OUTLINE

Drought Contingency Planning (DCP)
1. Background
2. Contingency Planning Process 2013-Present

Colorado River Risk Study
1. Background
2. Link to DCP
3. Work to Date

What’s Next?
What if drought periods of past 25 years repeated?

- Current conditions at Powell: about half full summer 2016
- Three recent droughts superimposed on current conditions (drawdowns based on historical record)
- No contingency planning actions in place; no water banking in place

Elevation 3525: Threshold for Lower Operating Tier; Reclamation is concerned about Hydropower efficiency and hydraulics/cavitation below this level

Elevation 3490: Ability to make releases per 2007 Interim Guidelines (and hence Compact Compliance) is jeopardized
BACKGROUND AND CATALYST FOR DCP AND RISK STUDY

• July 2013: Secretary Jewell asks basin states “if 2000 – 2013” drought conditions continue, are you prepared: ANSWER – NO!

• Fall 2013: SNWA and Reclamation analysis for Lower Basin States illustrate possibility of critical storage levels in Mead and Powell and potential for a compact “hole”.

• Upper Basin and Lower Basin begin coordinated, but independent development of contingency plans.

• Dec 2014 Joint West Slope BRT Meeting, Request was made for additional studies.

• Colorado’s Water Plan: Take actions that will minimize risk of compact curtailment actions (pt. 4 of Seven Point Framework)
WHAT ARE “CRITICAL ELEVATIONS” AT POWELL?

• If Lake Powell drops below el. 3525’ on January 1, 2007 Guideline operations are in the Lower Balancing Tier – This can lead to an increase in releases

• Minimum elevation for turbine intakes is el. 3490’, but Reclamation will be concerned about air entrainment and generation efficiency at ~el. 3525’
UPPER BASIN DROUGHT CONTINGENCY PLANNING

Upper Basin Objective:

Identify actions that can reduce the risk of either losing power production at Powell or lose ability to meet our compact obligations

Three Component Solution:

1. Coordinated Drought Operations of initial CRSP Reservoirs (Powell, Flaming Gorge, Aspinall, Navajo)
   • First line of defense against critical Powell elevations

2. Demand Management
   • System Conservation Pilot Project
   • Water Bank Work Group

3. Cloud Seeding
Upper Basin DCP:
Drought Operations Details

- Initial Storage Units of CRSP (Powell, Flaming Gorge, Aspinall, Navajo)
- If August 24-month forecast indicates January 1 Powell elevation will be below the trigger elevation (3525’), implement Drought Operations
  - 1\textsuperscript{st} option: modify timing of Powell Releases
  - 2\textsuperscript{nd} option: Utilize Flaming Gorge, Aspinall, Navajo
- Move water from those CRSP units to Powell
  - Implement at all three upper CRSP reservoirs simultaneously
    - \textit{Does not} mean all three can necessarily contribute.
    - Constraints of Contracted water, Records of Decision, Hydrology
  - Operations covered by current Records of Decision (NO reconsultation)
- Formal agreement between Reclamation and States is in the works.
LOWER BASIN DCP (AND MEXICO)

• Lower Basin reductions based on Mead elevations, and are in addition to 2007 Interim Guidelines’ Shortage Criteria

• Lower Basin conservation begins at elevation 1090’ (200 kaf), which is higher than the current IG shortage criteria threshold

• Could result in as much as 1.2 maf of Lower Basin conservation if Mead is forecast to drop below 1020’

• Agreement valid through 2026 (if approved)

• Minute 323 – U.S. / Mexico Treaty
  • MX participation in shortage sharing pro-rata with 07 Guidelines
  • MX will participate in DCP if and when LB States approve and implement
# LOWER BASIN DCP CONSERVATION SCHEDULE

