DROUGHT CONTINGENCY PLANNING AND COLORADO RIVER RISK STUDY

AN OVERVIEW AND STATUS REPORT

MARCH 2018

OUTLINE

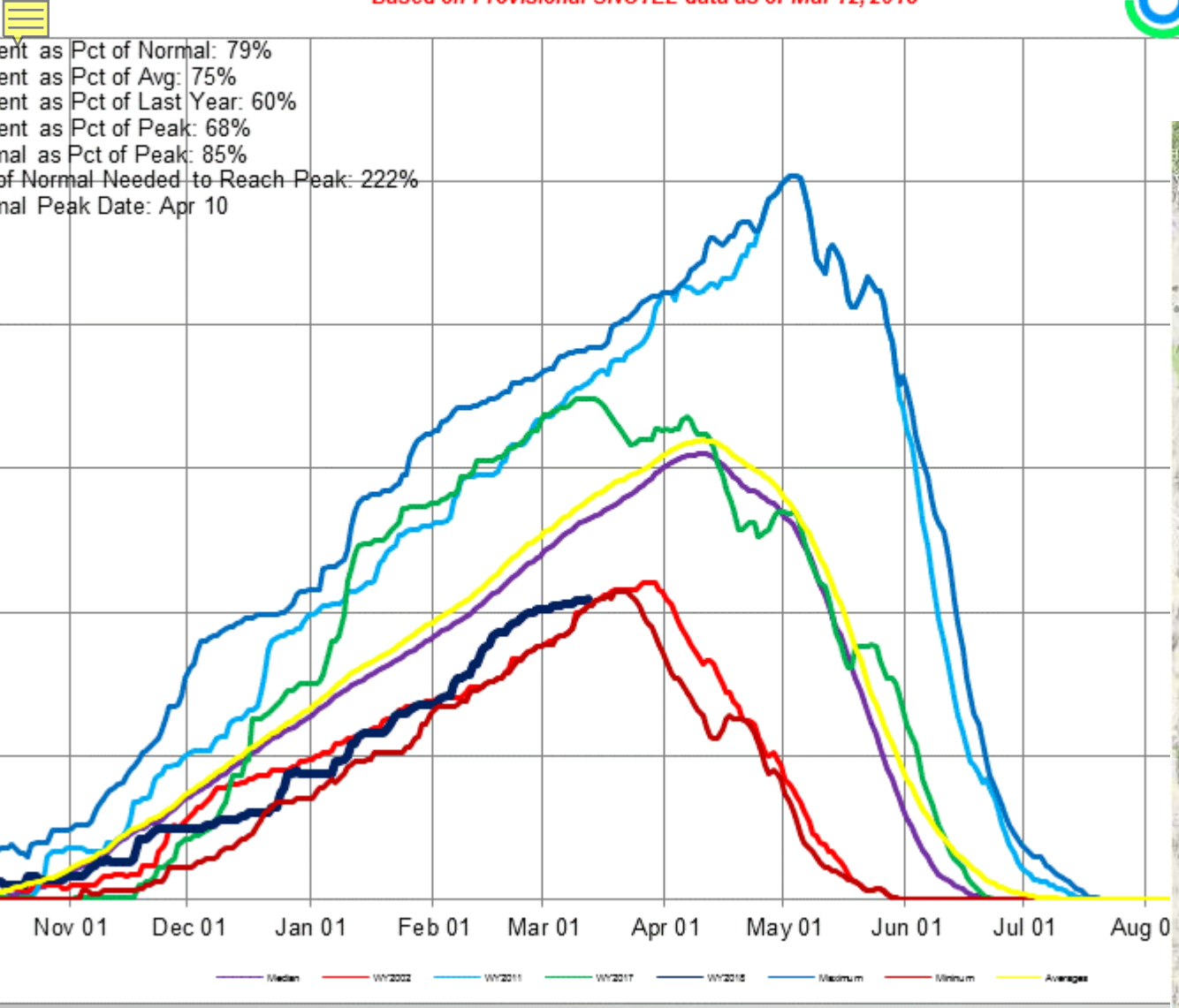
Drought Contingency Planning (DCP)

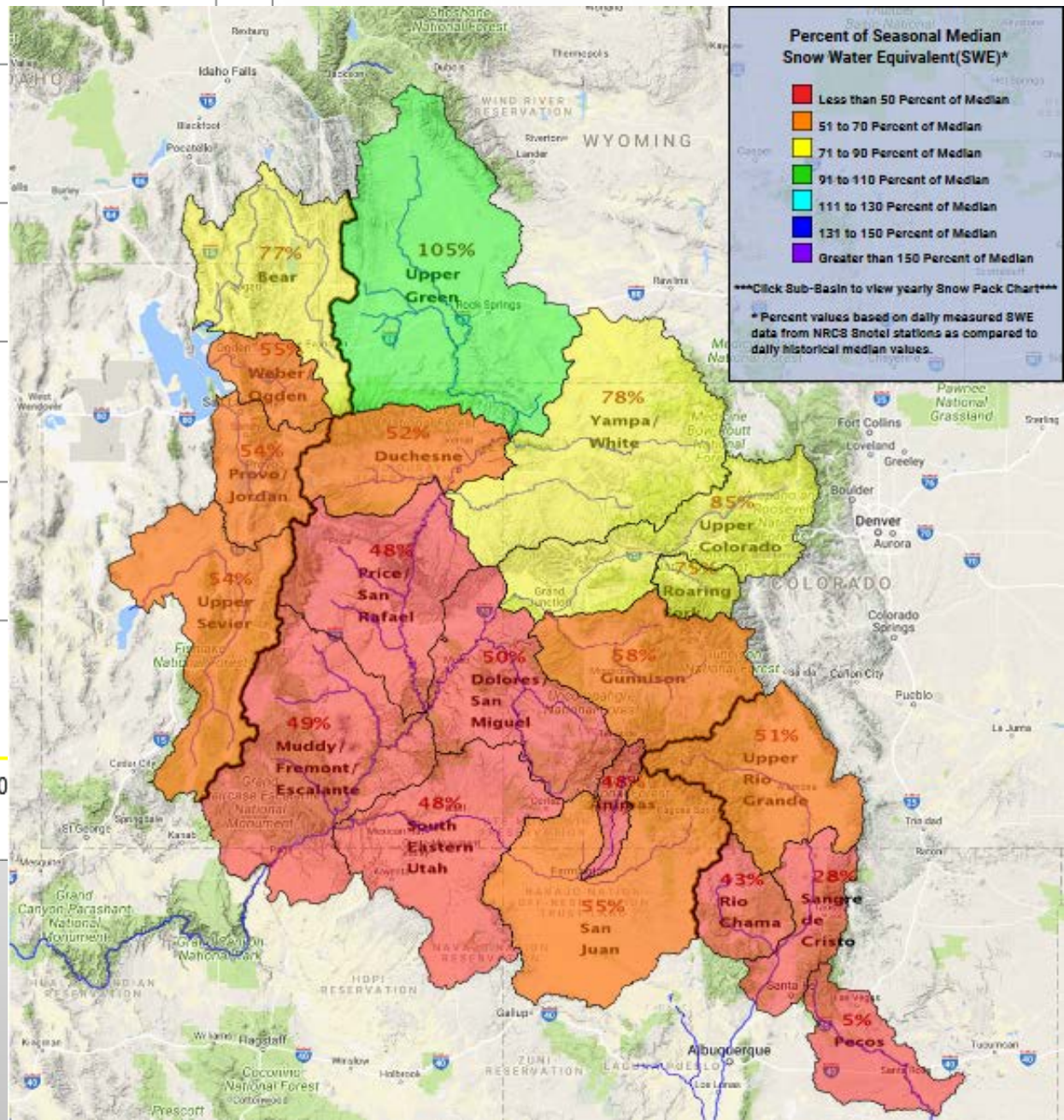
1. Background
2. Planning Process 2013-Present

Colorado River Risk Study (West Slope BRTs)

