RECLAMATION

Managing Water in the West

Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Draft EIS

Modeling Workshop
Henderson, Nevada
March 6, 2007

U.S. Department of the Interior
Bureau of Reclamation

Sessions

SESSION I (9:00 AM - 12:00 PM)

9:00	Introduction
9:30	CRSS Modeling Assumptions Common to All Alternatives
10:15	CRSS Modeling Assumptions Specific to Each Alternative
10:30	Break
10:45	CRSS Output & Results
11:20	Shortage Allocation Model Overview

SESSION II (1:30 PM - 4:00 PM)

1:30	Detailed Modeling Assumptions – Coordinated Operations
1:40	Detailed Modeling Assumptions – Storage and Delivery Mechanism
1:50	Alternate Hydrologic Sequences
2:00	Open Question and Answer Session
3:45	Closing Comments
4:00	Adjourn

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Introduction

- Project Background
- Federal Action
- Alternatives Studied
- Geographic Scope and Resources Analyzed
- Overview of Models

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Project Setting

- Seven years of unprecedented drought
- Increased water use
- Increased tension among the Basin States
- To date, there has never been a shortage in the Lower Basin and there are currently no shortage guidelines
- Operations between Lake Powell and Lake Mead are currently coordinated only at the higher reservoir levels ("equalization")

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Project Schedule

- ✓ Summer 2005
  - Solicited public comments on proposed content, format, mechanisms and analysis
- ✓ Fall 2005
  - Announced intent to initiate NEPA process, solicited public comments on scope and alternatives development
- ✓ March 2006
  - Published Scoping Summary Report
- ✓ June 2006
  - Published the proposed alternatives
- ✓ February 2007
  - Published Draft EIS on February 28th

- March - April 2007 — Public Comment Period through April 30th; Public Hearings April 3, 4, and 5th
- September 2007 — Publish Final EIS
- December 2007 — Publish Record of Decision

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Key Considerations
(Identified through Scoping Process)

- Importance of encouraging conservation of water
- Importance of considering reservoir operations at all operational levels
- Guidelines for an interim period (assumed to be 2008 through 2026)

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Proposed Federal Action

- Key Elements:
  - Shortage strategy for Lake Mead and the Lower Division states
  - Coordinated operation of Lakes Powell and Mead
  - Mechanism for the storage and delivery of conserved system and non-system water in Lake Mead
  - Modification/extension of the existing Interim Surplus Guidelines

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Alternatives Analyzed in the Draft EIS

- Alternatives
  - No Action Alternative
  - Basin States Alternative
  - Conservation Before Shortage Alternative
  - Water Supply Alternative
  - Reservoir Storage Alternative
- No preferred alternative is identified in the Draft EIS and will be identified after the public comment period

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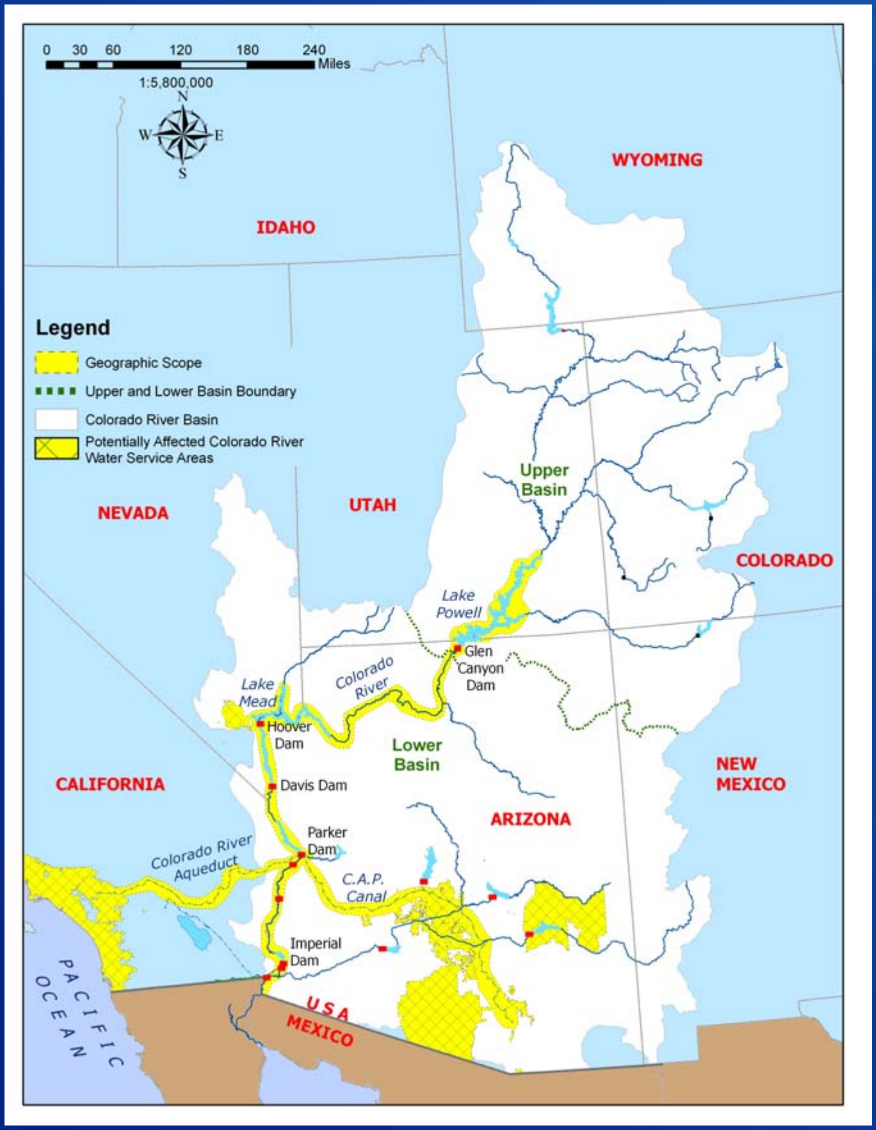
Geographic Scope



- River Corridor from Lake Powell to SIB
- Affected service areas of water users
  - Arizona - lower priority water users along river and CAP users
  - California - MWD service area
  - Nevada - SNWA service area

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Resources Analyzed

- Hydrologic
- Water Deliveries
- Water Quality
- Air Quality
- Visual
- Biological
- Cultural
- Indian Trust Assets
- Electrical Power Resources
- Recreation
- Transportation
- Socioeconomics and Land Uses (includes Agriculture and Irrigation)
- Environmental Justice (includes Population and Housing)

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Modeling for this Draft EIS

- Hydrology (reservoir levels, releases and river flows)
  - Colorado River Simulation System (CRSS), implemented in the RiverWare™ modeling system
- Water Deliveries
  - Shortage Allocation Model, implemented in Microsoft Excel
- CRSS and Shortage Allocation Model are available on CD by contacting strategies@lc.usbr.gov
- Others (water quality, electrical power resources, socioeconomics)

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Other Models Utilized

- Water Quality
  - CRSS salinity module for salinity down to Imperial Dam
  - CE-QAL-W2 model for temperature in Lake Powell
  - Generalized Environmental Modeling System for Surface Waters (GEMSS) for river temperatures below Glen Canyon Dam
  - Estuary and Lake Computer Model (ELCOM) and Computational Aquatic Ecosystem Dynamic Model (CAEDYM) for Lake Mead (SCOP FEIS, October 2006)
- Electrical Power Resources
  - Generation and Transmission Maximization (GTMax) for Glen Canyon Dam generation and capacity
- Socioeconomics
  - Agriculture production model (change in production due to reductions in water deliveries in Arizona)
  - IMPLAN (employment, income, tax revenues)

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CRSS Modeling Assumptions & Output

Modeling Workshop
Henderson, Nevada
March 6, 2007

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CRSS Modeling Assumptions – Common to All Alternatives

- Configuration
- Input Data
- Operational Policies
- Other Assumptions

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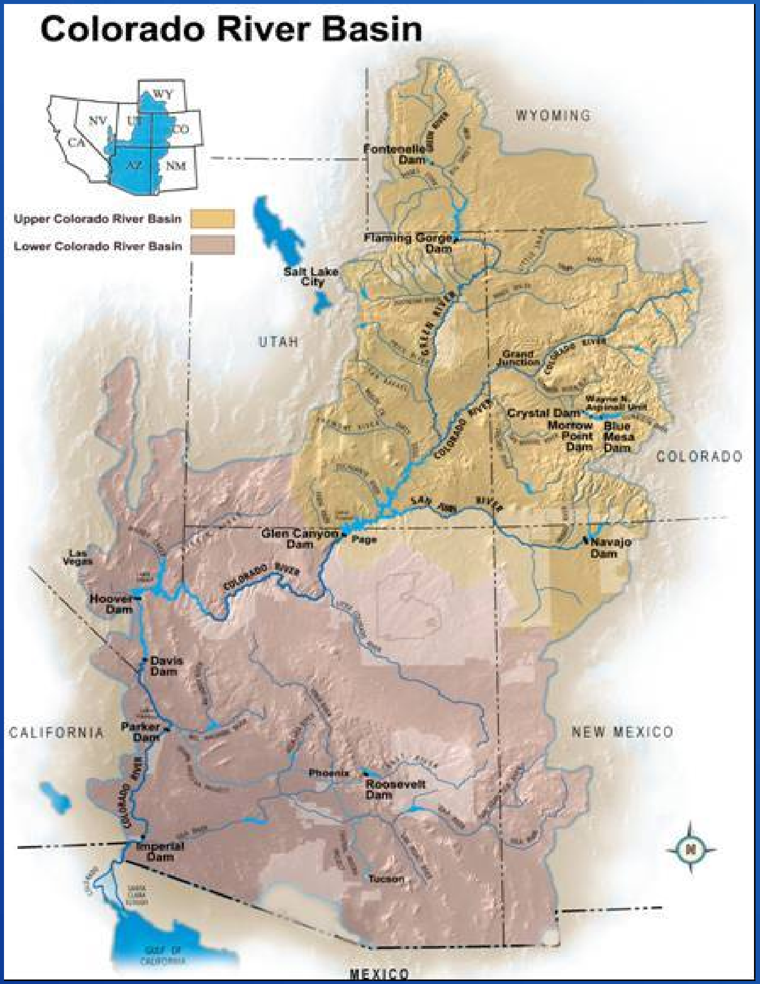
CRSS: A Basin-Wide, Long-Term Planning and Policy Model

- Not a predictive model
- Gives a range of potential future system conditions
- Examples:
  - Reservoir levels
  - Releases
  - River flows



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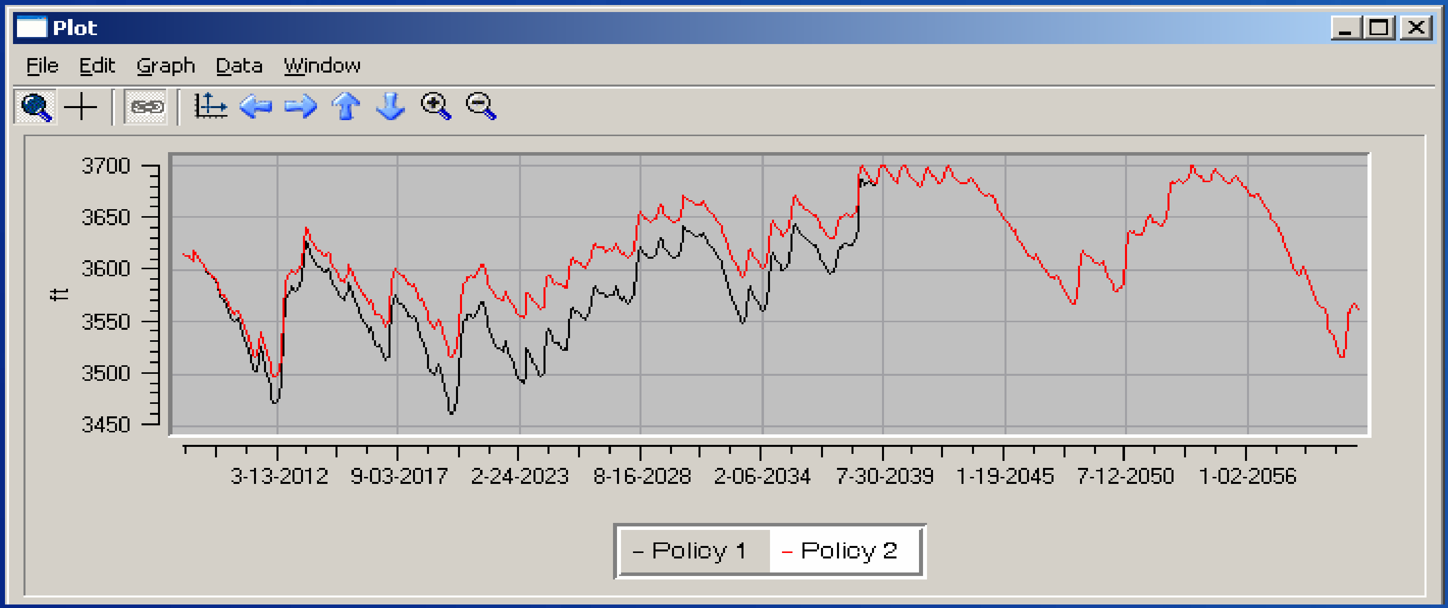
CRSS: A Basin-Wide, Long-Term Planning and Policy Model

- Excellent for comparative analysis
  - Hold most variables constant between model runs
  - Compare the differences due to changing the variables of interest (e.g., shortage and coordinated operations)



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Background

- Developed by Reclamation in the early 1970s
  - Comprehensive model of the Colorado River Basin
  - Primary tool for studying river operations and projected development
  - Used in a number of environmental compliance studies (e.g., ISG and MSCP)
- Updated and maintained continually by Reclamation's Upper and Lower Colorado Regions
- Provided hydrologic data for resource analysis in the Draft EIS

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Background

- CRSS was implemented in RiverWare™ in 1996
- RiverWare™ is a generalized river and reservoir modeling tool (software) developed and supported by the University of Colorado (CADSWES)
  - CRSS is built in RiverWare™
  - Much the same as a spreadsheet (.xls file) is built in Microsoft Excel
- RiverWare™ is a licensed product and is available at http://cadswes.colorado.edu
- RiverWare™ Viewer is also available from CADSWES
  - Free license enabling the user to view a model and ruleset
  - No simulation capability (functionality to run a model is disabled)

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Model Configuration

- CRSS is a monthly time-step model with simulations beginning in 2008
- Modeling addresses guidelines that are in effect for a 19-yr interim period (2008-2026)
- Action alternatives revert to No Action in 2027
- Simulations through 2060 to assess long-term hydrologic effects of each alternative

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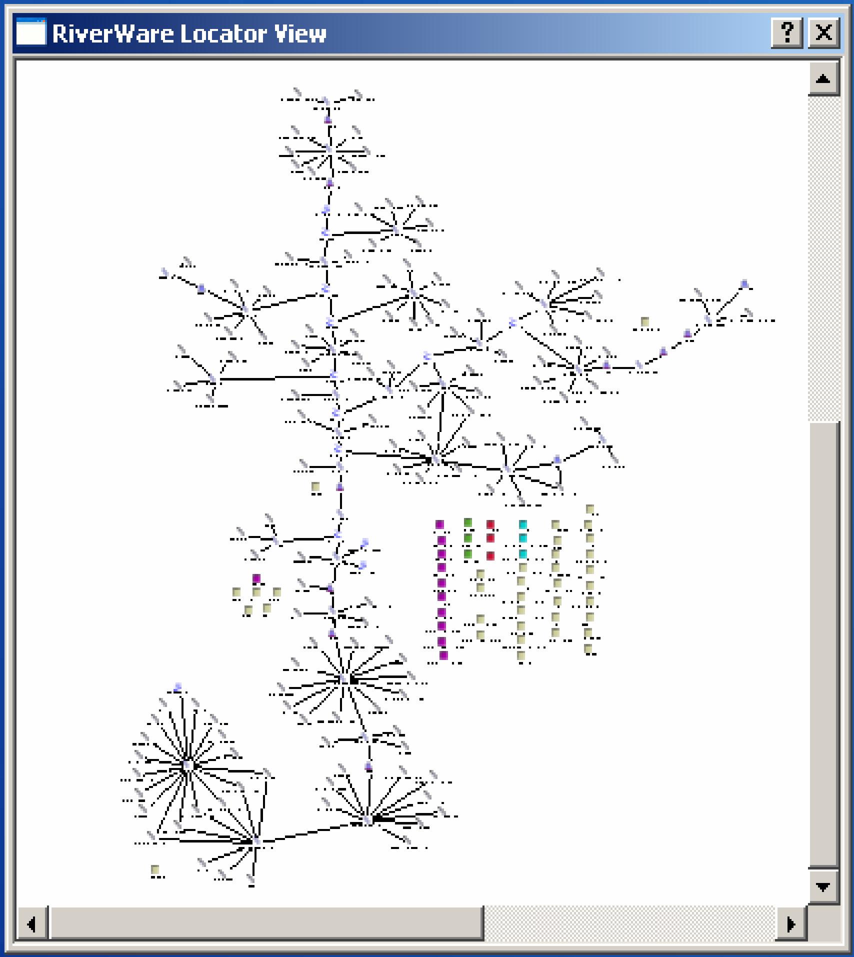
Spatial Configuration

- Physical layout:
  - Full basin model from the headwaters of the mainstem and major tributaries, down to the Northerly international boundary with Mexico
  - Reservoirs: 12
  - Diversions: ~225
  - Natural inflow points: 29



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CRSS Modeling Assumptions –
Common to All Alternatives

- Configuration
- Input Data
- Operational Policies
- Other Assumptions

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Data Requirements: Inputs

- Major inputs to the model:
  - Initial conditions for all reservoirs
    - System storage as of December 31, 2007
    - Projections from the August 2006 24-Month Study model
  - Future water use schedules
    - Upper Basin from the UCRC
    - Lower Basin from each state
  - Future inflows into the system
- Results are most sensitive to future inflows
  - Use historical inflows to postulate future inflows
  - Index Sequential Method (Ouarda et al., 1997) to quantify the uncertainty

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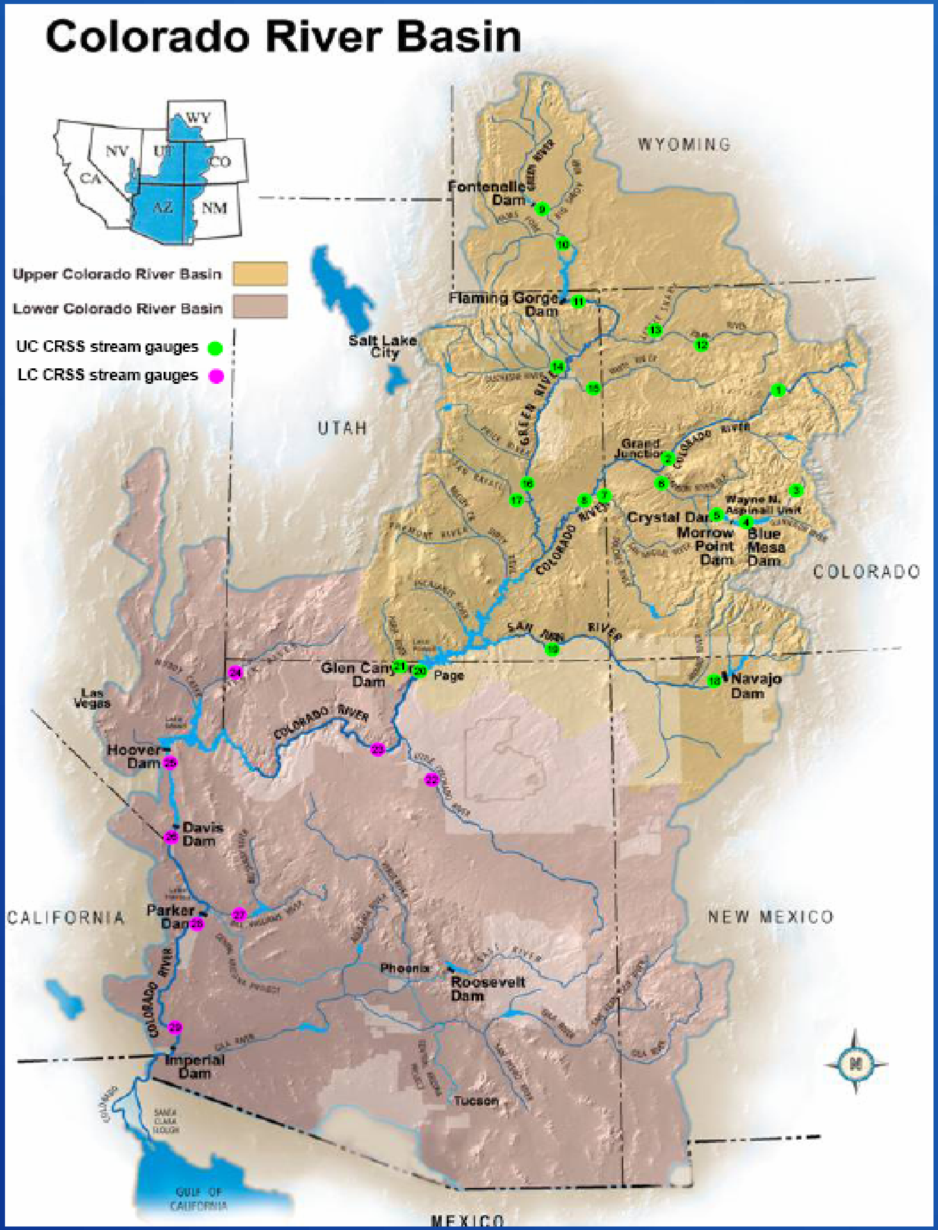
29 Natural Inflow Stations in CRSS

1	Colorado River at Glenwood Springs, CO
2	Colorado River near Cameo, CO
3	Taylor River below Taylor Park Reservoir, CO
4	Gunnison River below Blue Mesa Reservoir, CO
5	Gunnison River at Crystal Reservoir, CO
6	Gunnison River near Grand Junction, CO
7	Dolores River near Cisco, UT
8	Colorado River near Cisco, UT
9	Green River below Fontenelle Reservoir, WY
10	Green River near Green River, WY
11	Green River near Greendale, UT
12	Yampa River near Maybell, CO
13	Little Snake River near Lily, CO
14	Duchesne River near Randlett, UT
15	White River near Watson, UT
16	Green River at Green River, UT
17	San Rafael River near Green River, UT
18	San Juan River near Archuleta, NM
19	San Juan River near Bluff, UT
20	Colorado River at Lees Ferry, AZ
21	Paria River at Lees Ferry, AZ
22	Little Colorado River near Cameron, AZ
23	Colorado River near Grand Canyon, AZ
24	Virgin River at Littlefield, AZ
25	Colorado River below Hoover Dam, AZ-NV
26	Colorado River below Davis Dam, AZ-NV
27	Bill Williams River below Alamo Dam, AZ
28	Colorado River below Parker Dam, AZ-CA
29	Colorado River above Imperial Dam, AZ



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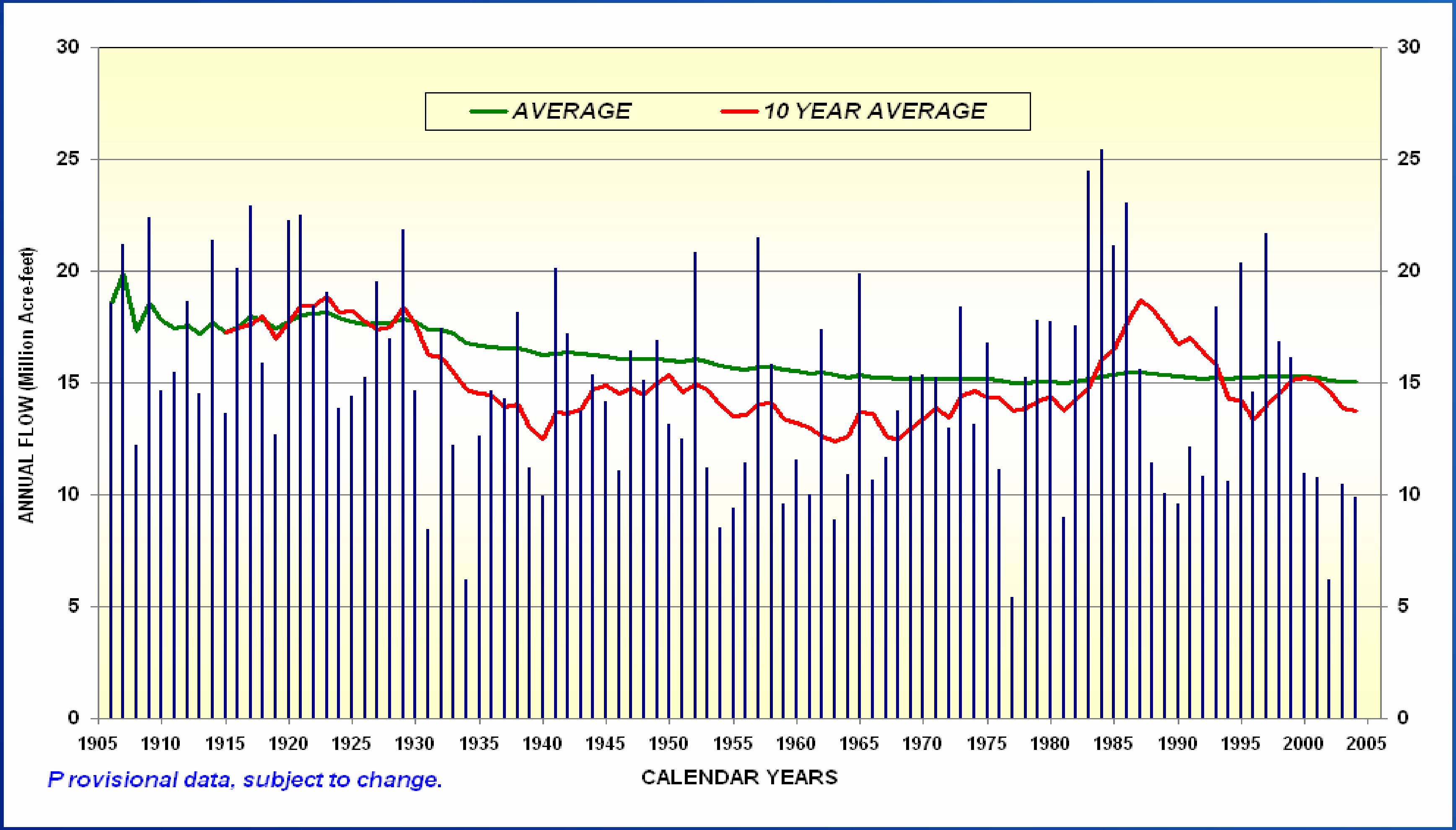
Natural Flow

Colorado River at Lees Ferry Gaging Station, Arizona

Calendar Year 1906 to 2004



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CRSS Modeling Assumptions –
Common to All Alternatives

- Configuration
- Input Data
- Operational Policies
- Other Assumptions

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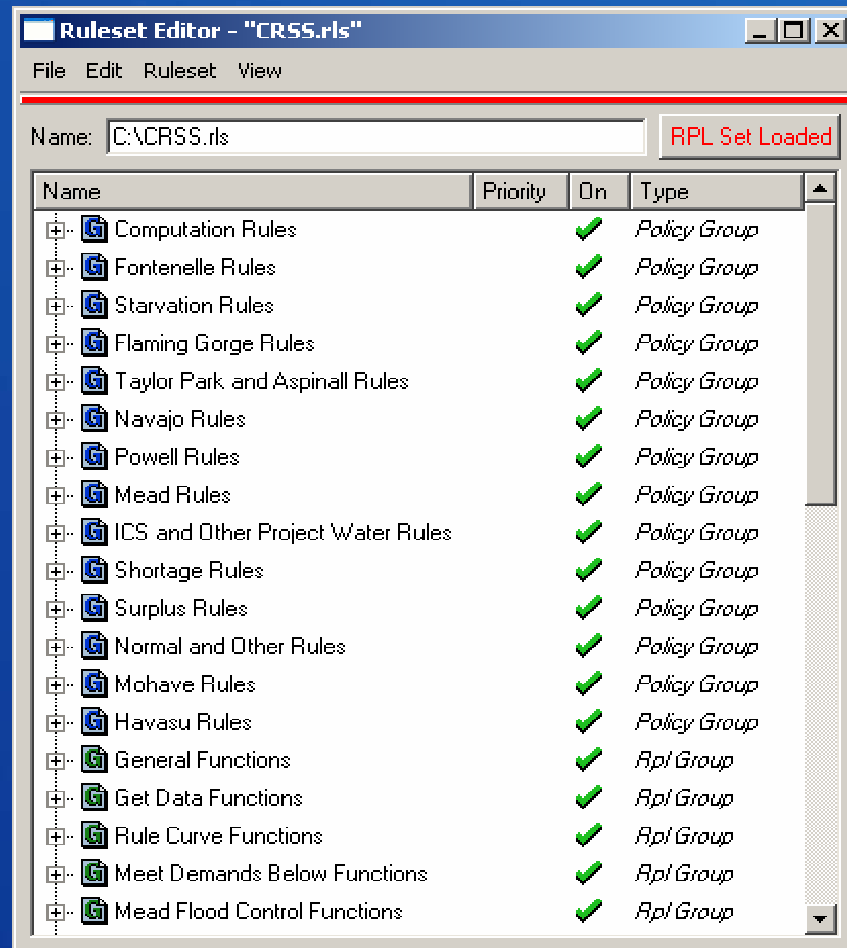
Data Requirements: Operating Policy

- Operating policies are prioritized as “Rules”
- A group of rules and functions (a “Ruleset”), along with user inputs, provide the necessary information for the model to solve
- Rules drive simulation by providing the necessary logic (e.g., IF statements) to mimic how the system would be operated in practice



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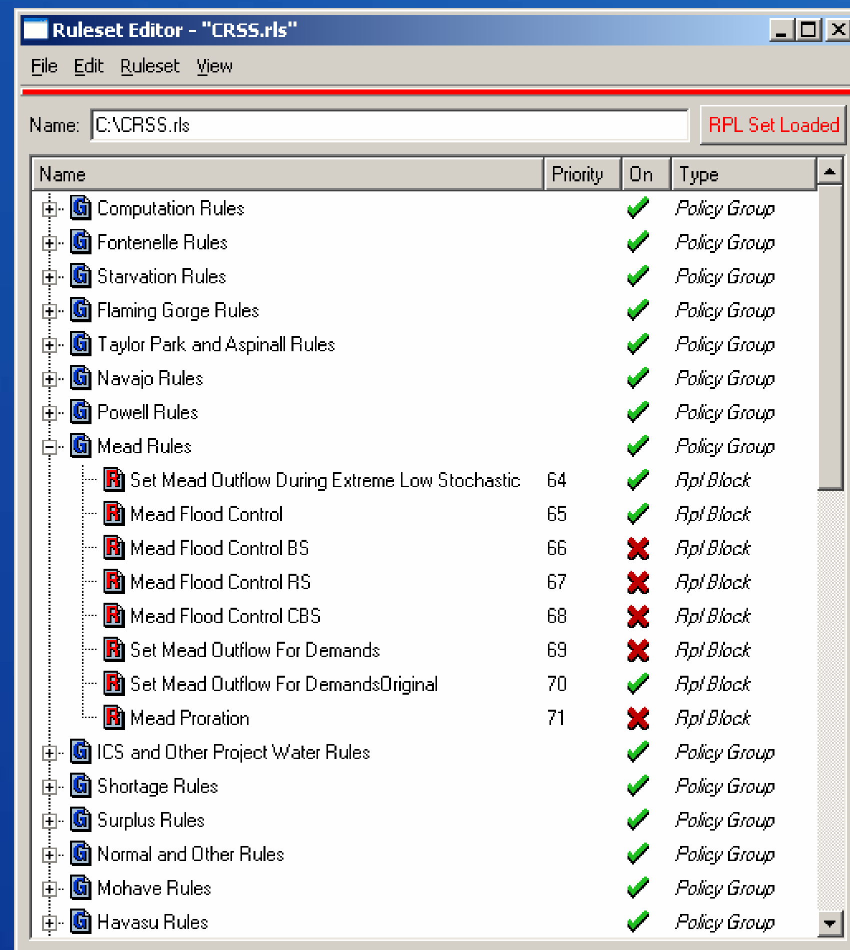
Major Operating Rules in CRSS

- Upper Basin Reservoirs above Lake Powell
- Lake Powell
- Lake Mead
- Lakes Mohave and Havasu



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Operating Policy
Upper Basin Reservoirs Above Lake Powell

- For the following Upper Basin Reservoirs:
  - Fontenelle and Flaming Gorge (Green River)
  - Taylor Park, Blue Mesa, Morrow Point, Crystal (Gunnison)
  - Navajo (San Juan)
- Basic operation:
  - Release water sufficient to meet monthly storage targets (or “rule curves”) and downstream demands, within fixed minimum and maximum releases
- Legal framework:
  - Authorized project purposes
  - Anticipate major changes due to the Recovery Implementation Programs and associated environmental compliance

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Operating Policy
Upper Basin Reservoirs Above Lake Powell

- For Flaming Gorge, Blue Mesa and Navajo:
  - The rule curves are computed during the simulation for the spring runoff season (January through July) to simulate operations based on the imperfect inflow forecast.
  - Inflow forecasts are weighted averages of the known inflow for the year and the long term average.
- For the remaining reservoirs:
  - The rule curves are fixed for each month.
- Reservoirs on the Gunnison are used in tandem to meet demands below Crystal.

