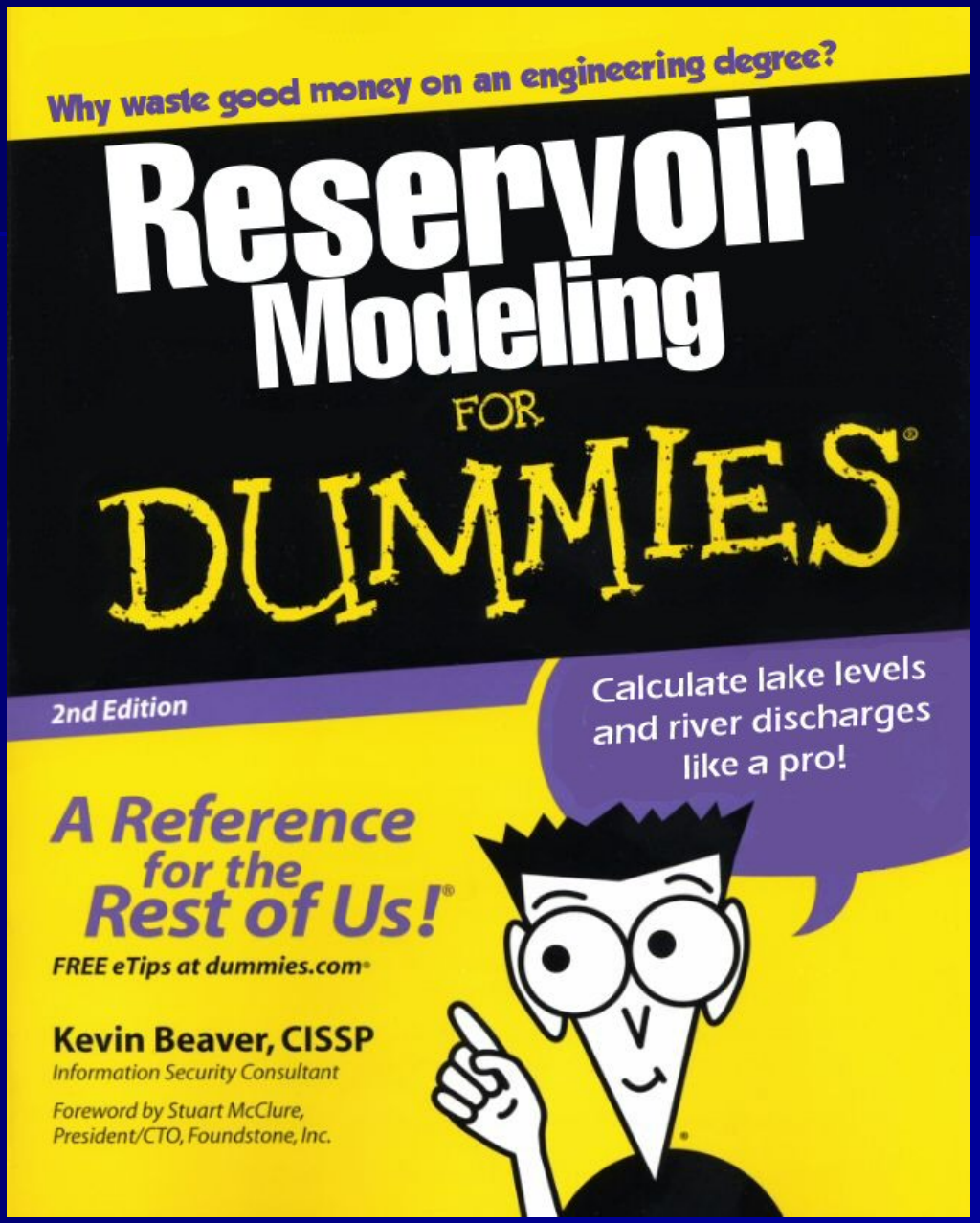
Getting started

- Start with rock solid documentation

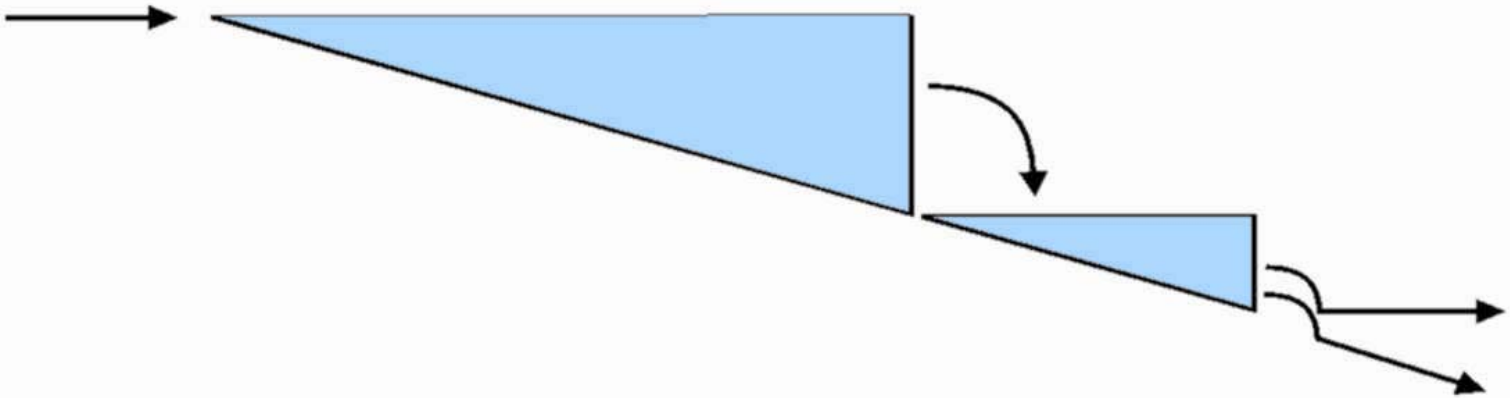
Friends of the Bighorn River

Getting started



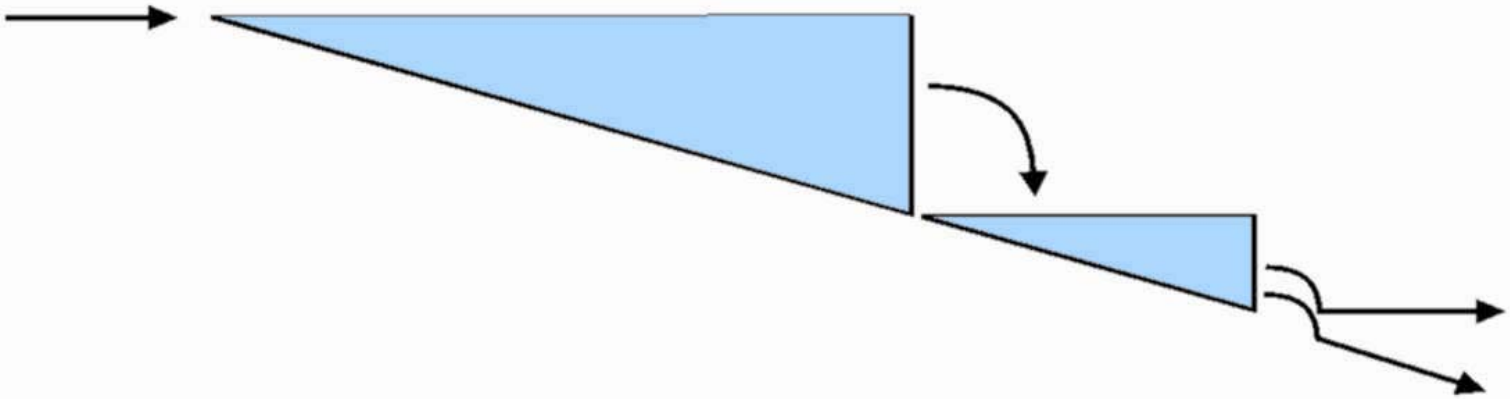
Reservoir Parameters

What parameters are required to model for either lake elevation or river discharge?



Reservoir Parameters

What parameters are required to model for either lake elevation or river discharge?



What data is readily available to use?

Search Reclamation

Great Plains Home
About Us
Area Offices
Environment and Cultural Resources
Lakes and Reservoirs
Programs & Activities
Recreation

Water Operations

HydroMet
Available Stations by Area Office
Available Stations by State
Archive Request Form: Last 5 Days
Dayfile Request Form: Last 24-hours
TEACUP Reservoir Models
TEACUP Reservoir Models by River Basin
ARC040 Reports
ARC050 Reports
ARCPOR Reports

Welcome to the HYDROMET Data System

Program Information

The Bureau of Reclamation operates a network of automated hydrologic and meteorologic monitoring stations (Hydromet) located throughout the Great Plains Region. The Hydromet network collects remote field data and transmits it via satellite to provide real-time water management capability. Hydromet data is then integrated with other sources of information to provide streamflow forecasting and current runoff conditions for river and reservoir operations. Please read this important Disclaimer about the real-time, PROVISIONAL data displayed on these pages.