1. Background
2. Phase I
3. Phase II

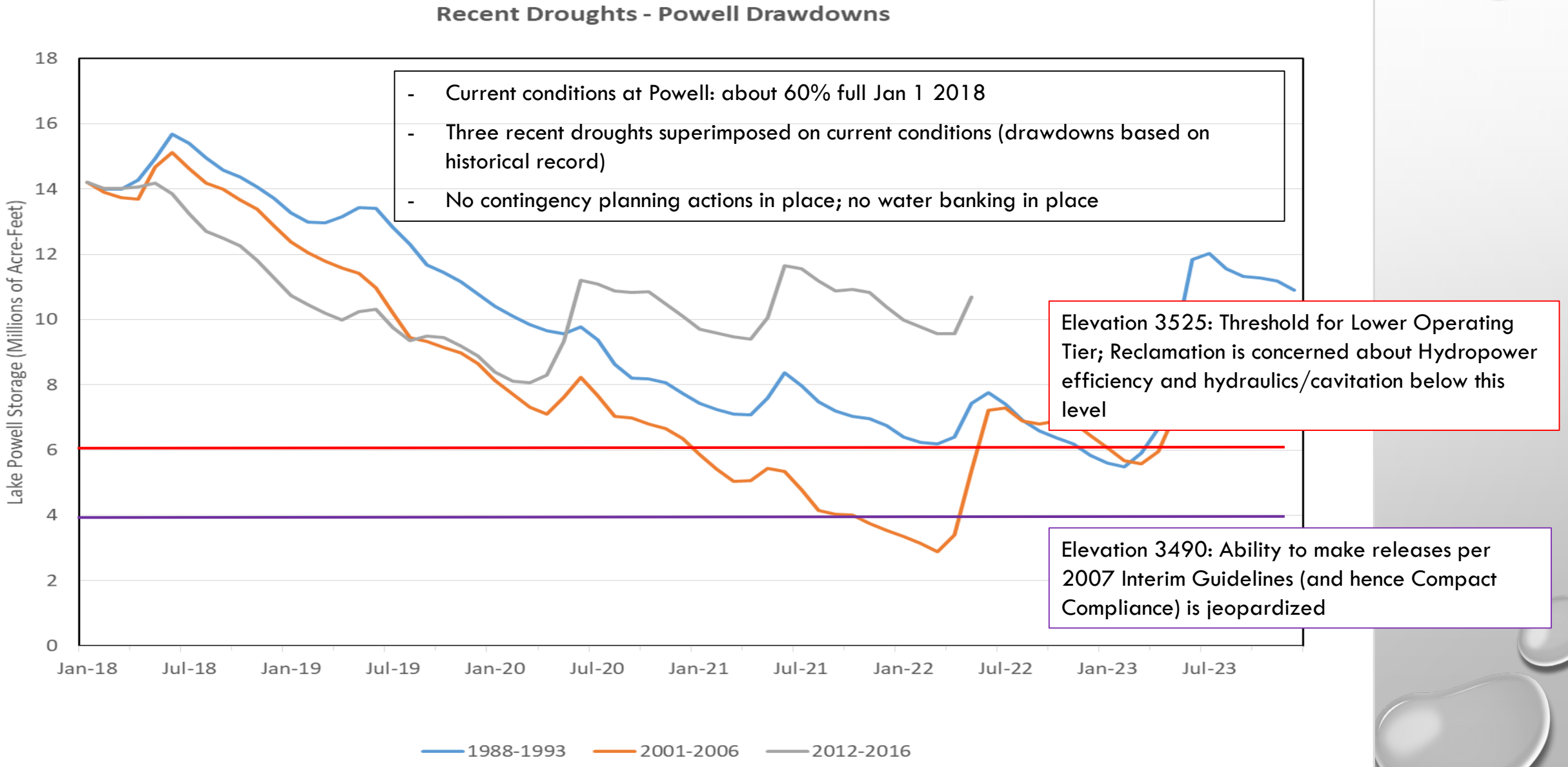
What's Next?





Forecast spring runoff into Powell = 47% of average

What if drought periods of past 25 years repeated?

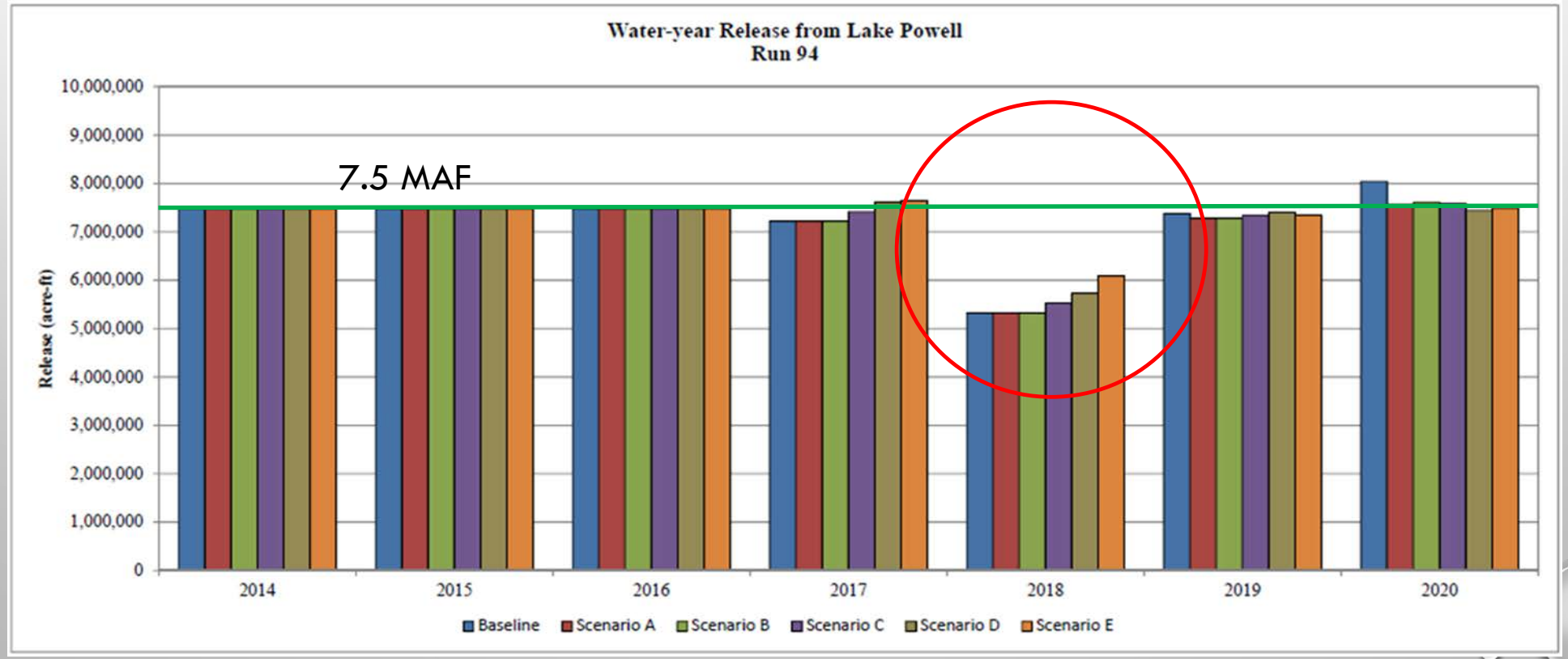


BACKGROUND AND CATALYST FOR DCP AND RISK STUDY

- 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'



December 2007: Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead

Lake Powell Operational Tiers (subject to April adjustments or mid-year review modifications)		
Lake Powell Elevation (feet)	**Lake Powell Operational Tier**	**Lake Powell Active Storage** (maf)
3,700	**Equalization Tier** equalize, avoid spills or release 8.23 maf	**24.32**
3,636 – 3,666 (see table below)	**Upper Elevation Balancing Tier** release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	**15.54 – 19.29** (2008 – 2026)
3,575	**Mid-Elevation Release Tier** release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	**9.52**
3,525	**Lower Elevation Balancing Tier** balance contents with a min/max release of 7.0 and 9.5 maf	**5.93**
3,370		**0**

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
- 1st option: modify timing of Powell Releases
- 2nd option: Utilize Flaming Gorge, Aspinall, Navajo
- Move water from those CRSP units to Powell
  - Implement at all three upper CRSP reservoirs simultaneously
    - 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 UB 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