<table>
<thead>
<tr>
<th>Lake Mead Elevation</th>
<th>AZ (2007)</th>
<th>AZ (Plan)</th>
<th>AZ Total</th>
<th>NV (2007)</th>
<th>NV (Plan)</th>
<th>NV Total</th>
<th>CA (2007)</th>
<th>CA (Plan)</th>
<th>CA Total</th>
<th>USBR</th>
<th>Mexico Minute 319*</th>
<th>Total</th>
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<td>50,000</td>
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<tr>
<td>1,050-1,045</td>
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<td>192,000</td>
<td>592,000</td>
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<td>25,000</td>
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<td>1,045-1,040</td>
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<td>640,000</td>
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<td>27,000</td>
<td>0</td>
<td>200,000</td>
<td>200,000</td>
<td>100,000</td>
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<td>640,000</td>
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<td>10,000</td>
<td>27,000</td>
<td>0</td>
<td>250,000</td>
<td>250,000</td>
<td>100,000</td>
<td>70,000</td>
<td>1,087,000</td>
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<tr>
<td>1,035-1,030</td>
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<td>240,000</td>
<td>640,000</td>
<td>17,000</td>
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<td>27,000</td>
<td>0</td>
<td>300,000</td>
<td>300,000</td>
<td>100,000</td>
<td>70,000</td>
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<td>1,030-1,025</td>
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<td>&lt;1,025</td>
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<td>350,000</td>
<td>350,000</td>
<td>100,000</td>
<td>125,000</td>
<td>1,325,000</td>
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DCP OUTCOMES

Powell and Mead are operationally coupled through the ‘07 Guidelines.

Neither Basin can completely mitigate its own risk: The best solutions require participation by both Upper and Lower Basins.
COLORADO RIVER RISK STUDY

- Originated from joint West Slope BRT discussions and reflection on DCP process
- Funding via Colorado River District, Southwestern Water, W.S. BRTs (CWCB)
- Colorado’s Water Plan: Take actions that will minimize risk of compact curtailment actions (pt. 4 of Seven Point Framework)
- Phase I completed Fall 2016
- Phase II ongoing (completion est. Spring 2018)
WEST SLOPE BRT STUDY – PHASE I

• Questions to answer in Phase I:
  • What are magnitude and duration of Powell shortages below elevation 3525’?
  • How much of the above shortages can be met by contributions from Drought Operations of CRSP reservoirs? (A: up to about 2 MAF)
  • How much consumptive use reduction (“demand management”) would be needed by Upper Basin states - AFTER use of stored CRSP water - in order to maintain Powell pool elevations?
  • What are possible implications to Colorado River water users? What is range of volumes that Colorado might need to conserve? (Colorado’s apportionment under the 1948 Upper Basin Compact is 51.75%, but we’re currently using about 56-58% of UB total)

• Use CRSS Model to address these “What If” questions…
EXAMPLE: HYDROLOGIC SENSITIVITY
EXAMPLE : DEMAND SENSITIVITY

Jan 1 Powell PE ≤ 3525’
25yr ISM

- Demand Schedule A
- Demand Schedule D1
- Demand Schedule 90% D1
CRSP DROUGHT OPERATIONS AND LOWER BASIN CONSERVATION REDUCES THE RISK, BUT DOES NOT ELIMINATE IT.
WHAT WOULD IT TAKE TO COMPLETELY ELIMINATE RISK?

Annual Volumes Needed to Maintain Powell > 3525 on Dec 31
2016-2036 Simulation Period

- Demand Schedule A
- Demand Schedule 90% D1

Count per Scenario

Volume (KAF)

≤ 50 50 - 100 100 - 500 500 - 1,000 1,000 - 1,500 1,500 - 2,000 2,000 - 2,500 2,500 - 3,000
WEST SLOPE BRT STUDY – PHASE II

Phase II Scope of Work:

• Task 1: CRSS “Infilling” - additional model runs and completion of CRSS modeling report
  • Water Banking
  • Paleo Hydrology
  • Sensitivity Analysis (Storage Conditions, Demands)

• Task 2: StateMod investigations
  • Investigate use of StateMod for addressing water use, storage, and demand management questions
  • Look at coupling of StateMod / CRSS and
PHASE II STATEMOD WORK

• “Evaluate the utility of using StateMod in addressing questions related to voluntary demand management. Understand capabilities and limitations”
  a) Use of non-federal reservoirs to bank conserved water. Timing and magnitude of availability
  b) “Allocation” of demand management (who/when/where)
  c) Shepherding questions arising from a) and b)
  d) Representation of storage and delivery for TBDs
  e) Coupling with CRSS

• Scheduling: This task is in progress (10/2017).
STATEMOD EXAMPLE

- Targeted reductions in Consumptive Use
- How much yield at State Line?

