BUREAU OF RECLAMATION

Deep Dive on Shasta Operations

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Overview

- Exploratory Modeling
- Cost on Shasta Calculation
- Position Analysis with Different Initial Conditions
- Tradeoff Analysis

BUREAU OF
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Exploratory Modeling

Purpose

- Exploratory modeling establishes an analytical foundation to support common understanding of where Reclamation and DWR have discretion in operations of project facilities

- Intended Use of Exploratory Analysis:
  - Showing the layering of permits and programs on hydrology results and tradeoffs on the availability of water within a year and with subsequent years
  - Developing scenarios that may assist discussions with FWS, NMFS, CDFW, Water Board, and interested parties
  - Inform development of an ESA Proposed Action

Exploratory Modeling Approach

- Layer high-level operational objectives in scenarios of increasingly complex system requirements
- Review capabilities and constraints of each layer

Methodology - Tools

- Simulation tool: CalSim II
- Planning horizon: Year 2030
- Planning simulation period: 82 years (1922-2003)
- Hydrology: 2035CT projected changes in temperature and precipitation
- Sea level rise: Increase of 15 cm
- Post-processing tool: FlowTracker
  - FlowTracker is a post-processor that tracks water from source to destination

Methodology - Layers

- EXP1 – Run of River
  - Description:
    - Identifies hydrologic conditions in the absence of the operation of projects
  - Inflow will be passed through CVP/SWP reservoirs
    - Not considering outletworks capacity
    - Releases can be limited by downstream channel capacity
  - Level 1 Refuges can divert, as hydrologically available
  - Senior water right holders can divert, as hydrologically available
  - Demands met upstream to downstream
  - No diversions or rerouting of flows would occur at CVP/SWP facilities

Methodology - Layers

- EXP2 – Maximize Storage
  - Description:
    - Operate the CVP/SWP reservoirs to store water
  - Pass-through inflow diverted to Level 1 Refuges, senior water rights, navigation, and D-1641 (as in EXP1)
  - EXP2A-meets senior water rights deliveries first
  - EXP2B-meets flow and D-1641 requirements first
  - Stored water is only released for flood control – no other uses

Methodology - Layers

- EXP2.5 – Maximize Storage; Release Stored Water for Unmet Standards
  - Description:
    - Operate the CVP/SWP reservoirs to store water
  - Pass-through inflow diverted to Level 1 Refuges, senior water rights, navigation, and D-1641 (as in EXP1)
  - Release stored water to meet minimum flows and D-1641 standards
    - EXP2.5A-pass-through inflow used to meet senior water rights first
    - EXP2.5B-pass-through inflow used to meet flow and D-1641 requirements first

Methodology - Layers

- EXP3 – Meet Non-Discretionary Obligations
  - Description:
    - Reclamation and DWR make releases from reservoir storage to meet non-discretionary obligations
  - Release stored water to meet:
    - Minimum instream flow requirements
    - Senior water rights
    - Refuge Level 2
    - D-1641
  - Releases are used upstream to downstream
  - COA applied to project sharing of responsibility for Delta criteria
  - No project exports

Methodology - Layers

- EXP4 – Divert Excess
  - Description:
    - Project demands can divert water that cannot be stored and is not required for non-discretionary purposes
  - SOD Refuge Level 2 and Exchange Contractors met from Delta exports first and then with Friant water
  - All CVP/SWP facilities are used
  - COA governs project operations in Delta

Methodology - Layers

- EXP4 – Divert Excess
  - EXP4v1 – Does not include OMR restrictions on exports. Exports are delivered to Exchange Contractors and Refuge Level 2 and then stored in CVP San Luis. No deliveries are allowed to CVP service contracts. This version is the simplest way to meet senior CVP contractors with excess flow and full use of San Luis off-stream storage.
  - EXP4v2 – Does not include OMR restrictions on exports. Exports are delivered to all water users and then stored in CVP San Luis. This version demonstrates the maximum amount of Delta excess that could be exported and delivered, but delivery patterns are unrealistic and water supply is depleted early.
  - EXP4v3 – Does not include OMR restrictions on exports. Based on the results from EXP4v1, reserve exports and CVP San Luis storage to meet Exchange Contractors and Refuge Level 2; CVP agriculture (Ag) and municipal and industrial (M&I) can take exports and water stored in CVP San Luis that is not needed for Exchange Contractors and Refuge Level 2. This version attempted to strike a middle ground between versions 1 and 2 – senior water user demands are met first, but patterns of delivery to CVP service contractors reflect the "as available" basis.
  - EXP4v4 – EXP4v1, but with OMR limits on exports.
  - EXP4v5 – EXP4v2, but with OMR limits on exports.
  - EXP4v6 – EXP4v3, but with OMR limits on exports.