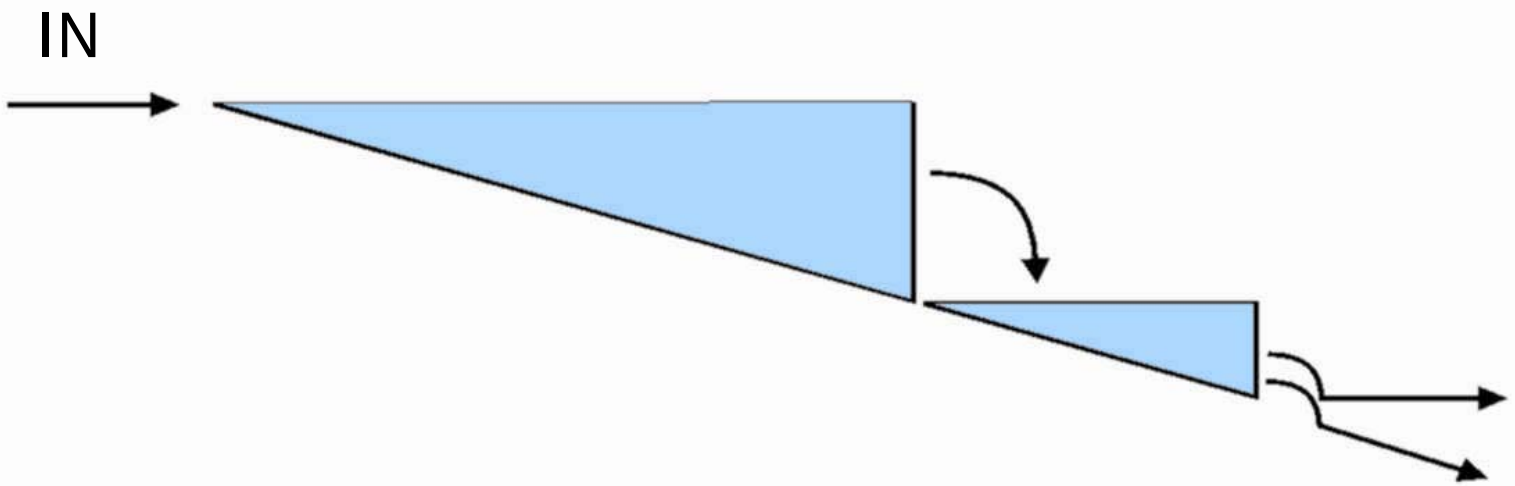
Station Information

- List of Available Stations by Area Office and Type
- Available Stations and Parameters by State

Data Request Forms

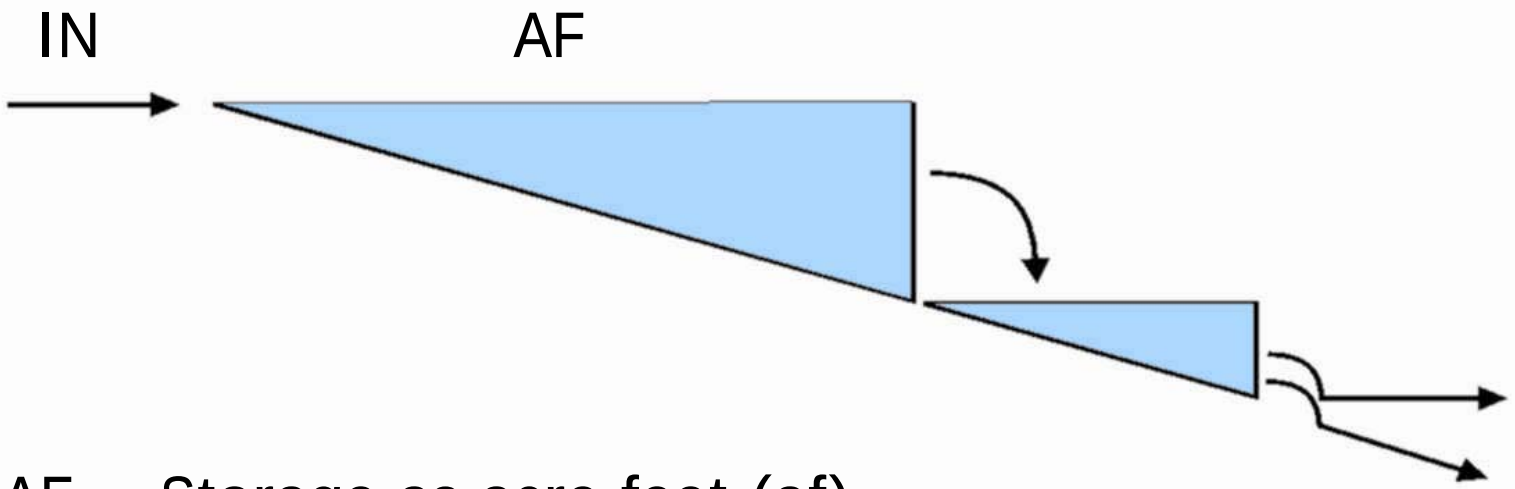
- TEACUP Reservoir Models by River Basin
- Archive Data Request Form Archive Values for Last Five Days of Record
- Dayfile Data Request Form Values for Last 24 Hours of Record
- TEACUP Reservoir Models Form
- ARC040 Report Daily Archive Values For One Month, One Station, Selected Parameters
- ARC050 Report Daily Archive Values For One Year, One Station, One Parameter
- ARCPOR Report Period of Record Data for One Station and up to Five Parameters
- RES070 Monthly values for one station, one parameter, period of record
- INFLOW Inflow Computations

Reservoir Parameters



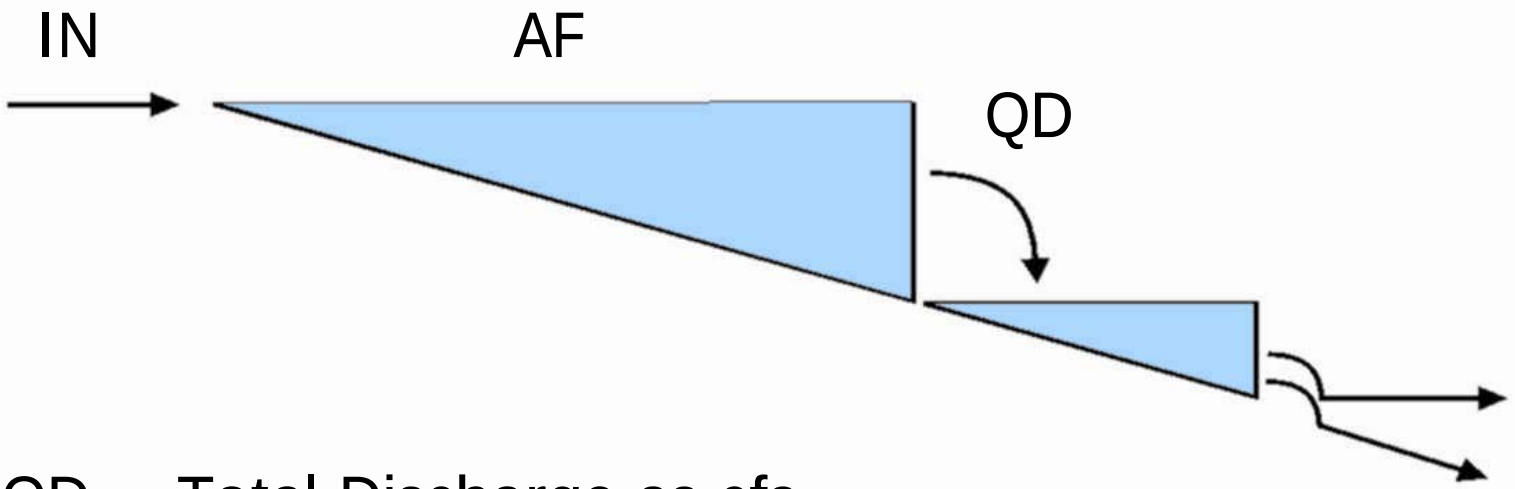
IN = Inflows as cubic feet per second (CFS).
Bighorn, Shoshone, tribs, precipitation, runoff, etc.

Reservoir Parameters



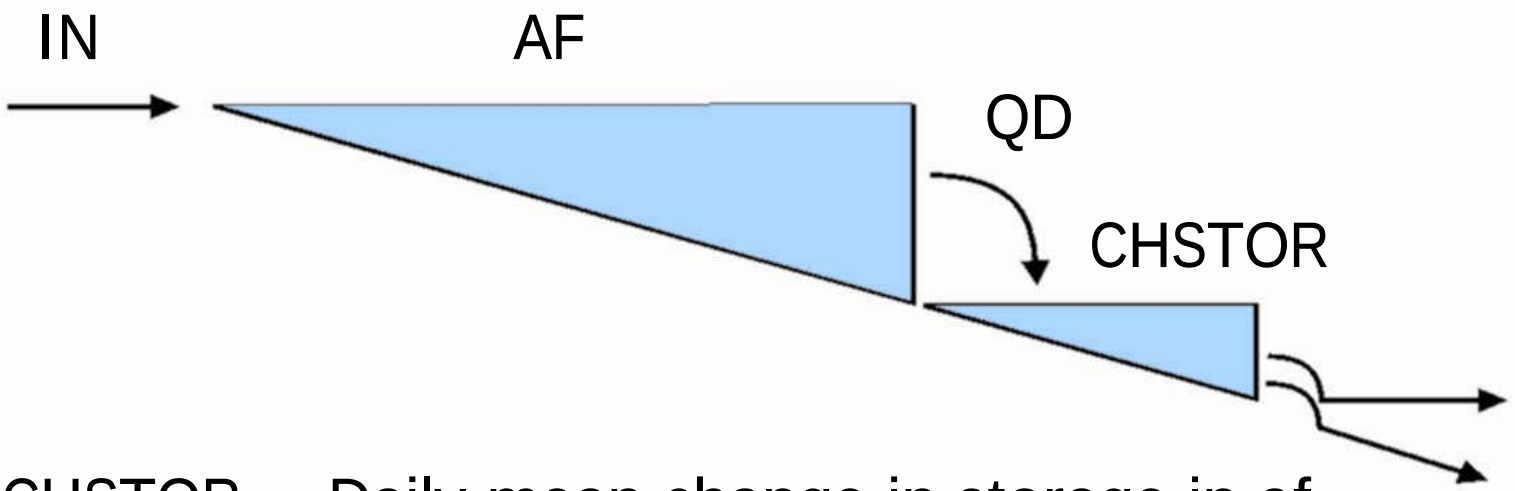
AF = Storage as acre feet (af).
Calculated from a capacity table where acre feet of storage equates to a specific elevation.

