Water & Sustainability in the Southwest US

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S = f( P * R * L * T * G + A)

(state variables & change trajectories)

- P: Population
- R: Resource Base (including Climate)
- L: Lifestyle (Consumption Patterns)
- T: Technology for Managing Resources
- G: Governance
- A: Adaptation (Resilience)
## Arizona Water Supply
### Annual Water Budget

<table>
<thead>
<tr>
<th>Water Source</th>
<th>Million Acre-Feet (maf)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SURFACE WATER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado River</td>
<td>2.8</td>
<td>37.8 %</td>
</tr>
<tr>
<td>CAP</td>
<td>1.6</td>
<td>22%</td>
</tr>
<tr>
<td>On-River</td>
<td>1.2</td>
<td>16%</td>
</tr>
<tr>
<td>In-State Rivers</td>
<td>1.4</td>
<td>18.9%</td>
</tr>
<tr>
<td>Salt-Verde</td>
<td>1.0</td>
<td>14%</td>
</tr>
<tr>
<td>Gila &amp; others</td>
<td>0.4</td>
<td>5%</td>
</tr>
<tr>
<td><strong>GROUNDWATER</strong></td>
<td>2.9</td>
<td>39.2%</td>
</tr>
<tr>
<td><strong>RECLAIMED WATER</strong></td>
<td>0.3</td>
<td>4.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7.4 maf</td>
<td></td>
</tr>
</tbody>
</table>
Arizona Consumption

Municipal: 20% (1.58 maf)

Industrial: 6% (0.47 maf)

Agriculture: 74% (5.82 maf)

Sources: ADWR, UofA, USGS
Colorado River Compact Allocations

Upper Basin (7.5 MAF)
- CO: 51.75%
- WY: 14%
- UT: 23%
- NM: 11.25%
- AZ: 50,000 af

Lower Basin (7.5 MAF)
- CA: 4.4 MAF
- AZ: 2.8 MAF
- NV: 0.3 MAF
- Mexico: 1.5 MAF
Growing Competition…

Water Supply and Demand in the Colorado River Basin

[Graph showing water supply and demand trends from 1923 to 2004.]
Water and …..

- Growth
- Energy
- Climate

- Agriculture…. Is this the source ?
- Environment ..... Is anything left ?

DRIVING FORCES
Lake Mead and Lake Powell: Backbone of the Colorado River

1/1/2000 87% Full (21.3 MAF)
9/05/2016 54% Full (13.0 MAF)

1/1/2000 91% Full (25 MAF)
9/05/2016 37% Full (9.6 MAF)
Colorado River Basin Supply and Demand Study

• Study was first of its kind to incorporate GCM downscaled projection in quantifying future water supply for Colorado River

• Modeling impact of climate change on water supply through downscaled GCM projected scenario results in decrease of 9% in mean streamflow in basin by 2060

• Basin study determined median imbalance in supply and demand of 3.2 MAF, under GCM projected water supply scenario this imbalance is approximately 5 MAF
Lake Mead Historical Operating Range & Shortage Tiers

Historical Lake Mead Elevations

- Filling '36 - '38
- '50s Drought
- Filling Powell
- Structural Deficit

- Observed Historical
- June 2014 24 Month Study Predicted
The Problem

- The Colorado River system is in a fragile state due to years of drought compounded by the “structural deficit”

- Storage in Lake Mead is in critical decline

- There is uncertainty about what actions the Secretary may take to protect storage if Lake Mead goes below 1025’

- CAP’s bears the brunt of impacts due to our junior priority
Water Budget at Lake Mead

- Inflow
  (release from Powell + side inflows) = 9.0 maf

- Outflow
  (AZ, CA, NV, and Mexico delivery + downstream regulation and gains/losses) = -9.6 maf

- Mead evaporation losses = -0.6 maf

- Balance = -1.2 maf

Given basic apportionments in the Lower Basin, the allotment to Mexico, and an 8.23 maf release from Lake Powell, Lake Mead storage declines about 12 feet each year.
Impacts of the Structural Deficit

- Results in a decline of 12+ feet in Lake Mead every year when releases from Powell are “normal” (8.23 MAF)
- Results in a decline of 4 feet in Lake Mead every year when releases from Powell are “balancing” (9.0 MAF)
- Drives Lower Basin to shortage
- CAP forced to bear obligations of others
  - Evaporation and other system losses
  - Lower Basin’s half of Mexican Treaty obligation
Lake Mead Elevations