Methodology - Layers

- EXP4.95 – Divert Excess with ESA/CESA Criteria
  - Description:
    - Project demands can divert water that cannot be stored and is not required for non-discretionary purposes or ESA/CESA
  - SOD Refuge Level 2 and Exchange Contractors met from Delta exports first and then with Friant water
  - Meet Public Health and Safety
  - All CVP/SWP facilities are used
  - COA governs project operations in Delta

Methodology - Layers

- EXP5 – Manage Storage
  - Description:
    - Operate to ESA/ITP requirements and all other project obligations
  - This is the current Biological Opinion, without Article 21 or LYRA transfers

Methodology - Layers

- EXP5P – Manage Storage
  - Description:
    - Operate to ESA/ITP requirements and all other project obligations
  - This is the current Biological Opinion, with Article 21 and LYRA transfers

Methodology – Assumptions

Description	Storage	Deliveries	River Flows	Exports
EXP1	Store water above deadpool only due to downstream capacity	Senior water rights, including Level 1 Refuges may divert, as able	Follow pattern of natural hydrograph	No CVP/SWP exports
EXP2	Stored water is maximized to extent possible	Same as EXP1	Reservoir inflows are passed through to meet flow requirements	Same as EXP1
EXP2.5	Stored water is released for non-discretionary obligations	Same as EXP1	Stored water is released to meet flow requirements	Same as EXP1
EXP3	Same as EXP2.5	Senior water rights and Level 2 Refuges divert releases of stored water	Same as EXP2.5	Same as EXP1
EXP4	Same as EXP2.5	Same as EXP3, plus project demands can take delivery of excess flows	Same as EXP2.5	Export excess water
EXP5	Operations under current regulatory assumptions	Operations under current regulatory assumptions	Operations under current regulatory assumptions	Operations under current regulatory assumptions

Study Expectations

Runs	Storage	Deliveries	River Flows	Exports	Delta Outflow
EXP1	Dead pool	Senior water right deliveries limited by available flows	Reflect hydrologic mass balance	None	Reflects hydrologic mass balance
EXP2	Maximized up to flood limits	Similar to EXP1	Reduced flows aside from flood control releases and pass-through inflow	None	Reduced outflow aside from flood control releases
EXP2.5A	Storage affected by releases for D-1641 and minimum flows	Senior water right deliveries increase with stored water released for minimum flows	Increased river flows in summer due to stored water releases for D-1641 and minimum flows	None	Delta outflow reflects stored water releases for D-1641 and minimum flows
EXP3	Storage affected by releases for all non-discretionary uses	Senior water rights met by stored water releases	Increased river flows in summer due to stored water releases for non-discretionary uses	None	Delta outflow reflects stored water releases for non-discretionary uses
EXP4v6	Storage may reflect additional releases for Delta water quality due to use of excess water	Project deliveries from excess water enabled	Reflect delivery of excess water upstream to downstream	Export Excess water	Reduced due to delivery and export of excess water
EXP5P	Managed storage	Project deliveries increase with stored water releases and full exports	Reflect full project operations	Exports	Delta outflow reflects full project operations

Model Limitations

- CalSim II developed to represent CVP/SWP system – Exploratory applications stretch intended model use
- ANN for Delta water quality trained on real operations - may not be robust for Exploratory scenarios
- Monthly time-step does not capture daily variability