Reservoir Parameters



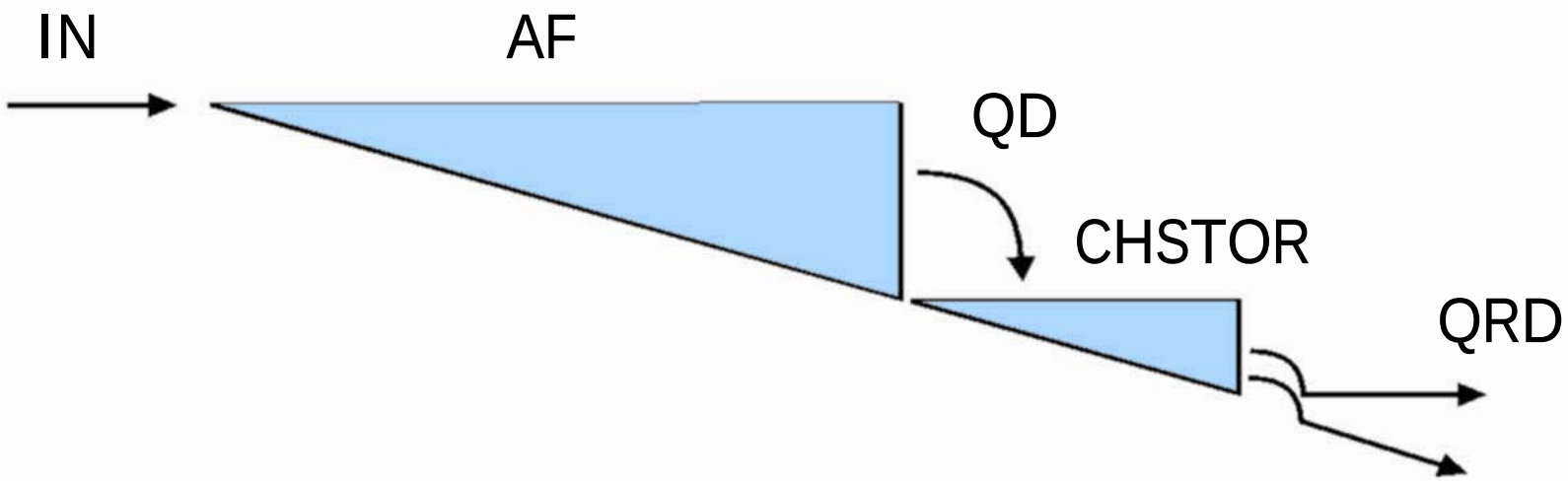
QD = Total Discharge as cfs
The total releases from Yellowtail Dam.

Reservoir Parameters



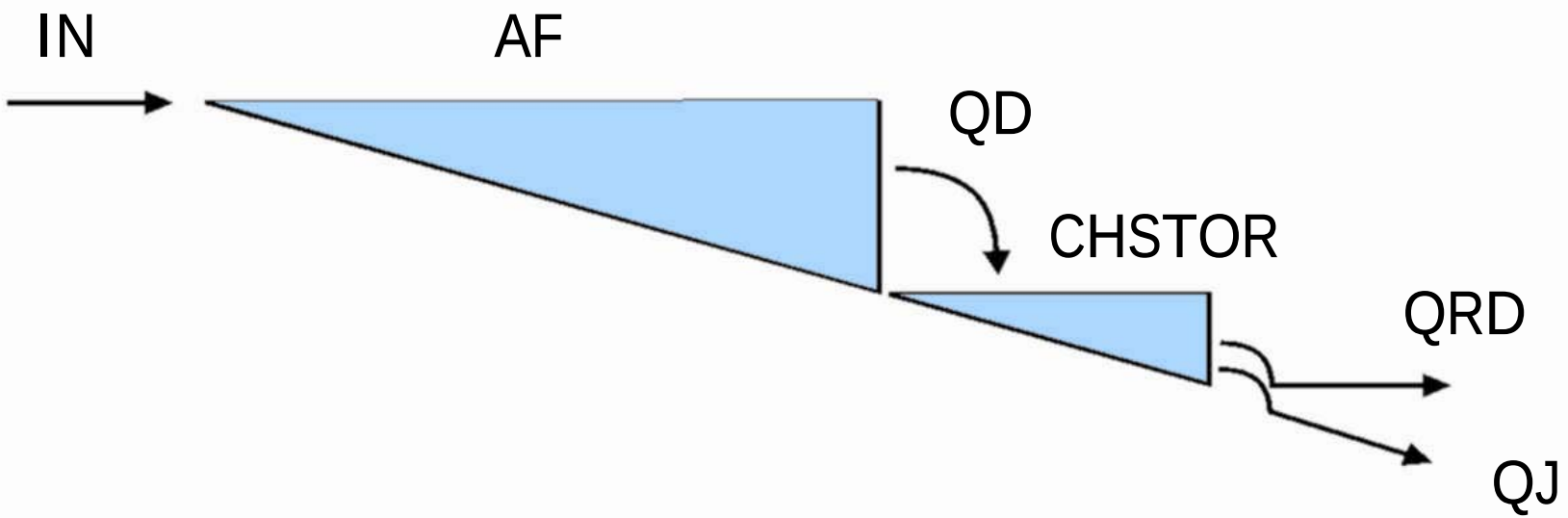
CHSTOR = Daily mean change in storage in af.
Afterbay daily mean change in storage.

Reservoir Parameters



QRD = River releases in cfs.

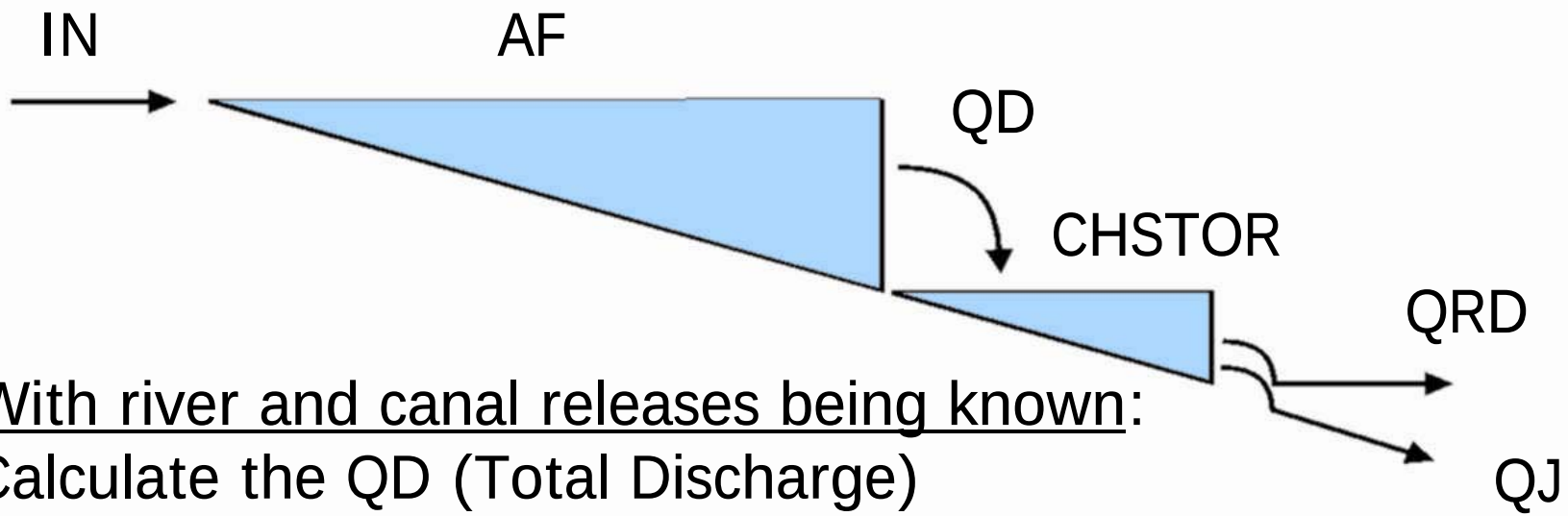
Reservoir Parameters



QJ = Canal releases in cfs.