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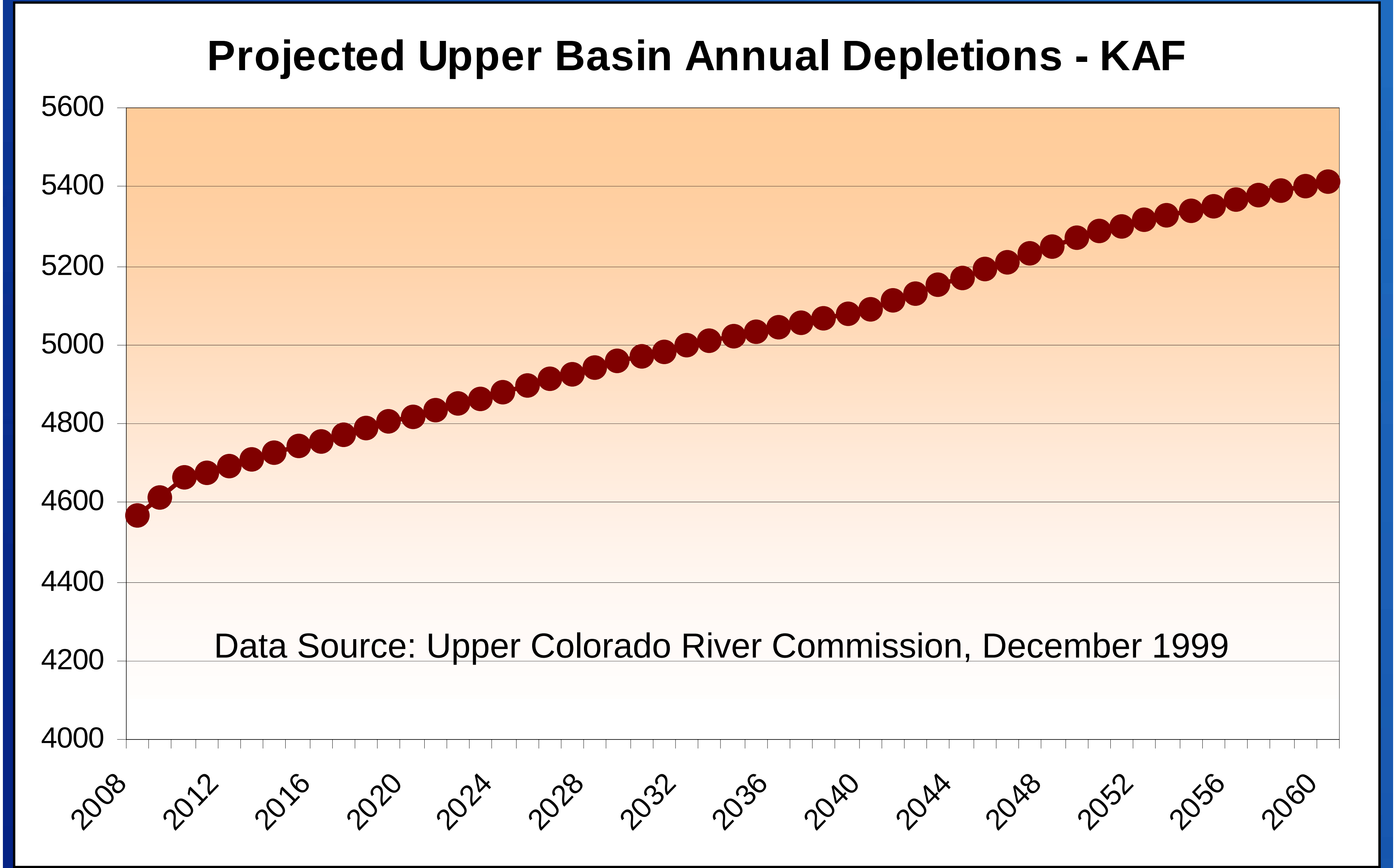

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Operating Policy
Upper Basin Reservoirs Above Lake Powell

- Operation of reservoirs above Lake Powell is identical for each of the 5 alternatives
- Upper Basin projected depletions are identical for each of the 5 alternatives

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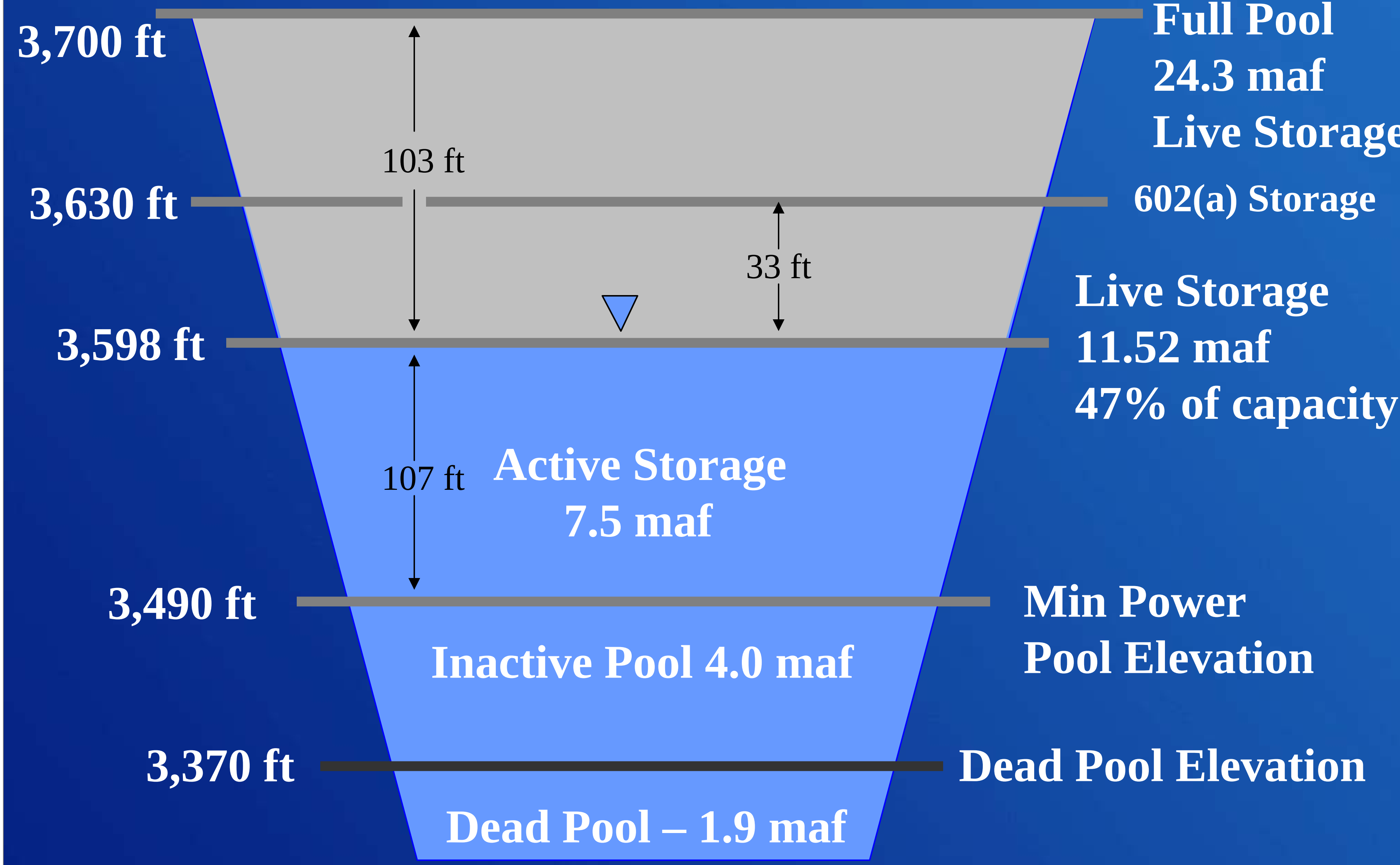
Lake Powell Capacity



Not to scale

As of Mar 4, 2007

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Operating Policy
Lake Powell – Glen Canyon Dam

- Operated consistent with the Long Range Operating Criteria (LROC)
- Power plant operations in accordance with 1996 Glen Canyon ROD/Glen Canyon Operating Criteria
- Beach Habitat Building Flows – 1996 ROD

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Operating Policy
Lake Powell – Glen Canyon Dam

- Annual release of water from Lake Powell determined according to the LROC
  - Three modes of governing annual releases from Lake Powell
    - Minimum objective release – 8.23 maf
    - Equalization – if Upper Basin storage is > 602(a) storage and Powell storage > Mead storage: Releases greater than 8.23 maf are made to equalize storage between Powell and Mead on September 30
    - Spill Avoidance

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602(a) Storage

- Defined in 1968 Colorado River Basin Project Act
- Storage in Upper Basin necessary to assure deliveries to Lower Basin without impairment to consumptive use in Upper Basin
- Equalization releases not required in years when Upper Basin storage is less than 602(a) storage
- Annual determination of 602(a) storage made in the Colorado River Annual Operating Plan

602(a) Storage in CRSS

- Computed at the beginning of each calendar year as:
  - 602a = {(UBDepletion + UBEvap)*(1 – percentShort/100) + minObjRel – criticalPeriodInflow} * 12 + minPowerPoolStorage
  - Where
    - 602a = the 602(a) storage requirement
    - UBDepletion = the average over the next 12 years of the UB scheduled depletion
    - UBEvap = the average annual evaporation loss in the UB (currently set to 560 kaf)
    - percentShort = the percent shortage that will be applied to UB depletions during the critical period (currently set to zero)
    - minObjRel = the minimum objective release to the LB (currently set to 8.23 maf)
    - criticalPeriodInflow = average annual natural inflow into the UB during the critical period (1953-1964, currently set to 12.18 maf)
    - minPowerPoolStorage = the amount of minimum power pool to be preserved in Upper Basin reservoirs (currently set to 5.179 maf)

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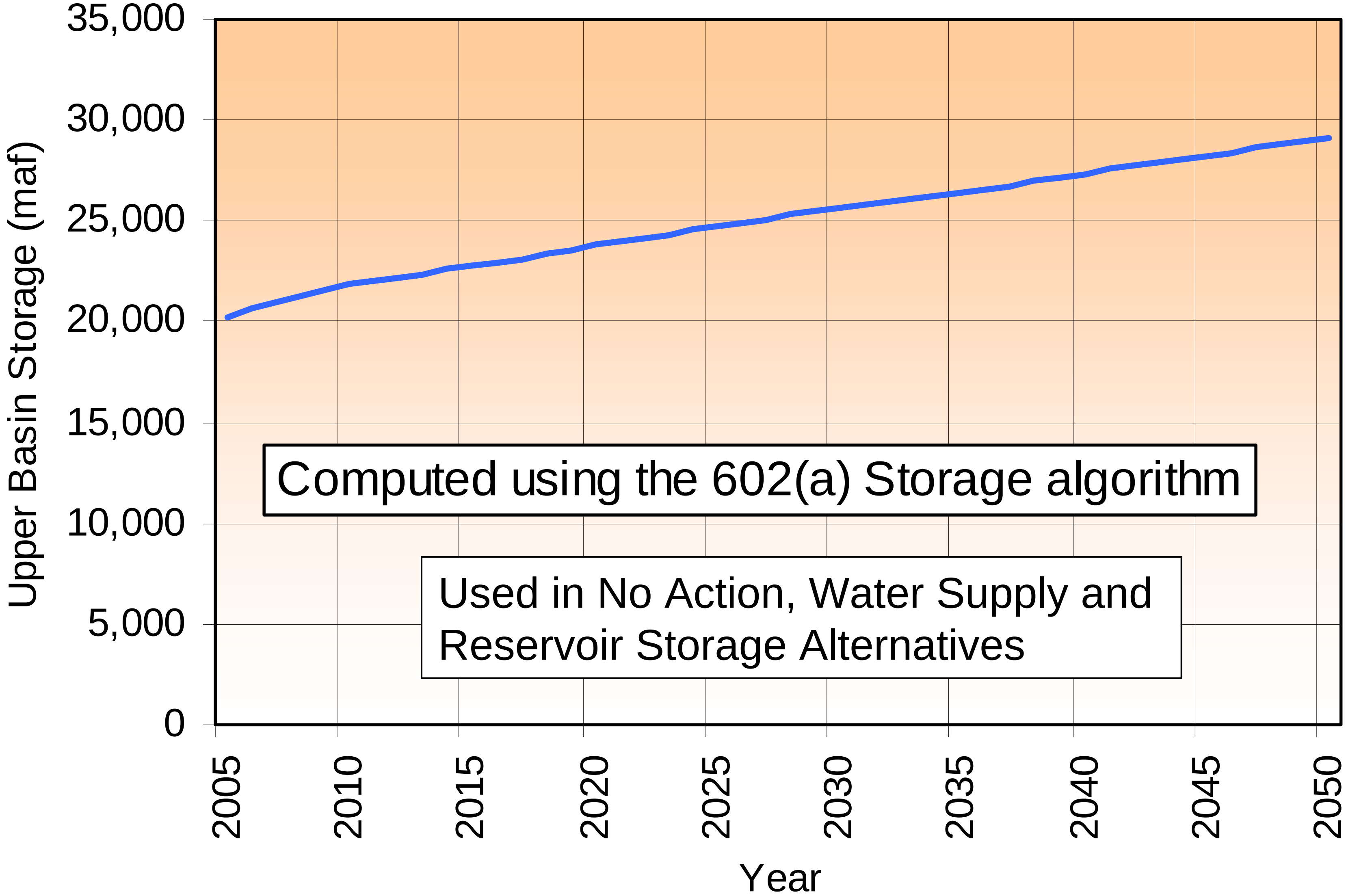
CRSS 602(a) Storage



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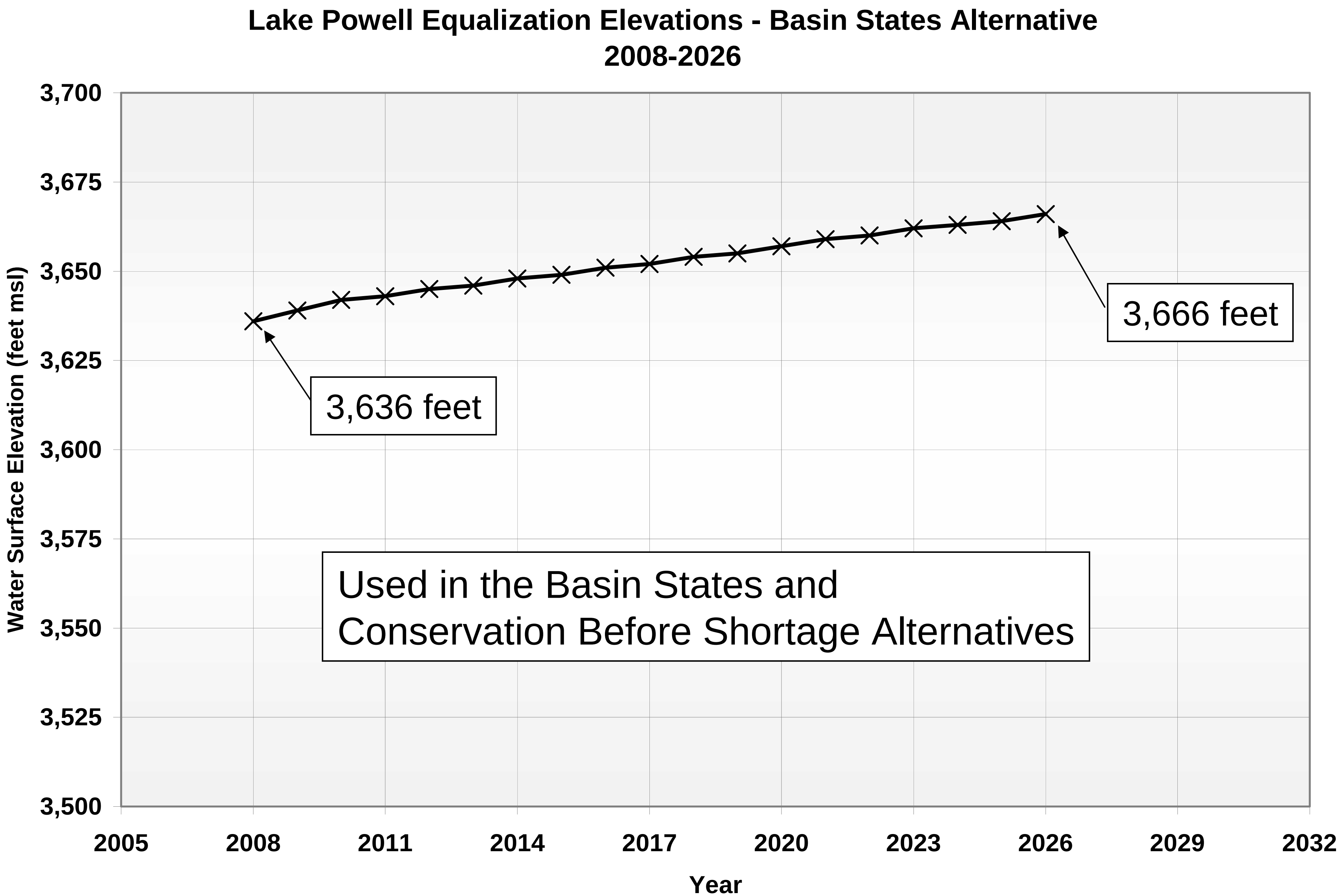

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Simulated Inflow Forecast for Lake Powell in CRSS

- Lake Powell Inflow forecast is simulated from January through July
- Inflow forecast is based on:
  - observed natural flow for the current year
  - monthly error term
  - previous months error
  - random error component
- Inflow forecast changes each month

Beach/Habitat Building Flows (BHBF)

- High releases of short duration ~ 45,000 cfs
- Build beaches and create habitats
- Occur in ‘wet’ years when risk of spills is high
- Trigger Criteria Established by AMWG in 1998 is used:
  - if January unregulated inflow forecast is > 13.0 maf
  - If releases greater then 1.5 maf per month are required during the January through July time period
  - 200 KAF bypass
  - only one BHBF per year

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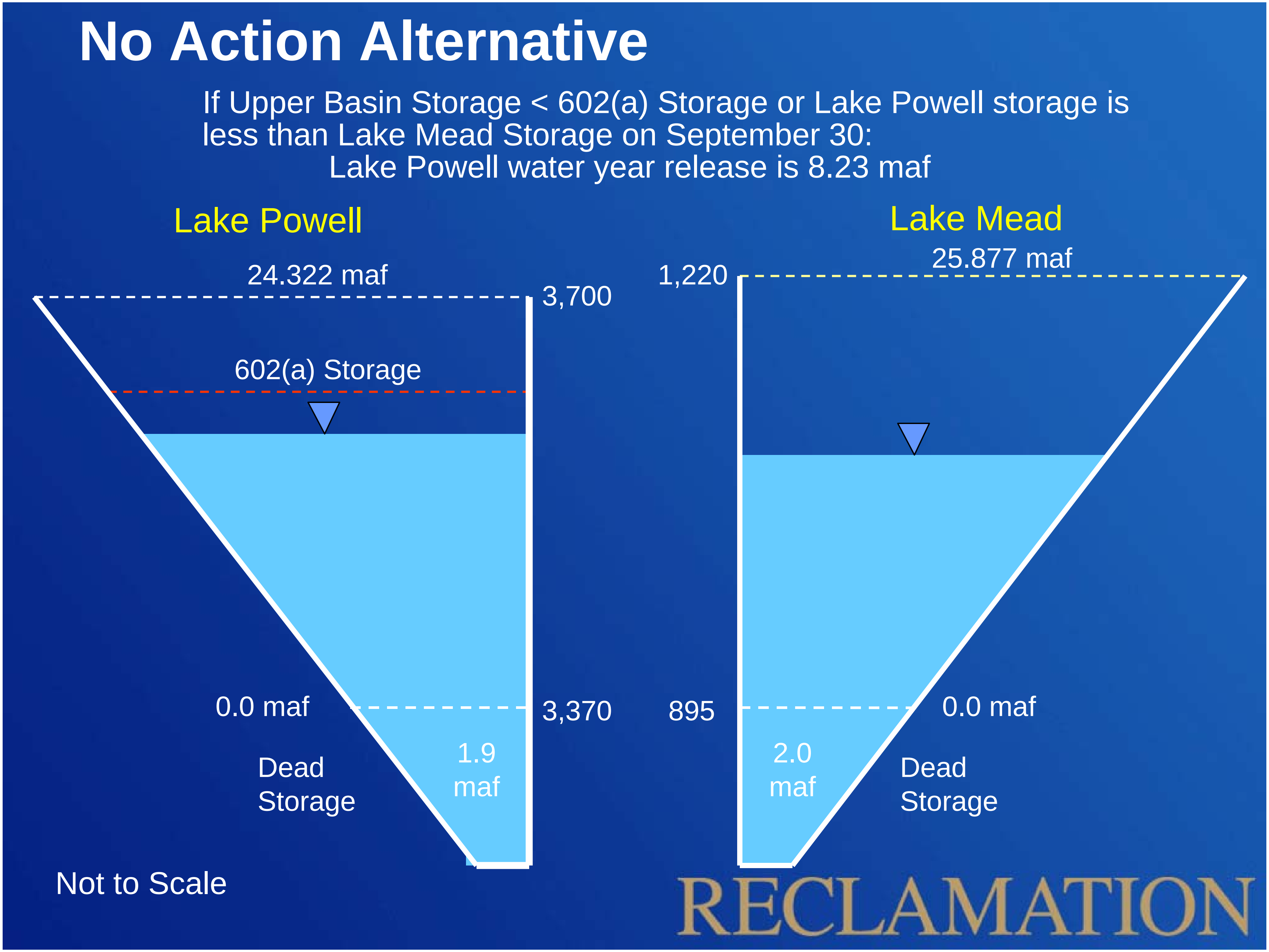
No Action Alternative
If Upper Basin Storage < 602(a) Storage or Lake Powell storage is less than Lake Mead Storage on September 30:
Lake Powell water year release is 8.23 maf
Lake Powell
24.322 maf
3,700
602(a) Storage
0.0 maf
3,370
Dead Storage
1.9 maf
Lake Mead
25.877 maf
1,220
895
0.0 maf
2.0 maf
Dead Storage
Not to Scale
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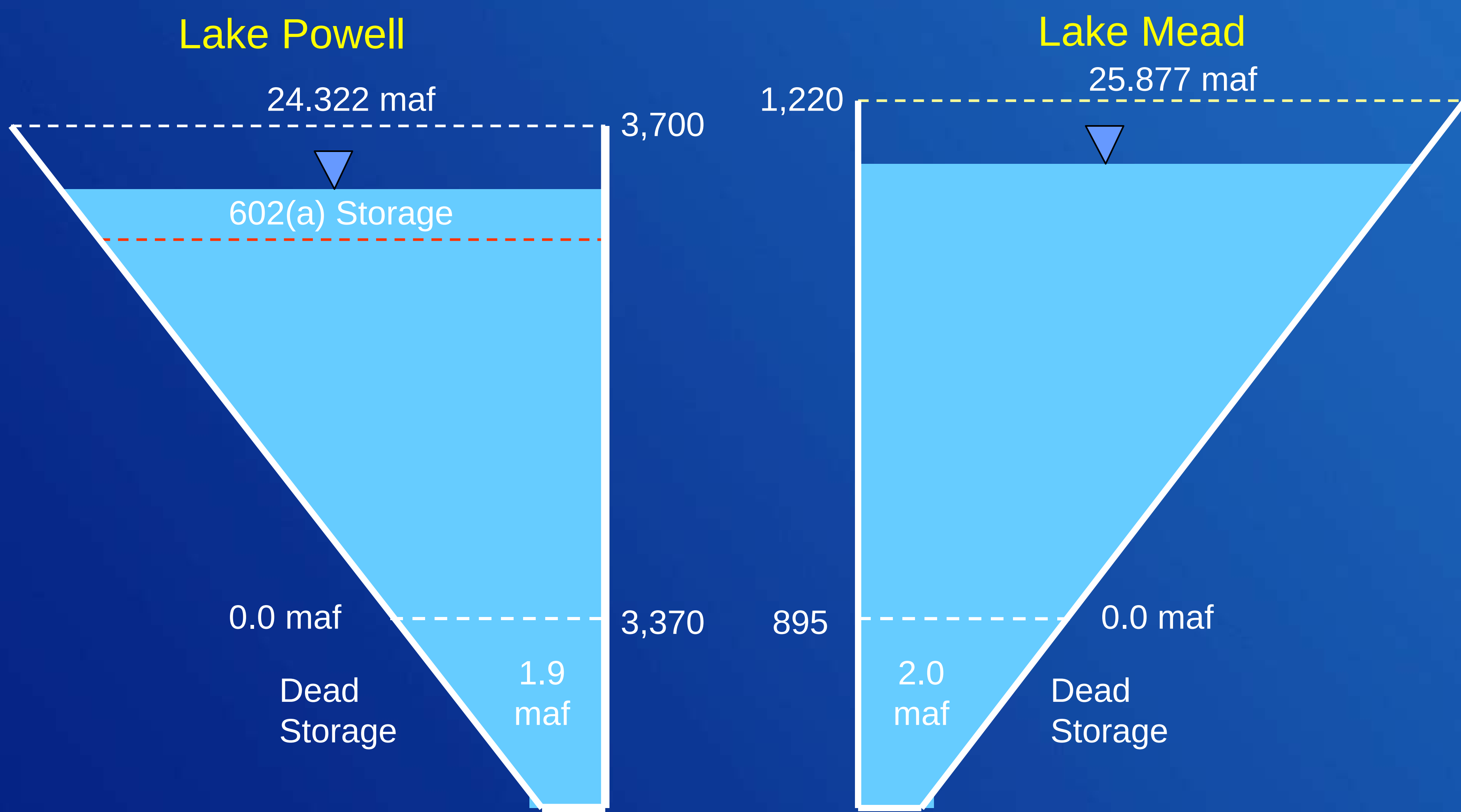
No Action Alternative

If Upper Basin Storage < 602(a) Storage or Lake Powell storage is less than Lake Mead Storage on September 30:
Lake Powell water year release is 8.23 maf



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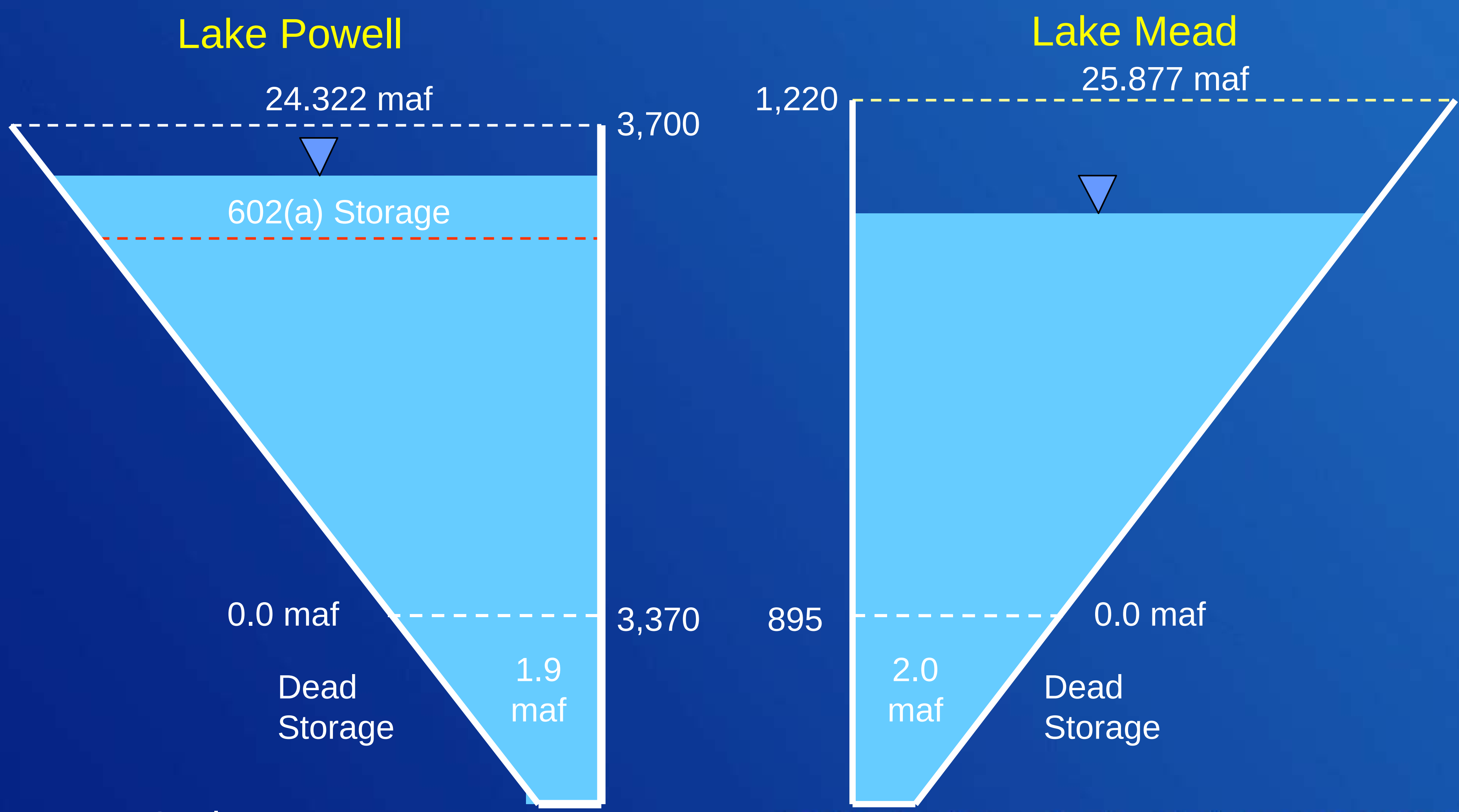
No Action Alternative

If Upper Basin Storage > 602(a) Storage and Lake Powell storage is greater than Lake Mead Storage on September 30:

