Colorado River Management under Uncertainty

Terry Fulp
Deputy Regional Director
Lower Colorado Region

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June 24, 2008
Colorado River Management under Uncertainty

- Overview of Colorado River Basin
- Decision-making under Uncertainty
  - Interim Guidelines for the Operation of Lake Powell and Lake Mead
- Future Needs and Directions
Colorado River Basin Hydrology

• 16.5 million acre-feet (maf) allocated annually
• 13 to 14.5 maf of consumptive use annually
• 60 maf of storage
• 15.1 maf average annual “natural” inflow into Lake Powell over past 100 years
• Inflows are highly variable year-to-year
Natural Flow
Colorado River at Lees Ferry Gaging Station, Arizona
Calendar Year 1906 to 2005

Provisional data, subject to change

RECLAMATION
## Colorado River Basin Storage
(as of June 15, 2008)

<table>
<thead>
<tr>
<th>Current Storage</th>
<th>Percent Full</th>
<th>MAF</th>
<th>Elevation (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Powell</td>
<td>58%</td>
<td>14.14</td>
<td>3623</td>
</tr>
<tr>
<td>Lake Mead</td>
<td>46%</td>
<td>12.03</td>
<td>1106</td>
</tr>
<tr>
<td>Total System Storage</td>
<td>57%*</td>
<td>33.77</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Total system storage was 33.81 maf or 57% this time last year*
2008 Upper Colorado Projected Apr–Jul Inflow (mid-month June forecast)

- Flaming Gorge – 66%
- Blue Mesa – 156%
- Navajo – 127%
- Lake Powell – 113%
## State of the System (1999-2008)

<table>
<thead>
<tr>
<th>WY</th>
<th>Unregulated inflow into Powell % of Average</th>
<th>Powell and Mead Storage, maf</th>
<th>Powell and Mead % Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>109</td>
<td>47.59</td>
<td>95</td>
</tr>
<tr>
<td>2000</td>
<td>62</td>
<td>43.38</td>
<td>86</td>
</tr>
<tr>
<td>2001</td>
<td>59</td>
<td>39.01</td>
<td>78</td>
</tr>
<tr>
<td>2002</td>
<td>25</td>
<td>31.56</td>
<td>63</td>
</tr>
<tr>
<td>2003</td>
<td>52</td>
<td>27.73</td>
<td>55</td>
</tr>
<tr>
<td>2004</td>
<td>49</td>
<td>23.11</td>
<td>46</td>
</tr>
<tr>
<td>2005</td>
<td>104</td>
<td>27.24</td>
<td>54</td>
</tr>
<tr>
<td>2006</td>
<td>72</td>
<td>25.80</td>
<td>51</td>
</tr>
<tr>
<td>2007</td>
<td>68</td>
<td>24.43</td>
<td>49</td>
</tr>
<tr>
<td>*2008</td>
<td>106</td>
<td>27.38</td>
<td>55</td>
</tr>
</tbody>
</table>

*Based on June 24 Month Study and June mid-month inflow forecast*
Natural Flow
Colorado River at Lees Ferry Gaging Station, Arizona
Calendar Year 1906 to 2005

Provisional data, subject to change

RECLAMATION
Annual Natural Flow at Lees Ferry
Tree-ring Reconstruction (Meko et al., 2007)
25-Year Running Mean
Interim Guidelines for the Operation of Lake Powell and Lake Mead

- Specifies a coordinated operation for the full operating range of Lake Powell and Lake Mead in order to better balance the water supply between the two basins
- Encourages more efficient and flexible use of Colorado River water in the Lower Basin by providing a “market-driven” mechanism for water conservation and transfers
- Implements a strategy for shortages in the Lower Basin, including a provision for additional shortages if warranted
- In place for an interim period (through 2026) to gain valuable operational experience
Lake Powell & Lake Mead Operational Diagrams