Reservoir Parameters

Solving for Lake Elevation



With river and canal releases being known:

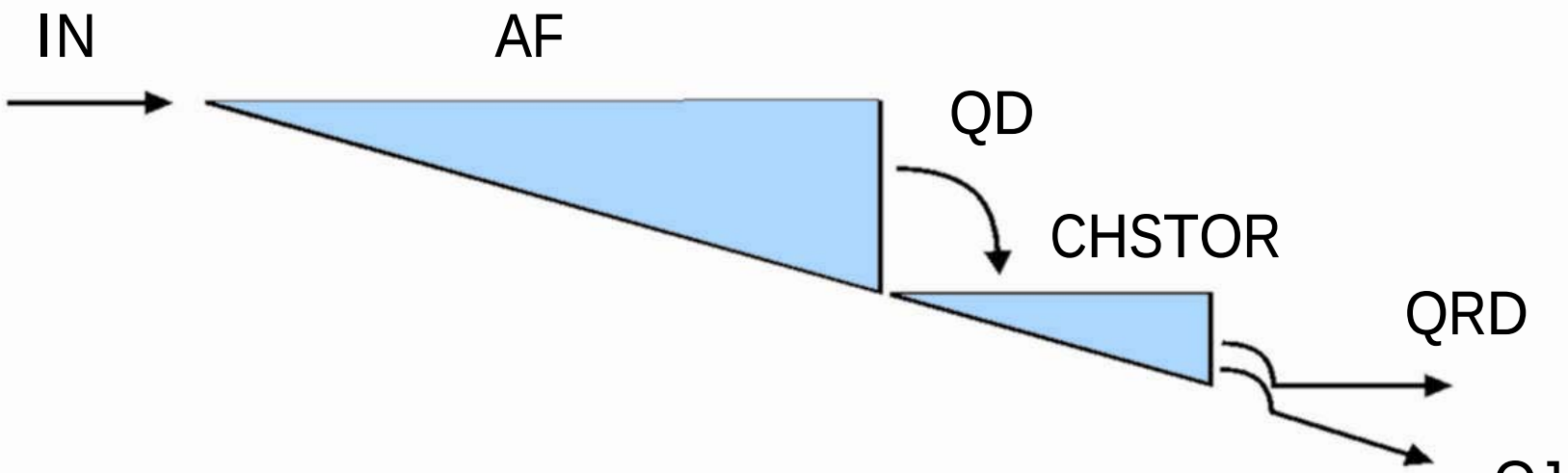
Calculate the QD (Total Discharge)

QD = (QRD + QJ) + (CHSTOR / 1.983471074)

Note: 1 cfs for 1 day = 1.983471074 acre feet

Reservoir Parameters

Solving for Lake Elevation



Now, with QD being known, calc the lake elevation:

AF = AF + ((IN - QD) * 1.983471074)

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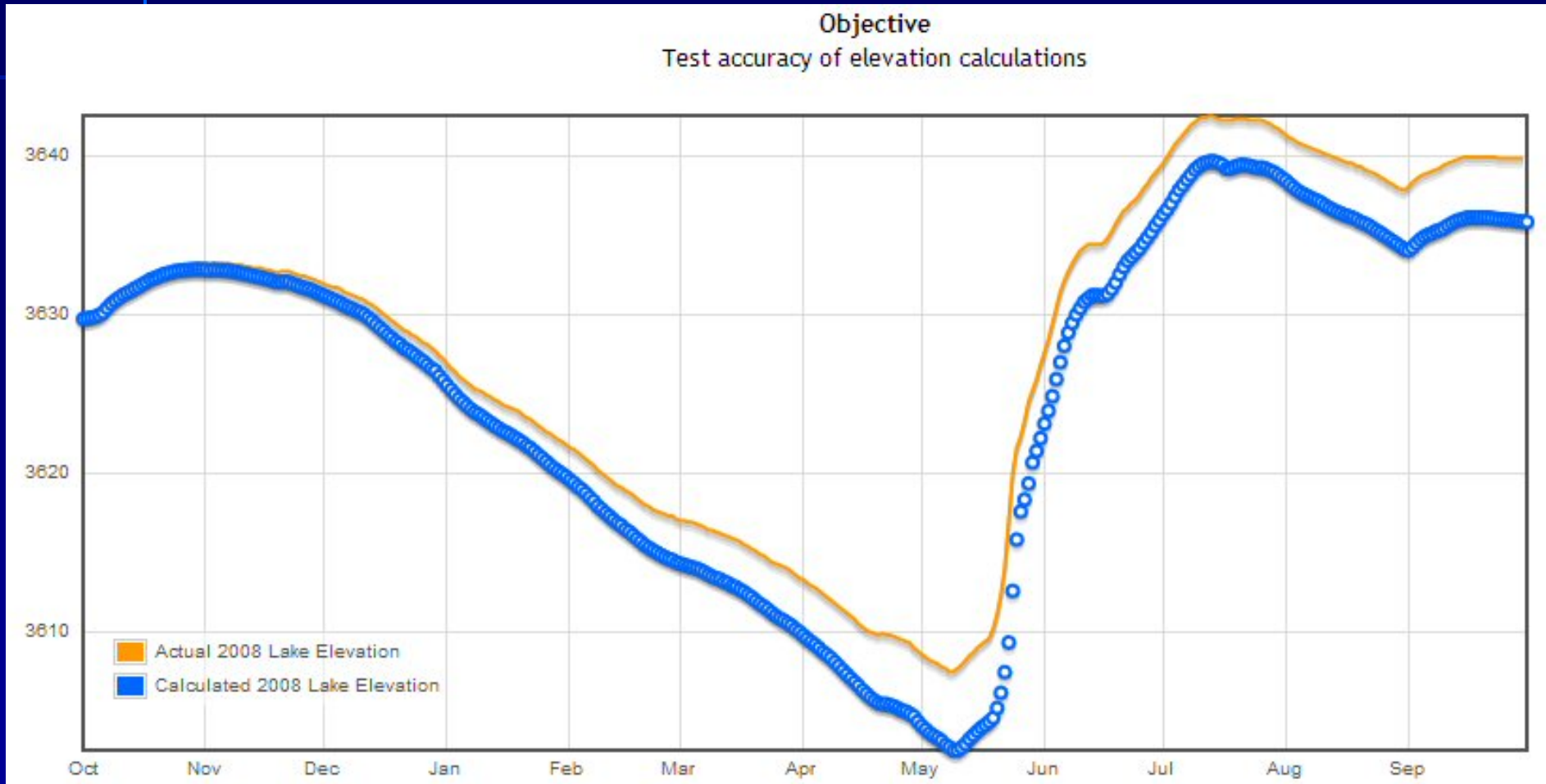
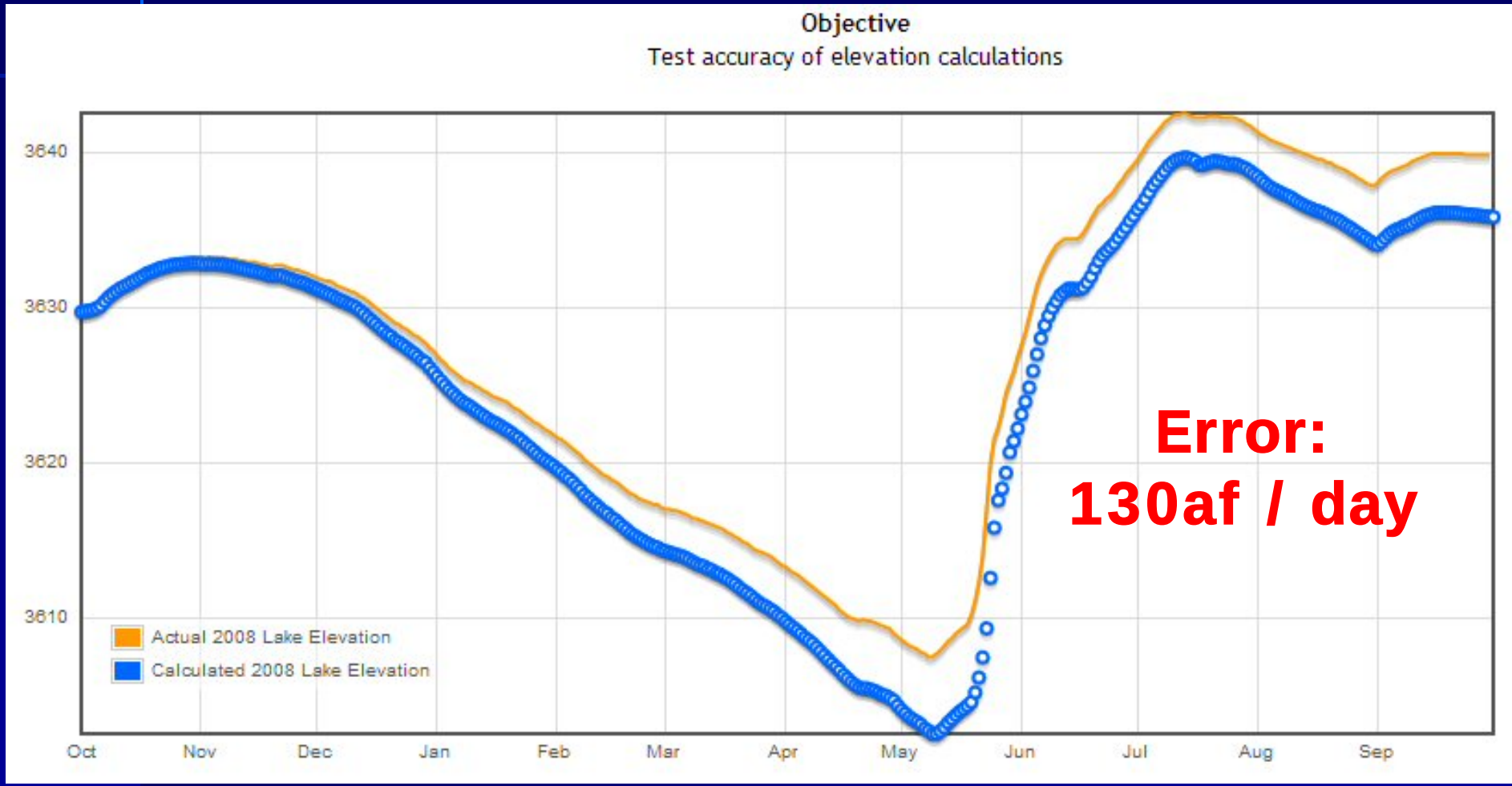