Releases > 8.23 maf are made to equalize storage on Sept 30



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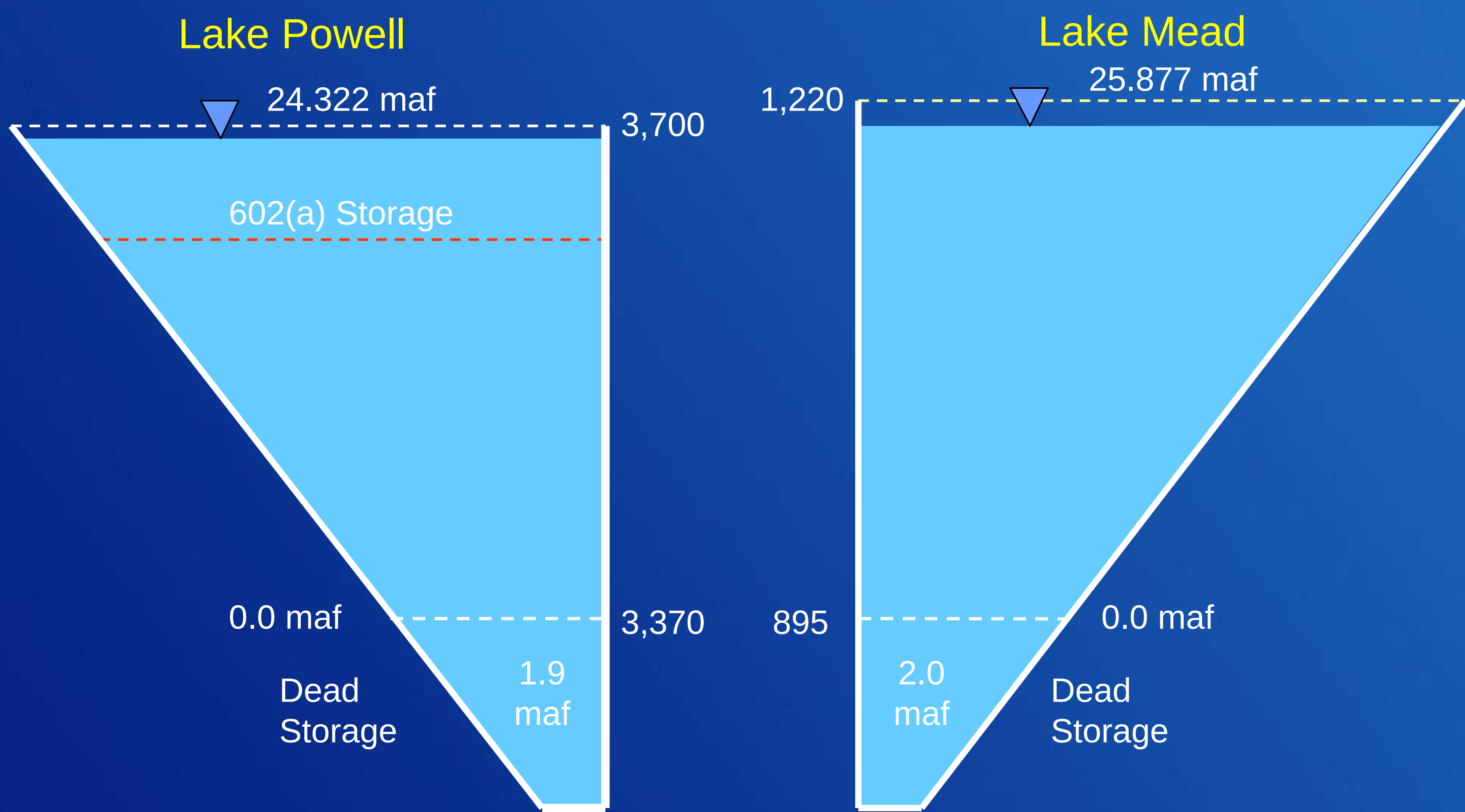
No Action Alternative

If Lake Powell is projected to fill and spill:
Releases greater than 8.23 maf are made to avoid spills and/or to equalize storage



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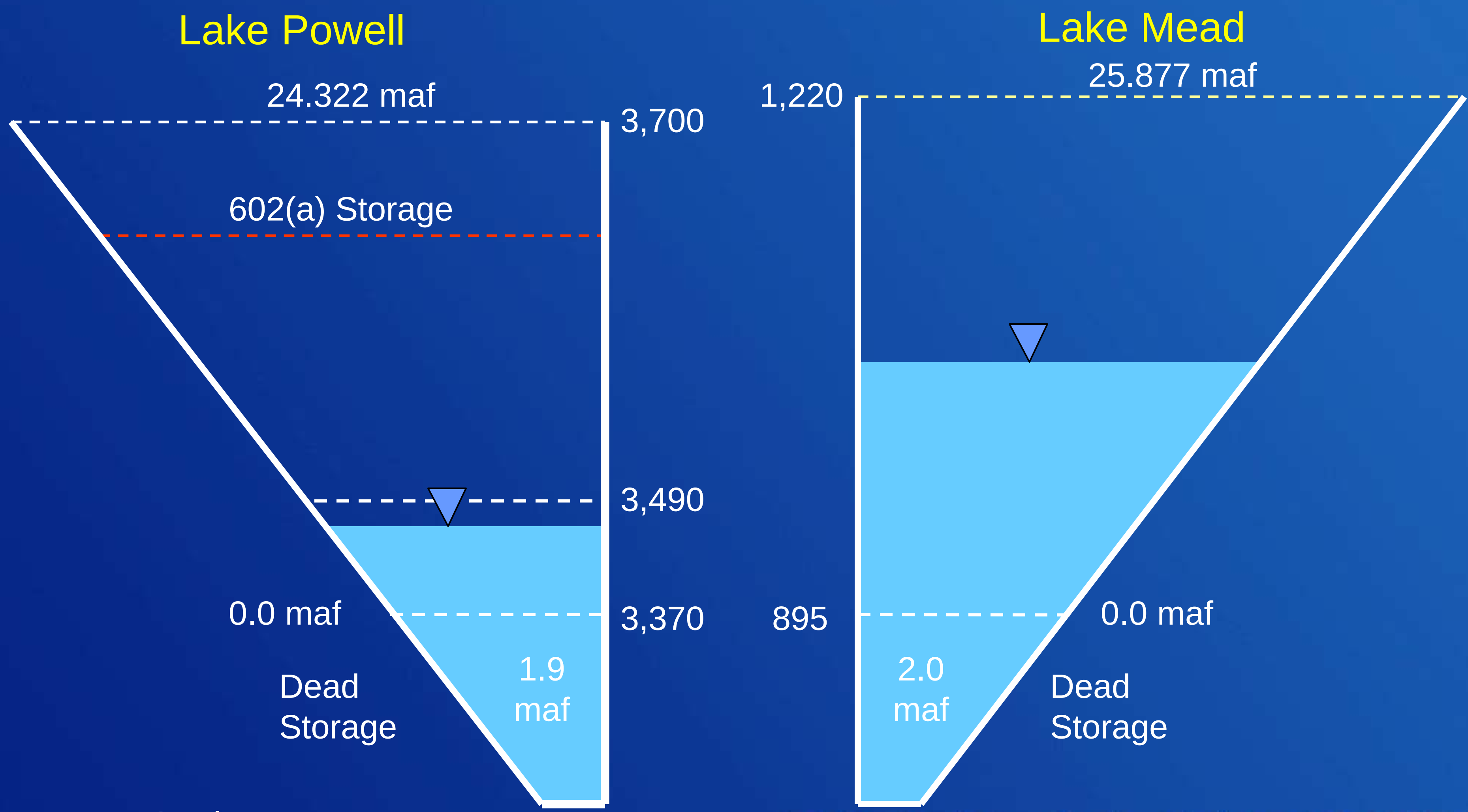
Minimum Power Pool at Lake Powell

Minimum Power Pool at Lake Powell is at elevation 3,490 feet
There is no absolute protection of minimum power pool at Lake Powell under any of the alternatives.



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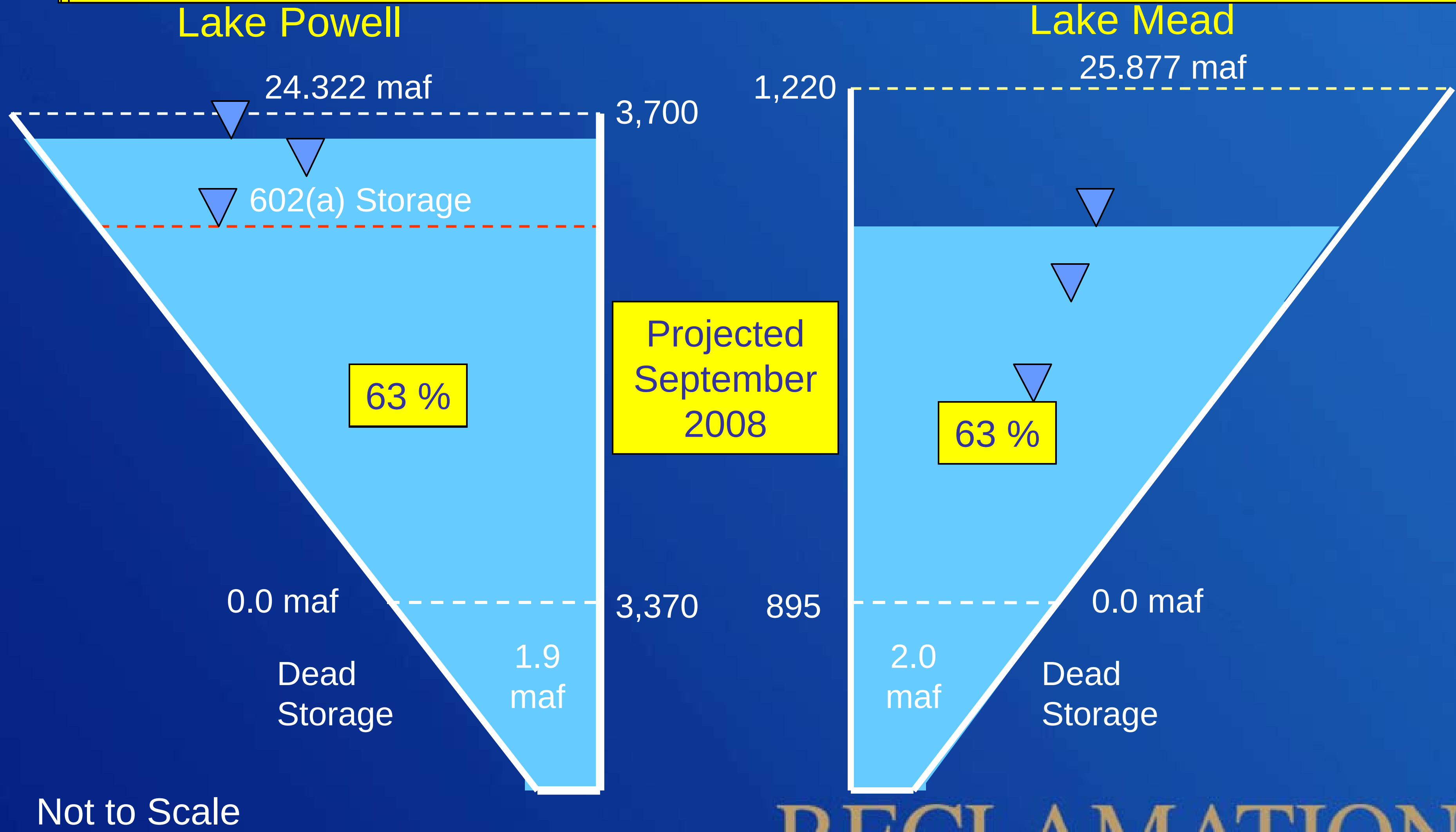
Operating Policy
Lake Powell Rules

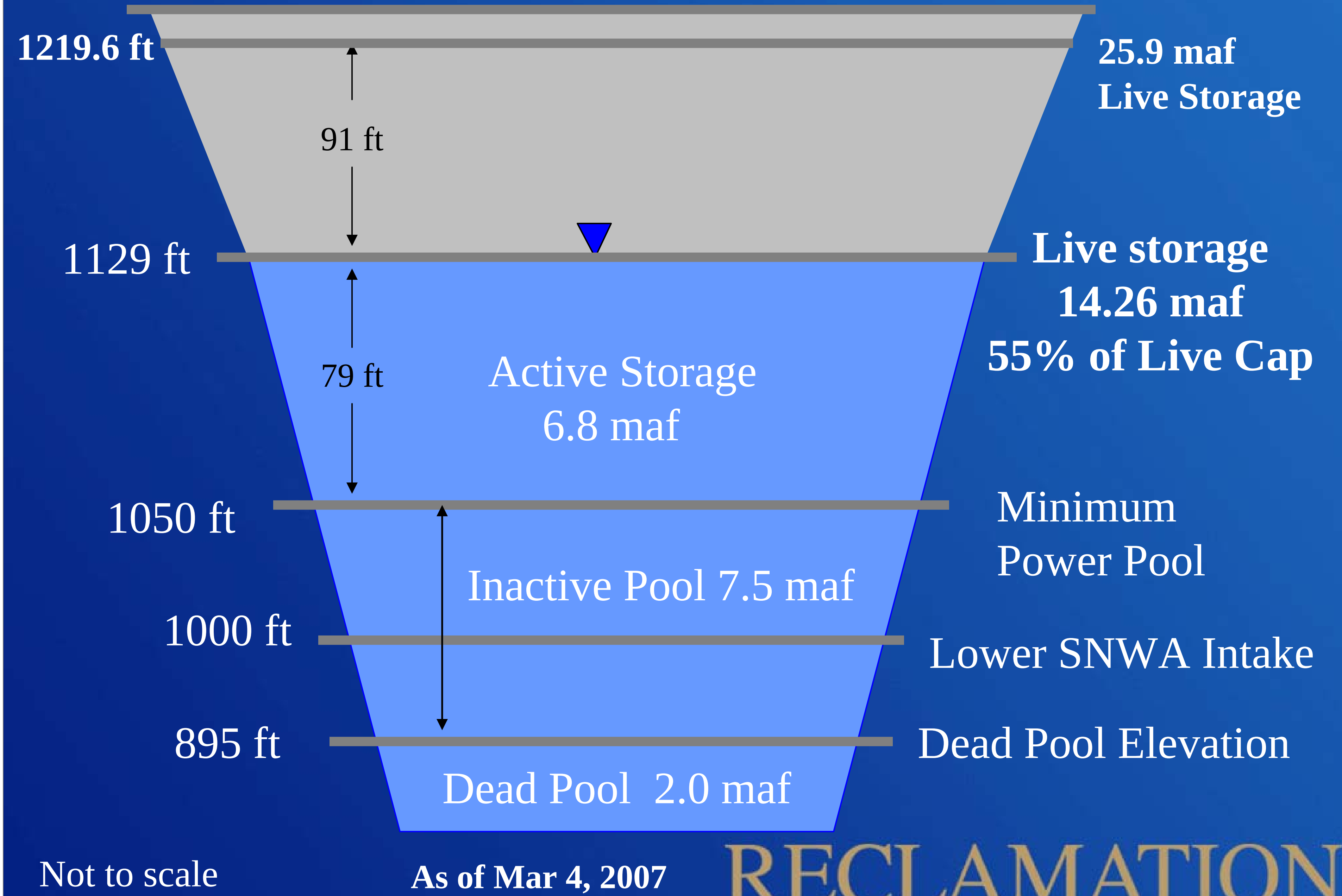
- Powell Operations rule
  - Determine monthly release based on spring inflow forecast or fall drawdown
    - Routes water to fill but not spill Lake Powell in January – July
    - Under full storage conditions releases extra water in August – December so the elevation of Lake Powell on January 1 is not greater than 3,684 feet
- Minimum Objective Release rule
  - Ensure that releases made by the Operations rule will meet the minimum objective release
- Equalization rule
  - Projects if equalization releases are needed to balance reservoirs by the EOWY, based on the forecasted EOWY storages, and checks the 602(a) storage criterion

No Action Alternative – Mock Simulation

Finally CRSS looks at Equalization. It sees that storage is greater than 602(a) and that Lake Powell storage is greater than Lake Mead storage. It increases releases to equalize storage on September 30. This is an even higher priority rule in CRSS.



Lake Mead Capacity



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Operating Policy
Lake Mead – Hoover Dam

- 1928 Boulder Canyon Project Act
  - Provide river regulation, improvement of navigation, and flood control
  - Provide water to meet irrigation and domestic uses
  - Generate hydropower
- 1944 Mexican Water Treaty
- Flood Control Act of 1944 and Working Field Agreement (1984) with the Army Corps of Engineers
- Consolidated Decree
  - Lower Basin Normal, Surplus, Shortage provisions

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Operating Policy
Lake Mead – Hoover Dam

- Two modes of governing annual Lake Mead releases:
- Meet Downstream Demands
  - Downstream demands include:
    - California 4.4 maf
    - Arizona 2.8 maf
    - Nevada 0.3 maf
    - Mexico 1.5 maf
    - Regulation of Lakes Mohave and Havasu
    - System gains and losses
  - Demands can be modified based on Surplus or Shortage
- Flood Control Operations
- Rules decide operating mode for each year of simulation

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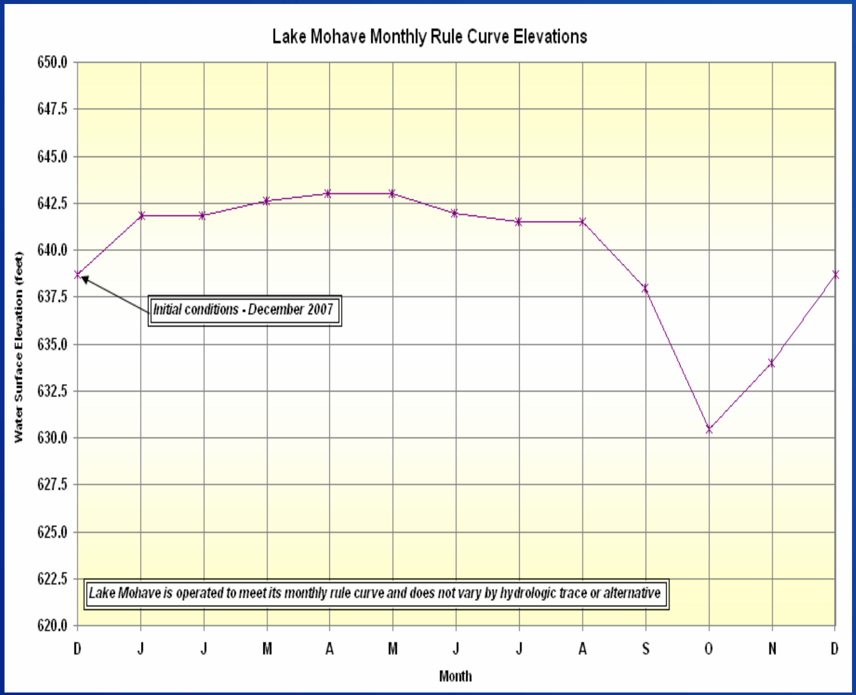
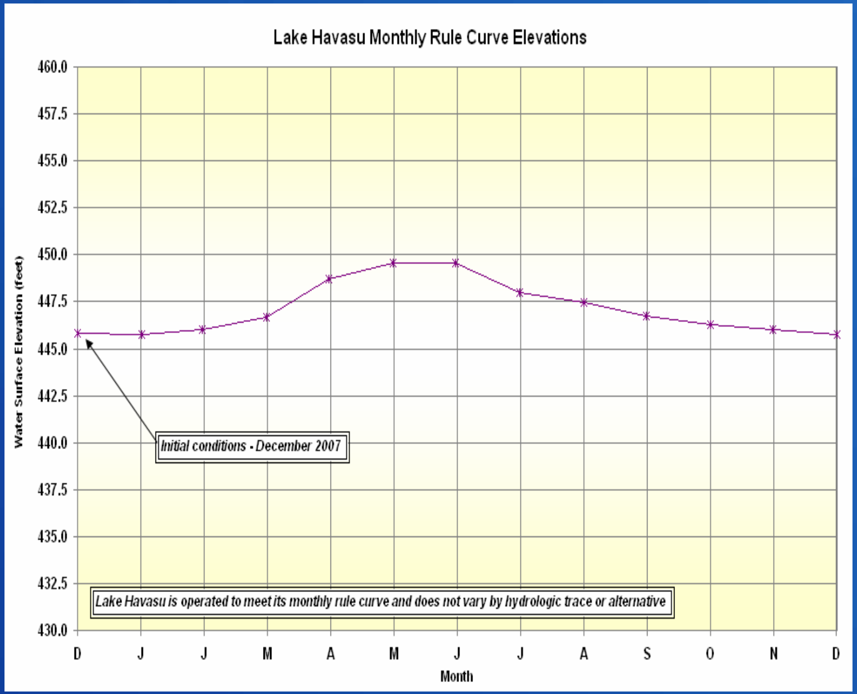
Operating Policy

Lakes Mohave & Havasu Rules





- Both follow fixed rule curves
- Target storage (or elevation) for each month is always met

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CRSS Modeling Assumptions –
Common to All Alternatives

- Configuration
- Input Data
- Operational Policies
- Other Assumptions

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Other Modeling Assumptions Common to All Alternatives

- Southern Nevada Water Project diversions are zero below Lake Mead elevation 1000 ft
- Drop 2 Reservoir
  - Conserves 69 kaf from 2010 to 2060
  - Reduces over-delivery from 77 kaf (30-yr average) to 8 kaf
- Bypass flows to the Cienega de Santa Clara assumed to be 109,000 acre-ft (1990-2005 average)
  - Yuma Desalting Plant assumed not to operate
- Distribution of water reductions in the Lower Basin

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CRSS Modeling Assumptions –
Specific to Each Alternative

- **Coordinated Operations, Shortage and Surplus**
  – No Action Alternative
  – Basin States Alternative
  – Conservation Before Shortage Alternative
  – Water Supply Alternative
  – Reservoir Storage Alternative
- **Storage and Delivery Mechanism**
  – Basin States Alternative
  – Conservation Before Shortage Alternative
  – Reservoir Storage Alternative

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No Action Alternative

Shortage, Surplus and Coordinated Operations

Lake Mead Operation

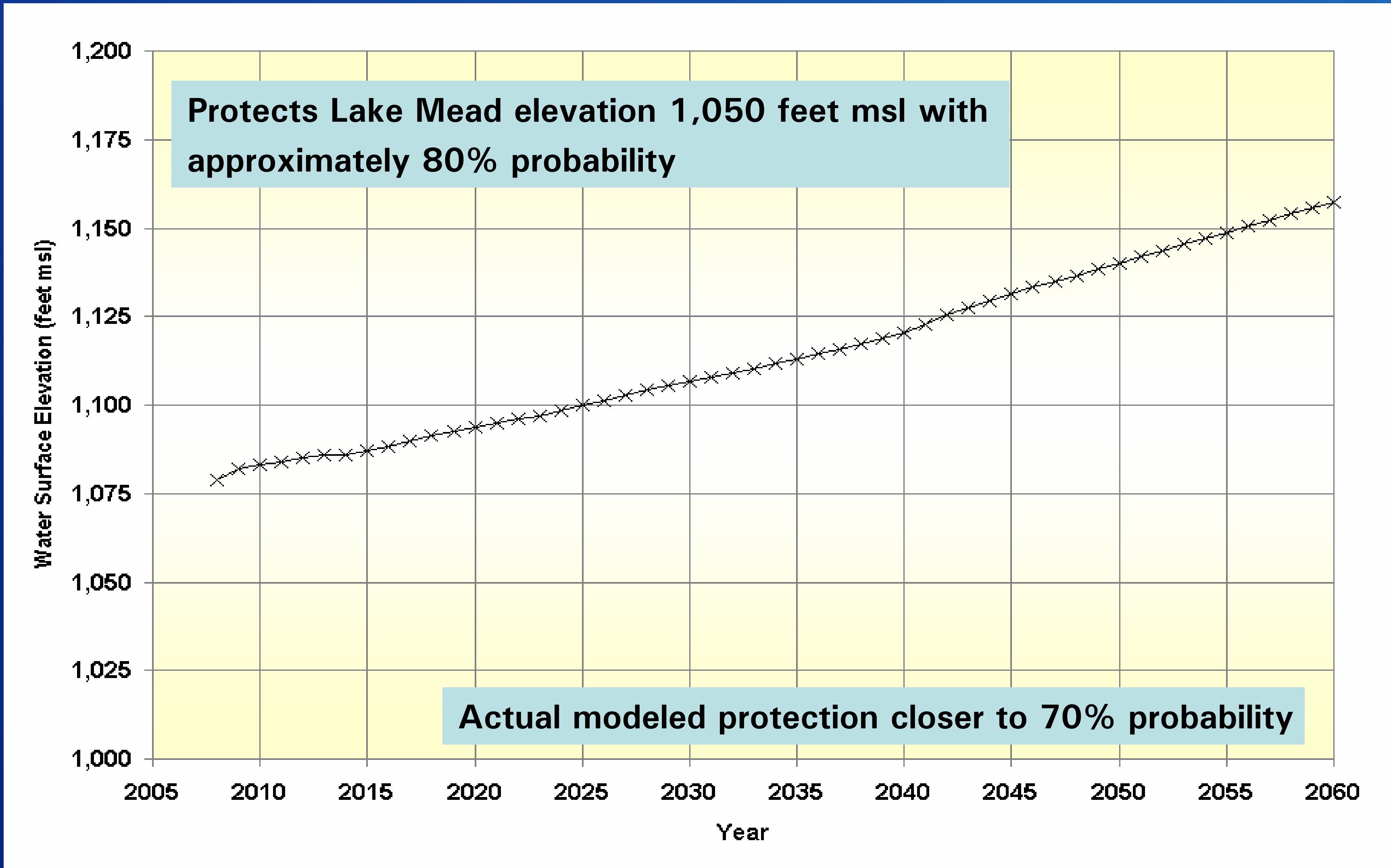
Elevation (ft)	No Action Alternative	Storage (MAF)
1220	Flood Control or 70R Surplus	25.9
1200		22.9
	Full Domestic Surplus (through 2016)	
1145		15.9
	Partial Domestic Surplus (through 2016)	
1125		13.9
	Normal Operations	
1100		11.5
1075	Shortage 80% Protection of elevation 1050'	9.4
1050		7.5
1025		5.8
1000		4.3
	Shortage Absolute Protection of elevation 1000'	
895		0

Lake Powell Operation

Elevation (ft)	No Action Alternative	Storage (MAF)
3700	Equalize or Release 8.23 MAF	24.3
Equalization	602(a)	Equalization
	Release 8.23 MAF	
3595		11.3
3575		9.5
3560		8.3
3525		5.9
3490		4.0
3370		0

No Action Alternative

Lake Mead Level 1 Shortage Trigger Elevations



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Basin States Alternative

Shortage, Surplus and Coordinated Operations

Lake Mead Operation

Elevation (ft)	Basin States Alternative	Storage (MAF)
1220	Flood Control or 70R Surplus	25.9
1200	Full Domestic Surplus	22.9
1145	Normal Operations	15.9
1125		13.9
1100		11.5
1075	Shortage 400 kaf	9.4
1050	Shortage 500 kaf	7.5
1025	Shortage 600 kaf and Reconsultation	5.8
1000		4.3
895		0

Lake Powell Operation

Elevation (ft)	Basin States Alternative	Storage (MAF)
3700	Equalize or Release 8.23 MAF	24.3
Equalization	Upper Equalization Line	Equalization
	Release 8.23 MAF; if Mead < 1075', balance contents with a min/max release of 7.0 and 9.0 MAF	
3595		11.3
3575	Release 7.48 MAF; if Lake Mead < 1025', release 8.23 MAF	9.5
3560		8.3
3525	Balance contents with a min/max release of 7.0 and 9.5 MAF	5.9
3490		4.0
3370		0

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Conservation Before Shortage Alternative

Shortage, Surplus and Coordinated Operations

Lake Mead Operation

Elevation (ft)	Conservation Before Shortage Alternative	Storage (MAF)
1220	Flood Control or 70R Surplus	25.9
1200		22.9
	Full Domestic Surplus	
1145		15.9
	Normal Operations	
1125		13.9
1100		11.5
1075		9.4
	Voluntary Conservation	
1050		7.5
1025		5.8
1000		4.3
	Shortage Absolute Protection of elevation 1000'	
895		0

Lake Powell Operation

Elevation (ft)	Conservation Before Shortage Alternative	Storage (MAF)
3700	Equalize or Release 8.23 MAF	24.3
Equalization	Upper Equalization Line	Equalization
	Release 8.23 MAF; if Mead < 1075', balance contents with a min/max release of 7.0 and 9.0 MAF	
3595		11.3
3575		9.5
	Release 7.48 MAF; if Lake Mead < 1025', release 8.23 MAF	
3560		8.3
3525		5.9
	Balance contents with a min/max release of 7.0 and 9.5 MAF	
3490		4.0
3370		0

RECLAMATION

Water Supply Alternative

Shortage, Surplus and Coordinated Operations

Lake Mead Operation

Elevation (ft)	Water Supply Alternative	Storage (MAF)
1220	Flood Control or 70R Surplus	25.9
1200		22.9
	Full Domestic Surplus	
1145		15.9
	Partial Domestic Surplus	
1125		13.9
	Normal Operations	
1100		11.5
1075		9.4
1050		7.5
1025		5.8
1000		4.3
895		0

Lake Powell Operation

Elevation (ft)	Water Supply Alternative	Storage (MAF)
3700	Equalize or Release 8.23 MAF	24.3
Equalization	602(a)	Equalization
	Release 8.23 MAF; if Mead < 1075', balance contents with a min/max release of 7.0 and 9.5 MAF	
3595		11.3
3575		9.5
	Balance contents with a min/max release of 7.0 and 9.5 MAF	
3560		8.3
3525		5.9
3490		4.0
3370		0

RECLAMATION

Reservoir Storage Alternative

Shortage, Surplus and Coordinated Operations

Lake Mead Operation

Elevation (ft)	Reservoir Storage Alternative	Storage (MAF)
1220		25.9
	Flood Control or 70R Surplus	
1200		22.9
	Normal Operations	
1145		15.9
1125		13.9
1100		11.5
	Shortage 600 kaf	
1075		9.4
	Shortage 800 kaf	
1050		7.5
	Shortage 1000 kaf	
1025		5.8
	Shortage 1200 kaf	
1000		4.3
895		0

Lake Powell Operation

Elevation (ft)	Reservoir Storage Alternative	Storage (MAF)
3700		24.3
	Equalize or Release 8.23 MAF	
Equalization	602(a)	Equalization
	Release 8.23 MAF	
3595		11.3
	Release 7.8 MAF	
3575		9.5
3560		8.3
	Balance contents with a min/max release of 7.8 and 9.5 MAF	
3525		5.9
3490		4.0
3370		0

RECLAMATION

Lake Mead Operational Diagram

Elevation (ft)	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative	Storage (maf)
1220	Flood Control or 70R Surplus	Flood Control or 70R Surplus	Flood Control or 70R Surplus	Flood Control or 70R Surplus	Flood Control or 70R Surplus	25.9
1200	Full Domestic Surplus (through 2016)	Full Domestic Surplus	Full Domestic Surplus	Full Domestic Surplus	Normal Operations	22.9
1145	Partial Domestic Surplus (through 2016)	Normal Operations	Normal Operations	Partial Domestic Surplus		15.9
1125	Normal Operations			Normal Operations		13.9
1100					Shortage 600 kaf	11.5
1075	Shortage 80% Protection of elevation 1050'	Shortage 400 kaf	Voluntary Conservation		Shortage 800 kaf	9.4
1050		Shortage 500 kaf			Shortage 1000 kaf	7.5
1025		Shortage 600 kaf and Reconsultation			Shortage 1200 kaf	5.8
1000	Shortage Absolute Protection of elevation 1000'		Shortage Absolute Protection of elevation 1000'			4.3
895	Dead Storage	Dead Storage	Dead Storage	Dead Storage	Dead Storage	0

RECLAMATION

Lake Powell Operational Diagram

Elevation (ft)	No Action Alternative	Basin States Alternative	Conservation Before Shortage Alternative	Water Supply Alternative	Reservoir Storage Alternative	Storage (maf)
3700	Equalize or Release 8.23 MAF	Equalize or Release 8.23 MAF	Equalize or Release 8.23 MAF	Equalize or Release 8.23 MAF	Equalize or Release 8.23 MAF	24.3
Equalization	602(a)	Upper Equalization Line	Upper Equalization Line	602(a)	602(a)	Equalization
	Release 8.23 MAF	Release 8.23 MAF; if Mead < 1075', balance contents with a min/max release of 7.0 and 9.0 MAF	Release 8.23 MAF; if Mead < 1075', balance contents with a min/max release of 7.0 and 9.0 MAF	Release 8.23 MAF; if Mead < 1075', balance contents with a min/max release of 7.0 and 9.5 MAF	Release 8.23 MAF	
3595						11.3
					Release 7.8 MAF	
3575						9.5
		Release 7.48 MAF; if Lake Mead < 1025', release 8.23 MAF	Release 7.48 MAF; if Lake Mead < 1025', release 8.23 MAF	Balance contents with a min/max release of 7.0 and 9.5 MAF		
3560						8.3
					Balance contents with a min/max release of 7.8 and 9.5 MAF	
3525						5.9
		Balance contents with a min/max release of 7.0 and 9.5 MAF	Balance contents with a min/max release of 7.0 and 9.5 MAF			
3490						4.0
3370	Dead Storage	Dead Storage	Dead Storage	Dead Storage	Dead Storage	0

CRSS Modeling Assumptions –
Specific to All Alternatives

- **Coordinated Operations, Shortage and Surplus**
  - No Action Alternative
  - Basin States Alternative
  - Conservation Before Shortage Alternative
  - Water Supply Alternative
  - Reservoir Storage Alternative
- **Storage and Delivery Mechanism**
  - Basin States Alternative
  - Conservation Before Shortage Alternative
  - Reservoir Storage Alternative

RECLAMATION

Basin States Alternative

Storage and Delivery Mechanism

Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Total	**625**	**2,100**	**1,000**

RECLAMATION

Conservation Before Shortage Alternative

Storage and Delivery Mechanism

Volume Limitations of Storage and Delivery Mechanism

Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Unassigned	825	2,100	600
Total	**1,450**	**4,200**	**1,600**