<table>
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<tr>
<th>Demand Management Yield by Basin</th>
<th>5%</th>
<th>15%</th>
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<tbody>
<tr>
<td>Target CU</td>
<td>Outflow</td>
<td>Efficiency</td>
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<tr>
<td>Yampa</td>
<td>9,434</td>
<td>8,774</td>
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<tr>
<td>White</td>
<td>2,832</td>
<td>2,917</td>
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<tr>
<td>Upper Colorado</td>
<td>49,852</td>
<td>42,873</td>
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<tr>
<td>Gunnison</td>
<td>26,450</td>
<td>20,631</td>
</tr>
<tr>
<td>San Juan &amp; Dolores</td>
<td>22,271</td>
<td>14,476</td>
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</table>

Preliminary Results – Not for Distribution
WATER BANKING CONCEPT

- Conserved CU is stored in the Bank
- Banked water does not become system water unless released from the Bank. (i.e., not subject to equalization)
- Water Bank releases water only to support Lake Powell elevation, after Drought Operations of upstream CRSP Reservoirs.
- We are looking at Colorado-specific banking options within StateMod model as part of Phase II of the Risk Study
### Effectiveness of water bank?

- Needs to be an add-on to Drought Contingency Plan
- Does not always keep Powell above 3525, but...
- Can increase minimum Powell elevation by ~15-20 ft. (e.g. 3481.2 to 3497.6 in Scenario 6 above)
- UB States need to control “if and when” of banked water releases

### Stress Test Hydrology (1988-2012)

<table>
<thead>
<tr>
<th>Scen 5: Water Bank; A Dem.</th>
<th>Count of Bank Release Years</th>
<th>Count of Release Years that did not fill to 3525'</th>
<th>Shortage 3525 after Bank Release (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>127</td>
<td>113</td>
<td>2,035,526</td>
<td></td>
</tr>
<tr>
<td>Scen 5: Water Bank; 90%D1 Dem.</td>
<td>61</td>
<td>50</td>
<td>1,570,560</td>
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<td>Scen 6: UB &amp; LB DCP; Water Bank; A Dem.</td>
<td>62</td>
<td>46</td>
<td>1,270,984</td>
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<tr>
<td>Scen 6: UB &amp; LB DCP; Water Bank; 90%D1 Dem.</td>
<td>26</td>
<td>13</td>
<td>607,293</td>
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</table>
THE BIG PICTURE

• Hydrology, Demands and Future Development levels matter; the higher the consumptive use in the UB the higher the risk to existing users.

• The most successful DCP requires joint participation by both Upper and Lower Basins. Additional measures in the UB may be necessary to eliminate risk.

• Contingency Planning is essential; CRSP reservoir drought operations reduces the risk, but in more severe droughts (e.g., 1988-1993 & 2001-2005), demand management would be necessary.

• Some of the volumes we are seeing in the model are very large and may not be feasible, need to consider the “trade-offs” and alternative strategies

• Demand Management combined with a Water Bank:
  • Could limit the Annual impact to CU by spreading Conservation over many years
  • Would provide greater control over conserved water (a “must have” condition)
END
PHASE II CRSS WORK

Additional Model Scenarios / Assumptions

• Water Bank concept: Assume different levels of pre-emptive banking with a “non-equalized” storage pool at Powell. Questions: amount/timing/usage
  (e.g., maintain 3525 vs Compact deficit avoidance)
  • Example: 100kaf per year, until needed or WB = 1.0maf; Increase to 200kaf if drought operations are initiated.

• Hydrology: Request to use PaleoHydrology ala Basin Study, and compare with Stress Period, Period of Record, and CMIP-3 Climate Change results

• Sensitivity of Powell/Mead to hydrologic and demand variability
PHASE II CRSS WORK (CONT)

Additional Model Scenarios / Assumptions

• Continue evaluating risk sensitivity to demands. Scenarios A, 90%D1, Other ???

• Sensitivity of risk time horizon to initial conditions (e.g., Powell projection for January 2018 is ~35 ft higher than initial conditions for Phase I Risk Study runs)

• Interim Guidelines vs 602a beyond 2026?

• Drought Contingency Plan Changes?

Scheduling: Scenario definition and model setup is happening now, will continue through summer.