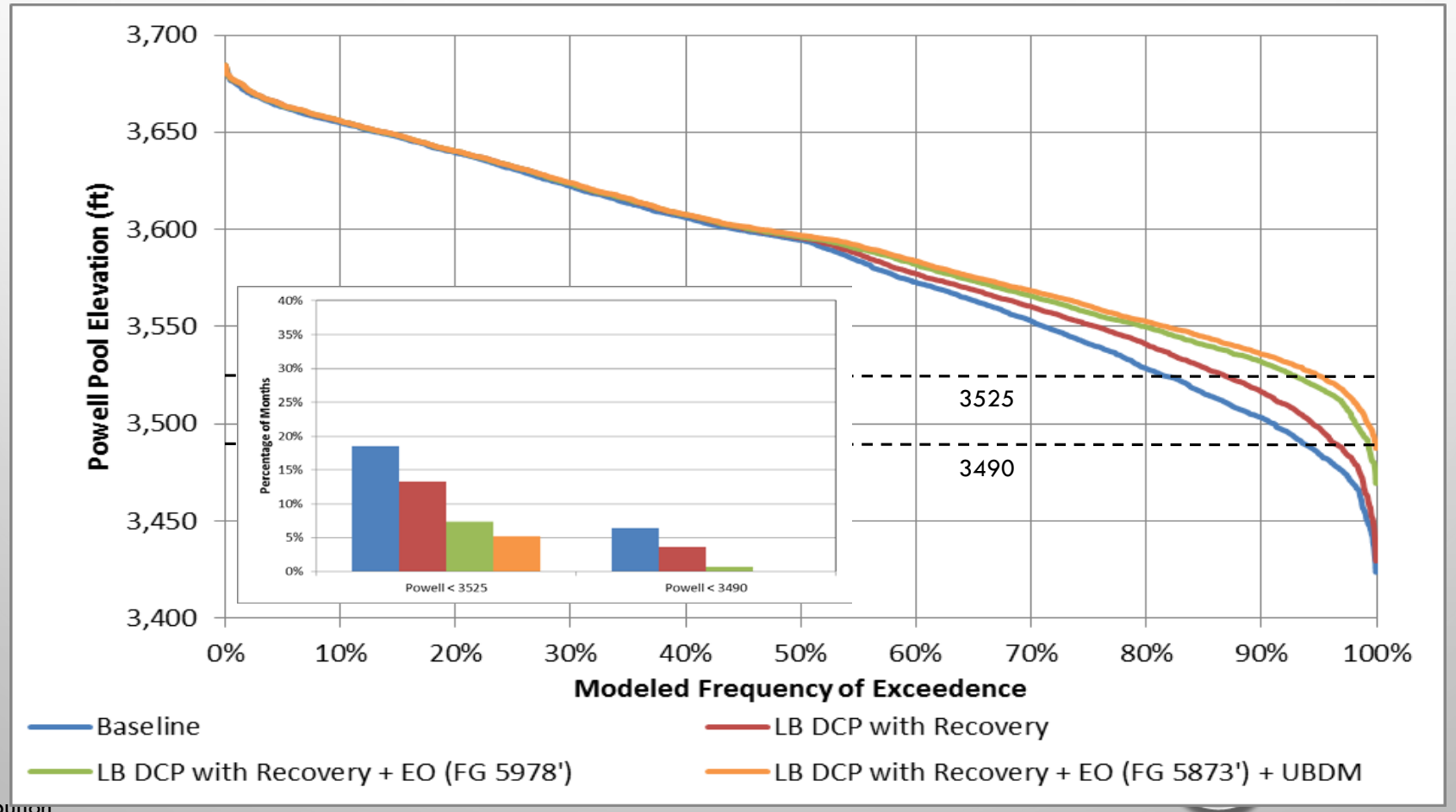
LOWER BASIN DCP CONSERVATION SCHEDULE

Lake Mead Elevation	AZ (2007)	AZ (Plan)	AZ Total	NV (2007)	NV (Plan)	NV Total	CA (2007)	CA (Plan)	CA Total	USBR	Mexico Minute 319*	Total
1,090-1,075	0	192,000	192,000	0	8,000	8,000	0	0	0	100,000	0	300,000
1,075-1,050	320,000	192,000	512,000	13,000	8,000	21,000	0	0	0	100,000	50,000	683,000
1,050-1,045	400,000	192,000	592,000	17,000	8,000	25,000	0	0	0	100,000	70,000	787,000
1,045-1,040	400,000	240,000	640,000	17,000	10,000	27,000	0	200,000	200000	100,000	70,000	1,037,000
1,040-1,035	400,000	240,000	640,000	17,000	10,000	27,000	0	250,000	250000	100,000	70,000	1,087,000
1,035-1,030	400,000	240,000	640,000	17,000	10,000	27,000	0	300,000	300000	100,000	70,000	1,137,000
1,030-1,025	400,000	240,000	640,000	17,000	10,000	27,000	0	350,000	350000	100,000	70,000	1,187,000
<1,025	480,000	240,000	720,000	20,000	10,000	30,000	0	350,000	350000	100,000	125,000	1,325,000

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.



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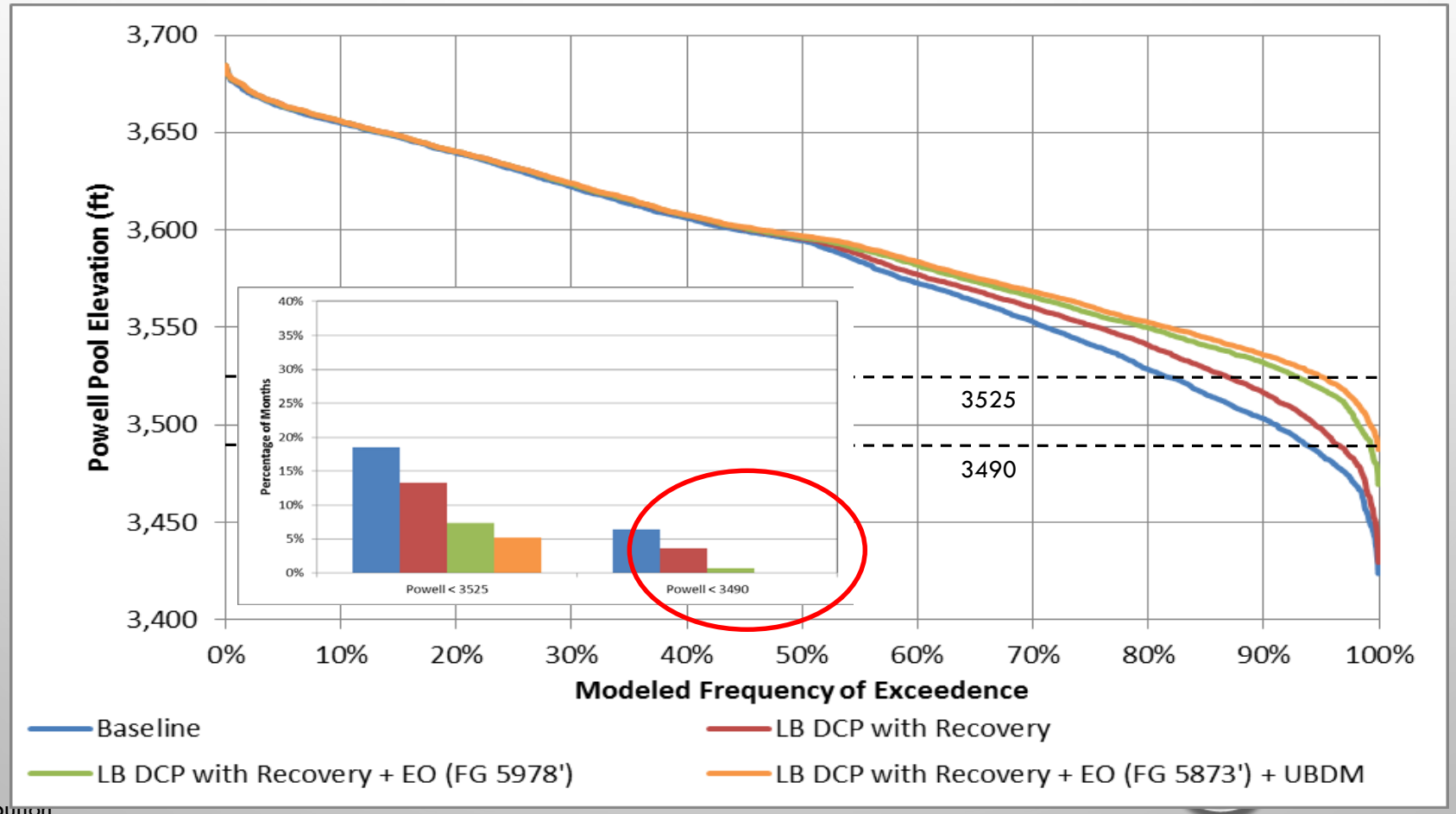