RECLAMATION

Reservoir Storage Alternative

Storage and Delivery Mechanism

Volume Limitations of Storage and Delivery Mechanism			
Entity	Maximum Annual Storage of Conserved System or Non-system Water (kaf)	Maximum Total Storage of Conserved System or Non-system Water (kaf)	Maximum Annual Delivery of Conserved System or Non-system Water (kaf)
Arizona	100	300	300
California	400	1,500	400
Nevada	125	300	300
Unassigned	475	950	950
Total	**1,100**	**3,050**	**1,950**

RECLAMATION

BREAK 10:30 – 10:45

Project website:
http://www.usbr.gov/lc/region/programs/strategies.html

RECLAMATION

CRSS Output and Results

- Modeling Hydrologic Variability and Uncertainty
- Key Model Output and Statistics

RECLAMATION

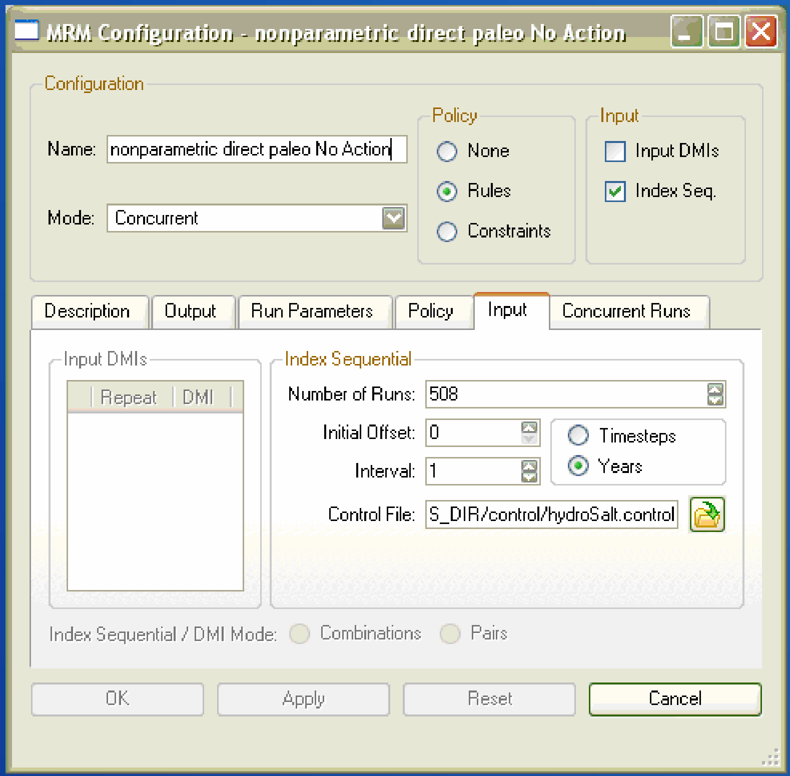
Modeling Hydrologic Variability

- Quantify uncertainty due to future streamflows
- Possible future streamflows generated from historic flow available from 1906-2004
- Probabilistic based model results

RECLAMATION

Index Sequential Method (ISM)
Stochastic Technique

- Sequentially resamples blocks of flow data
- Can only produce
  - Observed flow magnitudes
  - Observed flow sequences
- Easily generates data for multi-site model
- Easily preserves observed data statistics



RECLAMATION

Index Sequential Method

Observed Record

1906
1907
1908
…
1957
1958
1959
…
2003
2004
1906
1907
…
1956
1957

Trace 1

1906
1907
1908
…
1957
1958

Trace 2

1907
1908
…
1957
1958
1959

• • •

Trace 99

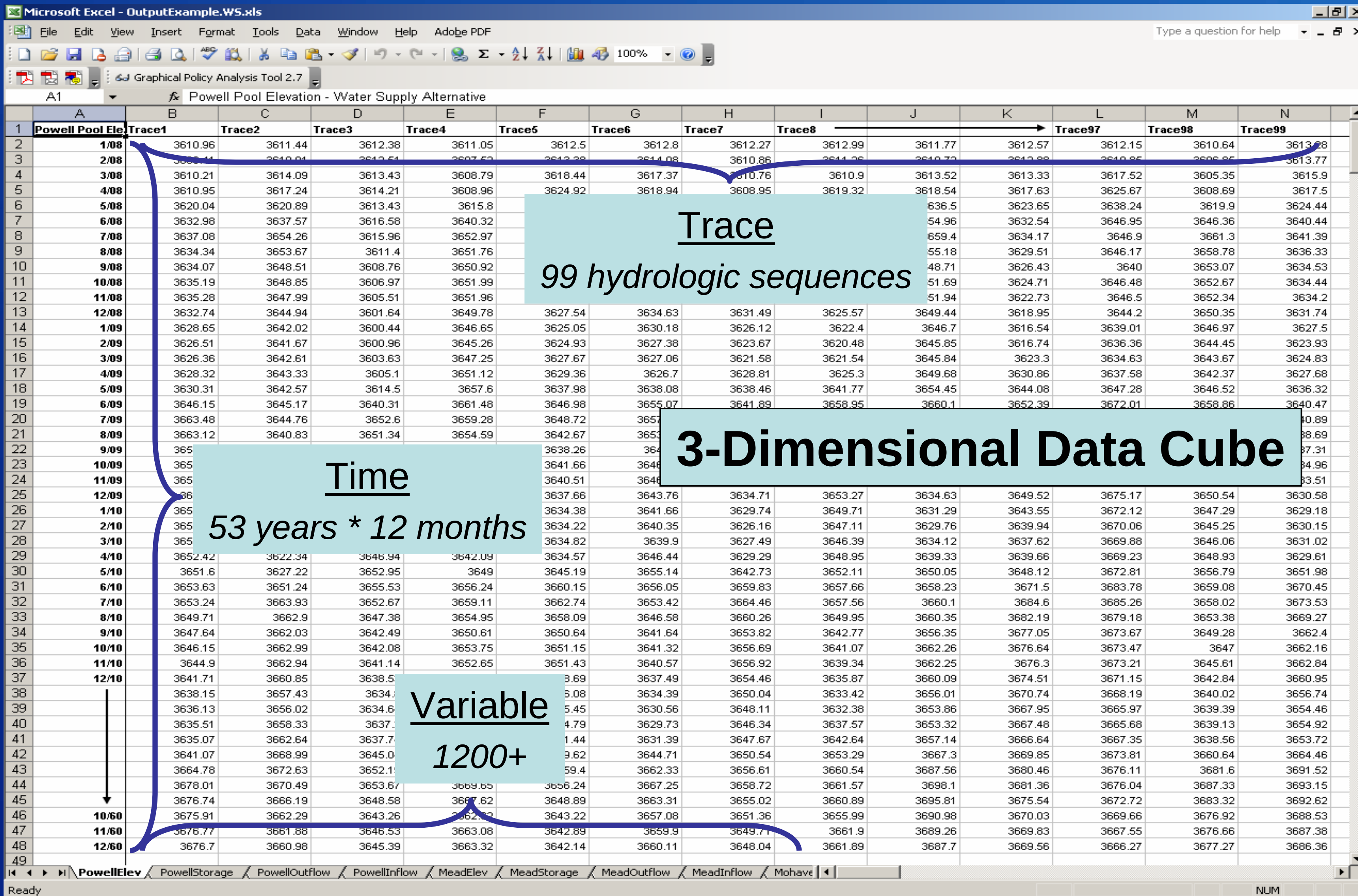
2004
1906
1907
…
1956
1957

Modeled Year

2008
2009
2010
…
2059
2060

RECLAMATION

Output Resulting from ISM



RECLAMATION

CRSS Output and Results

- Modeling Hydrologic Variability and Uncertainty
- Key Model Output and Statistics

RECLAMATION

Model Output & Post-Processing

- 3-Dimensional Data Cube for each alternative
- All traces (99 possibilities) are studied to project the probabilities of future events
  - e.g., for variable of interest, fix time and compute statistic
- Single traces are also analyzed to examine specific behavior under one inflow sequence
- Graphical Policy Analysis Tool (GPAT)
  - An Excel-based tool used to facilitate statistical comparison of alternatives and plotting

RECLAMATION

Key Model Output & Statistics

- Key Model Output
  - Reservoir Elevations, Storages and Releases
  - Deliveries to Major Water Users
  - Shortage and Surplus
    - Frequency and magnitude
  - River Flows
- Standard Statistical Techniques
  - Percentile Values
  - Probability of Occurrence
  - Cumulative Distribution (Duration Curve)
  - Minimum, Maximum and Average Values

RECLAMATION

Percentile Values

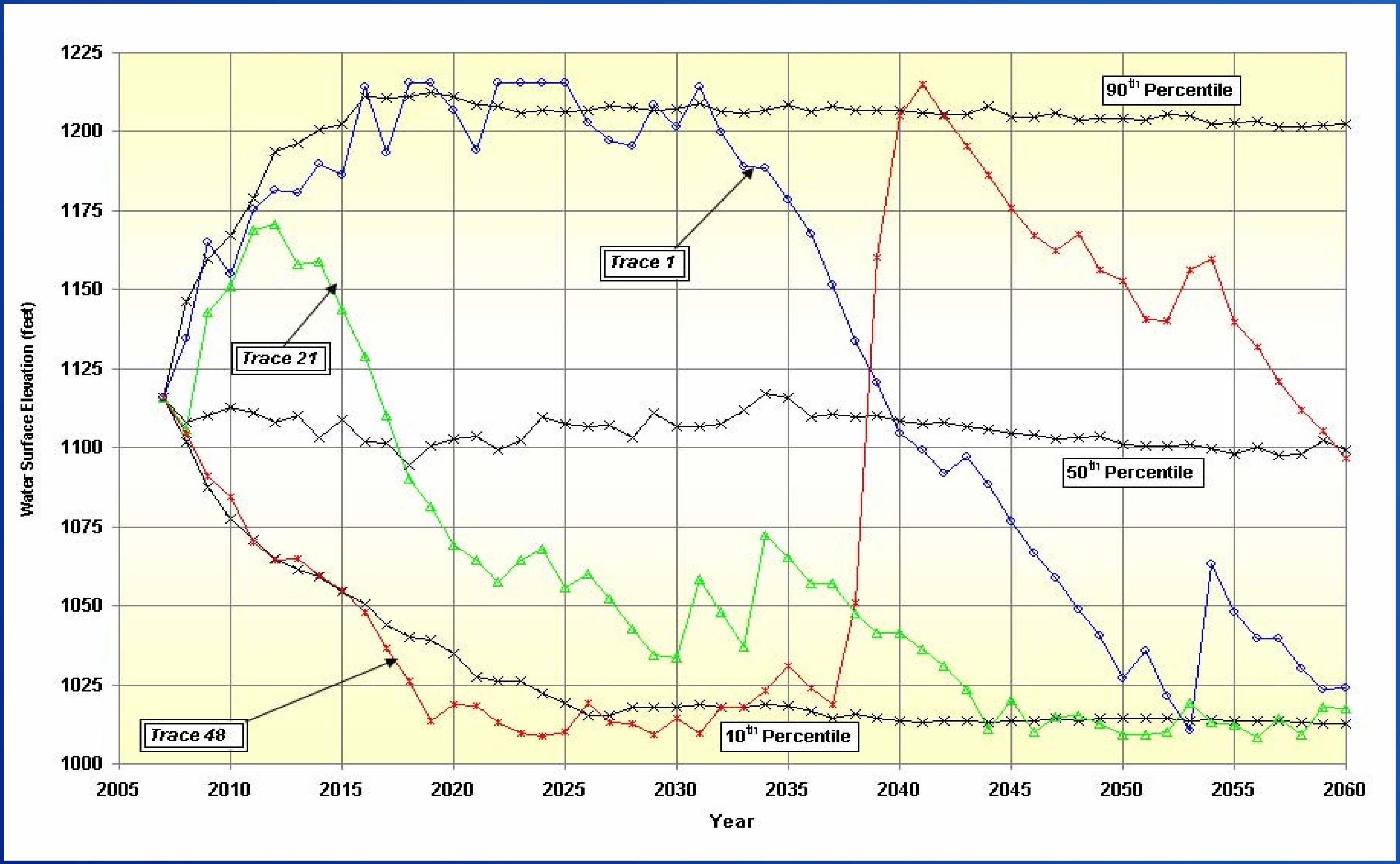
- View results of all traces in compact manner
  - Preserves high and low values that would be lost by averaging
- Represents ranking of results for a given year for all 99 traces modeled
- Computing percentile is not conditional on previous years
- For any year *n* at the x^{th} percentile:
  - In year n, there is an x percent chance of being at or below a value.
  - Example: “In 2015, there is a 10 percent chance of Lake Mead being at or below 1055 feet.”
- Used to compare reservoir elevations and releases, Lower Basin deliveries and river flows

RECLAMATION

Lake Mead End of December Elevations

No Action Alternative

10th, 50th and 90th Percentile Values



For any year *n* at the percentile *xth*:

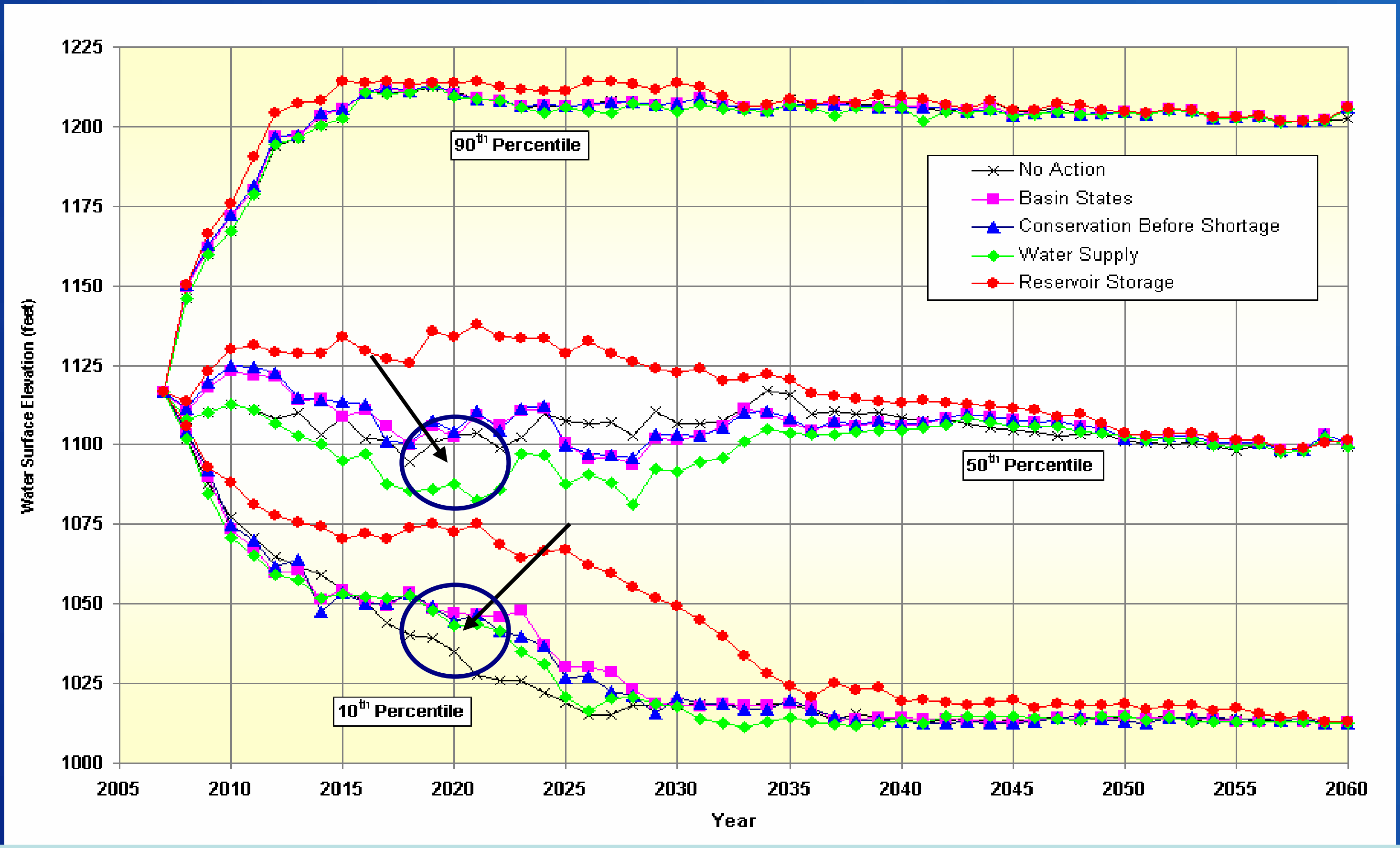
"In year *n*, there is a *x* percent chance that Lake Mead is at or below this elevation."

RECLAMATION

Lake Mead End of December Elevations

No Action and Action Alternatives

10th, 50th and 90th Percentile Values



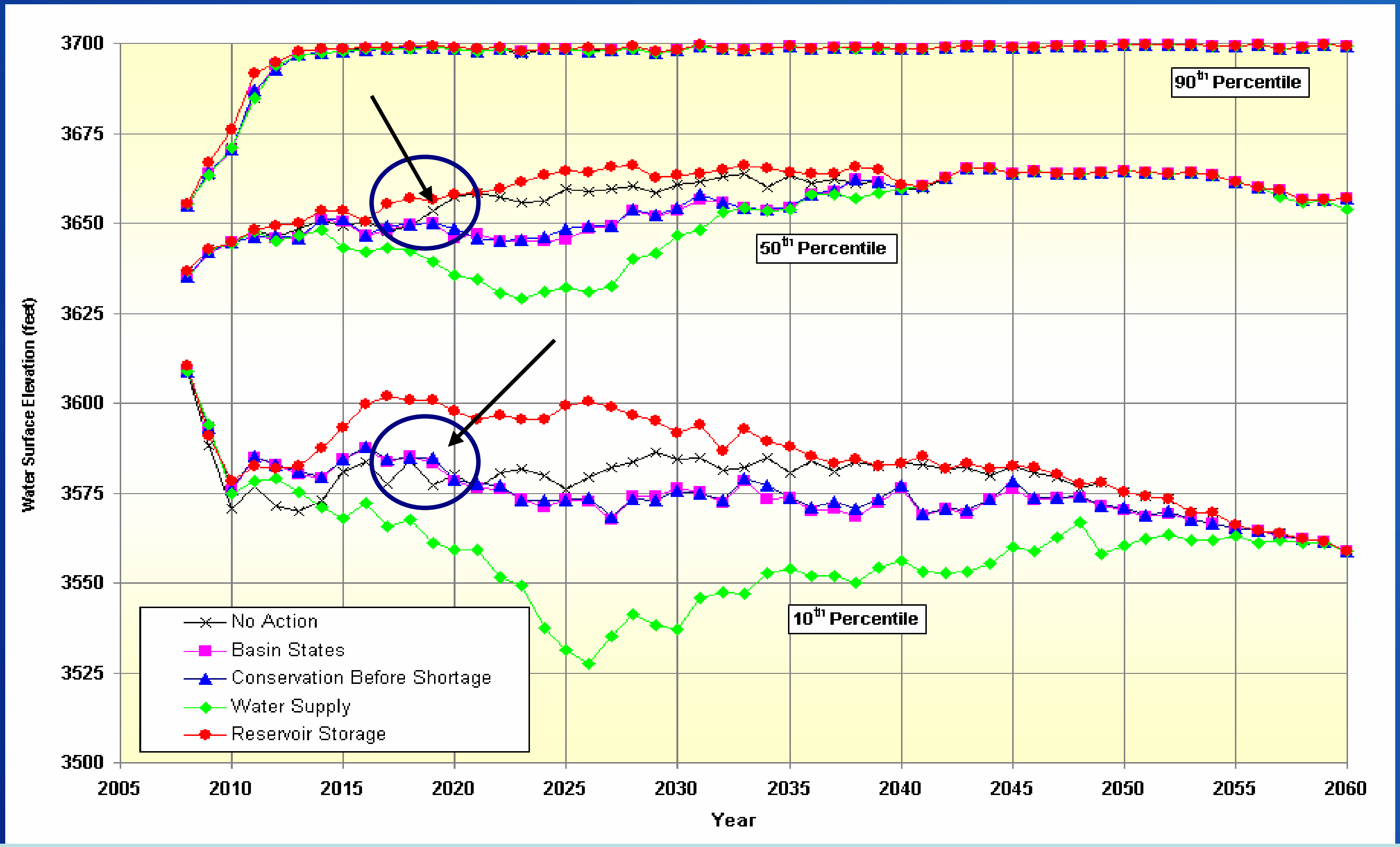
How does the Water Supply Alternative compare to the No Action Alternative in 2020 at the 10th and 50th percentiles?

RECLAMATION

Lake Powell End of July Elevations

No Action and Action Alternatives

10th, 50th and 90th Percentile Values



How do the Basin States and Conservation Before Shortage alternatives compare to the No Action Alternative in 2019?

RECLAMATION

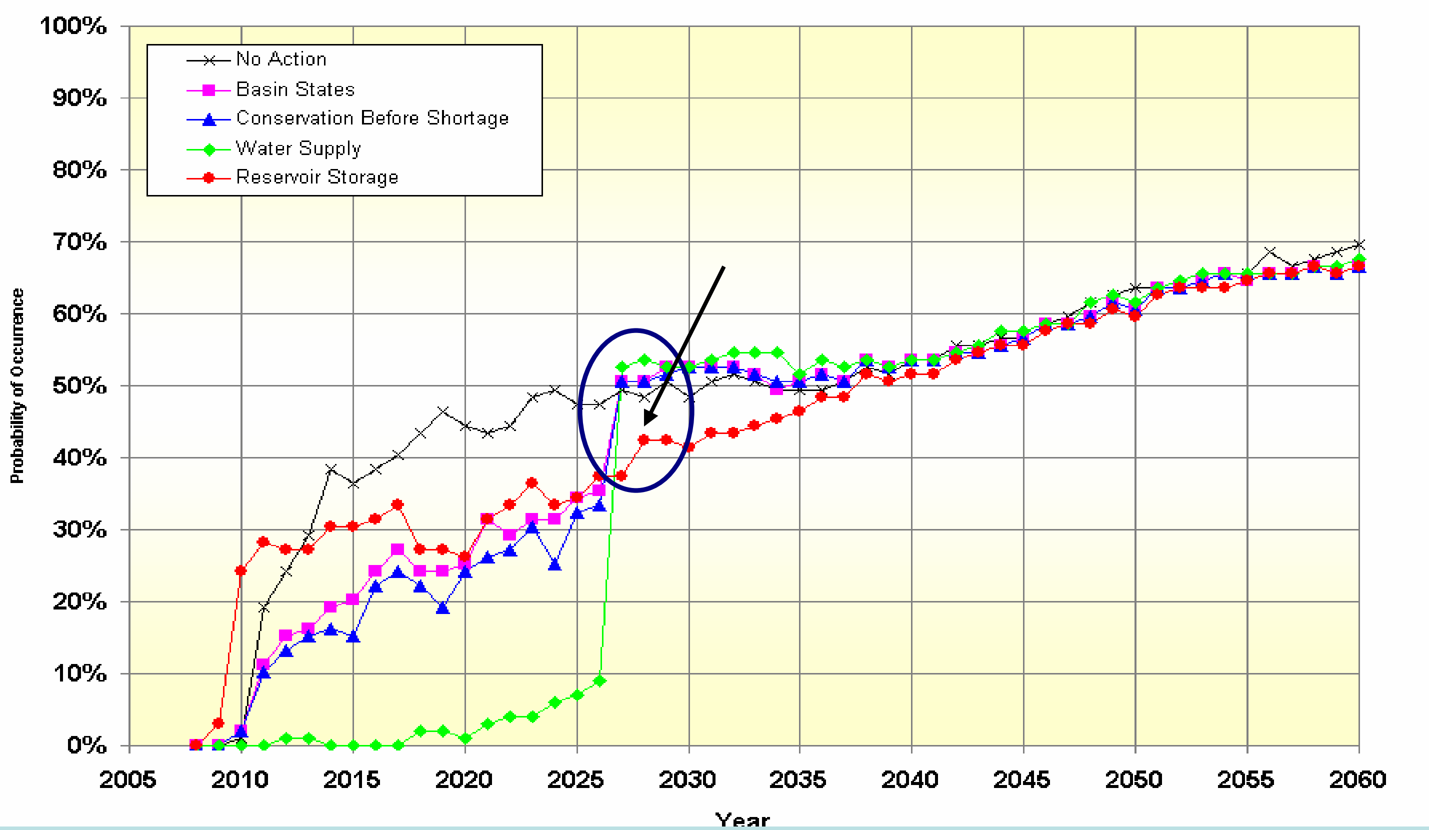
Probability of Occurrence

- Quantifies the likelihood of an event occurring in a given year
- Computed as the number of occurrences divided by the total possible outcomes
- For any year *n* for event *x*:
  - What is the probability of event x occurring in year n?
  - In what years does event x occur above or below a specific probability?
- Used to compare reservoir elevations, releases and voluntary and involuntary shortage

Involuntary & Voluntary Lower Basin Shortage

No Action and Action Alternatives

Probability of Occurrence of Any Amount



How does the probability of voluntary and involuntary shortage in 2027 under the Reservoir Storage Alternative compare to the probability under the other alternatives?

RECLAMATION

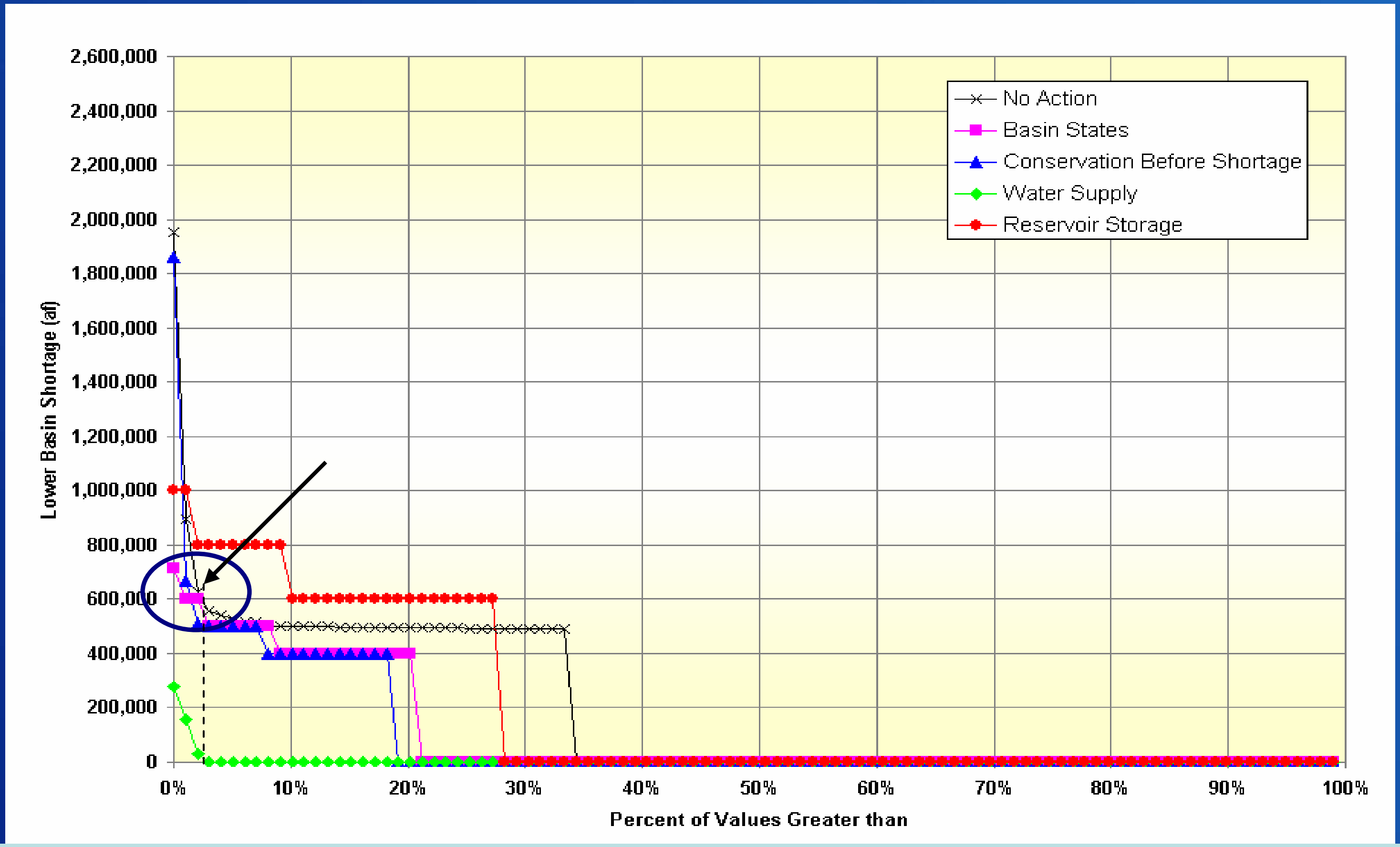
Cumulative Distribution
(Duration Curve)

- Quantifies the probability that a value will be exceeded over a specified time period
  - Describes frequency and magnitude over the time period
- Computed by ranking all values over the time period and dividing by the total number of values
- Time period is either 2008-2026 or 2027-2060
- Can be used to answer the following questions:
  - How often does a given value occur over the time period?
  - What value occurs most frequently over the time period?
  - What is the maximum, minimum or median value over the time period?
- Used to compare reservoir releases, involuntary and voluntary shortages, Lower Basin deliveries and river flows

Involuntary & Voluntary Shortage

No Action and Action Alternatives

Years 2008 – 2026



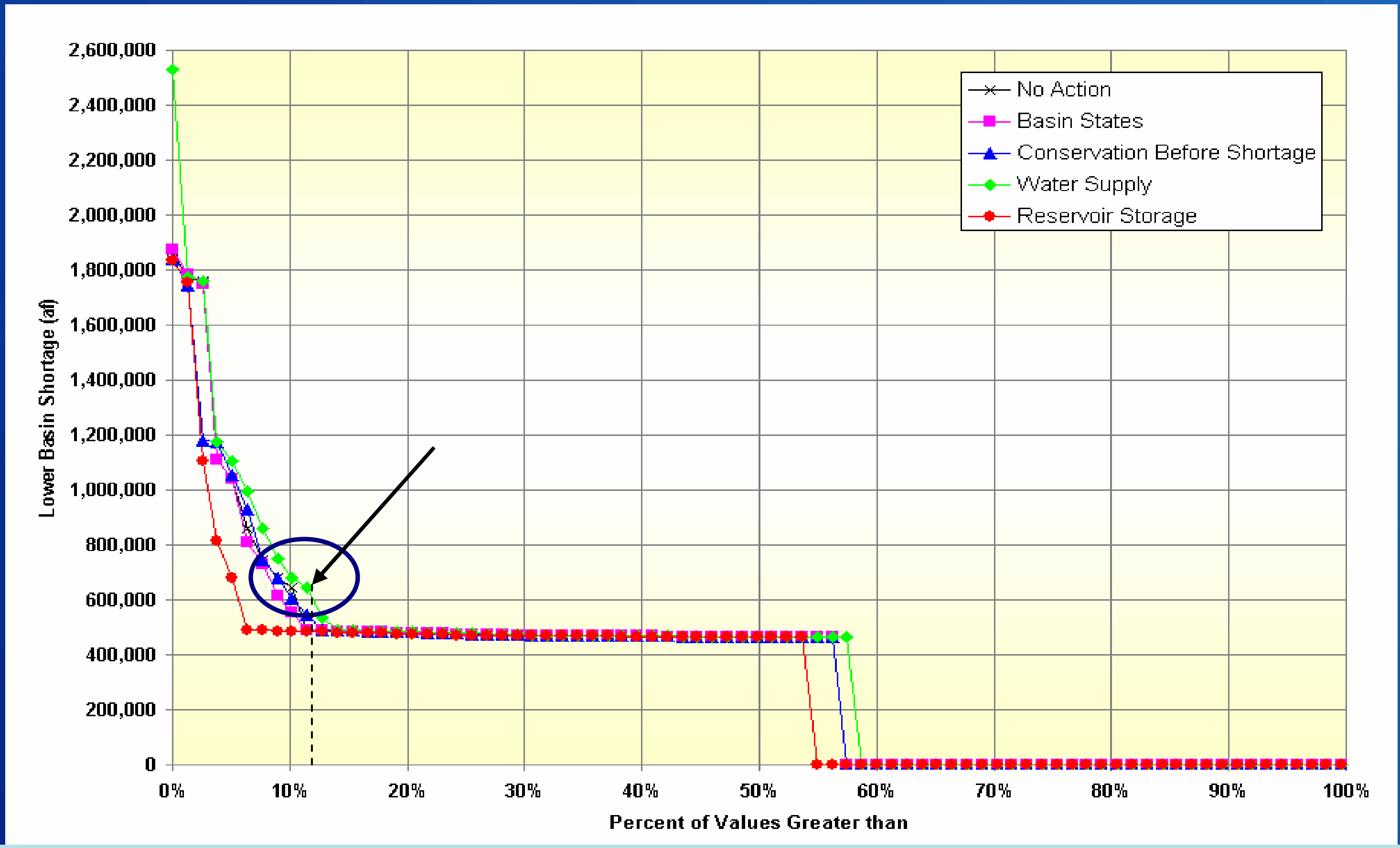
How often does a 600 kaf shortage under the Basin States Alternative occur from 2008 to 2026?