Friends of the Bighorn River



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Dramatization

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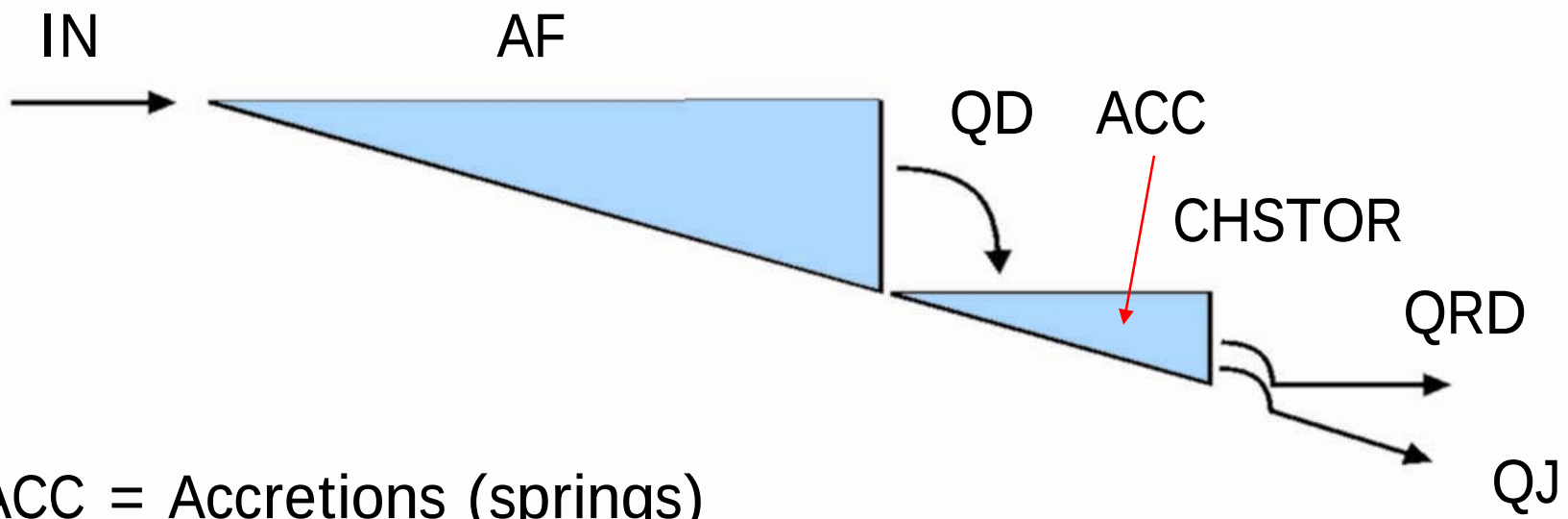
Dramatization

Reservoir Parameters

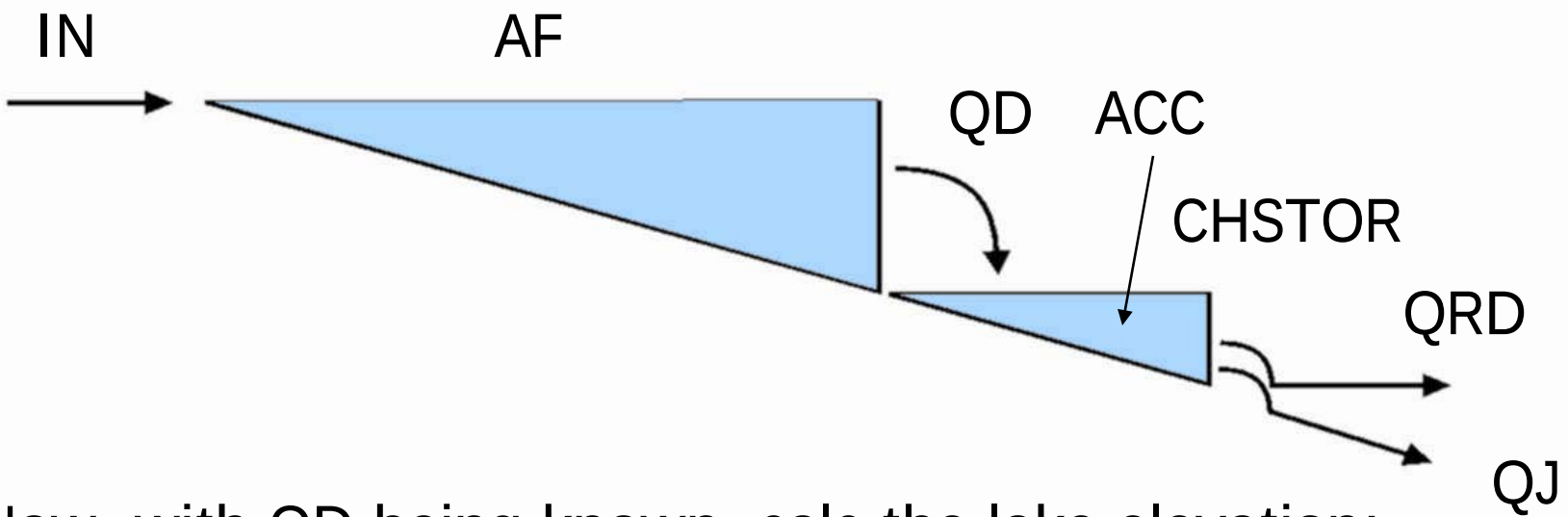
Solving for Lake Elevation



ACC = Accretions (springs)
130af into the Afterbay!

Reservoir Parameters

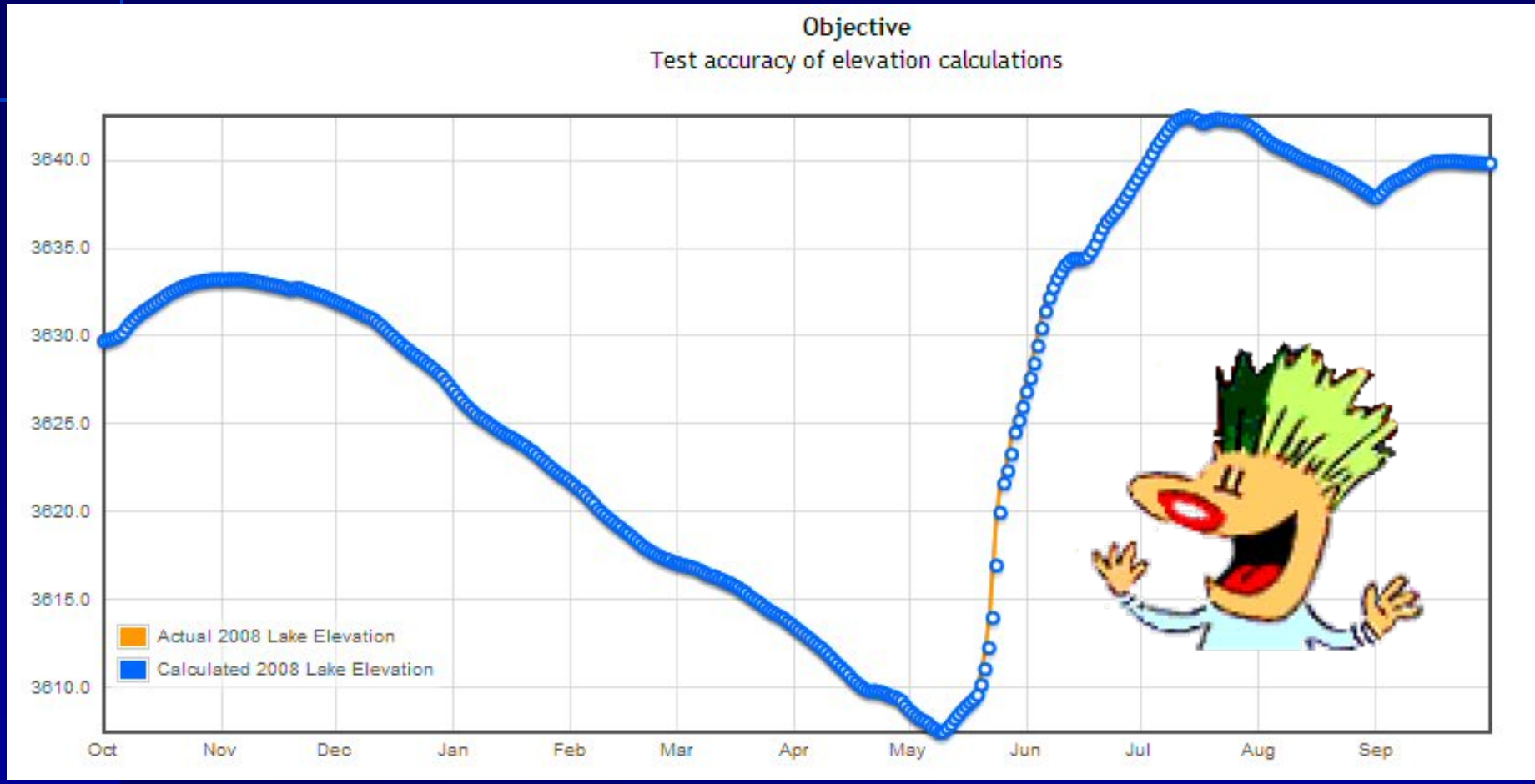
Solving for Lake Elevation



Now, with QD being known, calc the lake elevation:

AF = AF + ((IN - QD) * 1.983471074) + ACC

Friends of the Bighorn River



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Coding the Simulator

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Coding the Simulator

Criteria

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Coding the Simulator

Criteria

- Use a simple, familiar user interface

Friends of the Bighorn River

Coding the Simulator

Criteria

- Use a simple, familiar user interface
- Use a dynamic database

Friends of the Bighorn River

Coding the Simulator

Criteria

- Use a simple, familiar user interface
- Use a dynamic database
- Use real time and historical data

Friends of the Bighorn River

Coding the Simulator

Criteria

- Use a simple, familiar user interface
- Use a dynamic database
- Use real time and historical data
- Allow the user to input custom criteria

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Coding the Simulator

Implementation

- Web interface. Works with any browser that supports Javascript

Friends of the Bighorn River

Coding the Simulator

Implementation

- Web interface. Works with any browser that supports Javascript
- SQL Server Database

Friends of the Bighorn River

Coding the Simulator

Implementation

- Web interface. Works with any browser that supports Javascript
- SQL Server Database
- BOR Hydromet data

Friends of the Bighorn River

Step One

SOLVING FOR 2009 LAKE ELEVATION

PARAMETERS AND OPTIONS

Sep 30 Lake Elevation (ft)

3639.82 Lookup

Choose a Historical Comparison Year

None

River Discharge Schedule

Seed with model:

Select Seed

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep

Include debug information

Go!

INSTRUCTIONS

1. Enter a September 30 Lake Elevation or simply click the Lookup button to have the simulator look up the starting lake elevation for the current year.
2. If you'd like to see a historical year displayed along with the current year, choose a Historical Comparison Year from the dropdown list.
3. You can build your own river discharge schedule, use an existing schedule, or a combination of both. Whichever you choose, enter a desired river release (cubic feet per second) for each month.
4. If you'd like to see the raw data for each month displayed, check the box called Include debug information.
5. Click Go! to see the results of the calculation.

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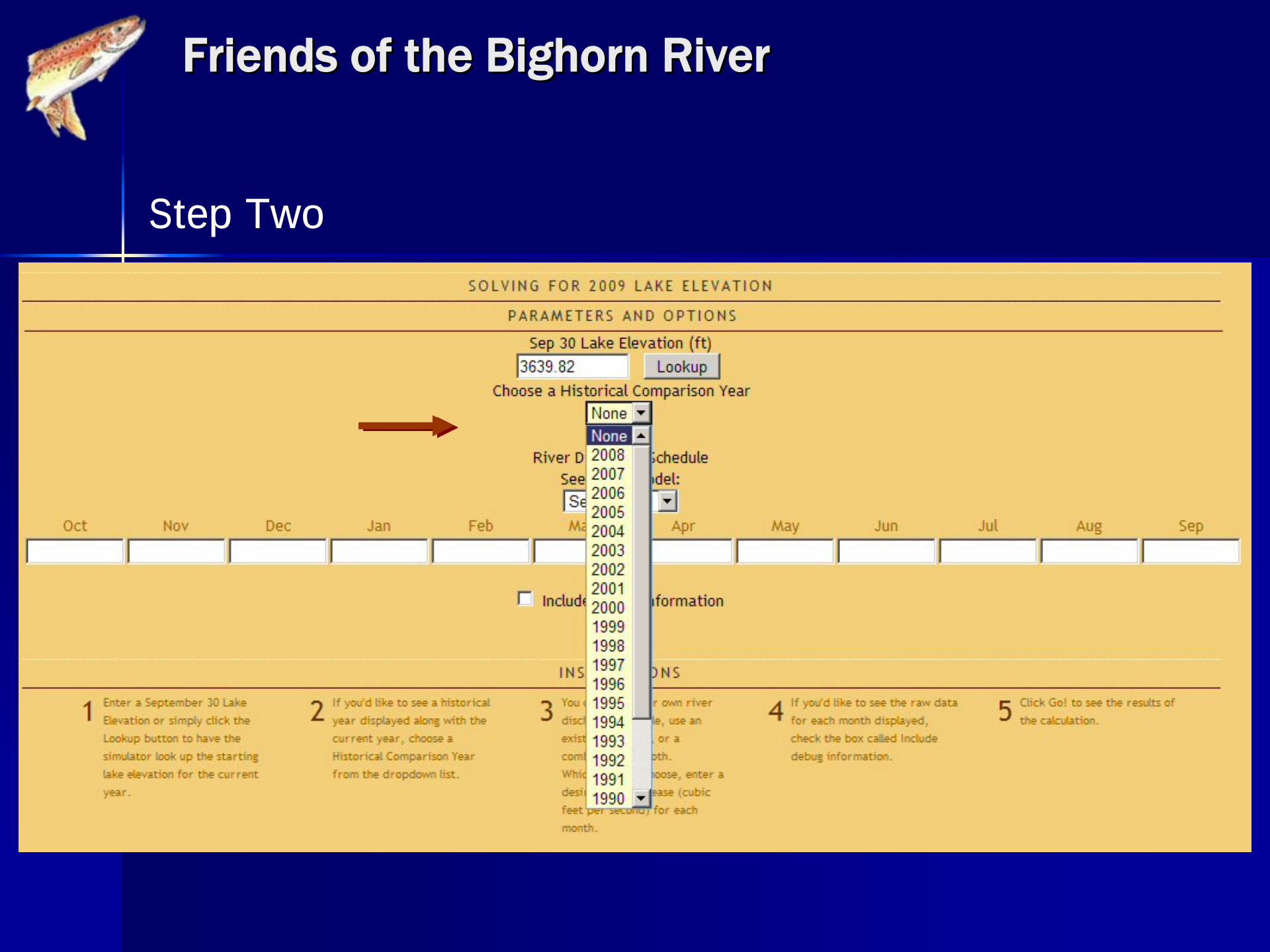
Step Two



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Step Three

SOLVING FOR 2009 LAKE ELEVATION

PARAMETERS AND OPTIONS

Sep 30 Lake Elevation (ft)

3639.82 Lookup

Choose a Historical Comparison Year

2008

River Discharge Schedule

Seed with model:

Select Seed

Select Seed
2500MIN
2700MIN

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep

Include debug information

Go!

INSTRUCTIONS

1. Enter a September 30 Lake Elevation or simply click the Lookup button to have the simulator look up the starting lake elevation for the current year.
2. If you'd like to see a historical year displayed along with the current year, choose a Historical Comparison Year from the dropdown list.
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4. If you'd like to see the raw data for each month displayed, check the box called Include debug information.
5. Click Go! to see the results of the calculation.

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Step Four

SOLVING FOR 2009 LAKE ELEVATION

PARAMETERS AND OPTIONS

Sep 30 Lake Elevation (ft)

3639.82 Lookup

Choose a Historical Comparison Year

2008

River Discharge Schedule

Seed with model:

2700MIN

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2700.00	2700.00	2700.00	2700.00	2700.00	2700.00	3000.00	3500.00	4500.00	4500.00	3500.00	3000.00

☐ Include debug information

Go!