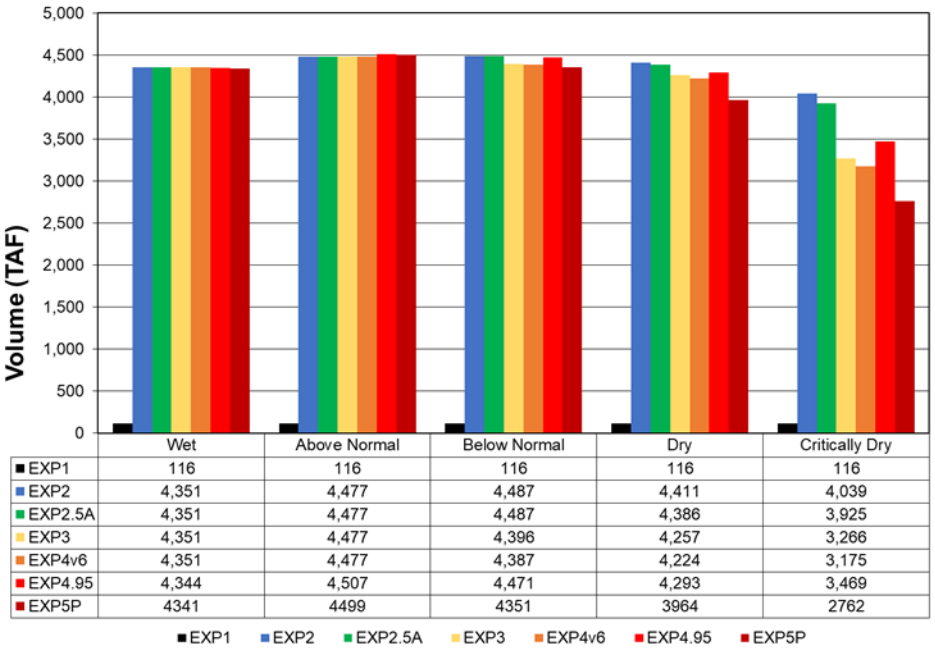
Exploratory layers will inform consultation - will not be used to model proposed operations

Modeling Challenges

- Adaptation of CalSim to “not model” the CVP/SWP
- Comparability of these early bare-bones scenarios is key
- EXP development revealed need for accommodations
  - Stream/Groundwater interaction terms fixed to benchmark study levels
  - Outletworks capacities
  - Delta outflow for WQ (C407_ANN) turned off until EXP4
  - “Upstream to downstream” – weights to avoid equivalent solutions
  - Knights Landing Ridge Cut operations
  - Friant logic to meet Mendota Pool demands and EXP4 variants