RECLAMATION

Involuntary & Voluntary Shortage

No Action and Action Alternatives

Years 2027 – 2060



How often does a shortage above 600 kaf occur under the Water Supply Alternative from 2027 to 2060?

RECLAMATION

Maximum, Minimum and Average

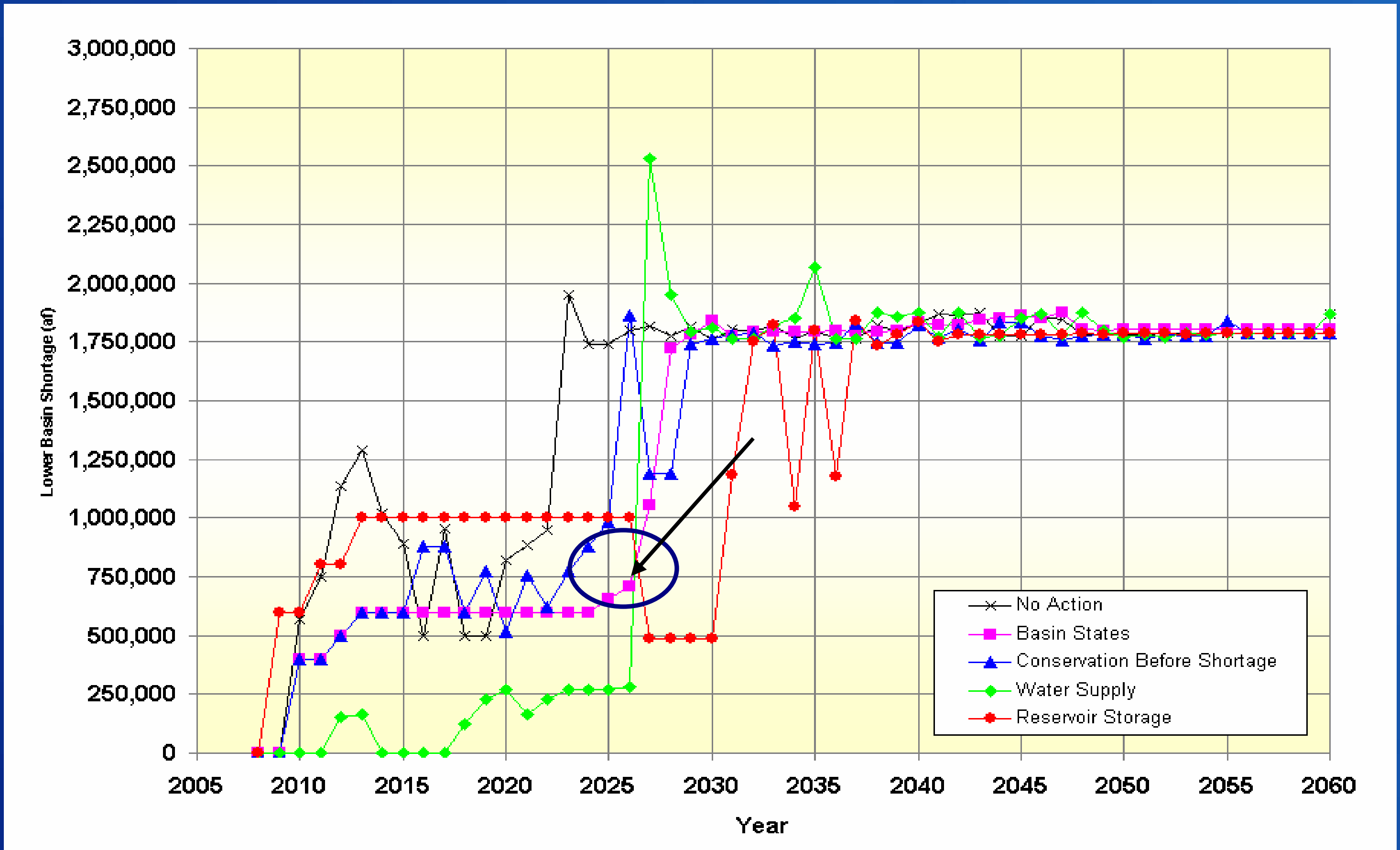
- Represents the maximum, minimum or average of all traces in a given year
- Compute statistic for all values in a given year
- Minimum and maximum values can also be obtained from a cumulative distribution – but, cannot say what year it occurred
- For year *n,* can ask the question:
  - In year n, what is the maximum (minimum or average) value that occurred?
  - In which year does the maximum (minimum) value for all years occur?
- Used to compare reservoir releases, energy production and involuntary and voluntary shortages.

RECLAMATION

Involuntary & Voluntary Shortage

No Action and Action Alternatives

Maximum Amounts



In which year, during the interim period, does the maximum shortage under the Basin States Alternative occur?

RECLAMATION

Shortage Allocation Model Assumptions & Output

Modeling Workshop
Henderson, Nevada
March 6, 2007

RECLAMATION

Shortage Allocation Model

- Purpose
- Framework
- Key Modeling Assumptions
- Example Shortages
- Model Output & Results

RECLAMATION

Purpose

- The Shortage Allocation Model simulates the distribution of water delivery reductions to Lower Basin entitlement holders using specific modeling assumptions.
- The Shortage Allocation Model is primarily used to distribute shortage to Arizona and CAP entitlement holders.
- The Shortage Allocation Model provides input for the Socioeconomic analysis in the DEIS.

RECLAMATION

Framework

- Legal guidance in regard to shortage sharing:
  - Colorado River Basin Project Act of 1968: Post-1968 Colorado River contracts in Arizona will be reduced completely before California shares in shortage
  - Consolidated Decree: Present Perfected Rights must be delivered CR water first in order of priority date without regard to state lines
  - Arizona Water Settlement Act: Establishes a framework and order in which shortages are distributed to users within CAP

RECLAMATION

Key Modeling Assumptions

- Two Stages of Shortage
- Stage 1 Shortage
  - A shortage of magnitude that does not reduce Arizona post-1968 contracts completely
  - Total shortage varies from approximately 1.7-1.8 maf (shortage to Arizona of approximately 1.4-1.5 maf)
  - Nevada's consumptive use is reduced 3.33% of the total shortage
  - Mexico's consumptive use is reduced 16.67% of the total shortage
  - Arizona's consumptive use is reduced 80% of the total shortage

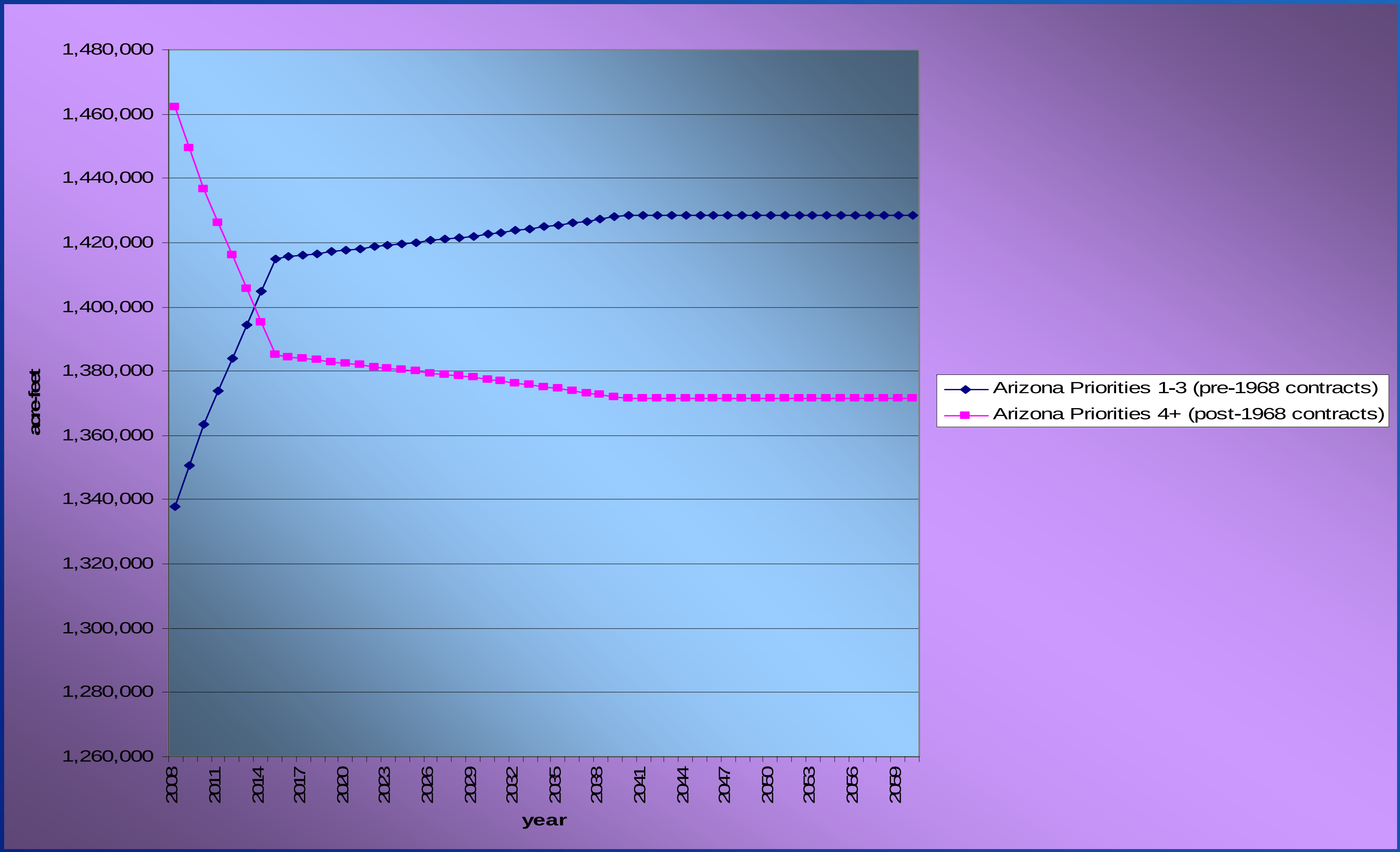
RECLAMATION

Key Modeling Assumptions

- Stage 2 Shortage
  - A shortage of magnitude that does reduce Arizona post-1968 contracts completely
  - A shortage greater than approximately 1.7-1.8 maf (shortages to Arizona greater than approximately 1.4-1.5 maf)
  - Nevada's consumptive use is reduced 3.33% of the additional shortage
  - Mexico's consumptive use is reduced 16.67% of the additional shortage
  - Arizona's consumptive use is reduced approximately 20% of the additional shortage
  - California's consumptive use is reduced approximately 60% of the additional shortage

- CRSS assumes the same distributions

Arizona Scheduled Uses



RECLAMATION

Arizona Modeling Assumptions

- The Shortage Allocation Model uses the quantity of water scheduled in a given year as a basis for reducing deliveries
  - Arizona projected use schedules from 2008-2060 were provided by ADWR
  - State & CAP entitlement holders with multiple priorities are assumed to use their highest (oldest) priority first
- All users within a given priority share in shortage on a pro-rata basis based on their schedules
- For a given shortage an entire priority is reduced completely before the next, more senior, priority is reduced

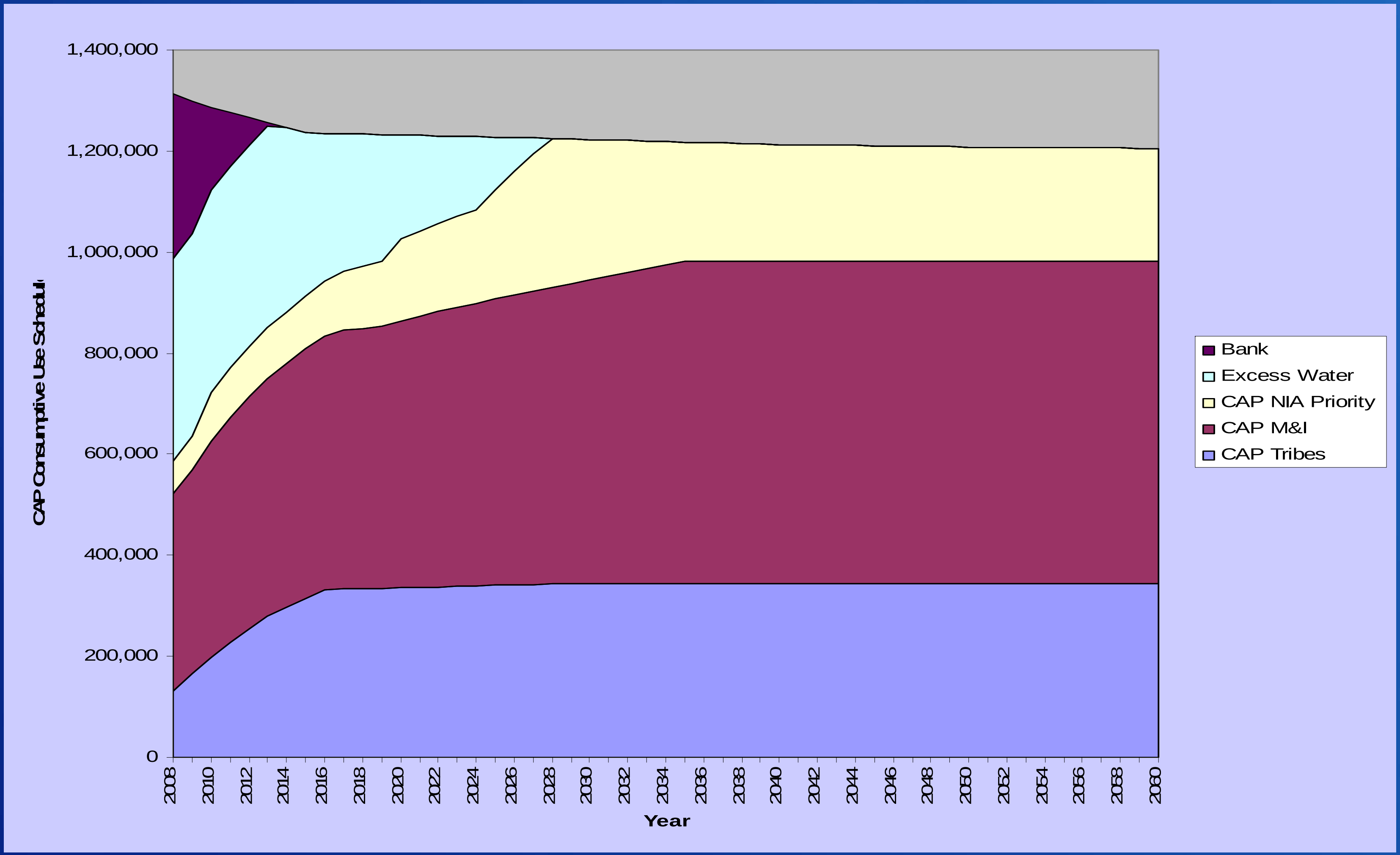
RECLAMATION

Arizona Priorities
(Larger number equals lower priority)

Priority	Date
Arizona Ground Water Bank	CR entitlement to take the balance of unused water in Arizona
5	CR entitlements permitted to take un-used entitlement water in Arizona
4	CR entitlements secured on September 30, 1968 or after
2 & 3	CR entitlements secured between June 25, 1929 and September 30, 1968
1	CR entitlements secured before June 25, 1929

RECLAMATION

CAP Scheduled Uses (after losses)



RECLAMATION

CAP Modeling Assumptions

- Arizona Water Settlement Act
  - Distributes shortages based on available water supply to CAP
  - Shortage Allocation Model uses this information
- Leases between CAP Tribes and cities are not modeled

RECLAMATION

CAP Modeling Assumptions
(Larger number equals lower priority)

<table>
<tr><th colspan="4">CAP PRIORITIES BEFORE 2044 (after losses)</th><th>Total Entitlement by Priority</th></tr>
<tr><td>CAP 5:</td><td colspan="3">Arizona Water Bank: Balance of State's Unused Apportionment</td><td>Balance</td></tr>
<tr><td>CAP 4:</td><td colspan="3">Excess Agriculture: Available CAP Water</td><td>Available</td></tr>
<tr><td>CAP 3:</td><td>M&I: 148,598af</td><td colspan="2">Indian: 216,100af</td><td>364,698</td></tr>
<tr><td rowspan="4">CAP 2:</td><td rowspan="4">M&I: 638,823af</td><td rowspan="4">Indian: 343,079 af</td><td>GRIC & Tohono O'Odham Nation: 32,770af</td><td rowspan="4">981,902</td></tr>
<tr><td>GRIC: 11,305af</td></tr>
<tr><td>San Carlos & Salt River: 7,340af</td></tr>
<tr><td>Indian: 291,574af</td></tr>
<tr><td>CAP 1:</td><td>Salt River Exchange Cities: 20,900af</td><td colspan="2">Ak-Chin: 47,500af</td><td>68,400</td></tr>
<tr><td colspan="4">TOTAL:</td><td>1,415,000</td></tr>
</table>

RECLAMATION

CAP Modeling Assumptions

- Before 2044:
  - If water supply < 981,902 af and > 853,079 af, then Indian Priority receives about 25% of supply plus 93,303 af – M&I receives the difference
  - If water supply < 853,079 af, then Indian Priority receives about 36% of water supply – M&I receives the difference

CAP Modeling Assumptions
(Larger number equals lower priority)

<table>
<tr><th colspan="4">CAP PRIORITIES AFTER 2044 (after losses)</th><th>Total Entitlement by Priority</th></tr>
<tr><td>CAP 5:</td><td colspan="3">Arizona Water Bank: Balance of State's Unused Apportionment</td><td>Balance</td></tr>
<tr><td>CAP 4:</td><td colspan="3">Excess Agriculture: Available CAP Water</td><td>Available</td></tr>
<tr><td>CAP 3:</td><td>M&I: 101,295af</td><td colspan="2">Indian: 216,100af</td><td>317,395</td></tr>
<tr><td rowspan="4">CAP 2:</td><td rowspan="4">M&I: 686,126af</td><td rowspan="4">Indian: 343,079 af</td><td>GRIC & Tohono O'Odham Nation: 32,770af</td><td rowspan="4">1,029,205</td></tr>
<tr><td>GRIC: 11,305af</td></tr>
<tr><td>San Carlos & Salt River: 7,340af</td></tr>
<tr><td>Indian: 291,574af</td></tr>
<tr><td>CAP 1:</td><td>Salt River Exchange Cities: 20,900af</td><td colspan="2">Ak-Chin: 47,500af</td><td>68,400</td></tr>
<tr><td colspan="4">TOTAL:</td><td>1,415,000</td></tr>
</table>

RECLAMATION

CAP Modeling Assumptions

- After 2044:
  - If water supply < 1,029,205 af and > 853,079 af, then Indian Priority receives about 19% of supply plus 151,691 af – M&I receives the difference
  - If water supply < 853,079 af, then Indian Priority receives about 36% of water supply – M&I receives the difference

RECLAMATION

Shortage Example
500 kaf total shortage in 2017

- Stage 1 Shortage
- Mexico: 83.3 kaf or 16.67% of the total shortage
- Nevada: 16.7 kaf or 3.33% of the total shortage
- California: 0%
- Arizona: 400 kaf or 80% of the total shortage
  - Water is not available to the Arizona Ground Water Bank & Fifth Priority
  - 4th Priority users are reduced by 400 kaf (approximately 29% of their consumptive use in 2017)
    - River users are reduced approximately 25 kaf
    - CAP is reduced approximately 375 kaf
    - CAP 4 (Agriculture) is reduced completely and CAP 3 is reduced by about 73%

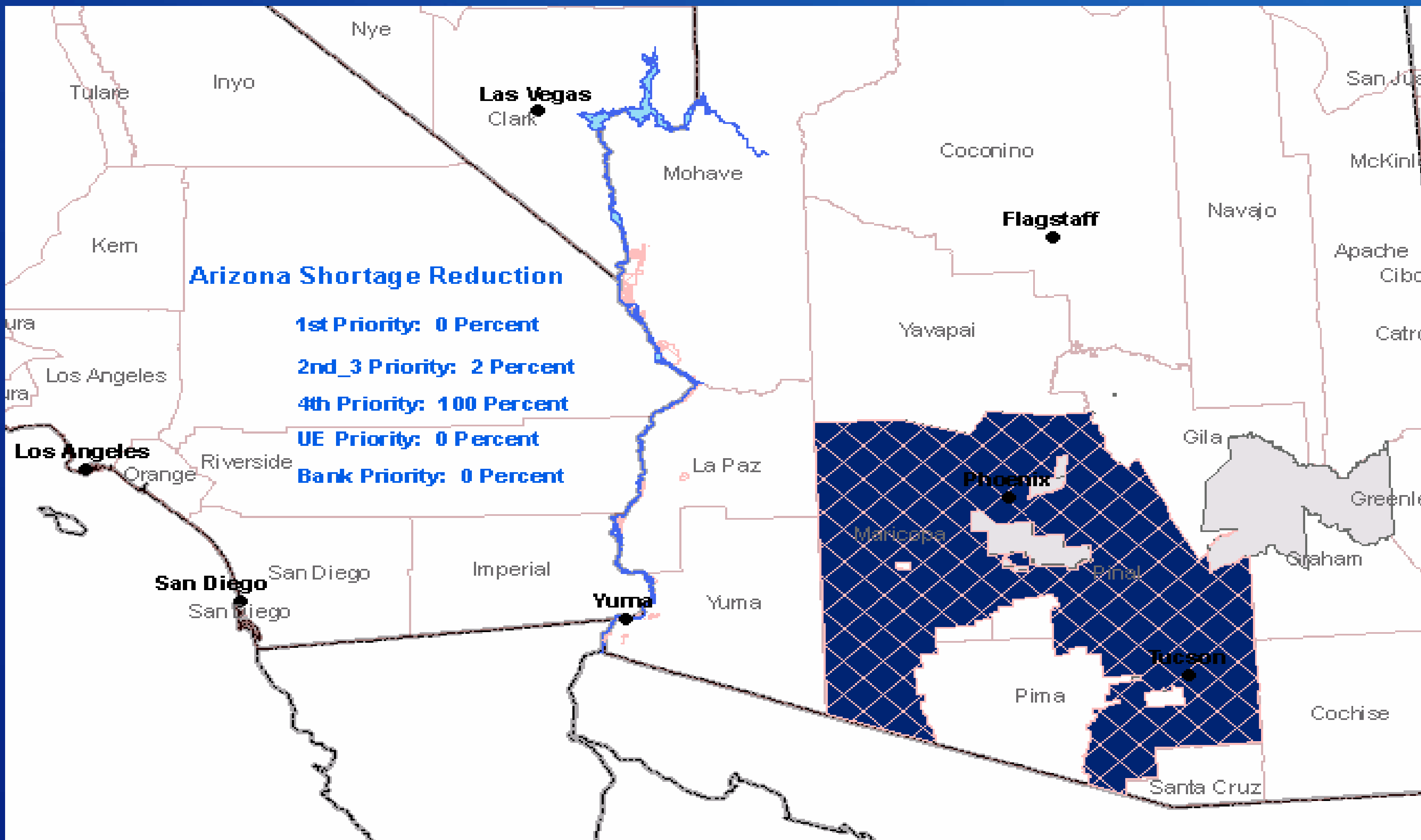
RECLAMATION

Shortage Example
1.8 maf total shortage in 2017

- Stage 1 and 2 Shortage
- Mexico – 300 kaf or 16.67% of the total shortage
- Nevada – 60 kaf or 3.33% of the total shortage
- California – 42.4 kaf or 60.52% of the Stage 2 Shortage
- Arizona – 1,384 kaf of Stage 1 at 80% and 13.6 kaf of Stage 2 at 19.48%
  - Water is not available to the Arizona Ground Water Bank & Fifth Priority
  - 4th Priority & CAP 2, 3, 4 are reduced completely
  - Arizona 2nd & 3rd Priority users (including CAP 1) are reduced 2% of their total consumptive uses

RECLAMATION

Shortage Example
1.8 maf total shortage in 2017



RECLAMATION

Shortages Analyzed

- Shortage Allocation Model is an annual model
- Since schedules change over time, specific years were analyzed
  - 2008, 2017, 2026, 2027, 2040, 2060
- A range of shortage volumes were also analyzed
  - From 200,000 af to 2,500,000 af

RECLAMATION

Model Output & Results

- Summary results in Section 4.4 (Water Deliveries)
- Detailed output in Appendix G
- See handout of Regional Summary Shortages for 2008, 2017, 2026, 2027, 2040, and 2060

RECLAMATION

LUNCH 12:00 – 1:30

Project website:
http://www.usbr.gov/lc/region/programs/strategies.html

RECLAMATION

Afternoon – Session II

Modeling Workshop
Henderson, Nevada
March 6, 2007

RECLAMATION

Session II

1:30 Detailed Modeling Assumptions – Coordinated Operations

1:40 Detailed Modeling Assumptions – Storage and Delivery Mechanism

1:50 Alternate Hydrologic Sequences

2:00 Open Question and Answer Session

3:45 Closing Comments

4:00 Adjourn

RECLAMATION

Detailed Modeling Assumptions – Coordinated Operations

- Basin States & Conservation Before Shortage Alternatives
- Reservoir Storage Alternative
- Water Supply Alternative

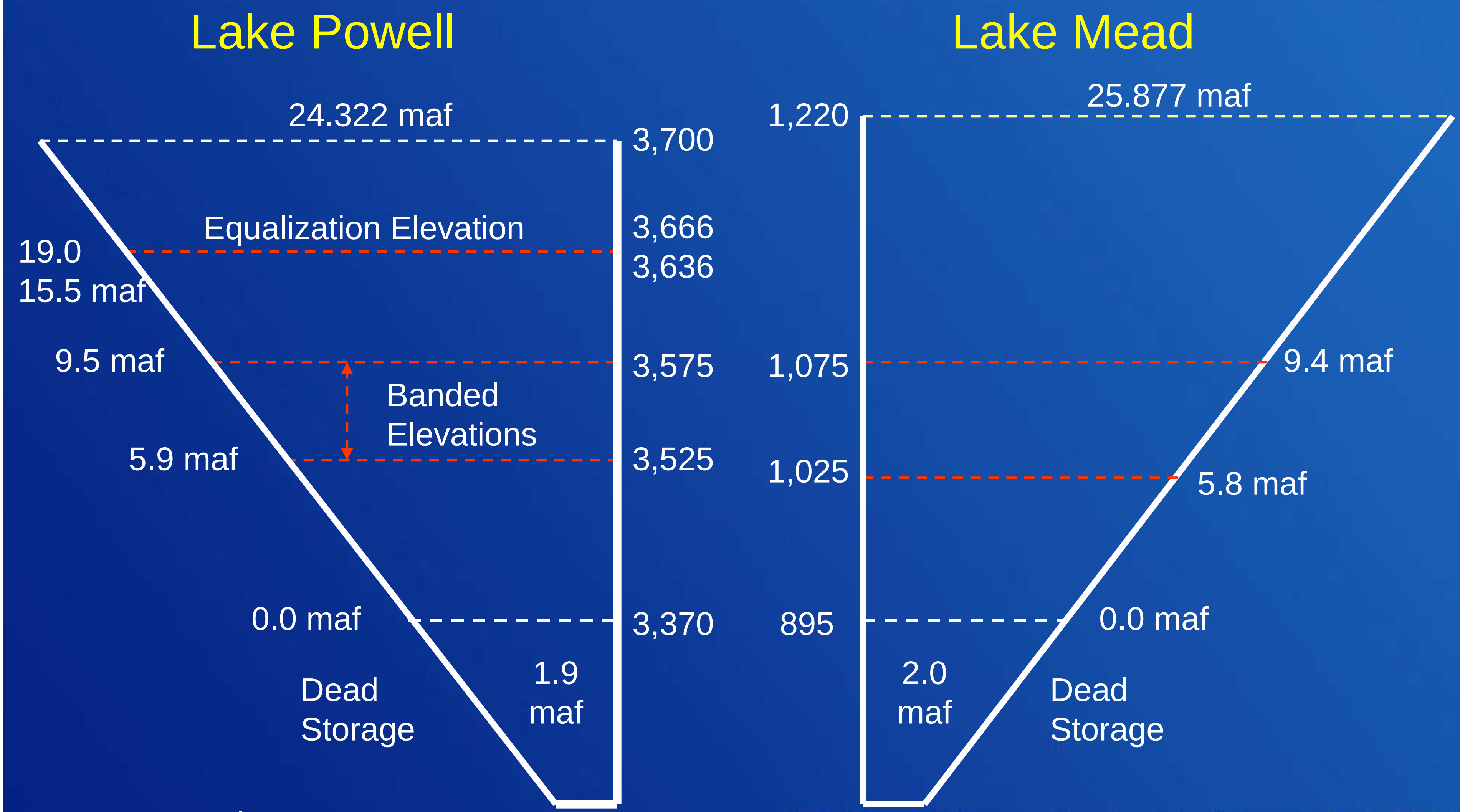
RECLAMATION

Coordinated Operations
Detailed Modeling Assumptions

- Equalization – All Alternatives
  - Occurs when Powell storage is relatively high
  - One directional – increase Powell releases
- Balancing – All Alternatives except No Action
  - Occurs when Powell storage is relatively low
  - Two directional – increase or decrease Powell releases
- Banded elevation ranges at Powell where Powell releases are reduced – Basin States, Conservation Before Shortage and Reservoir Storage Alternatives

Basin States & CBS Alternatives

Coordinated Operations - Trigger Elevations

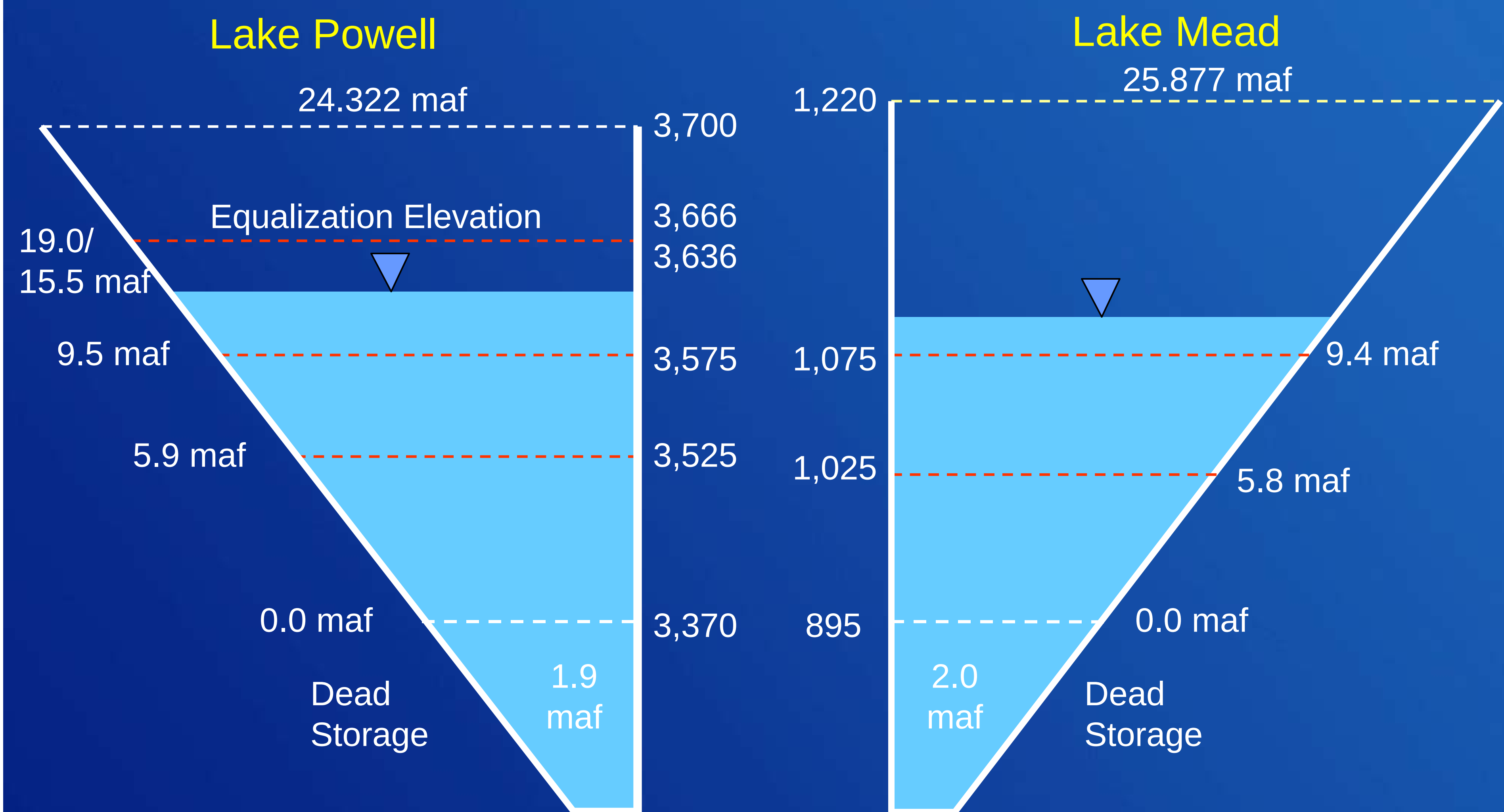


Not to Scale

RECLAMATION

Basin States & CBS Alternatives

If Lake Powell > 3,575 but less than Equalization and Mead > 1,075:
Lake Powell water year release is 8.23 maf