COLORADO RIVER RISK STUDY

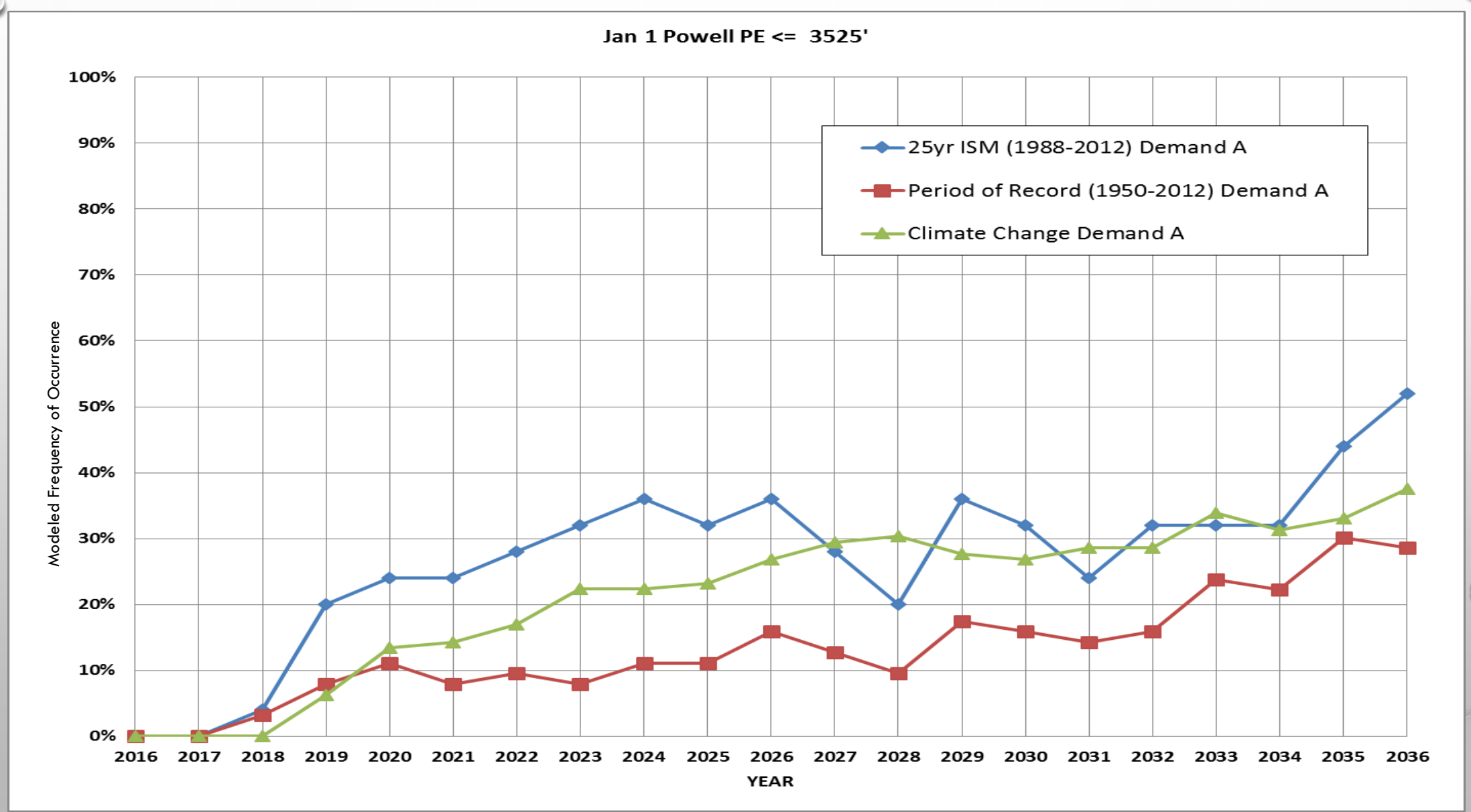
- Originated from joint West Slope BRT discussions and reflection on DCP process
- Funding via Colorado River District, Southwestern, West Slope BRTs (CWCB)
- Colorado's Water Plan: Take actions that will minimize risk of compact curtailment actions (pt. 4 of Seven Point Framework)
- Phase I completed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

WEST SLOPE BRT STUDY – PHASE I

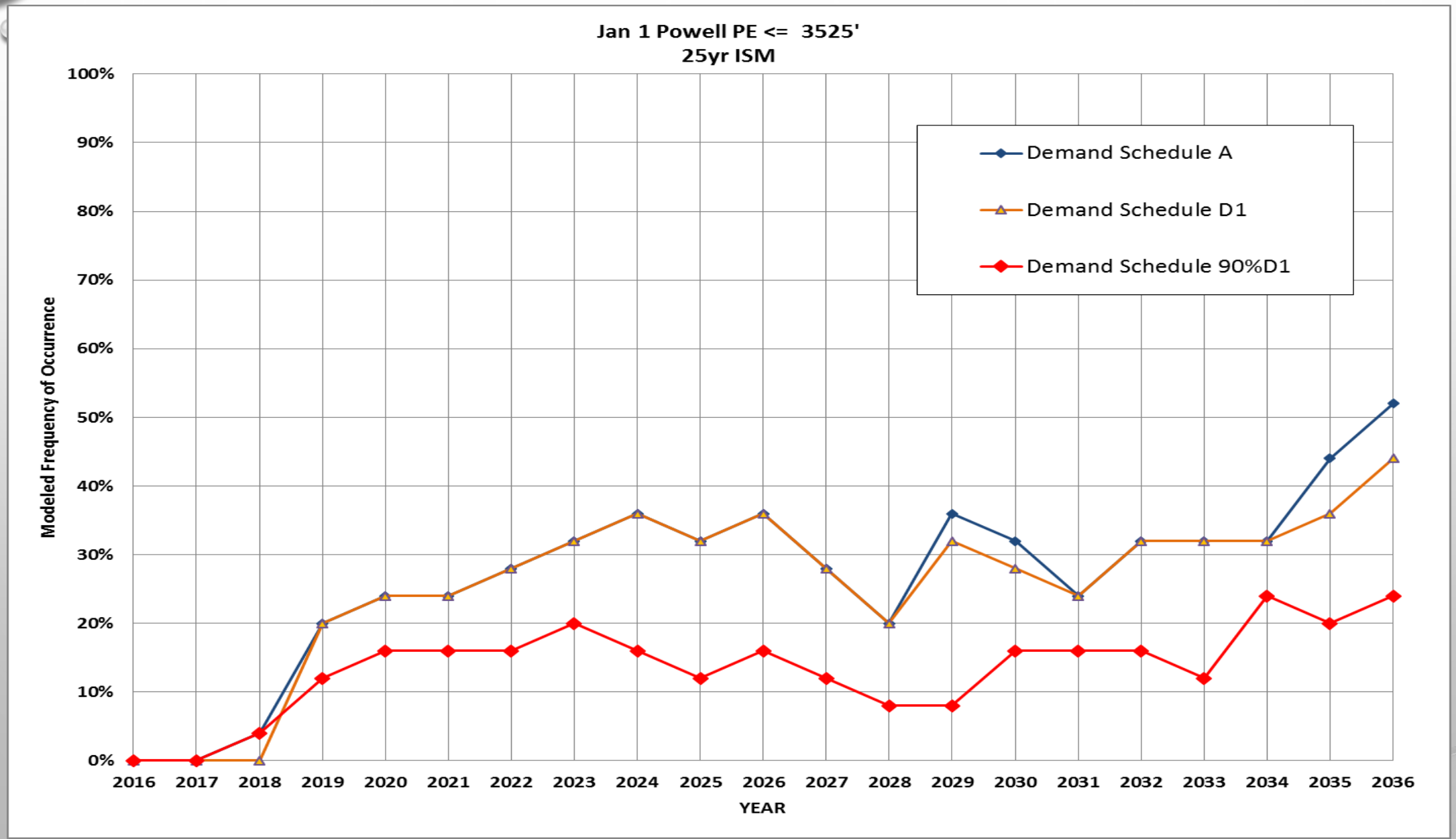
- Questions to answer in Phase I:
  - What are magnitude and duration of Powell shortages below elevation 3525'?
  - How much of the above shortages can be met by contributions from Drought Operations of CRSP reservoirs? (A: up to about 2 MAF)
  - How much consumptive use reduction ("demand management") 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 Reclamation's "Big River" CRSS Model to address these "What If" questions…