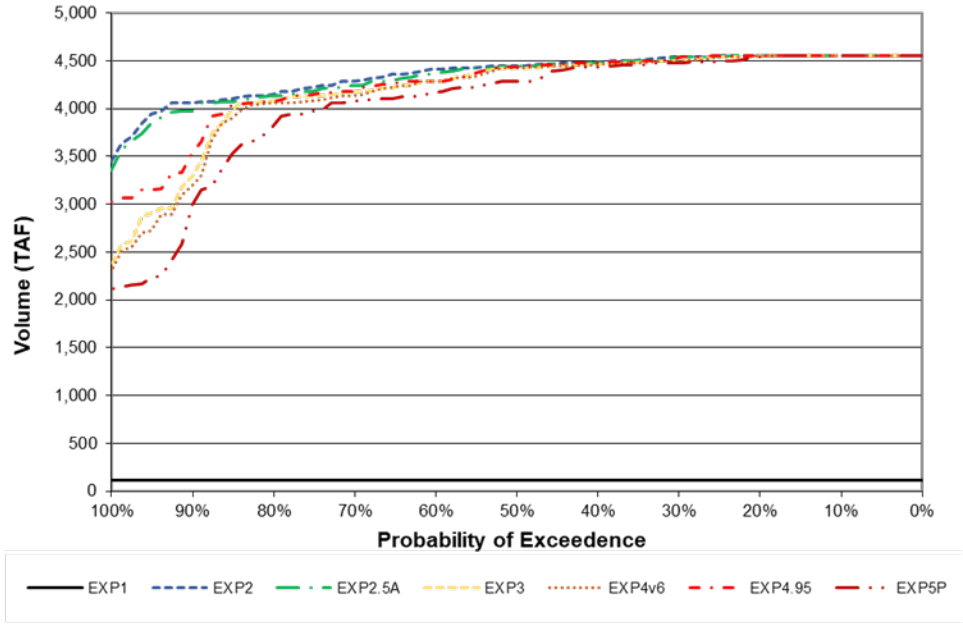
Storage - Shasta

End of April Shasta Storage



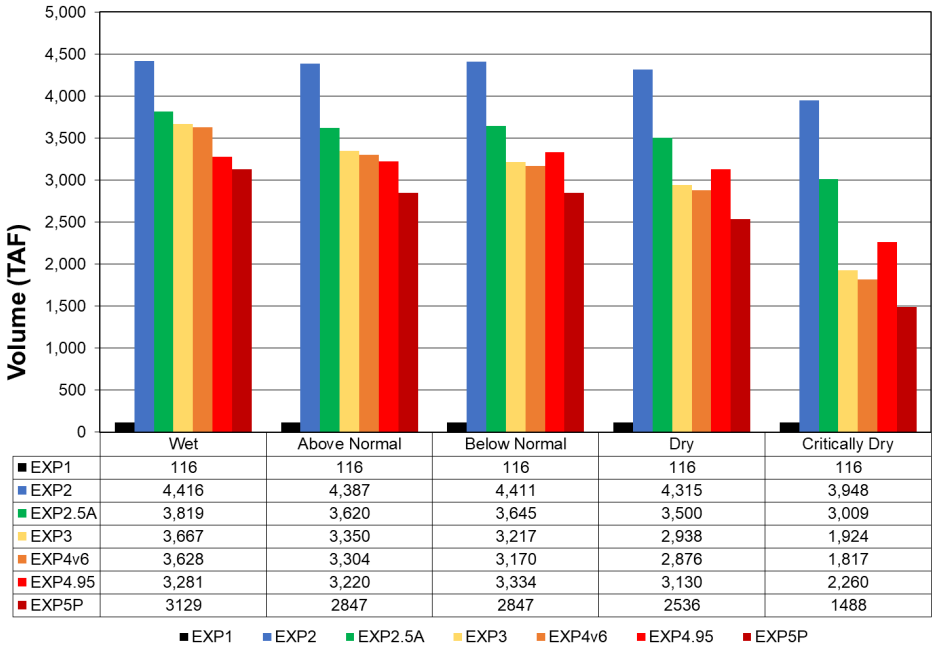
	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	116	116	116	116	116
EXP2	4,351	4,477	4,487	4,411	4,039
EXP2.5A	4,351	4,477	4,487	4,386	3,925
EXP3	4,351	4,477	4,396	4,257	3,266
EXP4v6	4,351	4,477	4,387	4,224	3,175
EXP4.95	4,344	4,507	4,471	4,293	3,469
EXP5P	4341	4499	4351	3964	2762