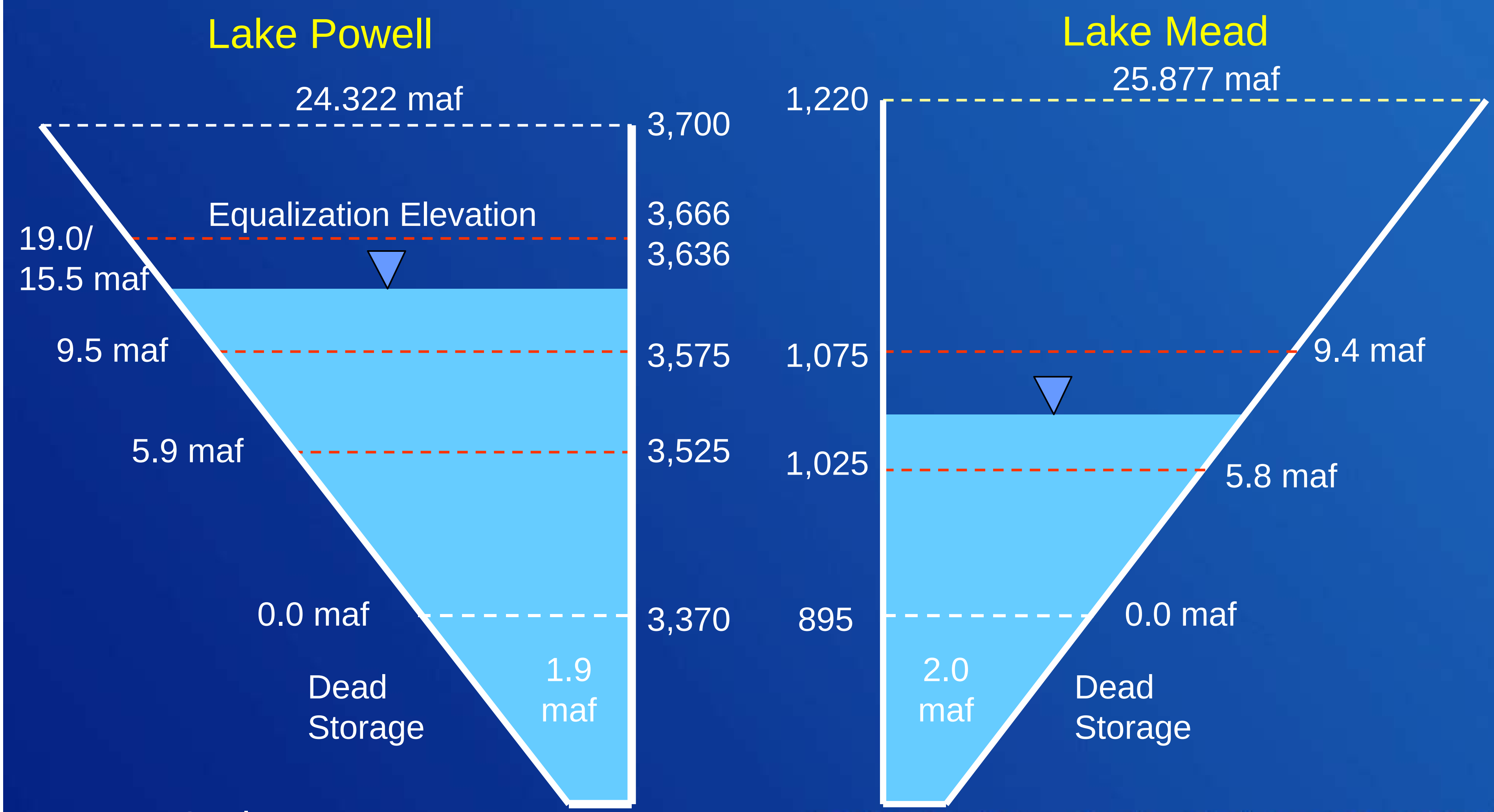


Not to Scale

RECLAMATION

Basin States & CBS Alternatives

If Lake Powell > 3,575 but less than Equalization and Mead < 1,075:
Balance Contents with a min/max release of 7.0 and 9.0 maf
In this configuration water year release from Powell is 9.0 maf

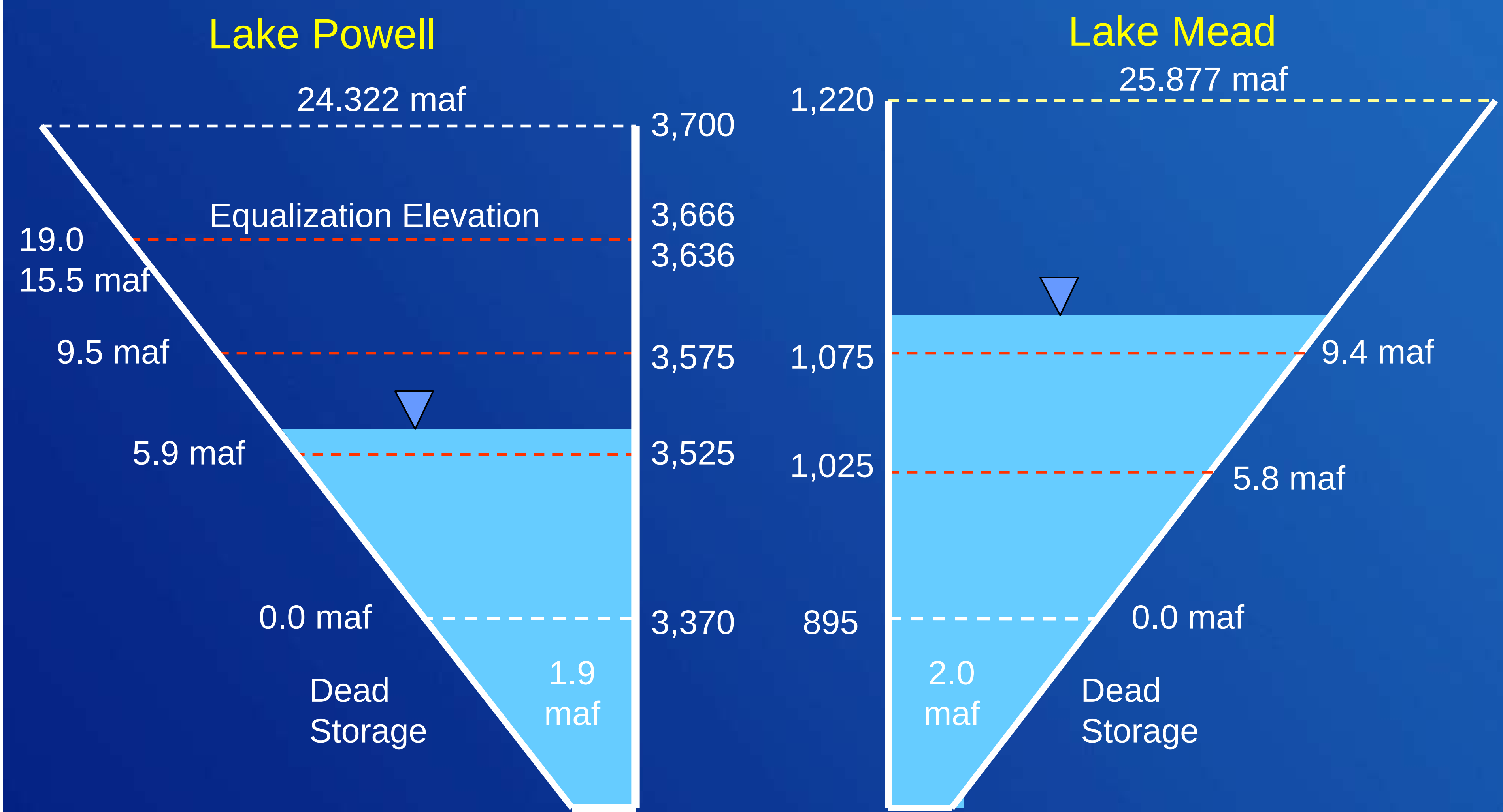


Not to Scale

RECLAMATION

Basin States & CBS Alternatives

If Lake Powell is between 3,525 and 3,575 and Lake Mead is > 1,025:
Lake Powell water year release is 7.48 maf

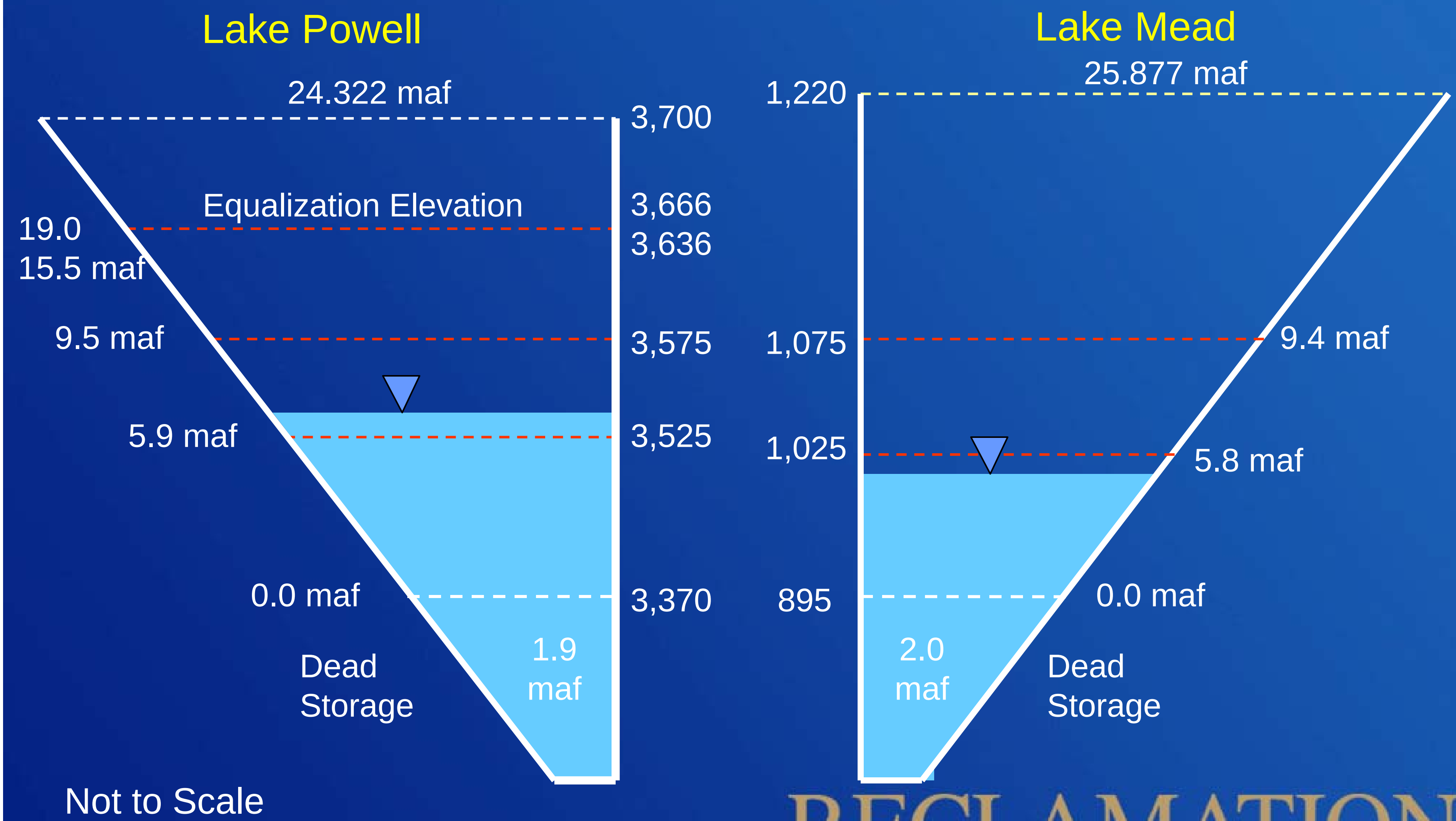


Not to Scale

RECLAMATION

Basin States & CBS Alternatives

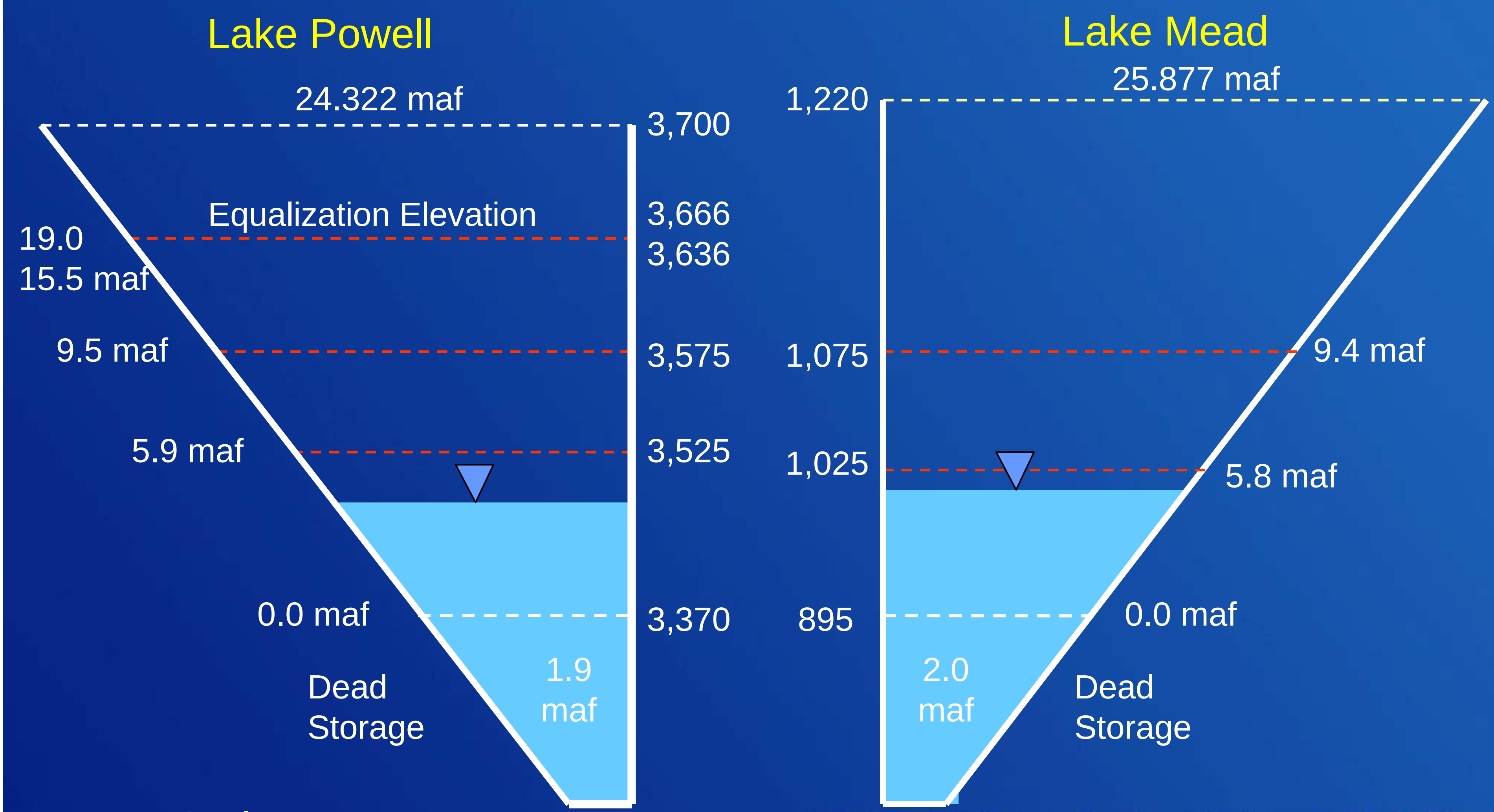
If Lake Powell is between 3,525 and 3,575 and Lake Mead is < 1,025:
Lake Powell water year release is 8.23 maf



RECLAMATION

Basin States & CBS Alternatives

If Lake Powell is below 3,525 feet:
Balance Contents with a min/max release of 7.0 and 9.5 maf from Lake Powell



Not to Scale

RECLAMATION

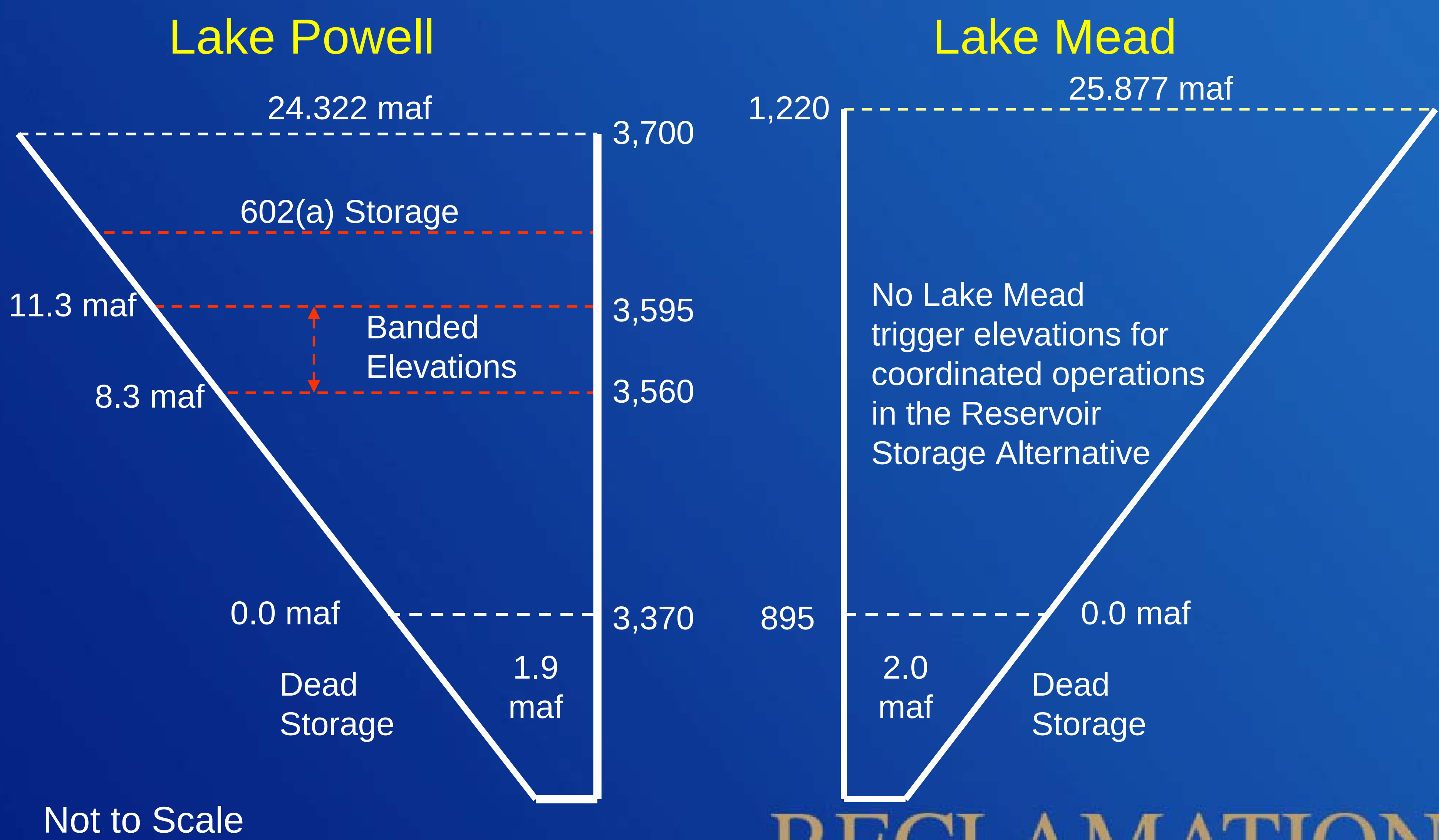
Detailed Modeling Assumptions – Coordinated Operations

- Basin States & Conservation Before Shortage Alternatives
- Reservoir Storage Alternative
- Water Supply Alternative

RECLAMATION

Reservoir Storage Alternative

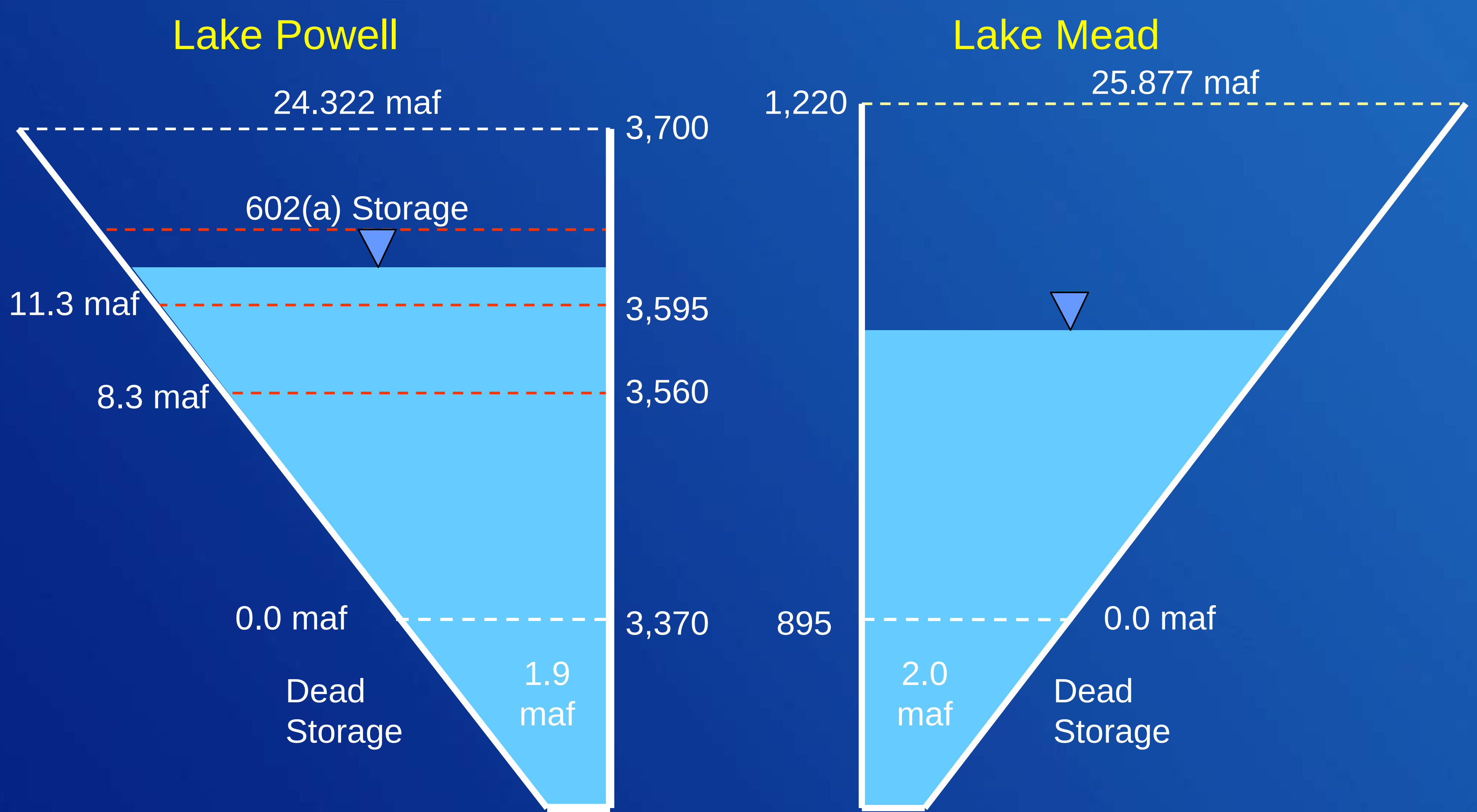
Coordinated Operations - Trigger Elevations



RECLAMATION

Reservoir Storage Alternative

If Lake Powell is below 602(a) and above 3,595:
Lake Powell water year release is 8.23 maf

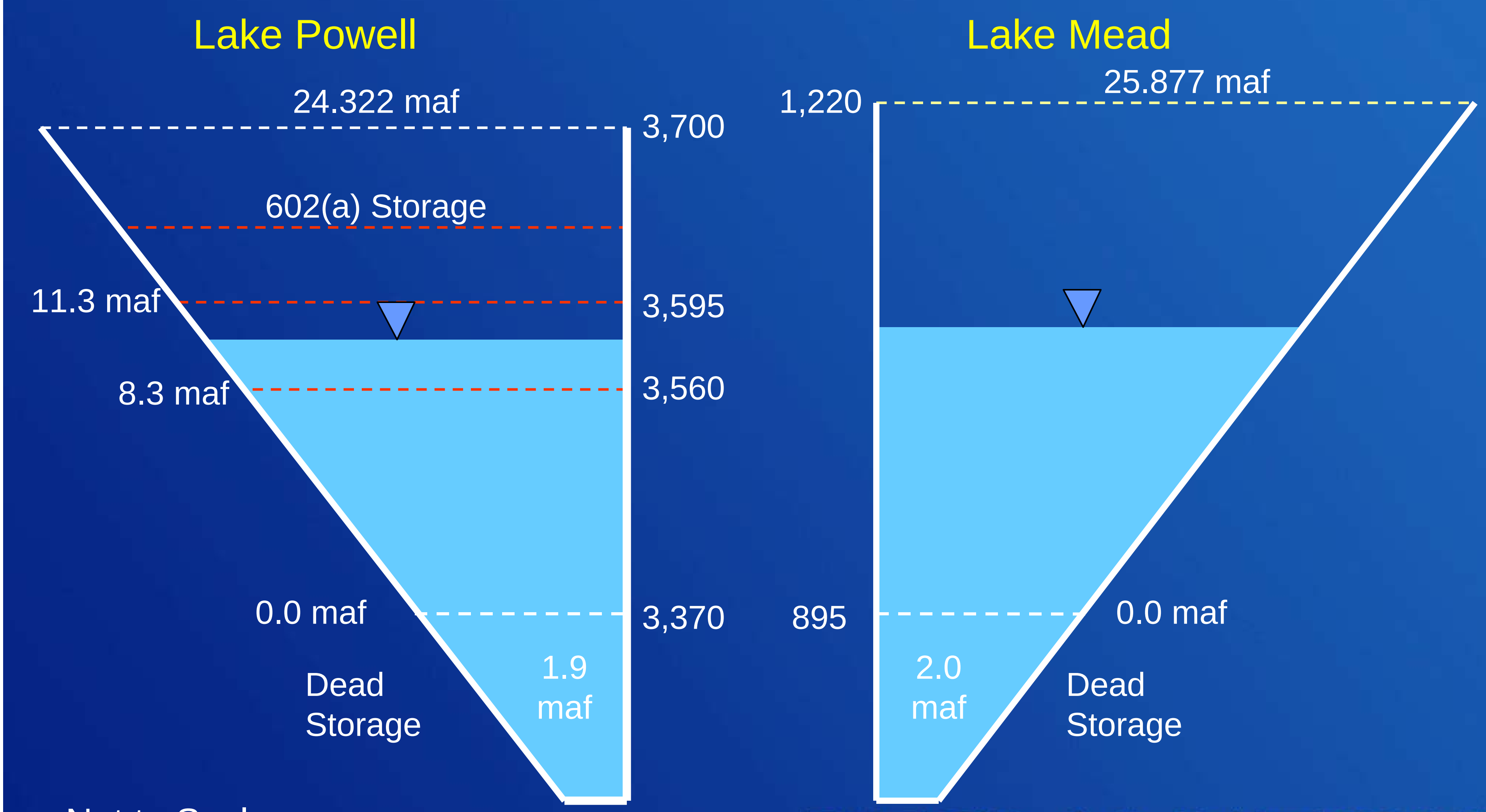


Not to Scale

RECLAMATION

Reservoir Storage Alternative

If Lake Powell is between 3,560 and 3,595:
Lake Powell water year release is 7.8 maf



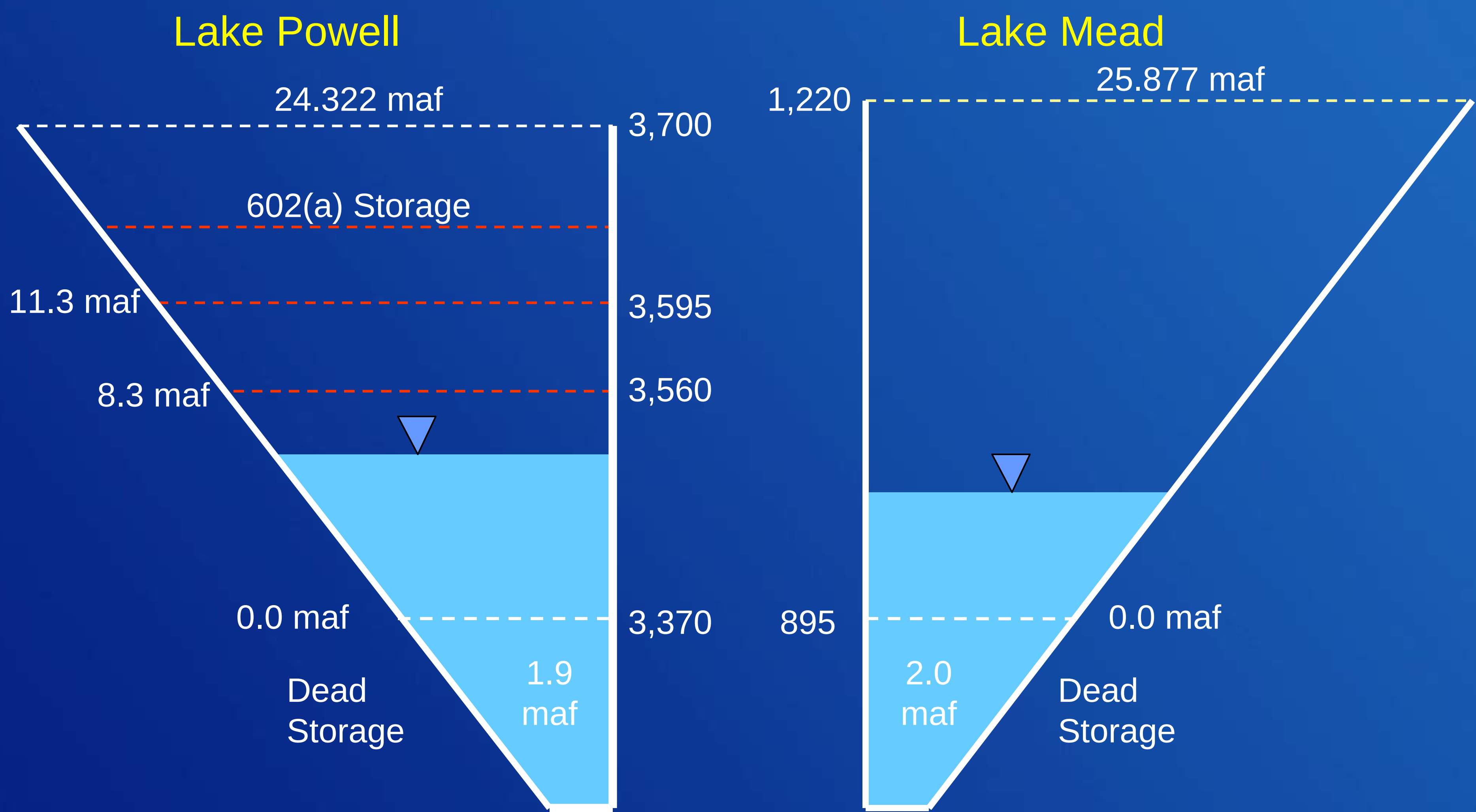
Not to Scale

RECLAMATION

Reservoir Storage Alternative

If Lake Powell is below 3,560 feet:

Balance Contents with a min/max release of 7.8 and 9.5 maf from Lake Powell



Not to Scale

RECLAMATION

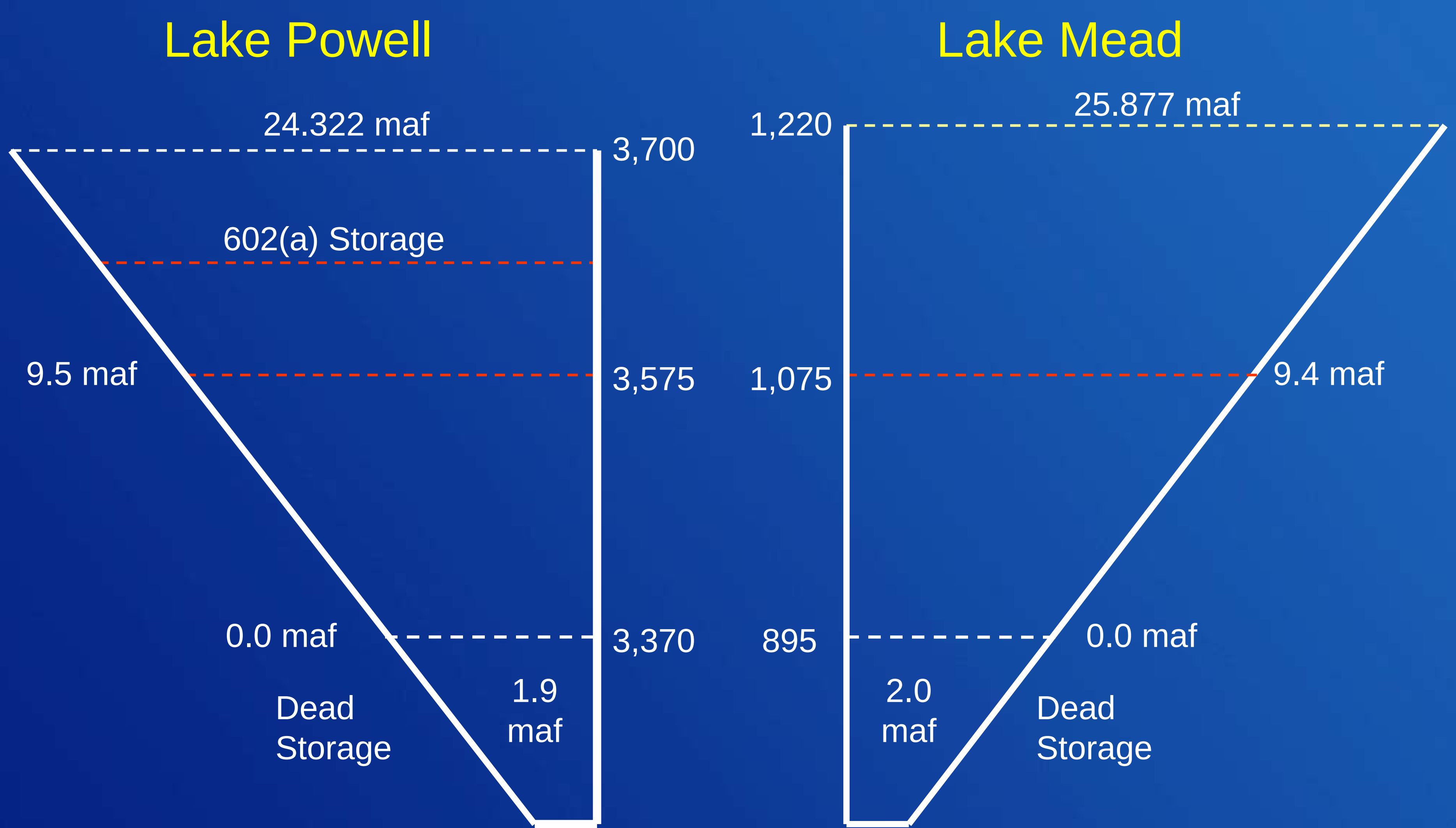
Detailed Modeling Assumptions –
Coordinated Operations

- Basin States & Conservation Before Shortage Alternatives
- Reservoir Storage Alternative
- Water Supply Alternative

RECLAMATION

Water Supply Alternative

Coordinated Operations - Trigger Elevations

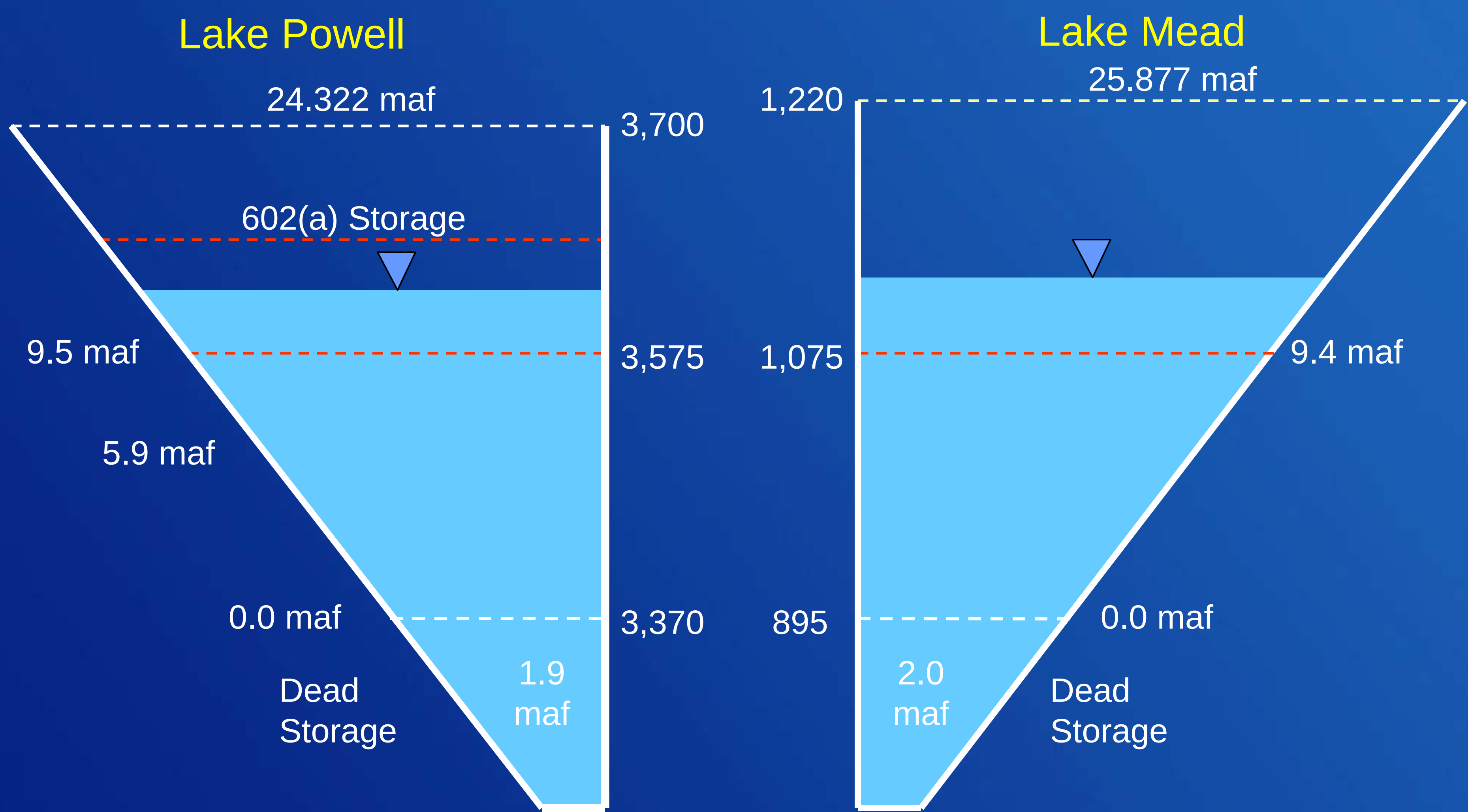


Not to Scale

RECLAMATION

Water Supply Alternative

If Lake Powell is below 3,575 or Lake Mead is below 1,075:
Balance Contents with a min/max release of 7.0 and 9.5 maf from Lake Powell. In this configuration annual release is 8.23 maf.

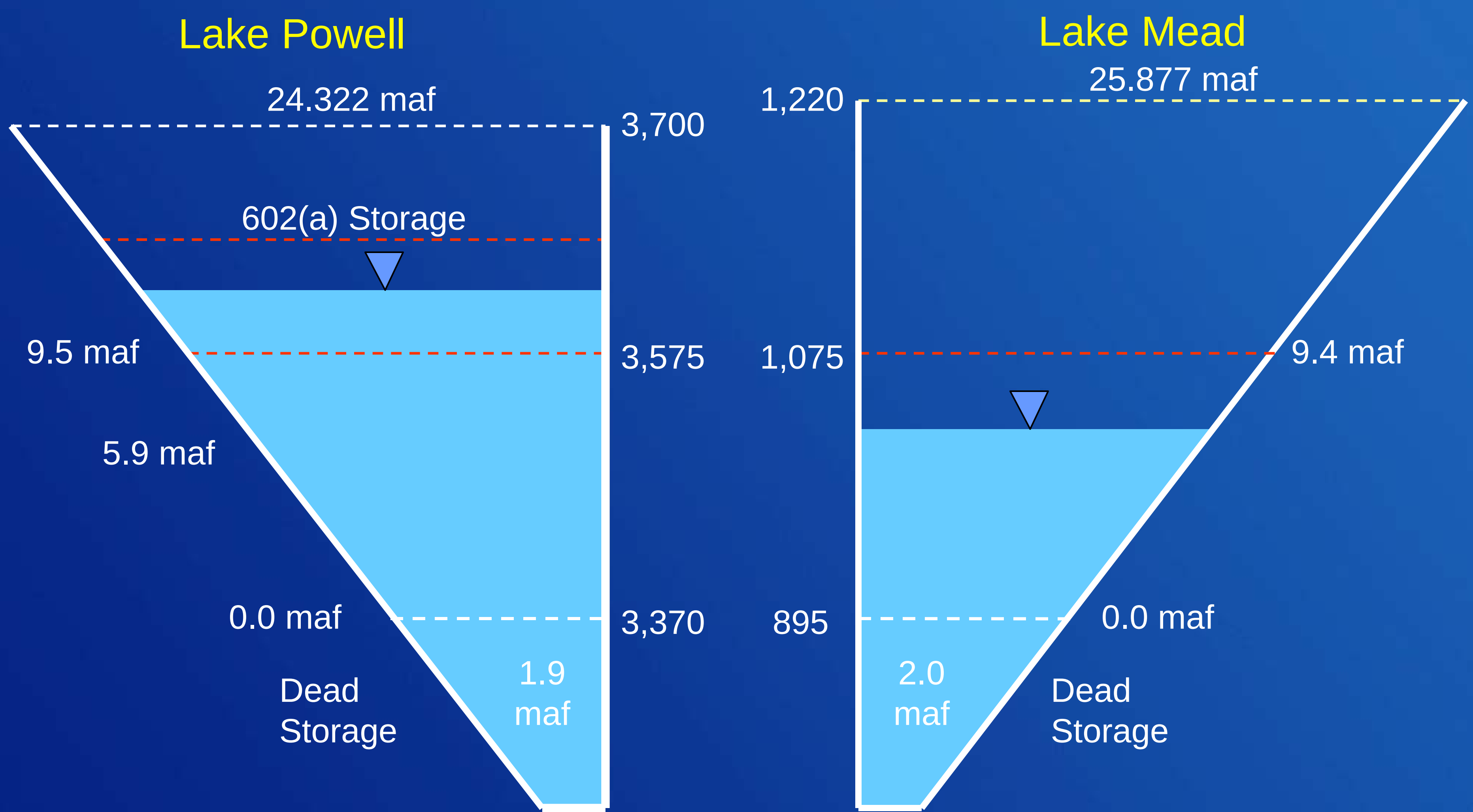


Not to Scale

RECLAMATION

Water Supply Alternative

If Lake Powell is below 3,575 or Lake Mead is below 1,075:
Balance Contents with a min/max release of 7.0 and 9.5 maf from Lake Powell. In this configuration annual release is 9.5 maf.

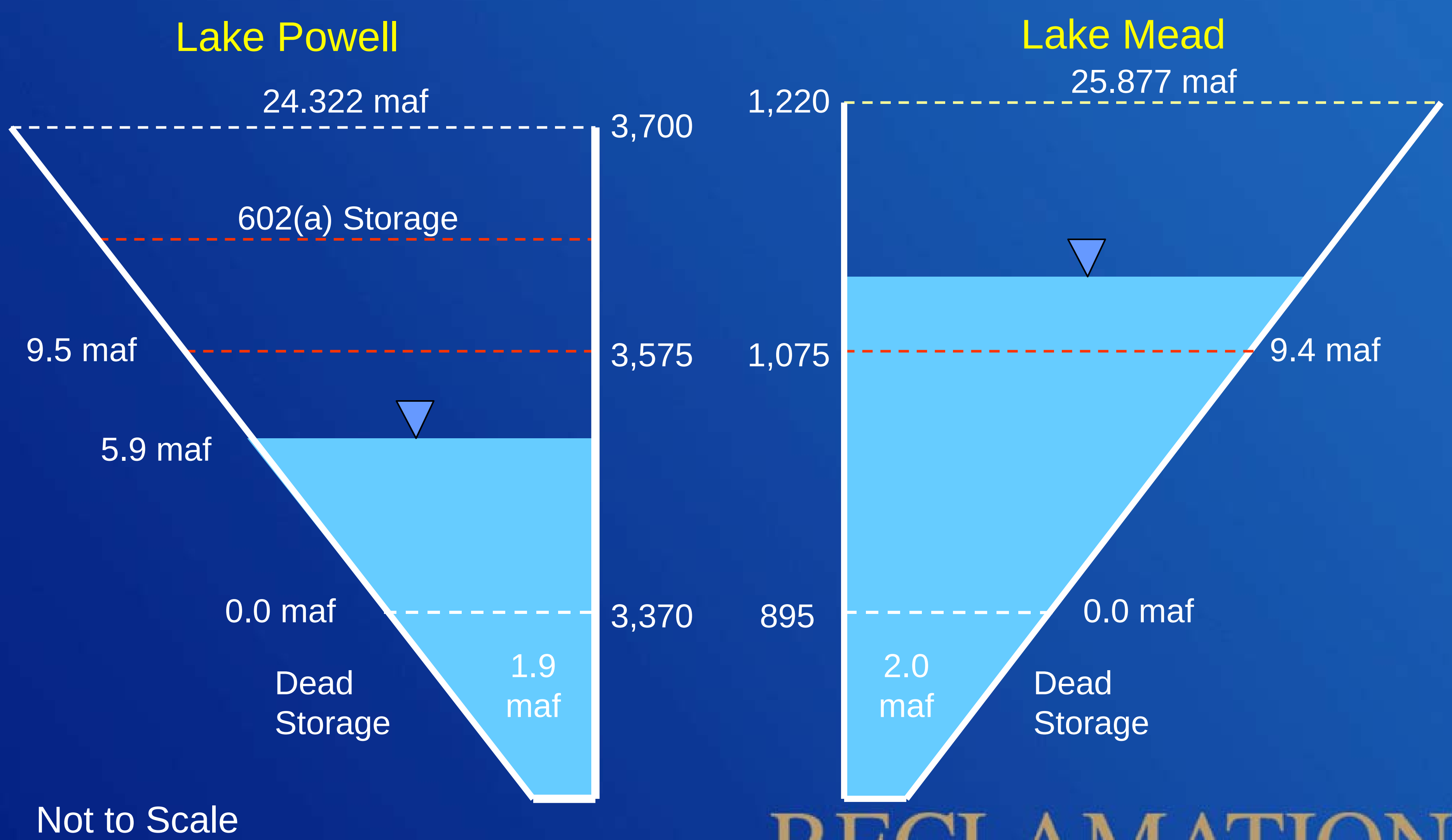


Not to Scale

RECLAMATION

Water Supply Alternative

If Lake Powell is below 3,575 or Lake Mead is below 1,075:
Balance Contents with a min/max release of 7.0 and 9.5 maf from Lake Powell. In this configuration annual release is 7.0 maf.



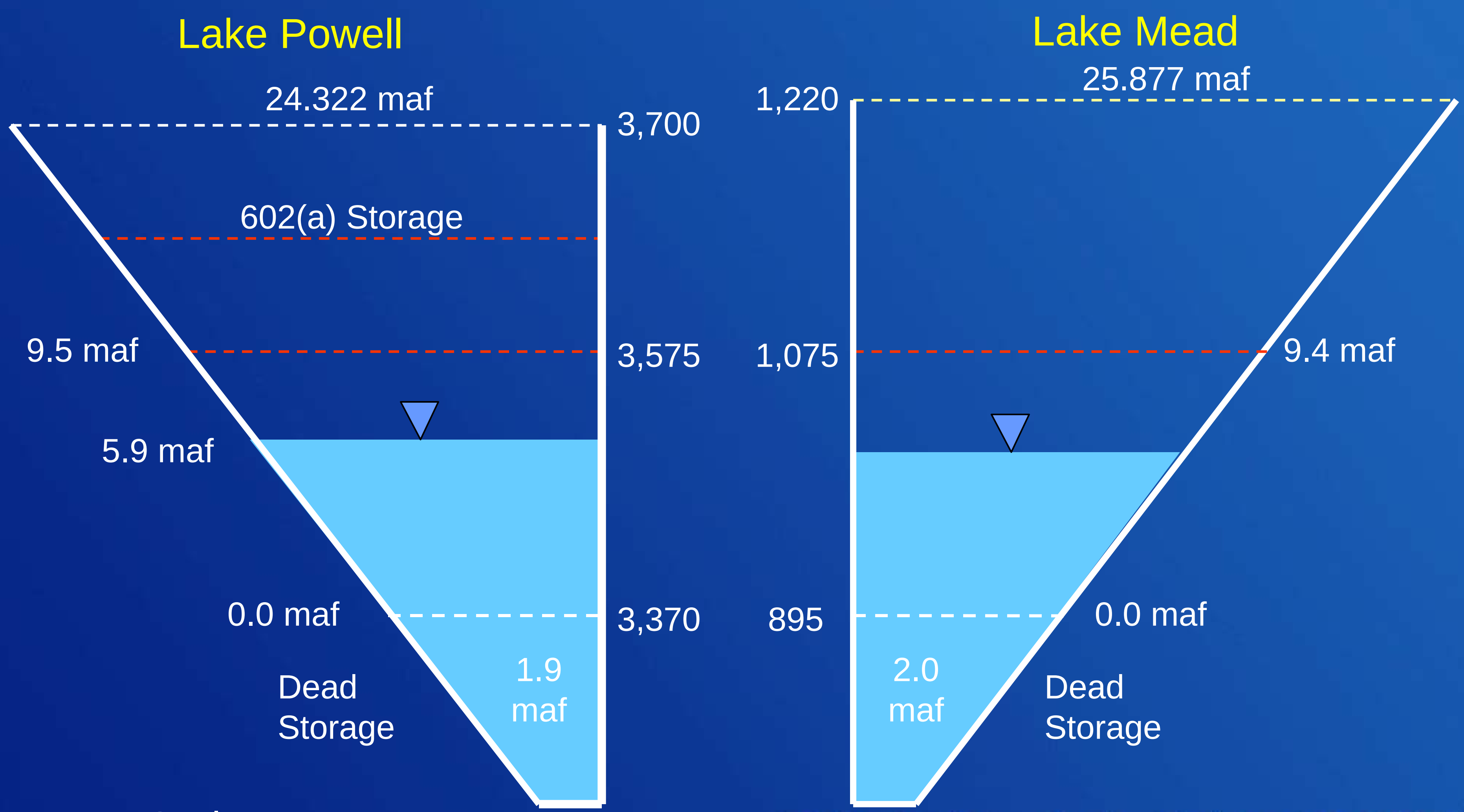
RECLAMATION

Water Supply Alternative

If Lake Powell is below 3,575 or Lake Mead is below 1,075:

Balance Contents with a min/max release of 7.0 and 9.5 maf

In this configuration annual release is between7.0 and 9.5 maf.



Not to Scale

RECLAMATION

Detailed Modeling Assumptions –
Storage and Delivery Mechanism

- Assumptions Common to All Alternatives
- Assumptions Specific to Each Alternative

RECLAMATION

Storage & Delivery Mechanism
Common Modeling Assumptions

- Mechanism in place for the Basin States, Conservation Before Shortage, and Reservoir Storage Alternatives
- Generation or delivery of credits is according to annual schedules
- Water stored 2008-2026, delivered 2008-2036
- Generation and storage credits subject to volume limitations

Storage & Delivery Mechanism
Common Modeling Assumptions

- Stored water increases Lake Mead storage
  - Demands reduced or gain added to the system
  - Demand reduction is to user lowest in the system with sufficient demand to capture maximum river effects
  - System assessment occurs when water is stored
  - Evaporation deduction is 3% at end of year, no deduction during Shortage
  - Storage credits lost in Flood Control
  - Storage credits not included in 70R calculation
- Delivered water decreases Lake Mead storage as demands are increased

RECLAMATION

Storage Credit Accounting

Balance_n =

Balance_{n-1} + Put(1 – Assessment%) – Take – Evap%(Balance_{n-1})

Example

Year	Put	Assessment	Put Adjusted for Assessment	Requested Take	Actual Take	Evaporation	Balance
1	0	0	0	0	0	0	0
2	200,000	10,000	190,000	0	0	0	190,000
3	100,000	5,000	95,000	50,000	50,000	5,700	229,300
4	0	0	0	200,000	200,000	6,879	22,421
5	0	0	0	50,000	21,748	673	0

RECLAMATION

Detailed Modeling Assumptions –
Storage and Delivery Mechanism

- Assumptions Common to All Alternatives
- Assumptions Specific to Each Alternative

RECLAMATION

Storage & Delivery Mechanism
Specific Modeling Assumptions

		BS, CBS & RS						CBS & RS	CBS	RS
		California	Arizona	Nevada				Mexico	Federal	Federal
Water Supply Condition		Extraordinary Conservation	Extraordinary Conservation	Tributary Conservation	Groundwater	Desalinization	Drop 2 Reservoir	Extraordinary Conservation	Extraordinary Conservation	Extraordinary Conservation
Flood Control Surplus	Store	no	no	no	no	No	no	No	no	no
	Deliver	no	no	no	no	No	no	No	no	no
Quantified (70R) Surplus	Store	no	no	yes	no	Yes	yes	Yes	yes	yes
	Deliver	no	no	no	no	Yes	yes	Yes	yes	yes
Full Domestic Surplus	Store	no	no	yes	no	Yes	yes	Yes	yes	yes
	Deliver	no	no	yes	no	Yes	yes	Yes	yes	yes
Normal	Store	yes	yes	yes	yes	Yes	yes	Yes	yes	yes
	Deliver	yes	yes	yes	yes	Yes	yes	Yes	yes	yes
Shortage (involuntary and voluntary)	Store	no	no	yes	yes	Yes	yes	No	no [5]	yes
	Deliver	no	no	yes	yes	Yes	no	No	no	yes
System Assessment		yes	yes	yes	yes	Yes	no	Yes	yes	yes
Project Considered Part of Storage and Delivery Mechanism		yes	yes	yes	no	no	no	Yes	yes	yes
Period of Activity		2006-2026	2017-2026	2009-2060	2009-2060	2020-2060	Temporary	2008-2026	2008-2026	2008-2026

RECLAMATION

Basin States Alternative

Storage & Delivery Mechanism Assumptions

	Arizona		California[2]		Nevada							
	Extraordinary Conservation		Extraordinary Conservation		Tributary Conservation		Groundwater		Desalinization		Drop 2	
YEAR	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2008	0	0	400,000	0	0	0	0	0	0	0	0	0
2009	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0	0	0
2010	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0	69,000	0
2011	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0	69,000	0
2012	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0	69,000	0
2013	0	0	400,000	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2014	0	0	100,000	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2015	0	0	0	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2016	0	0	300,000	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2017	100,000	0	400,000	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2018	100,000	0	300,000	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2019	100,000	0	200,000	0	30,000	5,000	13,000	13,000	0	0	69,000	40,000
2020	0	300,000	0	100,000	30,000	5,000	80,000	80,000	75,000	75,000	69,000	40,000

RECLAMATION

Conservation Before Shortage

Storage & Delivery Mechanism Assumptions

- Assumptions for Arizona, California and Nevada same as Basin States Alternative
- Includes bypass flow replacement account
- Assumes some conserved water delivered for environmental uses

	Delta Pulse Flows		Other Environmental Flows Below NIB		Additional Environmental Flows	
YEAR	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2008	52,632	0	42,105	0	105,263	100,000
2009	52,632	0	42,105	0	105,263	100,000
2010	52,632	0	0	80,000	105,263	100,000
2011	52,632	0	42,105	0	105,263	100,000
2012	50,000	250,000	42,105	0	105,263	100,000
2013	52,632	0	42,105	0	105,263	100,000
2014	52,632	0	42,105	0	105,263	100,000
2015	52,632	0	40,000	200,000	105,263	100,000
2016	52,632	0	42,105	0	105,263	100,000
2017	50,000	250,000	42,105	0	105,263	100,000
2018	52,632	0	42,105	0	105,263	100,000
2019	52,632	0	42,105	0	105,263	100,000
2020	52,632	0	40,000	200,000	105,263	100,000

RECLAMATION

Reservoir Storage

Storage & Delivery Mechanism Assumptions

- Assumptions for Arizona, California and Nevada same as Basin States Alternative
- Assumes some conserved water delivered for environmental uses
- System assessment is 10%

	Environmental Uses		Bypass Flow Replacement		Additional Conservation Activities	
YEAR	STORE	DELIVER	STORE	DELIVER	STORE	DELIVER
2008	55,555	50,000	121,111	109,000	150,000	100,000
2009	55,555	50,000	121,111	109,000	150,000	100,000
2010	55,555	50,000	121,111	109,000	150,000	100,000
2011	55,555	50,000	121,111	109,000	150,000	100,000
2012	55,555	50,000	121,111	109,000	150,000	100,000
2013	55,555	50,000	121,111	109,000	150,000	100,000
2014	55,555	50,000	121,111	109,000	150,000	100,000
2015	55,555	50,000	121,111	109,000	150,000	100,000
2016	55,555	50,000	121,111	109,000	150,000	100,000
2017	55,555	50,000	121,111	109,000	150,000	100,000
2018	55,555	50,000	121,111	109,000	150,000	100,000
2019	55,555	50,000	121,111	109,000	150,000	100,000
2020	55,555	50,000	121,111	109,000	150,000	100,000

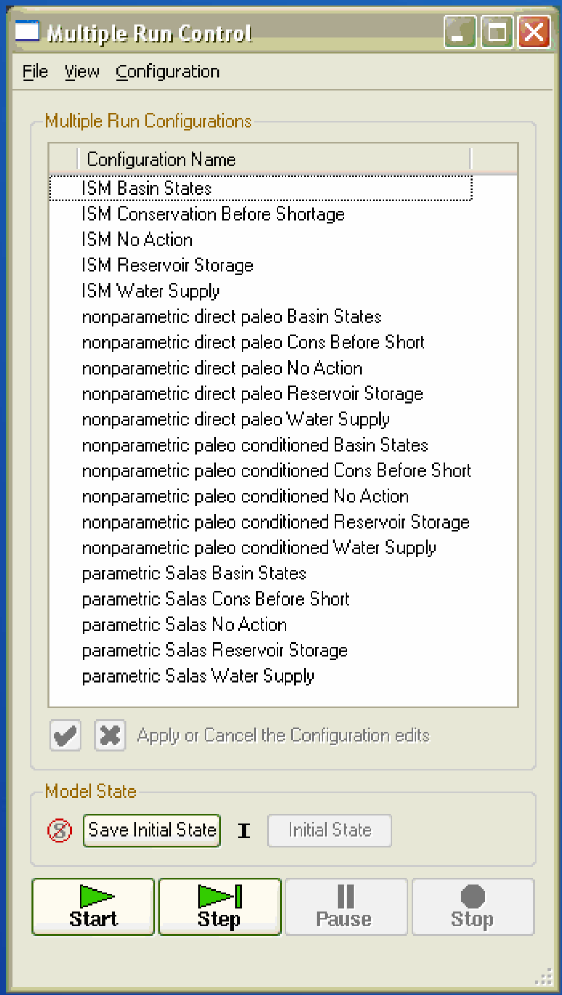
CRSS Modeling Assumptions –
Alternate Hydrologic Sequences

- Index Sequential Method & Alternate Stochastic Techniques
- Alternate Hydrologic Sequences & Results

RECLAMATION

Hydrologic Sensitivity Runs

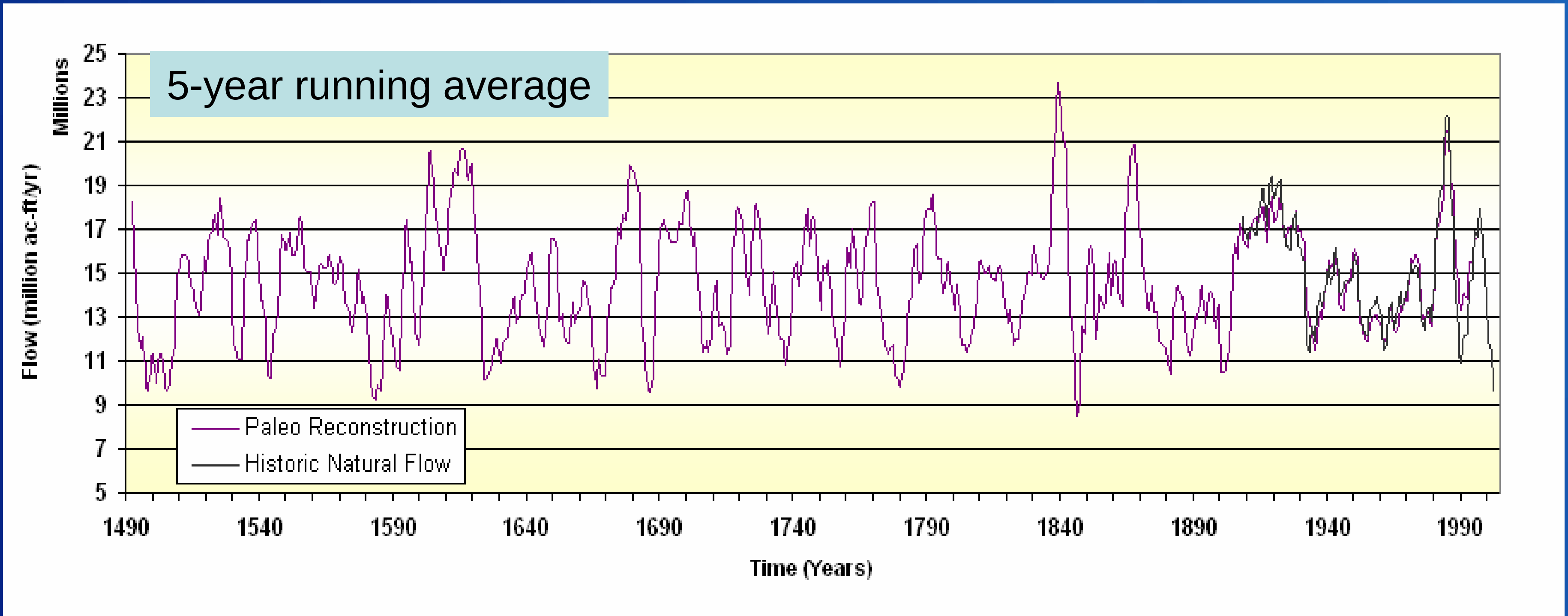
- **4 hydrologic inflow scenarios**
  - Records sampled from a dataset using ISM
    - Observed flow (1906-2004)
      - 99 traces
    - Paleo flow (1490-1997) (Woodhouse et al., 2006)
      - 508 traces
  - Other
    - Paleo conditioned (Prairie, 2006)
      - 125 traces
    - Parametric stochastic (Lee et al., 2006)
      - 100 traces
- **All 4 inflow scenarios were run for each alternative**