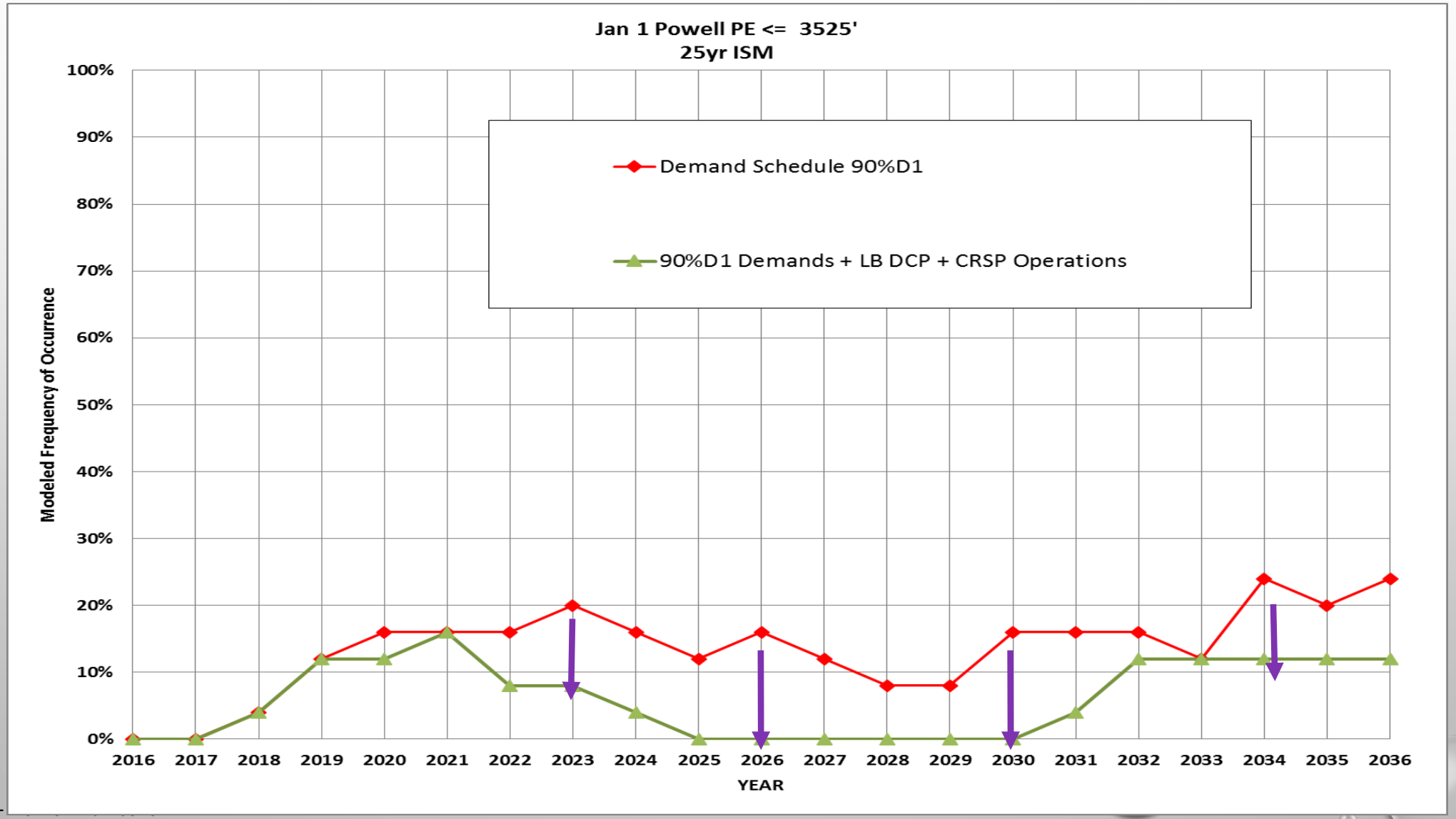
EXAMPLE : HYDROLOGIC SENSITIVITY



EXAMPLE : DEMAND SENSITIVITY

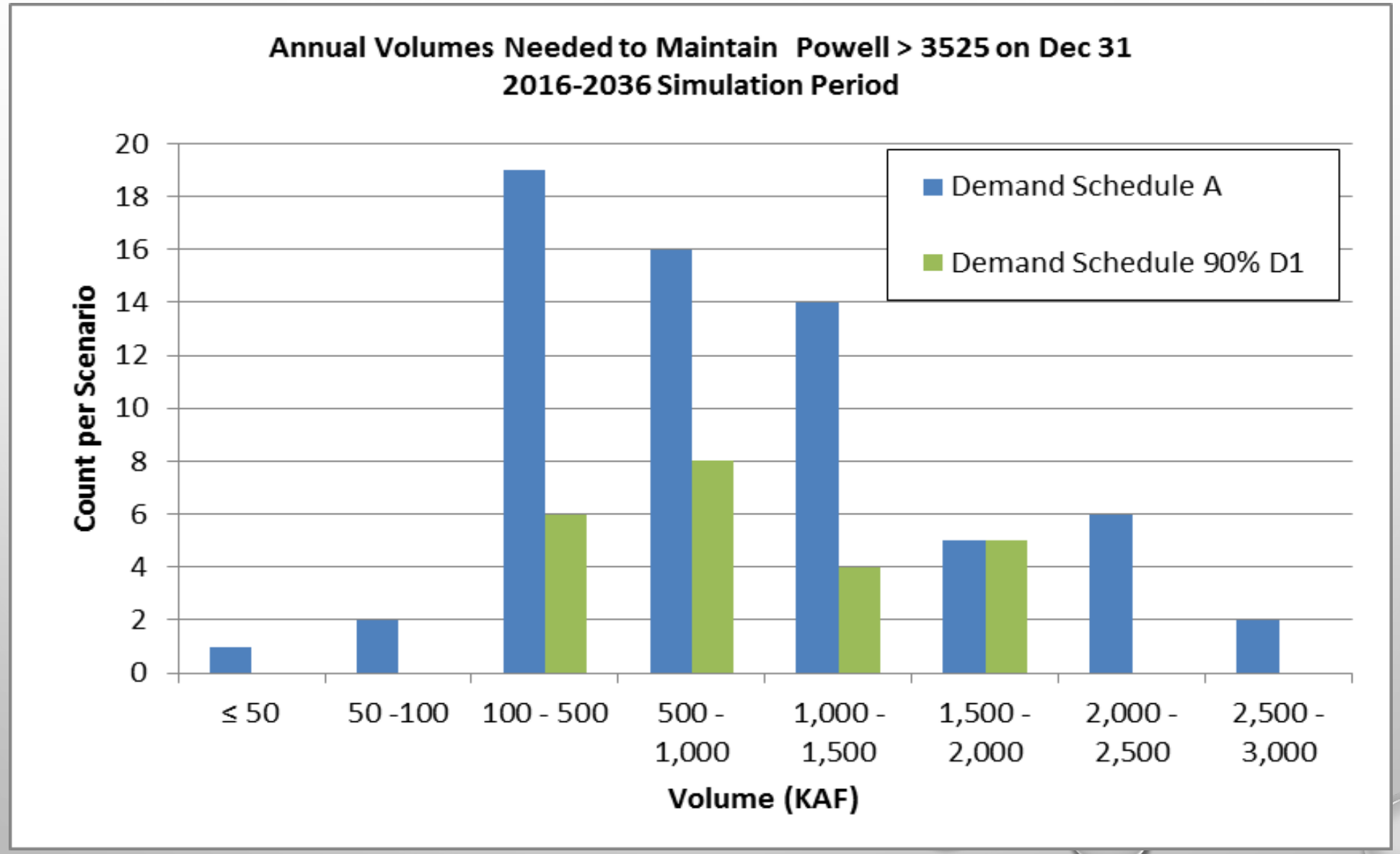


CRSP DROUGHT OPERATIONS AND LOWER BASIN CONSERVATION REDUCES THE RISK, BUT DOES NOT ELIMINATE IT



Preliminary Results –

WHAT WOULD IT TAKE TO COMPLETELY ELIMINATE RISK?