INSTRUCTIONS

1. Enter a September 30 Lake Elevation or simply click the Lookup button to have the simulator look up the starting lake elevation for the current year.
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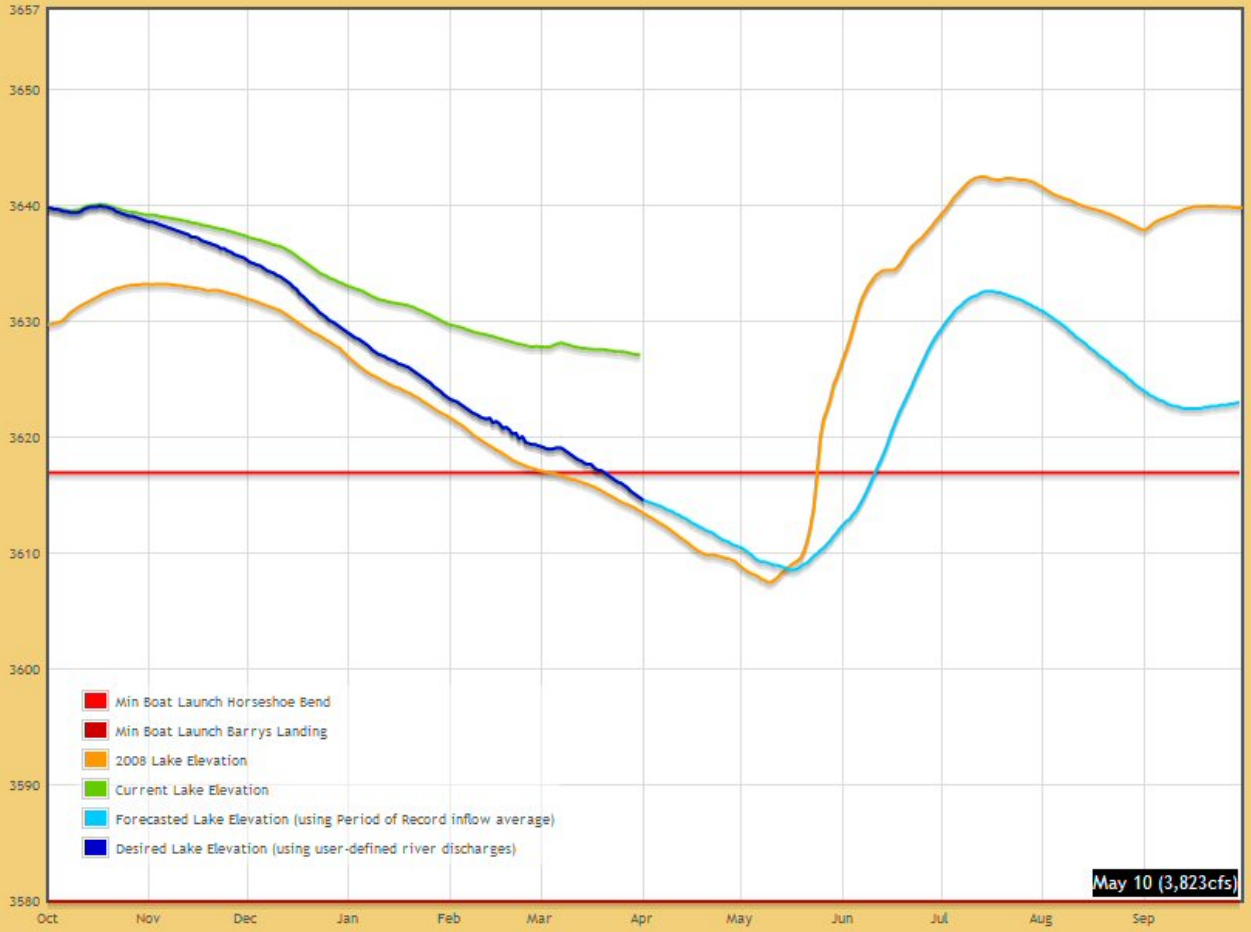
SOLVING FOR 2009 LAKE ELEVATION



PARAMETERS AND OPTIONS

Sep 30 Lake Elevation (ft)

3639.82 Lookup

Choose a Historical Comparison Year

None

River Discharge Schedule

Seed with model:

Select Seed

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2700.00	2700.00	2700.00	2700.00	2700.00	2700.00	3000.00	3500.00	4500.00	4500.00	3500.00	3000.00

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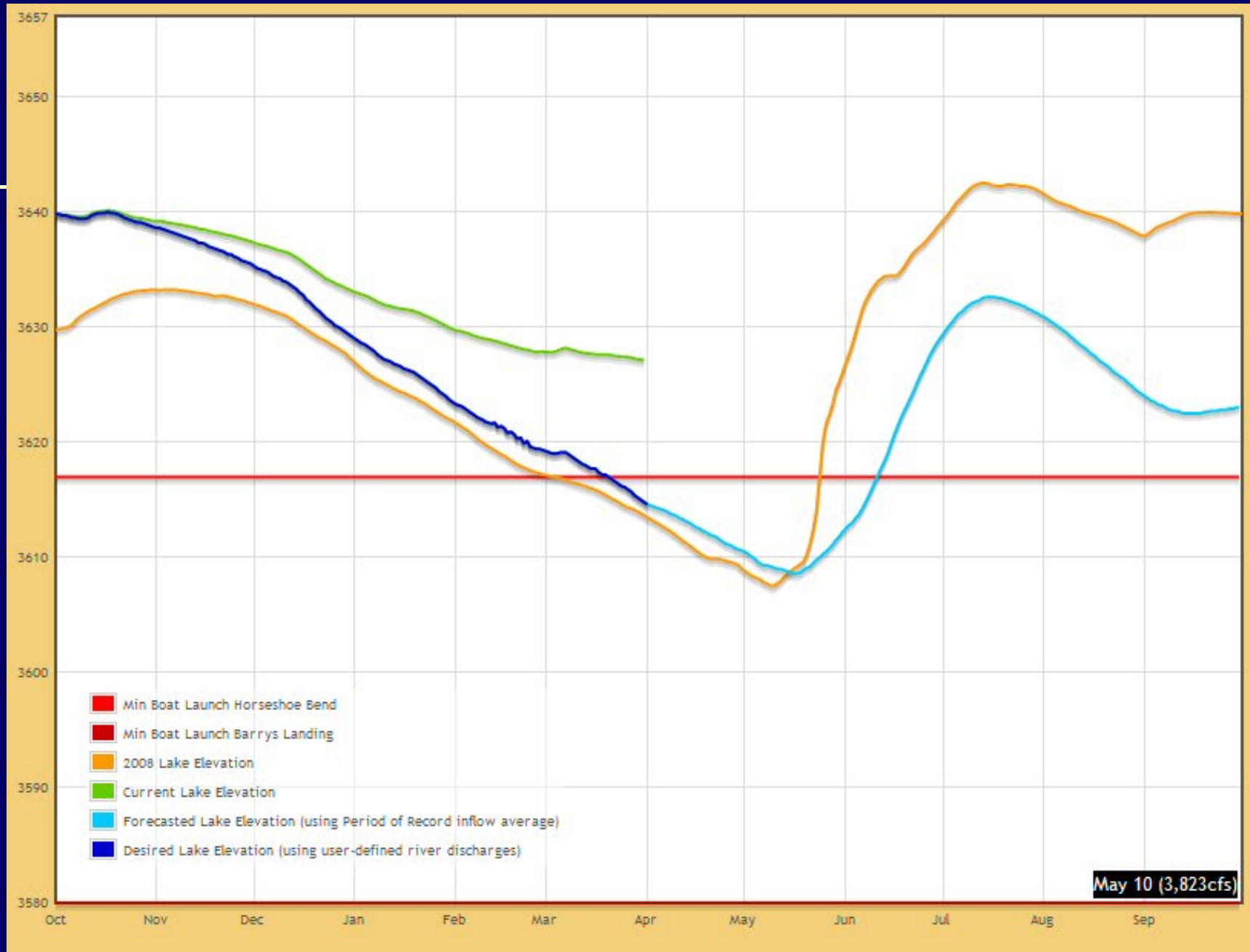
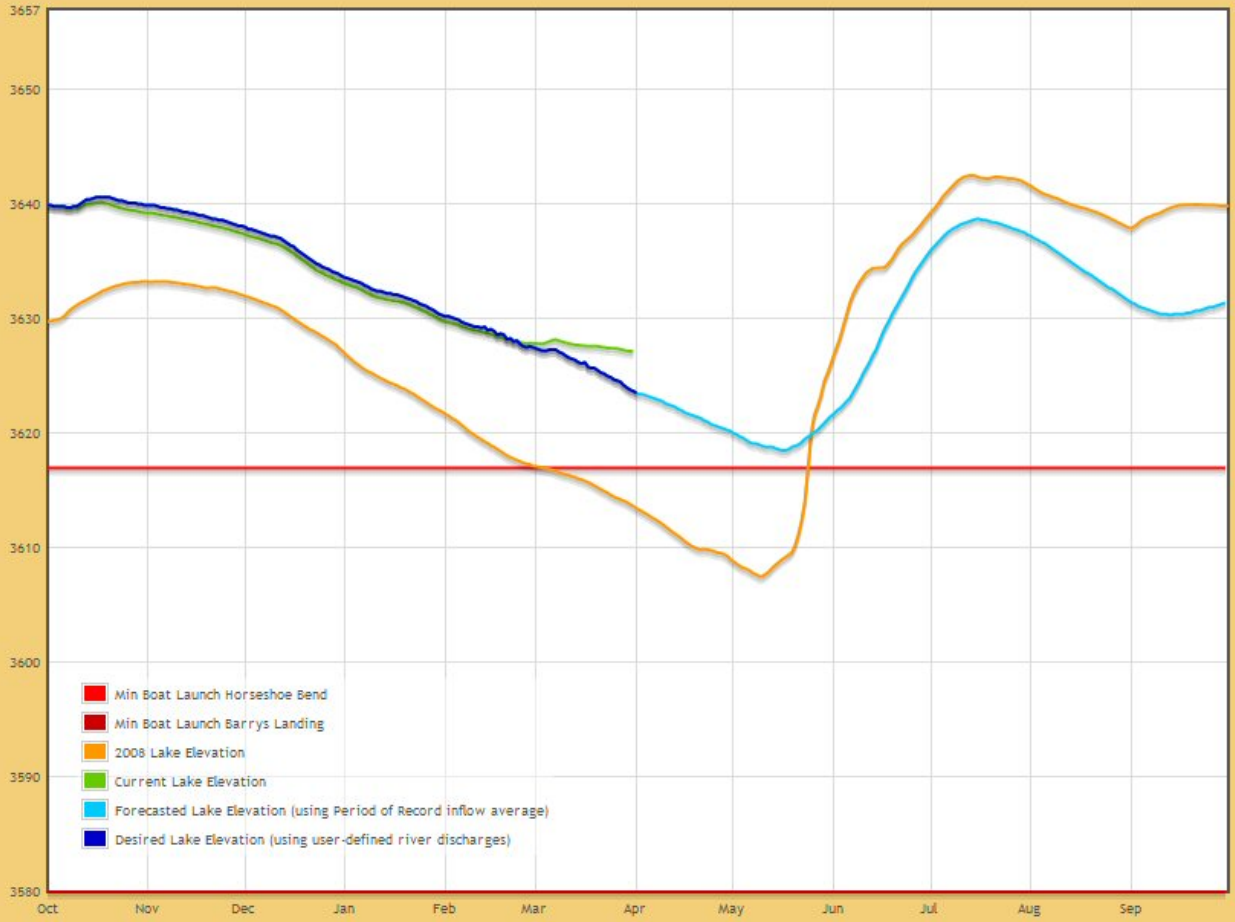