<table>
<thead>
<tr>
<th>Lake Powell Elevation (feet)</th>
<th>Lake Powell Operational Tiers</th>
<th>Lake Powell Storage (maf)</th>
<th>Lake Mead Elevation (feet)</th>
<th>Lake Mead</th>
<th>Lake Mead Storage (maf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,700</td>
<td>Equalization Tier</td>
<td>24.3</td>
<td>1,220</td>
<td>Flood Control or 70R Surplus</td>
<td>25.9</td>
</tr>
<tr>
<td>3,636 - 3,666 (2008-2026)</td>
<td>Equalize, Avoid Spills or Release 8.23 maf</td>
<td>15.5 - 19.3 (2008-2026)</td>
<td>1,200</td>
<td>Domestic Surplus</td>
<td>22.9</td>
</tr>
<tr>
<td>3,595</td>
<td>Upper Elevation Balancing Tier&lt;sup&gt;1&lt;/sup&gt;</td>
<td>11.3</td>
<td>1,145</td>
<td>Normal Operations</td>
<td>15.9</td>
</tr>
<tr>
<td></td>
<td>Release 8.23 maf; if Lake Mead &lt; 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf</td>
<td></td>
<td>1,125</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3,575</td>
<td>Mid-Elevation Release Tier</td>
<td>9.5</td>
<td>1,100</td>
<td></td>
<td>13.9</td>
</tr>
<tr>
<td></td>
<td>Release 7.48 maf; if Lake Mead &lt; 1,025 feet, release 8.23 maf</td>
<td></td>
<td>1,075</td>
<td>Shortage 333 kaf&lt;sup&gt;2&lt;/sup&gt;</td>
<td>9.4</td>
</tr>
<tr>
<td>3,560</td>
<td>Lower Elevation Balancing Tier</td>
<td>8.3</td>
<td>1,050</td>
<td>Shortage 417kaf&lt;sup&gt;2&lt;/sup&gt;</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Balance contents with a min/max release of 7.0 and 9.5 maf</td>
<td></td>
<td>1,025</td>
<td>Shortage 500 kaf&lt;sup&gt;2&lt;/sup&gt; and Consultation&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5.8</td>
</tr>
<tr>
<td>3,490</td>
<td></td>
<td>5.9</td>
<td>1,000</td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>3,370</td>
<td></td>
<td>0</td>
<td>895</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>1</sup> Subject to April adjustments that may result in balancing releases or releases according to the Equalization Tier.

<sup>2</sup> These are amounts of shortage (i.e., reduced deliveries in the United States).

<sup>3</sup> If Lake Mead falls below elevation 1,025 ft msl, the Department will initiate efforts to develop additional guidelines for shortages at lower Lake Mead elevations.
Decision-making Under Uncertainty
Interim Guidelines

• Multi-faceted research and development program begun in 2004
• Formation of work group of climate scientists to inform our EIS process – report published in EIS (Appendix U) and will be made available stand-alone
• Risk due to increasing climate variability analyzed in the EIS leading to this decision
Probability of Lower Basin Shortages
Comparison of Future Inflow Methodologies

Year

Probability of Occurrence

- - Direct Natural Flow Record (NA)
Direct Natural Flow Record (PA)
- - Nonparametric Paleo Conditioned (NA)
Nonparametric Paleo Conditioned (PA)
- - Direct Paleo (NA)
Direct Paleo (PA)
Major Conclusions from Colorado River Climate Technical Work Group

- Methodologies likely dependent upon time horizon of the decision
  - Climate variability potentially more important in the 10 to 20 year time frame than climate change
- For the 10 to 20 year time frame
  - “Condition” flows at Lee’s Ferry based on projections of climate indicators (i.e., AMO, PDO)
- For the 20+ year time frame
  - Model climate scenarios to generate temperature and precipitation on global scale
  - “Downscale” information to regional scale to drive runoff models
Decision-making Under Uncertainty
Next Steps

• Continued Research and Development

• The bottom line
  – Better quantification of uncertainties and improved understanding of risks
  – Better decision-making under uncertainty

Hoover Dam
C45-300-021094
Colorado River Management Under Uncertainty

For further information:
http://www.usbr.gov/lc/region