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"*

1. Uniform reduction in demands / consumptive use across all users
    a. What is state line "yield" with 5%, 10%, 15% reductions?
    b. How does this yield change with hydrology and by basin?
2. What is yield with and without shepherding?
    a. "Non-Shepherded" Scenario: Junior rights who may have been shorted initially may receive additional water by virtue of upstream reductions, even though their own demands are also reduced
    b. Shepherded Scenario: reductions arrive undepleted at state line (loss factor may be applied if desired)

PHASE II STATEMOD WORK

- *"Evaluate the utility of using StateMod in addressing questions related to voluntary demand management. Understand capabilities and limitations"*

3. How can we represent water banking mechanisms in the model?
    a. Size and location of reservoir(s)
    b. Ability to operated water bank using triggers?
4. Comparison to and linking with CRSS
    a. Data compatibility (hydrology, demands, etc.)
    b. "linked" simulations: ex: Powell elevations drive demand management, and increased flows accrue to Powell.

ALL YEARS (1988-2012)

- Reduce CU (demand management) on all direct flow rights
- Efficiency is percent of conserved water reaching state line (non-shepherded).

	5%			10%			15%		
	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield
Yampa	8,774	10,134	87%	17,930	20,269	88%	27,189	30,403	89%
White	2,917	2,982	98%	5,894	5,963	99%	8,940	8,945	100%
Upper Colorado	42,873	52,673	81%	87,250	105,346	83%	133,701	158,019	85%
Gunnison	20,631	28,655	72%	42,056	57,310	73%	64,256	85,964	75%
San Juan & Dolores	14,476	23,439	62%	31,387	46,879	67%	49,449	70,318	70%
TOTAL	89,671	117,883		184,517	235,766		283,535	353,650	

DRY YEARS

- Reduce CU (demand management) on all direct flow rights
- Efficiency is percent of saved water reaching state line (non-shepherded).

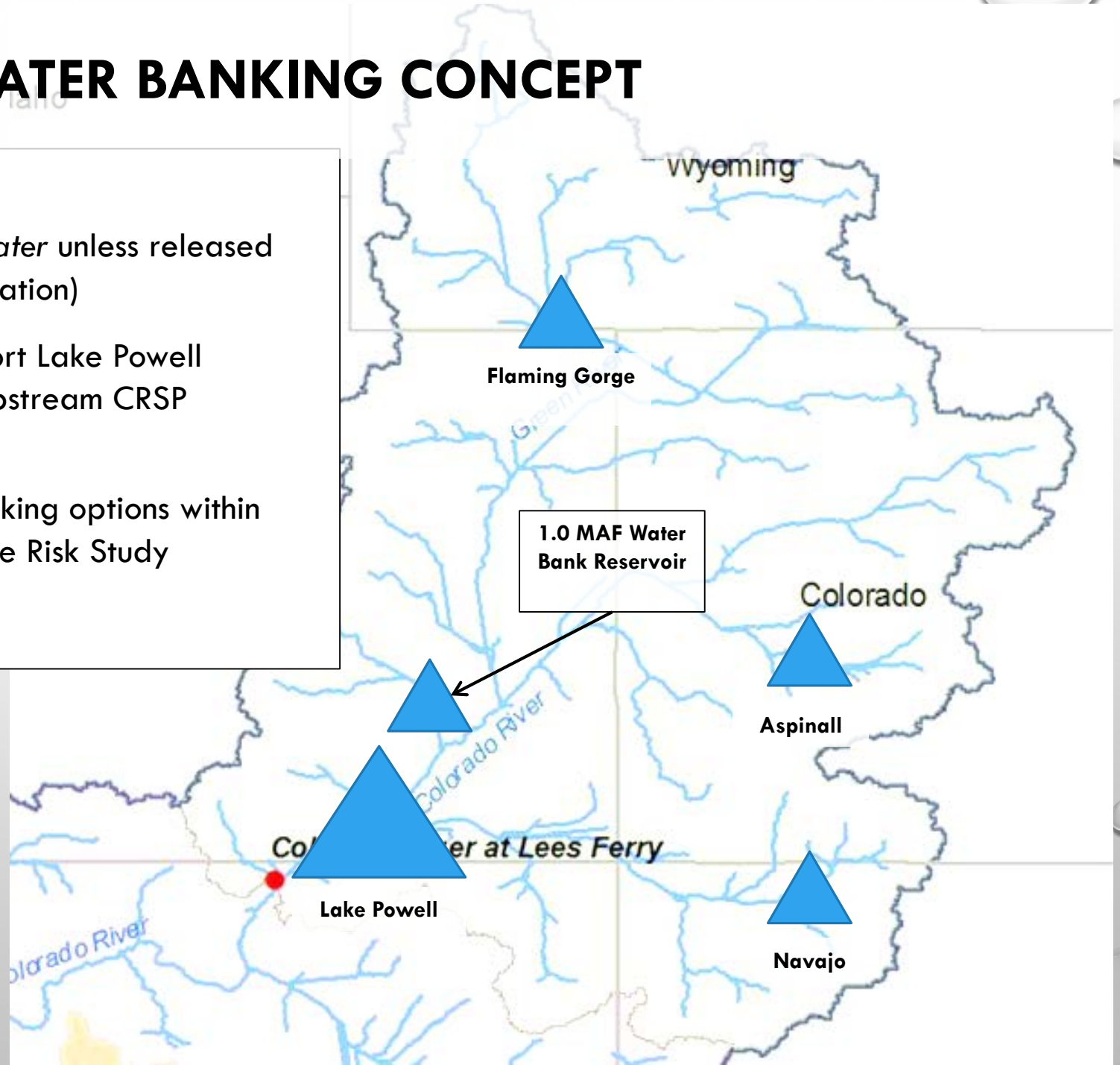
	5%			10%			15%		
	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield	Outflow (AF)	DM (AF)	% yield
Yampa	7,101	9,809	72%	14,852	19,617	76%	22,678	29,426	77%
White	2,720	2,916	93%	5,545	5,833	95%	8,434	8,749	96%
Upper Colorado	21,110	51,685	41%	40,213	103,370	39%	67,529	155,055	44%
Gunnison	8,427	26,345	32%	21,877	52,689	42%	37,658	79,034	48%
San Juan & Dolores	9,541	20,706	46%	19,744	41,412	48%	28,870	62,118	46%
TOTAL	48,899	111,461		102,231	222,921		165,168	334,382	

TAKE-AWAYS

- Distribution of yield:
  - Colorado Main stem ~ 40%-50%
  - Gunnison and SJ/Dolores ~ 10%-25% each
  - Yampa / White ~ 10%-20%
- Shepherding is important
  - Especially in dry years
  - And in basins with relatively higher demands as a % of flow (Colorado main stem, Gunnison*, San Juan/Dolores)
  - *Gunnison impacted by Aspinall (Blue Mesa) storage right
  - Note: Shepherding work by Anne Castle, Larry MacDonnell and others

