Friends of the Bighorn River

Reservoir Simulator

Why do this?
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1. Get a better understanding of the process.
Reservoir Simulator

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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.
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Getting started
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Getting started

Start with rock solid documentation
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?
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.

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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
- Carfile 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
IN = Inflows as cubic feet per second (CFS).
Bighorn, Shoshone, tribs, precipitation, runoff, etc.
AF = Storage as acre feet (af).
Calculated from a capacity table where acre feet of storage equates to a specific elevation.
Reservoir Parameters

\[ \text{QD} = \text{Total Discharge as cfs} \]

The total releases from Yellowtail Dam.
CHSTOR = Daily mean change in storage in af. Afterbay daily mean change in storage.
QRD = River releases in cfs.
Reservoir Parameters

IN → AF → CHSTOR → QD → QRD → QJ

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

\[ AF = AF + ((IN - QD) \times 1.983471074) \]
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Objective
Test accuracy of elevation calculations

Error: 130af/day
Dramatization
Solving for Lake Elevation

ACC = Accretions (springs)
130af into the Afterbay!
Now, with QD being known, calc the lake elevation:
AF = AF + ((IN - QD) * 1.983471074) + ACC
Objective
Test accuracy of elevation calculations

Actual 2008 Lake Elevation
Calculated 2008 Lake Elevation
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
Coding the Simulator

Criteria

- Use a simple, familiar user interface
- Use a dynamic database
Coding the Simulator

Criteria

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

Implementation

- Web interface. Works with any browser that supports JavaScript
- SQL Server Database
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Coding the Simulator

Implementation

- Web interface. Works with any browser that supports Javascript
- SQL Server Database
- BOR Hydromet data
<table>
<thead>
<tr>
<th>Step Two</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOLVING FOR 2009 LAKE ELEVATION</strong></td>
</tr>
<tr>
<td><strong>PARAMETERS AND OPTIONS</strong></td>
</tr>
<tr>
<td><strong>Sep 30 Lake Elevation (ft)</strong></td>
</tr>
<tr>
<td>3639.82</td>
</tr>
<tr>
<td><strong>Lookup</strong></td>
</tr>
<tr>
<td><strong>Choose a Historical Comparison Year</strong></td>
</tr>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td><strong>None</strong></td>
</tr>
<tr>
<td><strong>River</strong></td>
</tr>
<tr>
<td><strong>2008</strong></td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
</tr>
</tbody>
</table>

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 also use an external chart or a graph to display results.

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.
SOLVING FOR 2009 LAKE ELEVATION

PARAMETERS AND OPTIONS

Sep 30 Lake Elevation (ft)
3639.82

Choose a Historical Comparison Year
2008

River Discharge Schedule

Seed with model:
- Select Seed
- Select Seed
- 2500MIN
- 2700MIN

Include debug information

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.

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5. Click Go! to see the results of the calculation.
### SOLVING FOR 2009 LAKE ELEVATION

#### PARAMETERS AND OPTIONS

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<thead>
<tr>
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<th>3639.82</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choose a Historical Comparison Year</td>
<td>2008</td>
</tr>
</tbody>
</table>

#### River Discharge Schedule

<table>
<thead>
<tr>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td>2700.00</td>
<td>2700.00</td>
<td>2700.00</td>
<td>2700.00</td>
<td>2700.00</td>
<td>3000.00</td>
<td>3500.00</td>
<td>4500.00</td>
<td>4500.00</td>
<td>3600.00</td>
<td>3000.00</td>
<td></td>
</tr>
</tbody>
</table>

Include debug information

#### INSTRUCTIONS

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### Schedule Information

<table>
<thead>
<tr>
<th>Dataset Name</th>
<th>2450mar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Year</td>
<td>2009</td>
</tr>
<tr>
<td>Select parameter type</td>
<td>River Discharge</td>
</tr>
</tbody>
</table>

Optional
Seed with historical values
- Send to manual grid only
- Select Seed

<table>
<thead>
<tr>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td>2450</td>
<td>2450</td>
<td>2450</td>
<td>2450</td>
<td>2450</td>
<td>2700</td>
<td>3000</td>
<td>3500</td>
<td>4500</td>
<td>4500</td>
<td>3500</td>
<td>3000</td>
</tr>
<tr>
<td>2813.79</td>
<td>2986.75</td>
<td>2961.37</td>
<td>2940.30</td>
<td>2923.09</td>
<td>2995.70</td>
<td>3002.39</td>
<td>3009.06</td>
<td>4350.56</td>
<td>4083.75</td>
<td>2750.07</td>
<td>2529.37</td>
</tr>
</tbody>
</table>

**Build**

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### Parameters to Upload

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

```
2450mar|2006/10/01|2450.000
2450mar|2006/10/02|2450.000
2450mar|2006/10/03|2450.000
2450mar|2006/10/04|2450.000
2450mar|2006/10/05|2450.000
2450mar|2006/10/06|2450.000
2450mar|2006/10/07|2450.000
2450mar|2006/10/08|2450.000
2450mar|2006/10/09|2450.000
2450mar|2006/10/10|2450.000
2450mar|2006/10/11|2450.000
2450mar|2006/10/12|2450.000
```

**Upload**
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What was learned / gained
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  - Good coordination/cooperation absolutely essential
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- Better understanding of how to develop and implement rule curves
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- Inflows drive everything!
  - 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
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- Work with BOR to make inflow forecast data available online with other HydroMet data
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- Work with BOR to make inflow forecast data available online with other HydroMet data
- Develop rule curves for VARQ modeling
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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
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Special thanks!

Brian Marotz, FWP
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Jim Darling, FWP

Tim Felchle, BOR
Gordon Aycock, BOR

http://bighornriver.org