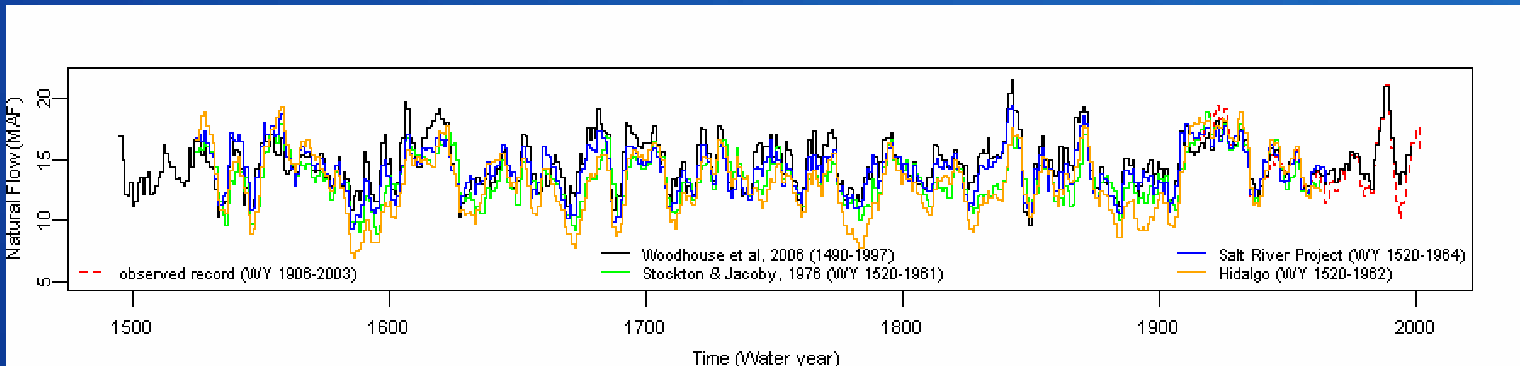
RECLAMATION

ISM-Based Flows

- Historic natural flow (1906-2004) : averages 15.0 MAF
- Paleo reconstruction (1490-1997) : averages 14.6 MAF
  - Lees B from Woodhouse et al., 2006



RECLAMATION



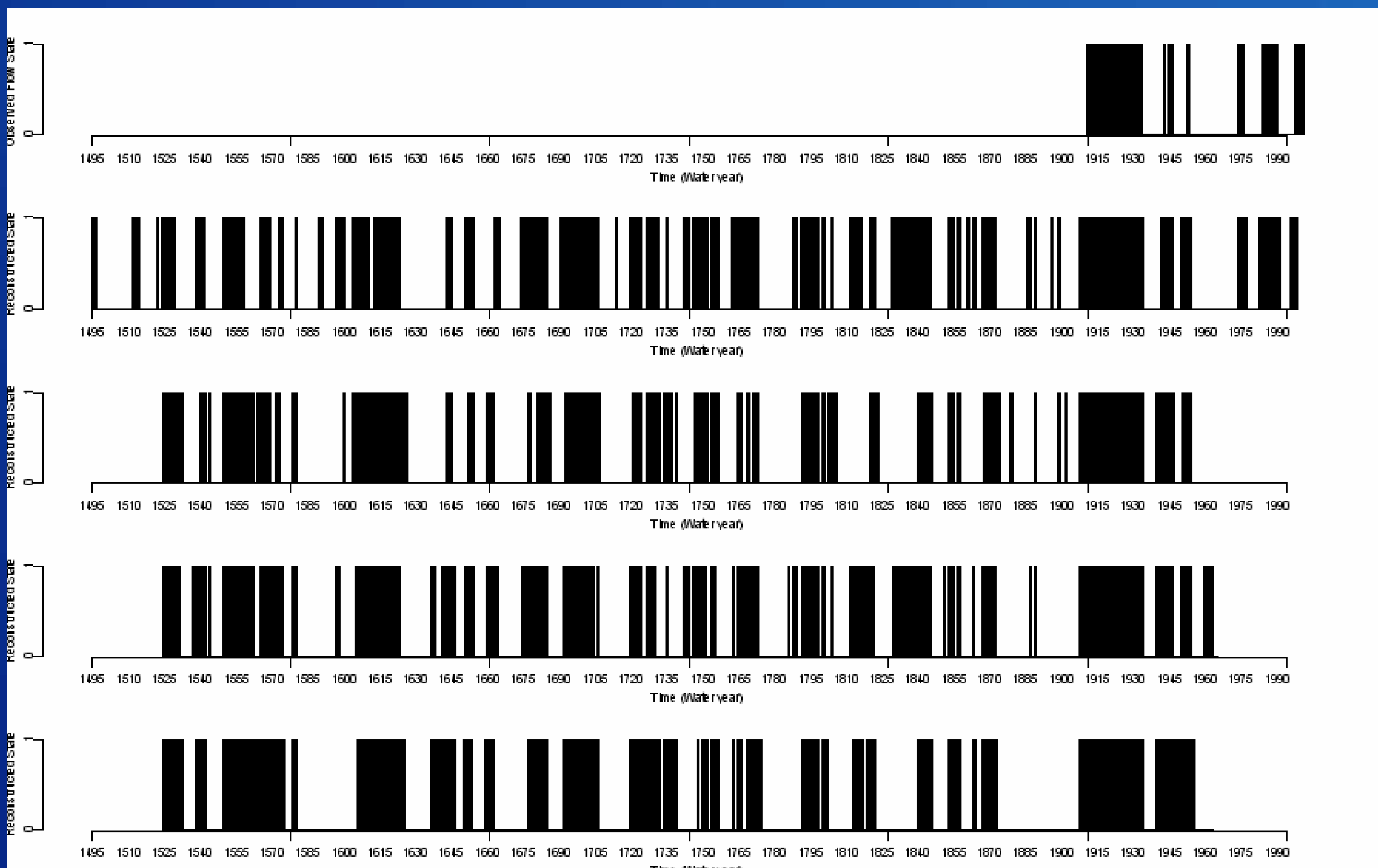
observed record

Woodhouse et al. 2006

Stockton and Jacoby, 1976

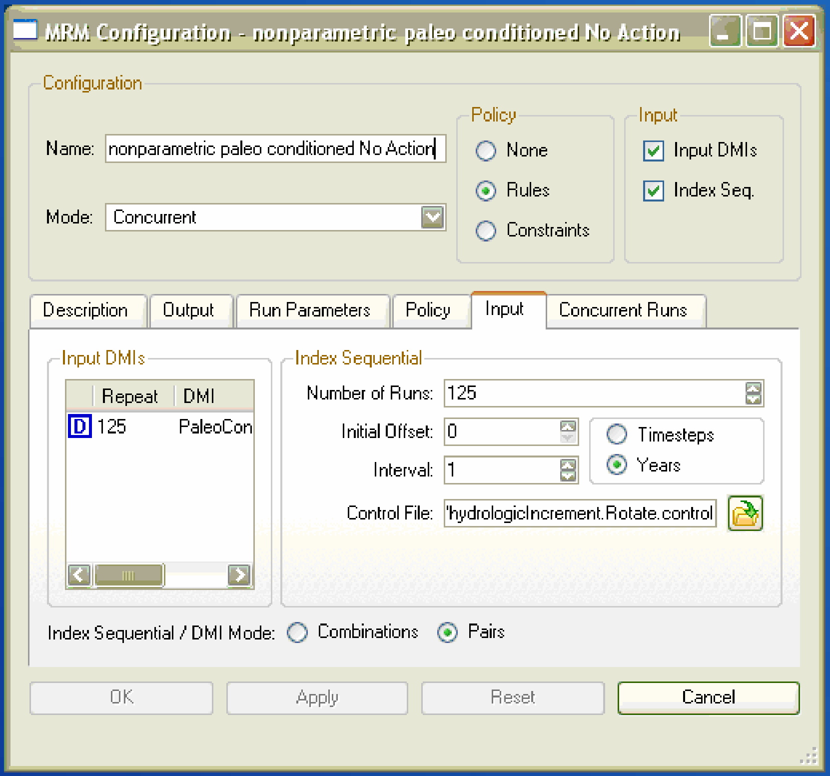
Hirschboeck and Meko, 2005

Hildalgo et al. 2002



Alternate Stochastic Techniques

- Paleo conditioned
  - Combines observed and paleo streamflows
  - Generates
    - Observed flow magnitudes
    - Flow sequences similar to paleo record
- Parametric
  - Fit observed data to appropriate model (i.e., CAR)
  - Generates
    - Flow magnitudes not observed
    - Flow sequences similar to observed record



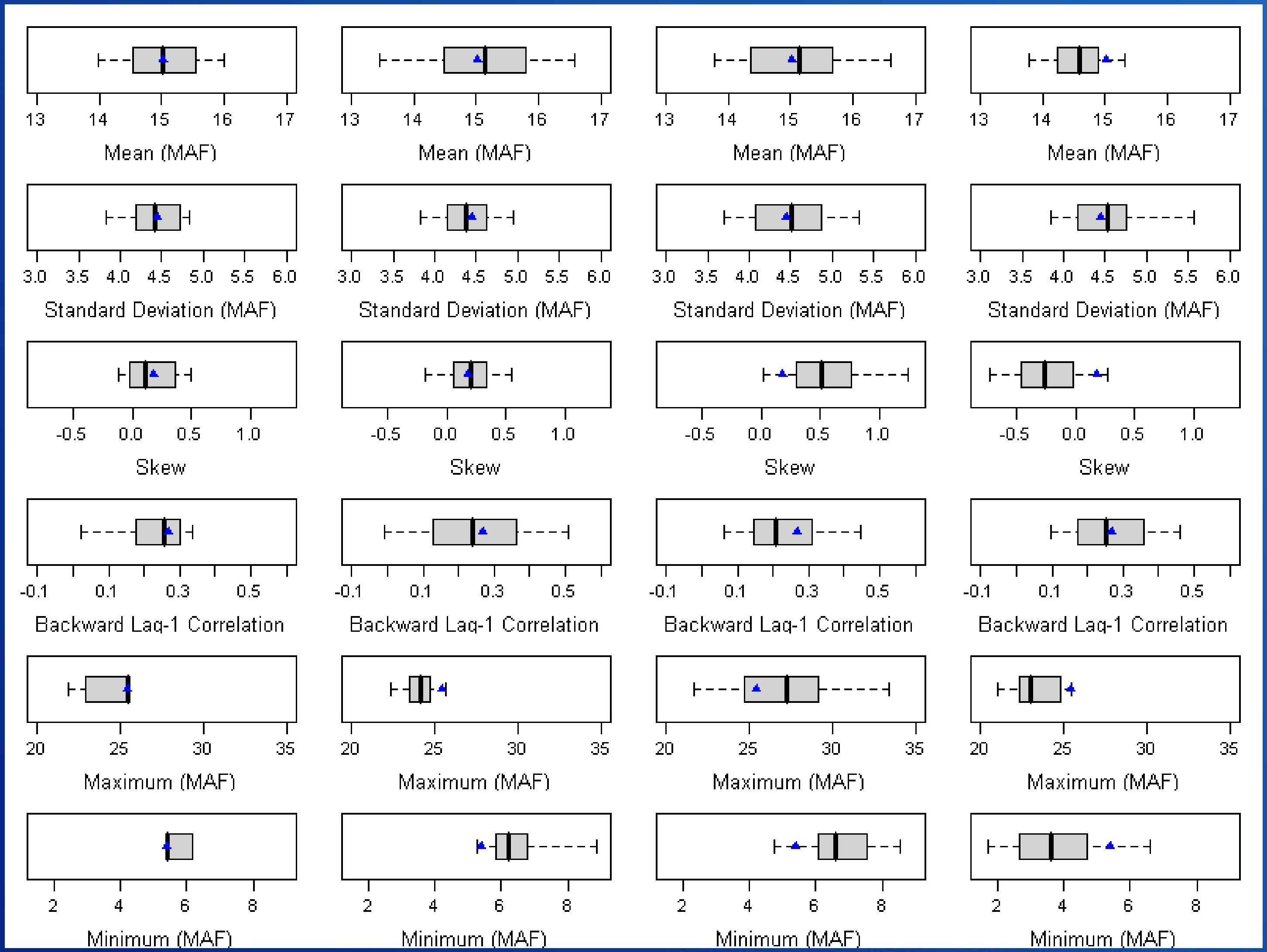
RECLAMATION

CRSS Modeling Assumptions –
Alternate Hydrologic Sequences

- Index Sequential Method & Alternate Stochastic Techniques
- Alternate Hydrologic Sequences & Results

RECLAMATION

Observed ISM	Paleo conditioned input DMI	Parametric input DMI	Direct Paleo ISM

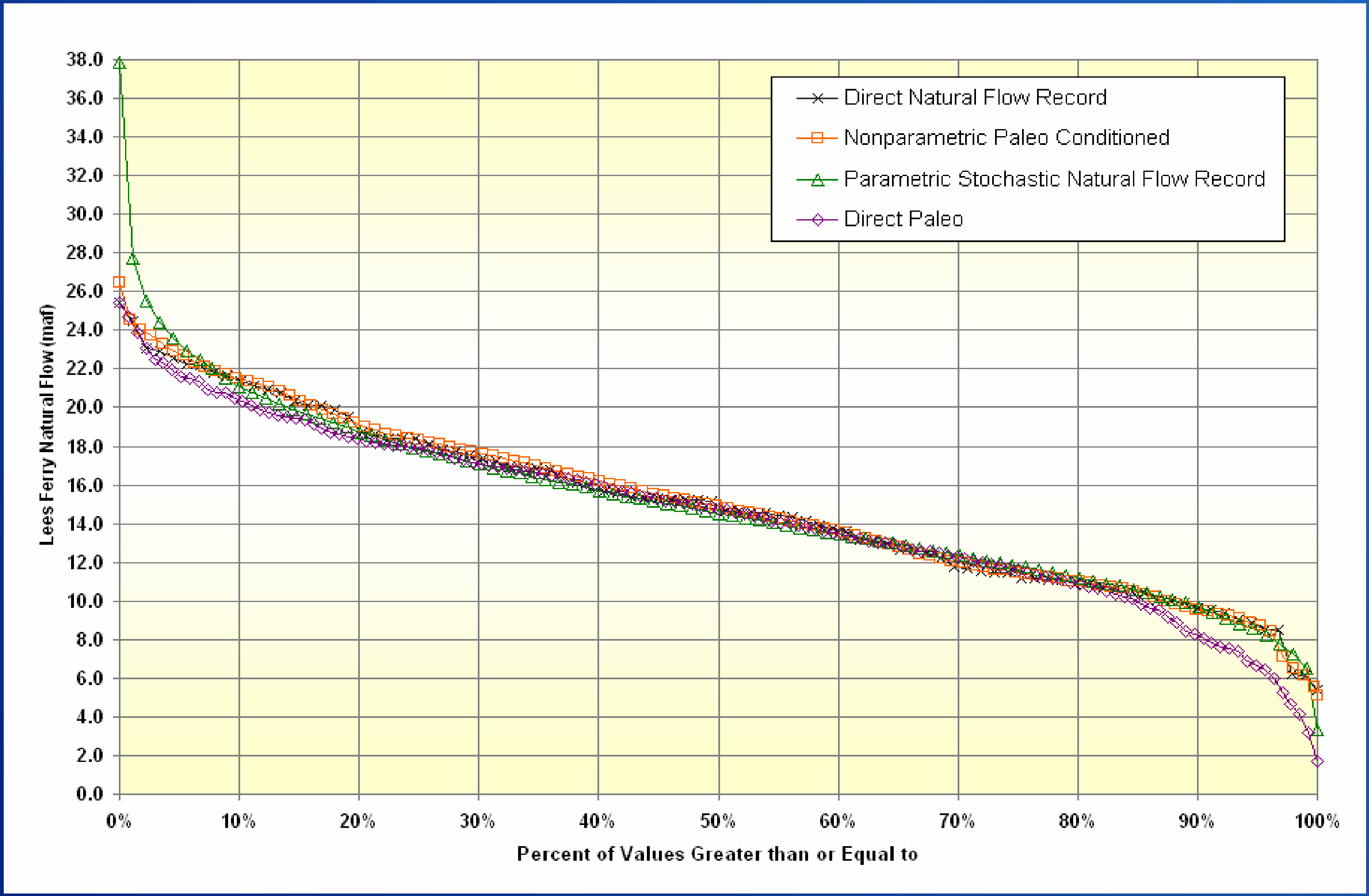


RECLAMATION

Annual Natural Flow at Lees Ferry

No Action Alternative

Years 2008-2060

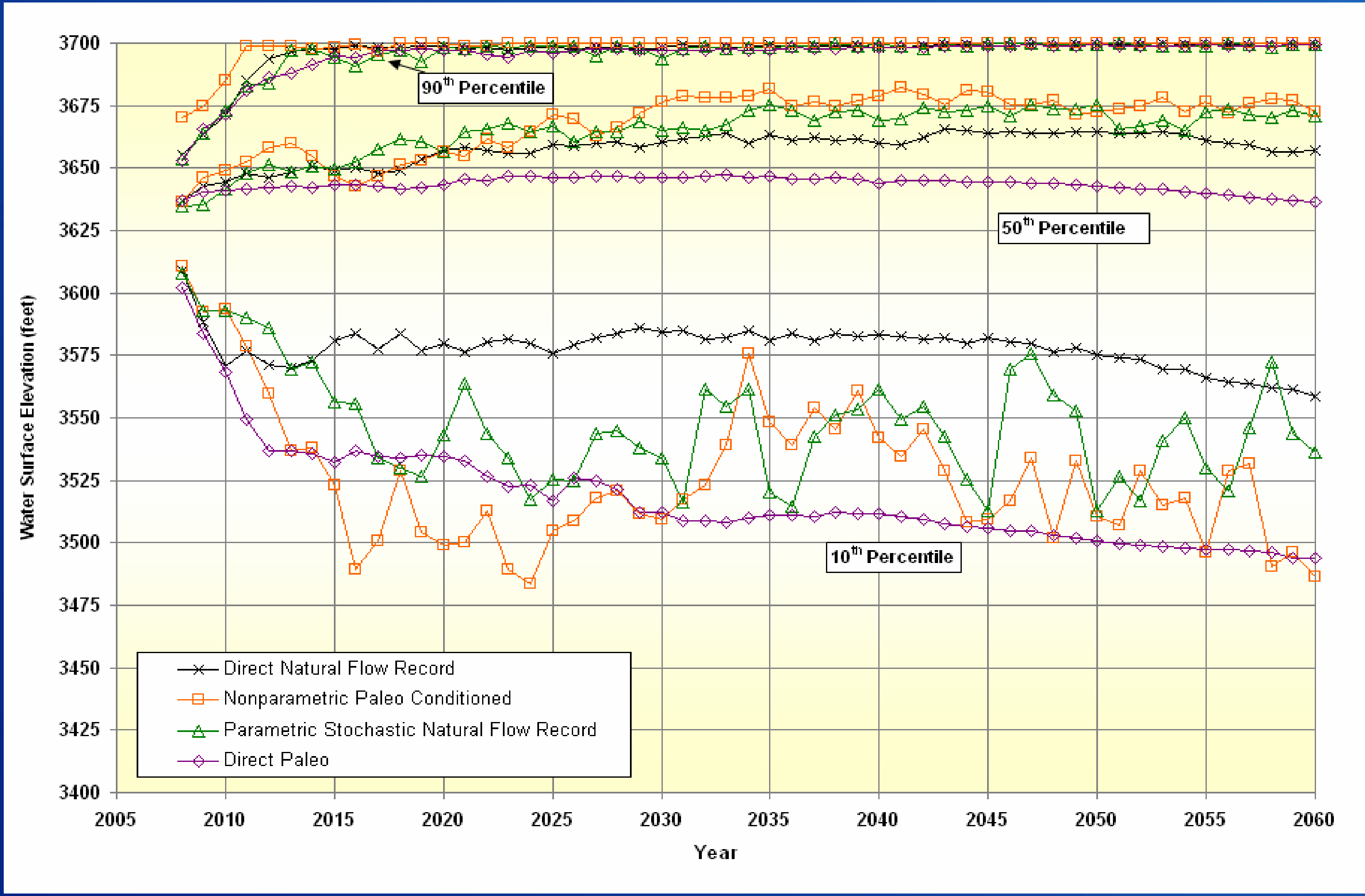


RECLAMATION

Lake Powell End of July Elevations

No Action Alternative

10th, 50th and 90th Percentile Values

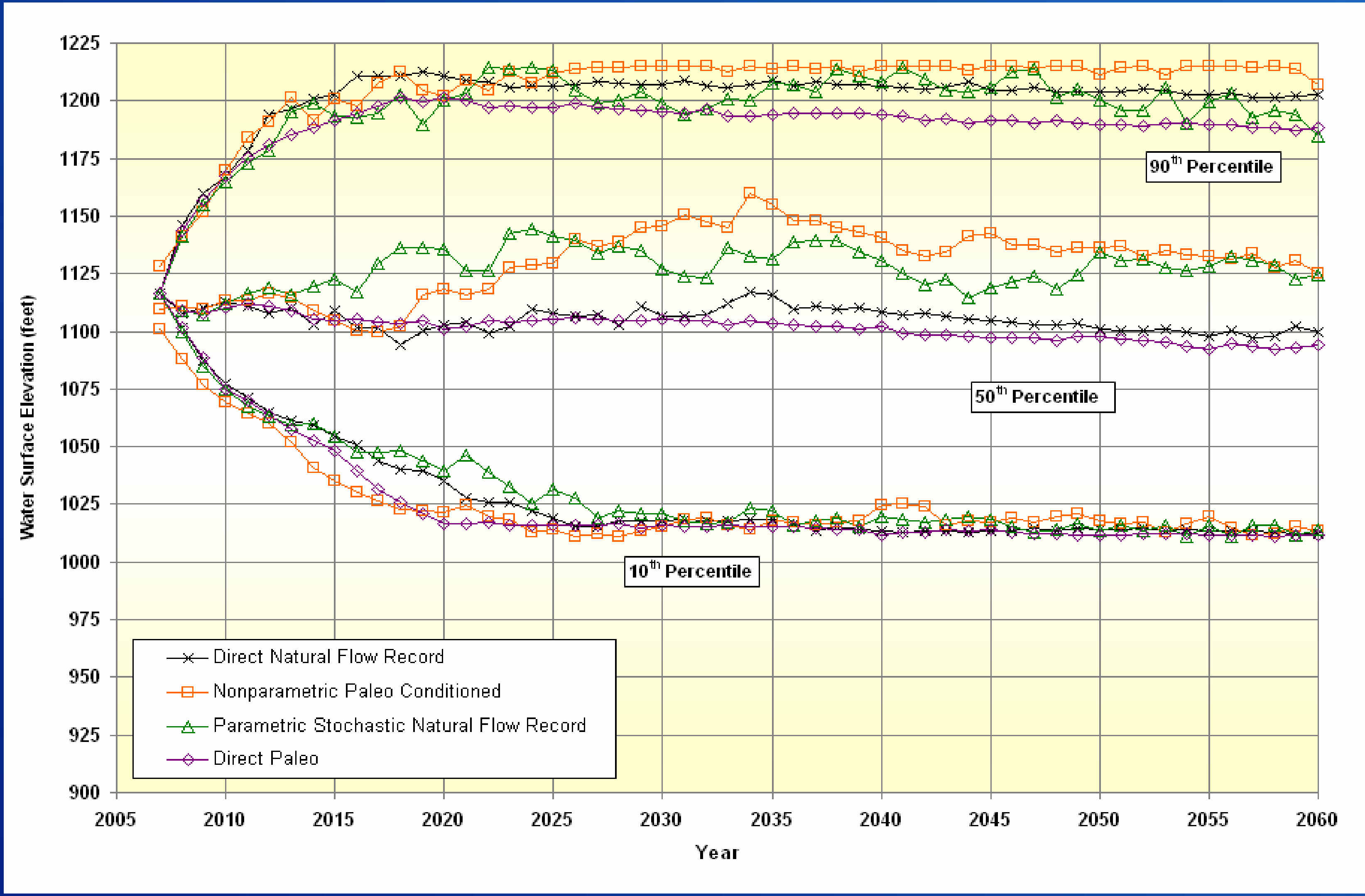


RECLAMATION

Lake Mead End of December Elevations

No Action Alternative

10th, 50th and 90th Percentile Values

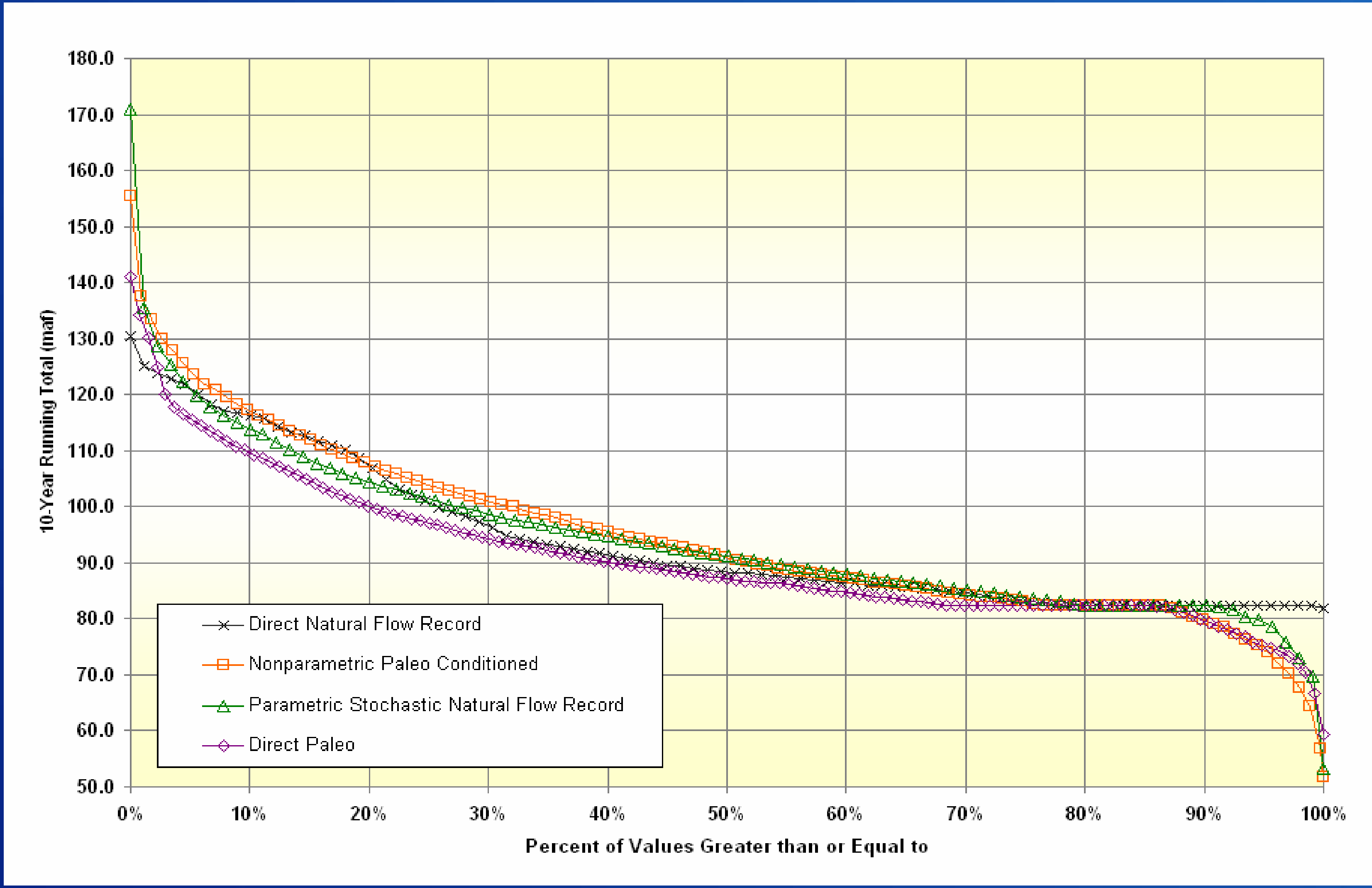


RECLAMATION

Glen Canyon 10-Year Release Volume

No Action Alternative

Years 2008-2060



RECLAMATION

Open Question and Answer Session

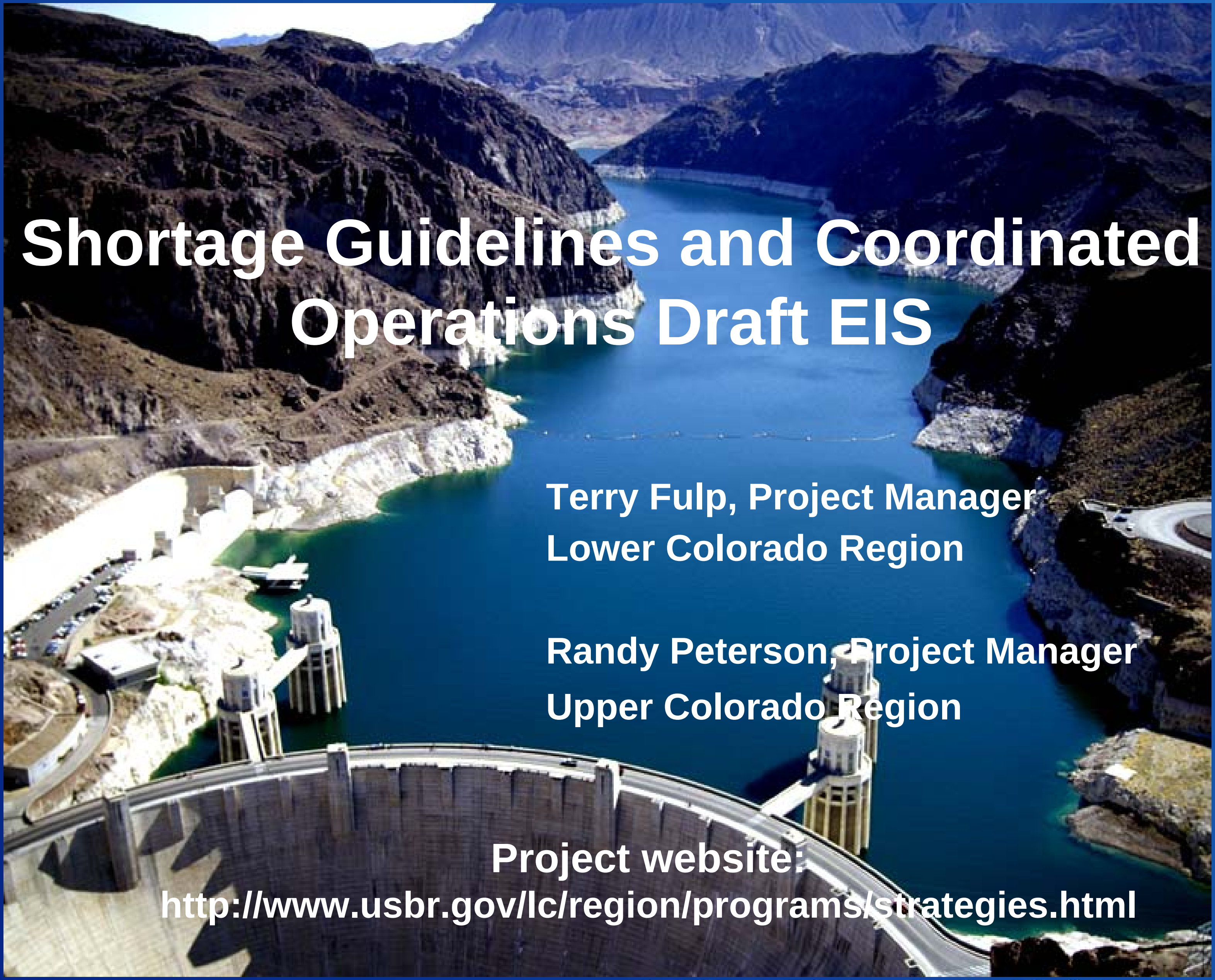
- CRSS
- Shortage Allocation Model
- Other

RECLAMATION

Wrap-up

- Closing Remarks
- Adjourn

RECLAMATION



Shortage Guidelines and Coordinated Operations Draft EIS

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Lower Colorado Region

Randy Peterson, Project Manager
Upper Colorado Region

Project website:
http://www.usbr.gov/lc/region/programs/strategies.html

RECLAMATION