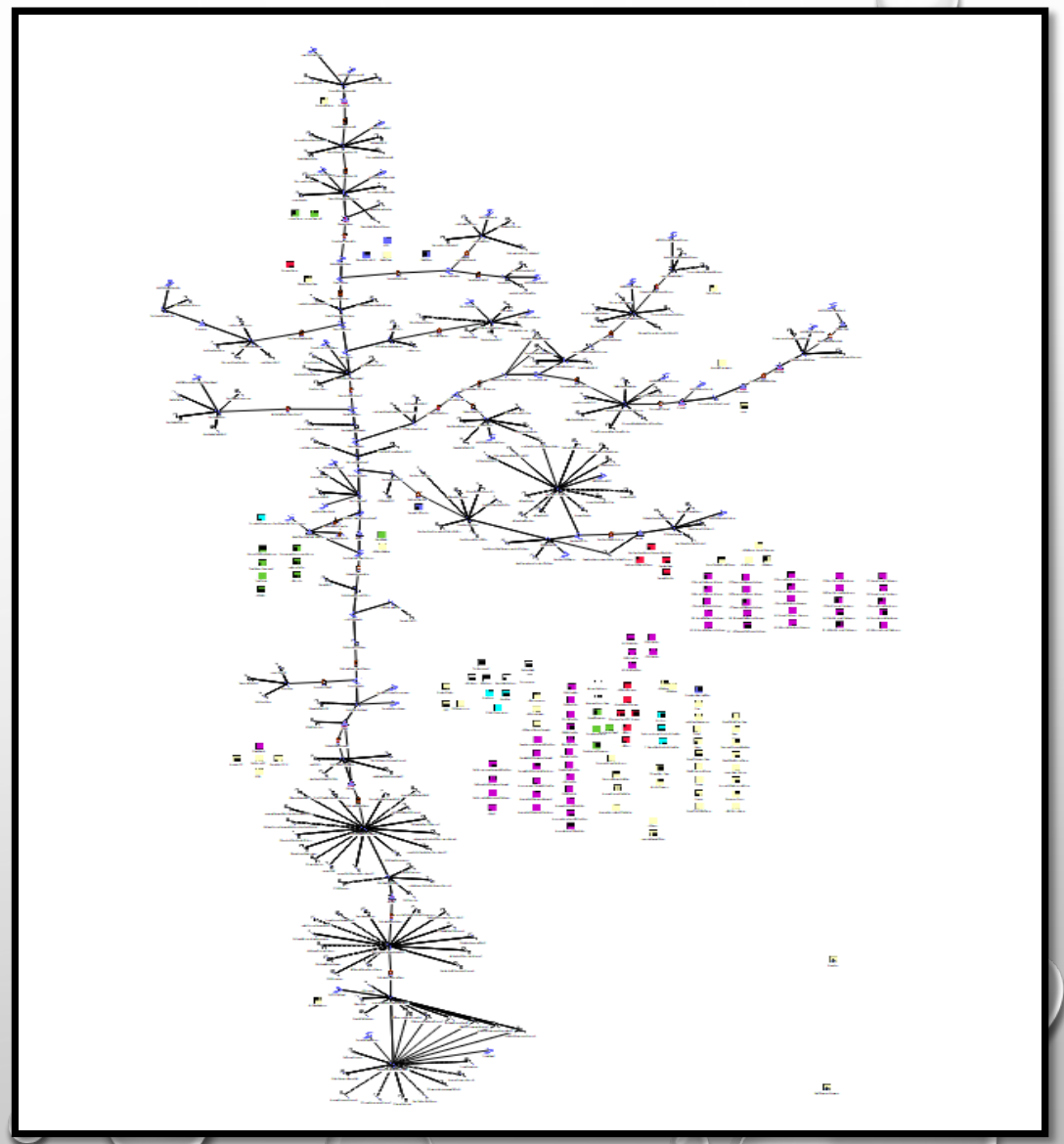
WATER BANKING CONCEPT

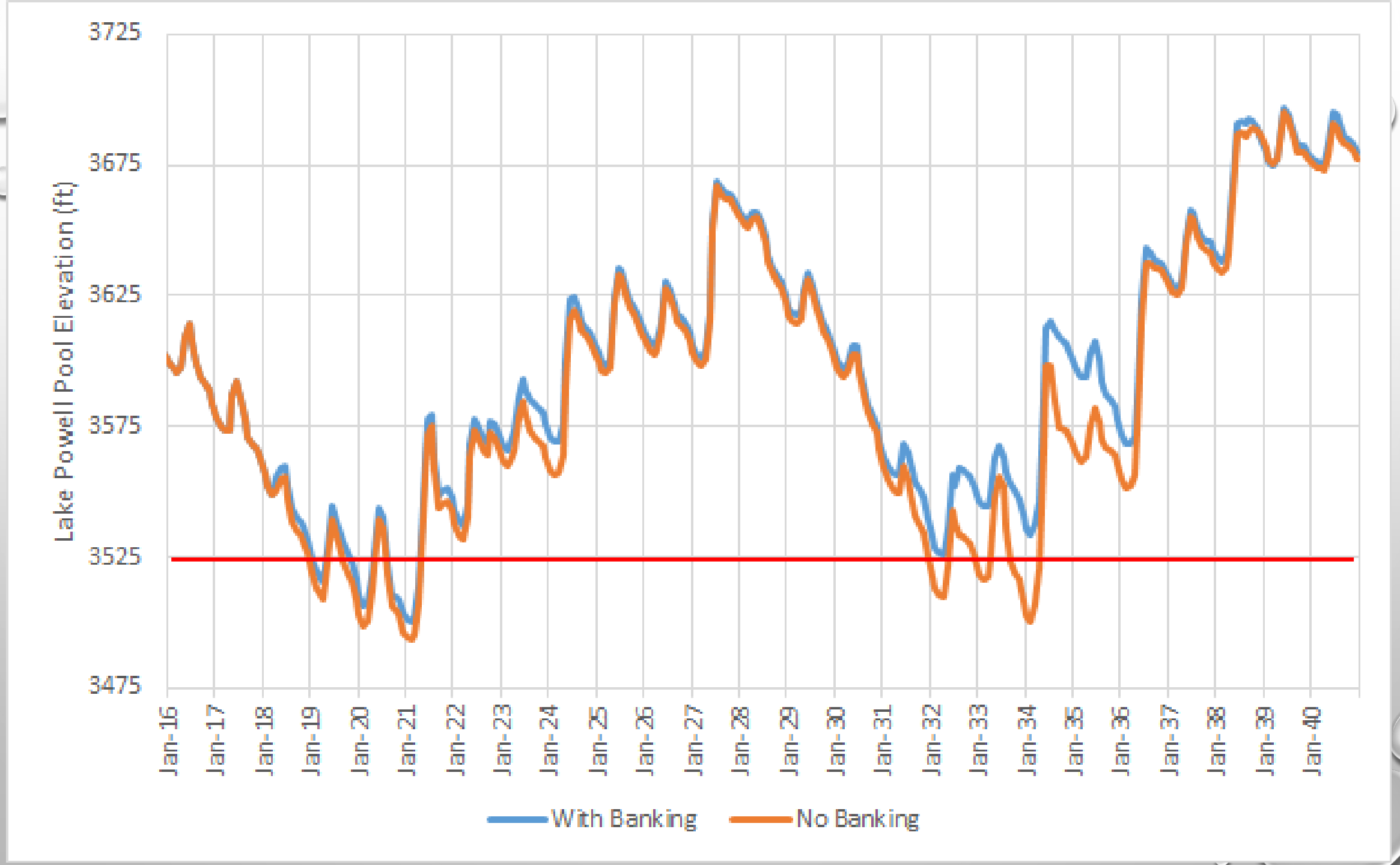
- Conserved CU is stored in the Bank
- Banked water does not become *system water* unless released from the Bank. (i.e., not subject to equalization)
- Water Bank releases water only to support Lake Powell elevation, after Drought Operations of upstream CRSP Reservoirs.
- We are looking at Colorado-specific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



CRSS / STATEMOD COUPLING

- Colorado River Simulation System (CRSS)
  - Good: representation of “Big River” operations; Powell/Mead; Drought Operations of CRSP facilities
  - Bad: does not simulate water right administration in Colorado
- StateMod
  - Good: Simulates priority administration of water, additional yield from demand management activities; the only tool available for detailed analysis of demand management and shepherding issues within Colorado. Can couple with other CDSS tools for estimating CU savings under conservation programs (e.g., StateCU, Lease-Fallow Tool)
  - Bad: model is Colorado-specific; No “knowledge” of Powell/Mead or other “big river” conditions; limited ability to “control” banked water
- Concept: Utilize StateMod for development of demand management yields, use CRSS to manage the resulting bank and usage of water at Powell