SOLVING FOR 2009 LAKE ELEVATION



PARAMETERS AND OPTIONS

Sep 30 Lake Elevation (ft)

3639.82 Lookup

Choose a Historical Comparison Year

None

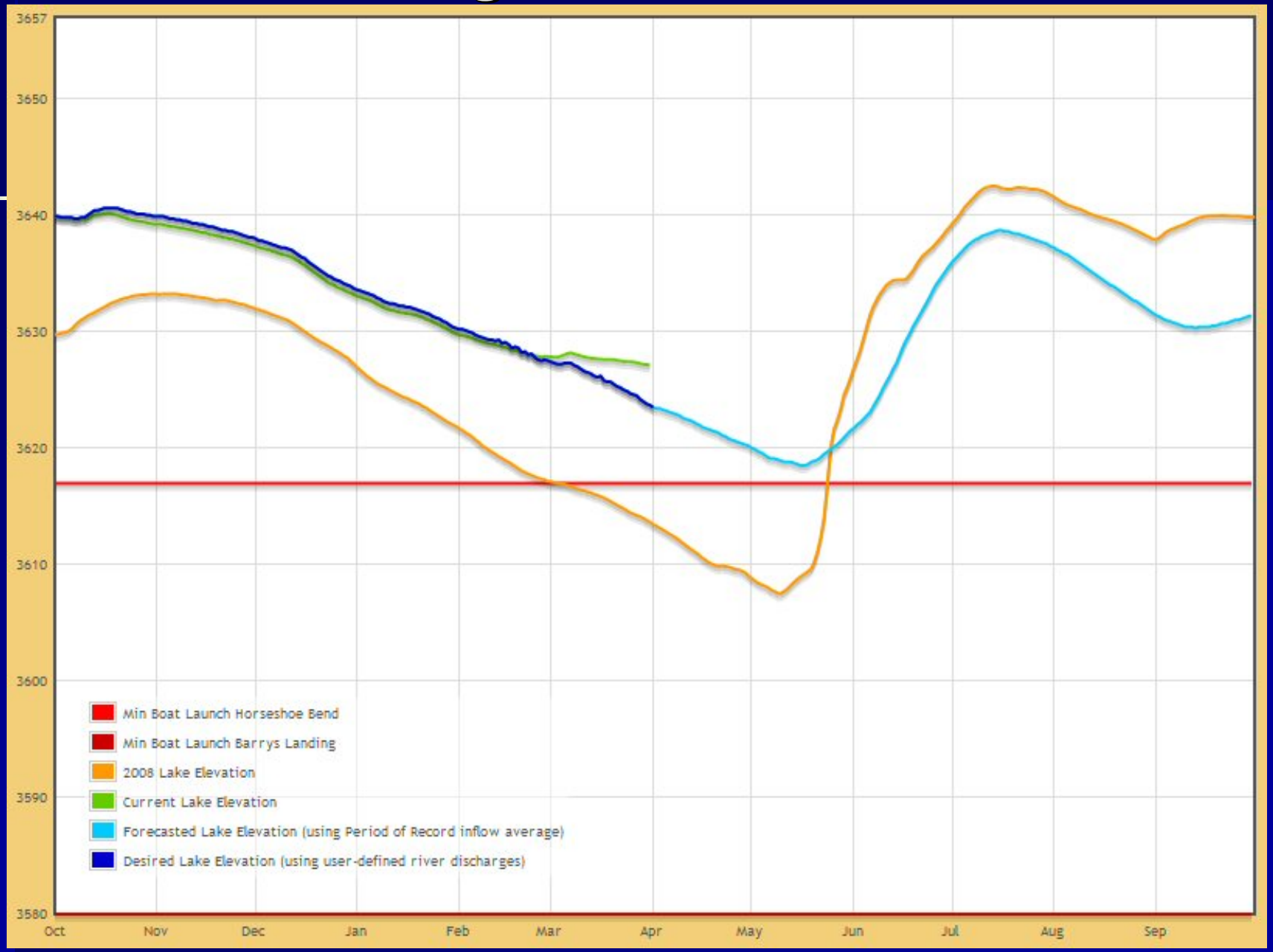
River Discharge Schedule

Seed with model:

Select Seed

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2450.00	2450.00	2450.00	2450.00	2450.00	2700.00	3000.00	3500.00	4500.00	4500.00	3500.00	3000.00

Friends of the Bighorn River



SCHEDULE INFORMATION

Dataset Name

2450mar

Water Year

2009

Select parameter type

River Discharge

Optional

Seed with historical values

Send to manual grid only

Select Seed

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
2450	2450	2450	2450	2450	2700	3000	3500	4500	4500	3500	3000
2813.79	2986.75	2961.37	2940.30	2923.09	2995.70	3002.39	3009.06	4350.56	4083.75	2750.07	2529.37

Build

PARAMETERS TO UPLOAD

If you built your dataset offline, you may
paste your dataset here as Date, Value pairs

```
2450mar|2008/10/01|2450.0000
2450mar|2008/10/02|2450.0000
2450mar|2008/10/03|2450.0000
2450mar|2008/10/04|2450.0000
2450mar|2008/10/05|2450.0000
2450mar|2008/10/06|2450.0000
2450mar|2008/10/07|2450.0000
2450mar|2008/10/08|2450.0000
2450mar|2008/10/09|2450.0000
2450mar|2008/10/10|2450.0000
2450mar|2008/10/11|2450.0000
2450mar|2008/10/12|2450.0000
```

UPLOAD

Upload

Friends of the Bighorn River

What was learned / gained

Friends of the Bighorn River

What was learned / gained

- Modeling is complicated, but not overly so

Friends of the Bighorn River

What was learned / gained

- Modeling is complicated, but not overly so
- Similar to (but less boring than) accounting

Friends of the Bighorn River

What was learned / gained

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- Inflows drive everything!

Friends of the Bighorn River

What was learned / gained

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- Inflows drive everything!
  - 70% of inflows come from Boysen/Buffalo Bill

Friends of the Bighorn River

What was learned / gained

- Modeling is complicated, but not overly so
- Similar to (but less boring than) Accounting
- Inflows drive <u>everything!</u>
  - 70% of inflows come from Boysen/Buffalo Bill
  - Good coordination/cooperation absolutely essential

Friends of the Bighorn River

What was learned / gained

- Modeling is complicated, but not overly so
- Similar to (but less boring than) Accounting
- Inflows drive <u>everything!</u>
  - 70% of inflows come from Boysen/Buffalo Bill
  - Good coordination/cooperation absolutely essential
- Better understanding of how to develop and implement rule curves

Friends of the Bighorn River

What was learned / gained

- Modeling is complicated, but not overly so
- Similar to (but less boring than) Accounting
- Inflows drive <u>everything!</u>
  - 70% of inflows come from Boysen/Buffalo Bill
  - Good coordination/cooperation absolutely essential
- Better understanding of how to develop and implement rule curves
- Appreciation for the efforts of MTAO

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Next Steps

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Next Steps

- Develop inflow deciles based on historical inflow data

Friends of the Bighorn River

Next Steps

- Develop inflow deciles based on historical inflow data
- Work with BOR to make inflow forecast data available online with other HydroMet data

Friends of the Bighorn River

Next Steps

- Develop inflow deciles based on historical inflow data
- Work with BOR to make inflow forecast data available online with other HydroMet data
- Develop rule curves for VARQ modeling

Friends of the Bighorn River

Next Steps

- Develop inflow deciles based on historical inflow data
- Work with BOR to make inflow forecast data available online with other HydroMet data
- Develop rule curves for VARQ modeling
- Fully test the VARQ strategy online and live

Friends of the Bighorn River

Special thanks!

Brian Marotz, FWP
Ken Frazer, FWP
Jim Darling, FWP

Tim Felchle, BOR
Gordon Aycock, BOR

http://bighornriver.org