Historic Levels, with July 2016 to July 2018 Projection

Legend:
- Observed Elevation
- Projected 24 Month
- 1075 - First Shortage Level
- Tier 2
- Tier 3
Continued Lake Mead Declines with Normal Releases


- 1025’ = 21% (5.8 MAF)
- 1000’ = 16% (4.3 MAF)
Based on Reclamation’s August 24 Month Projection of Jan 1, Lake Mead elevation,

Arizona and Nevada share Lower Basin shortages under the 2007 Guidelines

Mexico voluntarily agreed in Minute 319 to accept reductions in its deliveries at the same elevations

<table>
<thead>
<tr>
<th>Lake Mead Elevation</th>
<th>Arizona Reduction</th>
<th>Nevada Reduction</th>
<th>Mexico Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1075’</td>
<td>320,000 AF</td>
<td>13,000 AF</td>
<td>50,000 AF</td>
</tr>
<tr>
<td>1050’</td>
<td>400,000 AF</td>
<td>17,000 AF</td>
<td>70,000 AF</td>
</tr>
<tr>
<td>1025’</td>
<td>480,000 AF</td>
<td>20,000 AF</td>
<td>125,000 AF</td>
</tr>
</tbody>
</table>
Current Shortage Sharing, by Lake Mead Elevation and State/Country

- Tier 1
- Tier 2
- Tier 3

Shortage Reductions (x 1,000 AF)

Lake Mead Elevation
To put it a Tier 3 shortage in perspective...

Under current water use, a reduction of 7% in Colorado River water supply in the Lower Basin results in a reduction of 30% for water available to Central Arizona (CAP)
2017 Level 1 Shortage

- **Ag Pool Shortage** (163,000)
- **Other Excess Shortage** (157,000)
- **Ag Pool** 137,000
- **NIA Priority** 225,000
- **Indian Priority** 317,000
- **M&I Priority** 471,000
- **Priority 3** 68,400

**CAP Delivery Priority**
- Low
- High

**CAP Central Arizona Project**
Consequences of Lake Mead Decline

1075’ • Arizona takes 320 KAF shortage

1050’ • Arizona takes 400 KAF shortage reduction
- Reductions in hydropower generation

1025’ • Arizona takes 480 KAF shortage reduction
- Uncertainty about what actions Secretary will take to protect Lake Mead
- Potential loss of hydropower generation and instability in the electrical grid

1000’ • Active storage in Lake Mead is less than CA’s allocation (~4.3 MAF)
- “Run of River” operations – insufficient storage to meet deliveries to AZ, CA, NV and MX

895’ • Dead pool; only 2 MAF in storage
The Risk

There is a risk that Arizona, and CAP in particular, will be required to take catastrophically deep reductions, with associated adverse impacts on the society, environment and economy of Arizona.
Programs to Address Risks

Storage and Recovery
- 3.4 MAF of underground storage in partnership with AWBA

Augmentation
- Weather modification projects in the Upper Basin
- Local and binational desalination

Lower Basin Pilot Drought Response Actions MOU
- Interstate plan to leave 740 KAF in Lake Mead by end of 2017
- CAP’s share is 345 KAF – will be accomplished by end of 2016

Innovative Conservation ("Pilot System Conservation")
- Interstate funding to conserve >75 KAF in the Colorado River
- Conservation research grant program

Lower Basin Drought Contingency Plan ("DCP") Pending
Lower Basin Drought Contingency Plan - Background

- LBDCP is an “insurance policy” to provide more certainty and greater protection of Colorado River supplies
- LBDCP process led by BOR and LB States built on the initial progress in the pilot projects
- LBDCP process has identified key concepts outlining additional proposed reductions to “bend the curve” in the decline of Lake Mead
Lower Basin Drought Contingency Plan

- New proposed reductions (in addition to the ‘07 guidelines) by each Lower Basin State, and conservation commitment by USBR
- Earlier and larger reductions by Arizona and Nevada
- Conservation by USBR
- Reductions by California at lower Lake Mead elevations
- Mexico to be asked to participate via Minute 32x
- Overlay on the ‘07 Guidelines
# LBDCP Reductions Summary

