Yellowtail Reallocation Study

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Presentation Overview

- Project background
- Reservoir simulation information
- Summary of results
- Questions
Project Objective

- Evaluate the change in flood reduction benefits due to reallocation of flood control storage to joint use storage for Yellowtail Dam.
BIGHORN LAKE STORAGE ALLOCATION

- **Dam Crest Elev. 3660.0**
- **Surcharge** - 52,829 Acre-Feet
- **Exclusive Flood Control** - 258,331 Acre-Feet
- **Joint Use** - 240,342 Acre-Feet
- **Active Conservation** - 336,103 Acre-Feet
- **Top of Conservation Elev. 3547.00 (493,584 Acre-Feet)**
- **Inactive Conservation** - 477,576 Acre-Feet
- **Top of Dead Elev. 3296.50 (16,008 Acre-Feet)**
- **Dead** - 16,008 Acre-Feet

- **3657** (1,328,360 AF)
- **3640** (1,070,029 Acre - Feet)
- **3614** (829,687 Acre - Feet)
PROPOSED STORAGE ALLOCATION

**Surcharge - 52,829 Acre-Feet**

- **3657 (1,328,360 AF)**
- **3645 (1,137,514 Acre - Feet)**

**Exclusive Flood Control - 190,846 Acre - Feet**

- **3614 (897,172 Acre - Feet)**

**Joint Use - 307,827 Acre - Feet**

- **Top of Conservation Elev. 3547.00 (493,584 Acre - Feet)**

**Active Conservation - 336,103 Acre - Feet**

**Inactive Conservation - 477,576 Acre - Feet**

**Dead - 16,008 Acre - Feet**

**Top of Dead Elev. 3296.50 (16,008 Acre - Feet)**
HEC-ResSim
(Reservoir Evaluation System-Simulation)

- Single or multiple reservoir systems
- Flood control
- Hydropower
- Water supply (municipal, irrigation, etc)
- Diversions
- Navigation
- Flow targets (max & min)
- Period of record or event simulation
Yellowtail ResSim Schematic

Yellowstone River

Billings

Miles City

St. Xavier

Bighorn

Bighorn River

Sidney

Bighorn Lake

Yellowtail Outflow

Yellowtail Inflow

Yellowstone River

Bighorn River
Data Requirements

- Daily stream flow 1967-2006
- Daily reservoir inflow, outflow, storage
- Daily precipitation, evaporation
- Elevation-area-capacity relationships
- Spillway & outlet rating curves
- Downstream discharge-damage functions
- Reservoir operating criteria/storage zones
- Project design floods
- Local flow calculations
ResSim Modeling Process

- Gather input data
- Construct and calibrate models
  - Period of record, inflow design flood, project design flood, 1923 event
  - Establishment of a baseline condition
- Develop reallocated condition
  - Increase top of joint use pool to 3645 ft msl
- Evaluate change in net flood benefits between the baseline and reallocated simulations.
Period of Record Model Results
Summary of Analysis

- Comparison of elevation and outflow data
- Pool and flow duration relationships
  - Annual and seasonal
- Pool probability
- Flow frequency
- Change in flood benefits
  - Yearly and period of record
Summary of Analysis

- Two period of record models created
  - Fixed guide curve
    - Drafts to elevation 3600 ft msl each spring
    - Reallocation of joint use storage to 3645 ft msl
    - Based on historical operations
  - Time series guide curve
    - Drafts to an elevation based on spring inflow conditions
    - Reallocation of joint use storage to 3643 ft msl
    - Not based on historical operations, but potential future operations
Summary of Results

- Detailed write-up of all period of record results included in the Yellowtail Dam Reallocation Study report.
  - Information presented is only a portion of all period of record results.
Summary of Results

Baseline (solid) vs. reallocated (dashed) elevation data
Period shown is 1967-1975
Summary of Results

Baseline (solid) vs. reallocated (dashed) outflow data
Period shown is 1967-1975
Summary of Results

Annual Pool Probability analysis

Fixed Guide Curve
<table>
<thead>
<tr>
<th>Reach</th>
<th>Difference in Average Annual ($1000)</th>
<th>% of Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach 1 – Miles City</td>
<td>-1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Reach 2 – Miles City</td>
<td>-0.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Reach 3 – Sidney</td>
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<td>1.5</td>
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<tr>
<td>Reach 5 – Hardin</td>
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<td>0.0</td>
</tr>
<tr>
<td>Reach 6 – Bighorn</td>
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<td>0.0</td>
</tr>
</tbody>
</table>

Baseline vs. reallocated change in flood benefits (average annual). Difference is reallocated – baseline.
Summary of Results

Baseline (solid) vs. reallocated (dashed) elevation data
Period shown is 1967-1975
Summary of Results

Baseline (solid) vs. reallocated (dashed) outflow data
Period shown is 1967-1975
Summary of Results

Annual Pool Probability analysis

Time Series Guide Curve
## Summary of Results

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<th>Reach</th>
<th>Difference in Average Annual ($1000)</th>
<th>% of Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach 1 – Miles City</td>
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<td>1.4</td>
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<tr>
<td>Reach 2 – Miles City</td>
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<td>Reach 3 – Sidney</td>
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<td>1.0</td>
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<tr>
<td>Reach 5 – Hardin</td>
<td>0.2</td>
<td>50.0</td>
</tr>
<tr>
<td>Reach 6 – Bighorn</td>
<td>0.6</td>
<td>1.9</td>
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</table>

Baseline vs. reallocated change in flood benefits (average annual). Difference is reallocated – baseline.
Inflow Design Flood Results
Comparison of Outflow Data

Peak inflow – 126,000 cfs
Baseline Outflow – 98,020 cfs
Reallocated Outflow – 98,350 cfs
Comparison of Elevation Data

Baseline Elevation – 3658.6 ft msl
Reallocated Elevation – 3658.9 ft msl
Results Summary

- When comparing the baseline and reallocated simulations, increased pool elevation could be categorized as a dam safety issue.
  - Pool elevation in the reallocated scenario is only 1.1 ft from the top of the dam.
    - Changes in operations could create additional dam safety concerns.
Project Design Flood Results
Comparison of Outflow Data

Peak inflow – 37,100 cfs
Baseline Outflow – 20,500 cfs
Reallocated Outflow – 21,900 cfs
Comparison of Elevation Data

Baseline Elevation – 3655.6 ft msl
Reallocated Elevation – 3655.5 ft msl
Results Summary

- When comparing the baseline and reallocated simulations, increased outflow could be categorized as a dam safety concern.
  - Outflow is 1,150 cfs above the listed Yellowtail Afterbay capacity.
    - Changes in operations could create additional dam safety concerns.
1923 Flood Results
Comparison of Outflow Data

Peak inflow – 43,200 cfs
Baseline Outflow – 20,000 cfs
Reallocated Outflow – 28,800 cfs
Comparison of Elevation Data

Baseline Elevation – 3648.8 ft msl
Reallocated Elevation – 3651.5 ft msl
Results Summary

- When comparing the baseline and reallocated simulations, increased outflow could be categorized as a dam safety concern.
  - Outflow is 8,050 cfs above the listed Yellowtail Afterbay capacity.
    - Changes to operations could create additional dam safety concerns.
Next Steps

- Detailed study addressing the impacts presented
  - Identify appropriate mitigation measures
  - Update and sensitivity analysis of downstream flood damage curves
  - Analysis of downstream river capacity
- Is environmental assessment needed?
- Update flood control manual/Field Working Agreement
  - Approved by both the Bureau of Reclamation and U.S. Army Corps of Engineers