EXP1 EXP2 EXP2.5A EXP3 EXP4v6 EXP4.95 EXP5P



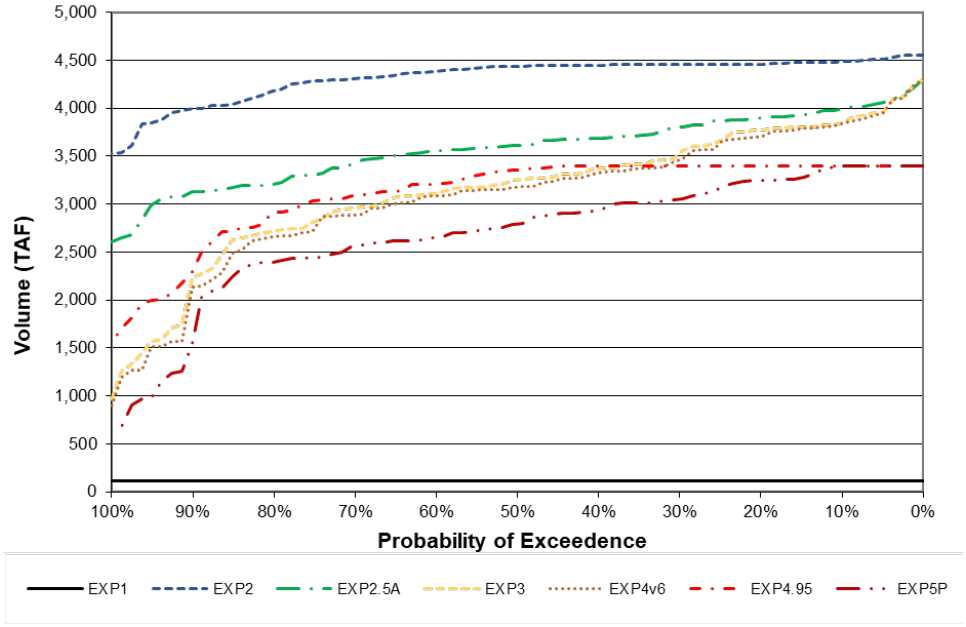
Storage - Shasta

End of September Shasta Storage



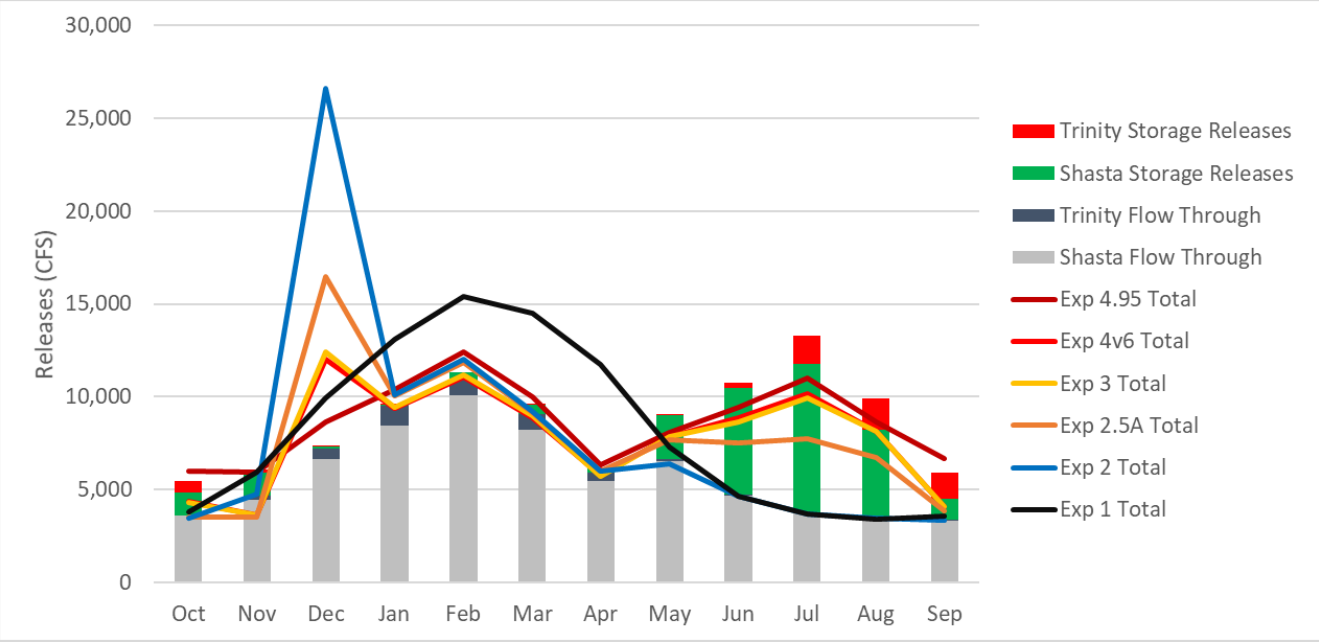
	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	116	116	116	116	116
EXP2	4,416	4,387	4,411	4,315	3,948
EXP2.5A	3,819	3,620	3,645	3,500	3,009
EXP3	3,667	3,350	3,217	2,938	1,924
EXP4v6	3,628	3,304	3,170	2,876	1,817
EXP4.95	3,281	3,220	3,334	3,130	2,260
EXP5P	3129	2847	2847	2536	1488