<table>
<thead>
<tr>
<th>Lake Mead Elevation</th>
<th>AZ Total</th>
<th>NV Total</th>
<th>CA Total</th>
<th>USBR</th>
<th>Mexico Minute 319*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,090-1,075</td>
<td>192,000</td>
<td>8,000</td>
<td>0</td>
<td>100,000</td>
<td>0</td>
<td>300,000</td>
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<tr>
<td>1,075-1,050</td>
<td>512,000</td>
<td>21,000</td>
<td>0</td>
<td>100,000</td>
<td>50,000</td>
<td>683,000</td>
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<tr>
<td>1,050-1,045</td>
<td>592,000</td>
<td>25,000</td>
<td>0</td>
<td>100,000</td>
<td>70,000</td>
<td>787,000</td>
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<td>1,045-1,040</td>
<td>640,000</td>
<td>27,000</td>
<td>200,000</td>
<td>100,000</td>
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<td>1,037,000</td>
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<td>1,040-1,035</td>
<td>640,000</td>
<td>27,000</td>
<td>250,000</td>
<td>100,000</td>
<td>70,000</td>
<td>1,087,000</td>
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<td>1,035-1,030</td>
<td>640,000</td>
<td>27,000</td>
<td>300,000</td>
<td>100,000</td>
<td>70,000</td>
<td>1,137,000</td>
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<td>1,030-1,025</td>
<td>640,000</td>
<td>27,000</td>
<td>350,000</td>
<td>100,000</td>
<td>70,000</td>
<td>1,187,000</td>
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<tr>
<td>&lt;1,025</td>
<td>720,000</td>
<td>30,000</td>
<td>350,000</td>
<td>100,000</td>
<td>125,000</td>
<td>1,325,000</td>
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</table>

*Minute 319 reductions extend through 2017. Assume reductions continue in Minute 32X.*
Drought Contingency Proposal

Potential Shortage Sharing and Protection Actions, by Lake Mead Elevation and State/Country

Current

Proposed

Shortage Reductions (x 1,000 AF)
Potential Shortage Sharing and Protection Actions, by Lake Mead Elevation and State/Country
‘07 Guidelines + LBDCP Reductions + Minute 32x

Potential Shortage Sharing and Protection Actions, by Lake Mead Elevation and State/Country
Lake Mead – Selected Percentile Elevations
Stress Test Hydrology – “No Action” and With DCP

No Action

With DCP
Summary

- Lake Mead is declining due to drought and imbalances between supplies and demands.
- Current projections show the ‘07 Guidelines may not be sufficient to address the declines.
- CAP, with partners, have invested in Lake Mead protection efforts, and Basin-wide conservation, resulting in avoiding shortages in 2016 and in 2017. The efforts are similar to the first level of DCP reductions.
- More actions are needed to address the continuing risks of Lake Mead falling below critical reservoir elevations.
- The LBDCP aims to address a large portion of the current risks in the system.
LBDCP vs. Base Case

Legend
- A Lot Better
- A Little Better
- No Change, No Supply
- No Change, Full Supply
- A Little Worse
- A Lot Worse

Other Excess
- NIA Priority
- M&I + Indian

Ag Pool

Other Excess
- A Lot Better
- A Little Better
- No Change, No Supply
- No Change, Full Supply
- A Little Worse
- A Lot Worse

M&I + Indian
- A Lot Better
- A Little Better
- No Change, No Supply
- No Change, Full Supply
- A Little Worse
- A Lot Worse
A Word About Central Arizona Project

336-mile aqueduct stretches from Lake Havasu to Tucson

14 pumping plants lift water nearly 3000 feet

8 siphons, 3 tunnels

Lake Pleasant/New Waddell Dam

Delivers 1.6 million acre-feet of Colorado River water annually

Navajo Generating Station provides power
CAP Recharge Facilities

- Tonopah Desert: 150k
- Hieroglyphic: 35k
- Agua Fria: 100k
- Superstition Mountains: 56.5k
- Lower Santa Cruz: 50k
- Pima Mine Road: 30k

Replenishment through direct recharge or groundwater savings projects.
95% of the energy used by CAP is produced at the Navajo Generating Station near Page, AZ.

CAP, through the Bureau of Reclamation, has access to nearly 25% of the power produced at NGS.
Central Arizona Groundwater Replenishment District (CAGRD)
A Global Responsibility:
If we can’t work it out here who can?

“We assume a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development — economic development, social development and environmental protection — at local, regional, and global levels.”

Johannesburg Declaration on Sustainable Development