3725
3675
3625
3575
3525
3475
Lake Powell Pool Elevation (ft)
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26
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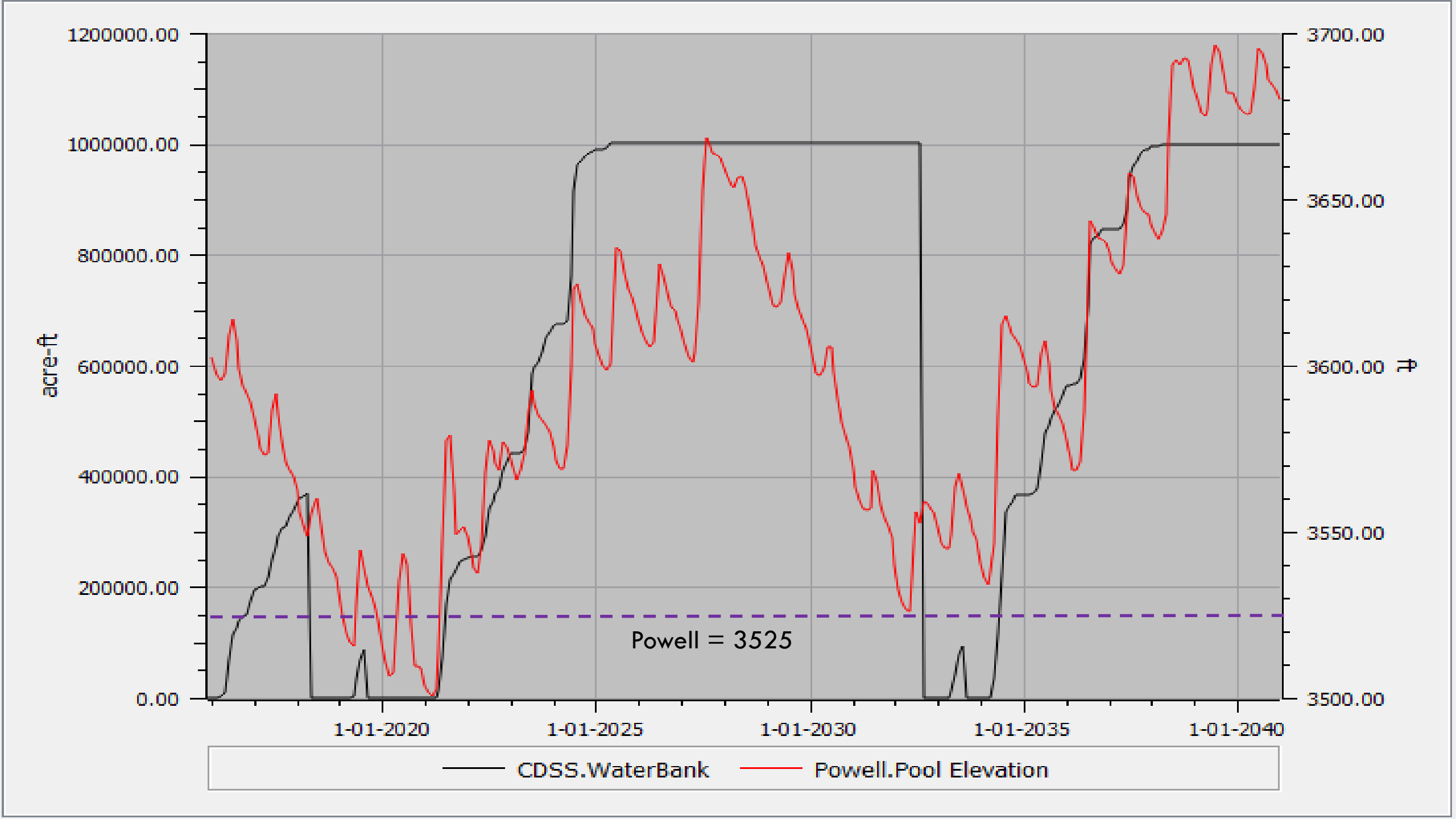
Jan-38
Jan-39
Jan-40
With Banking
No Banking


1200000.00
1000000.00
800000.00
600000.00
400000.00
200000.00
0.00
acre-ft
3700.00
3650.00
3600.00
3550.00
3500.00
ft
1-01-2020
1-01-2025
1-01-2030
1-01-2035
1-01-2040
Powell = 3525
CDSS.WaterBank
Powell.Pool Elevation

STATEMOD/CRSS LINKAGE SUMMARY

- Need to simulate "Big River" policy and operations together with sub-basin specific water rights administration questions.
- StateMod and CRSS each have strengths and weaknesses in this application, but together they can be an effective tool.
- There are some remaining challenges. For example:
  - Ensure "synchronization" of data across models, especially hydrology and demands
  - How to handle dynamic demand management and yields with specific water users, partial-season fallowing, return flow impact, other conservation activities

THE BIG PICTURE

- Hydrology, Current Consumptive Use, and Future Demands matter. We can't control hydrology, but 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, demand management could 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 <u>combined with a Water Bank</u>:
  - Could limit the Annual impact to CU by spreading Conservation over many years
  - Would provide greater control over conserved water (a "must have" condition)

WHAT'S NEXT?

- DRAFT Phase I & II Report to Technical Advisory Committee (March)
- Individual BRT Webinars (March)
- Joint West Slope BRT Meeting (Tentative April 25)
- CWCB Board Presentation (March 21)
- Phase III
  - Basin-specific questions as requested by BRTs.
  - Funding?
  - Participants?

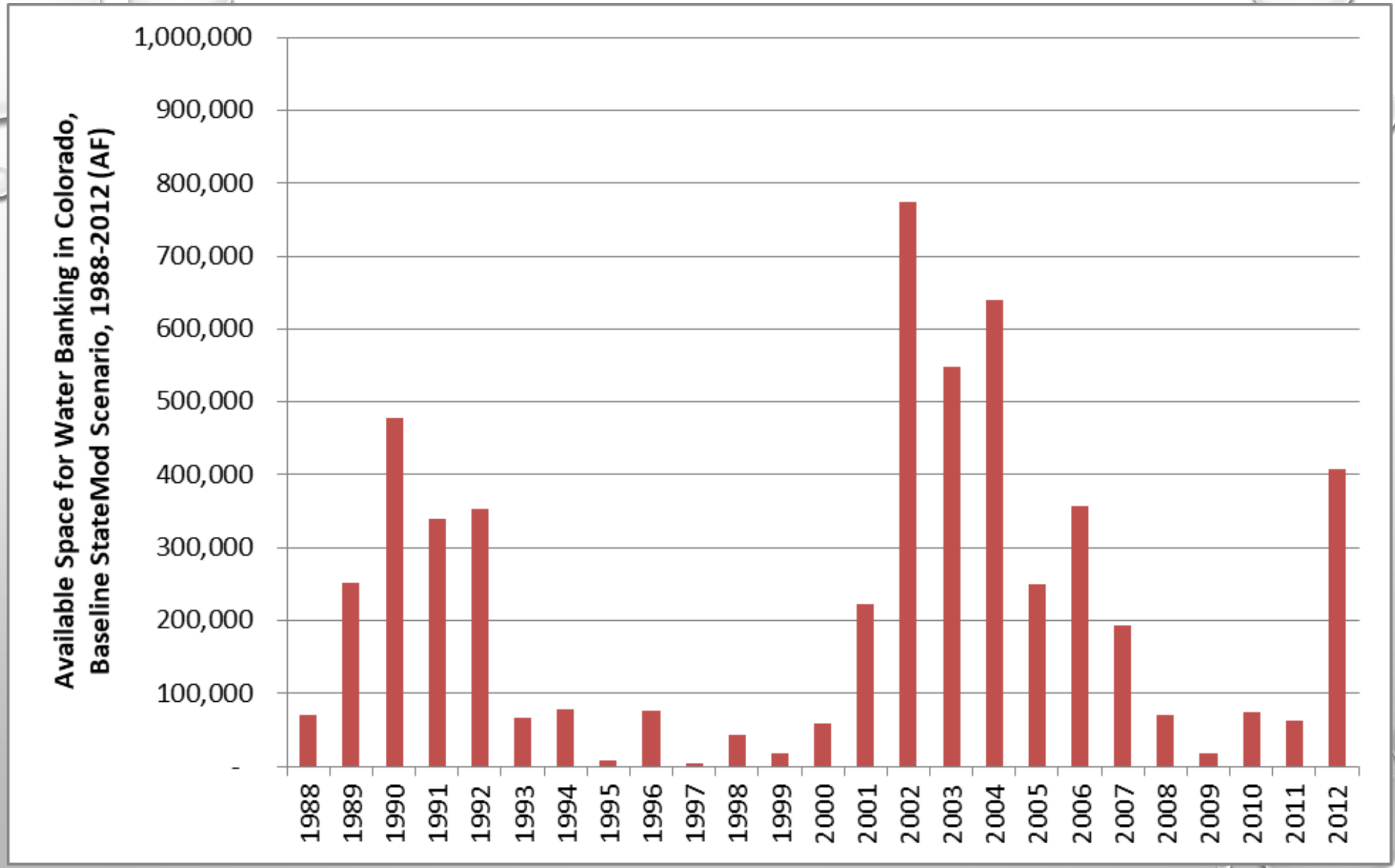
END

WATER BANK OUTCOMES

Stress Test Hydrology (1988-2012)	Count of Bank Release Years	Count of Release Years that did not fill to 3525'	Shortage 3525 after Bank Release (AF)
Scen 5: Water Bank; A Dem.	127	113	2,035,526
Scen 5: Water Bank; 90%D1 Dem.	61	50	1,570,560
Scen 6: UB & LB DCP; Water Bank; A Dem.	62	46	1,270,984
Scen 6: UB & LB DCP; Water Bank; 90%D1 Dem.	26	13	607,293

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


Available Space for Water Banking in Colorado, Baseline StateMod Scenario, 1988-2012 (AF)
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
1988
1989
1990
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