EXP1 EXP2 EXP2.5A EXP3 EXP4v6 EXP4.95 EXP5P



Sacramento River Flows

Flow Below Keswick



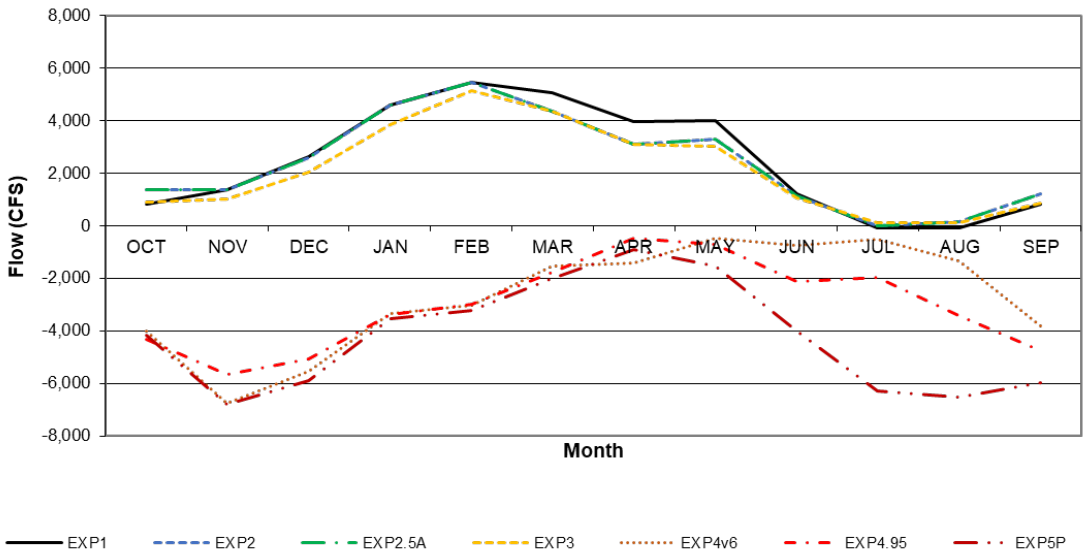
Annual Total[a]	EXP1	EXP2	EXP2.5	EXP3	EXP4v6	EXP5
Shasta Pass-Through Inflow	5,796	4,575	4,596	4,295	4,275	4,133
Shasta Stored Water Releases for Flood Control	0	1,092	442	313	297	100
Shasta Stored Water Release	34	0	630	1,084	1,121	1,472
Trinity Pass-Through Inflow	0	0	0	0	0	250
Trinity Stored Water Releases	0	0	0	0	0	343

[a] In thousand acre-feet.

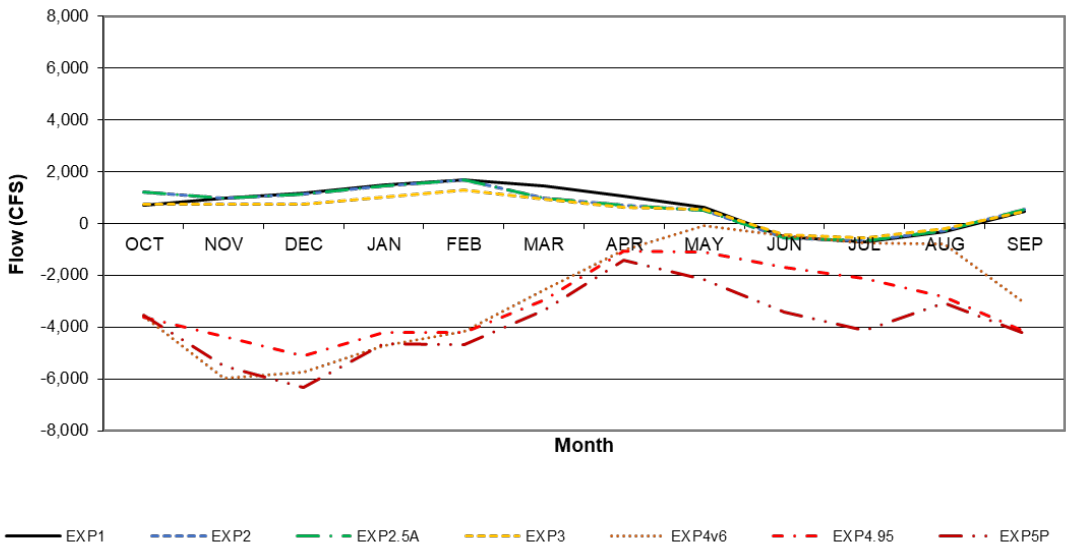
Delta - Flows

Old and Middle River Combined Flow

Long-term Average

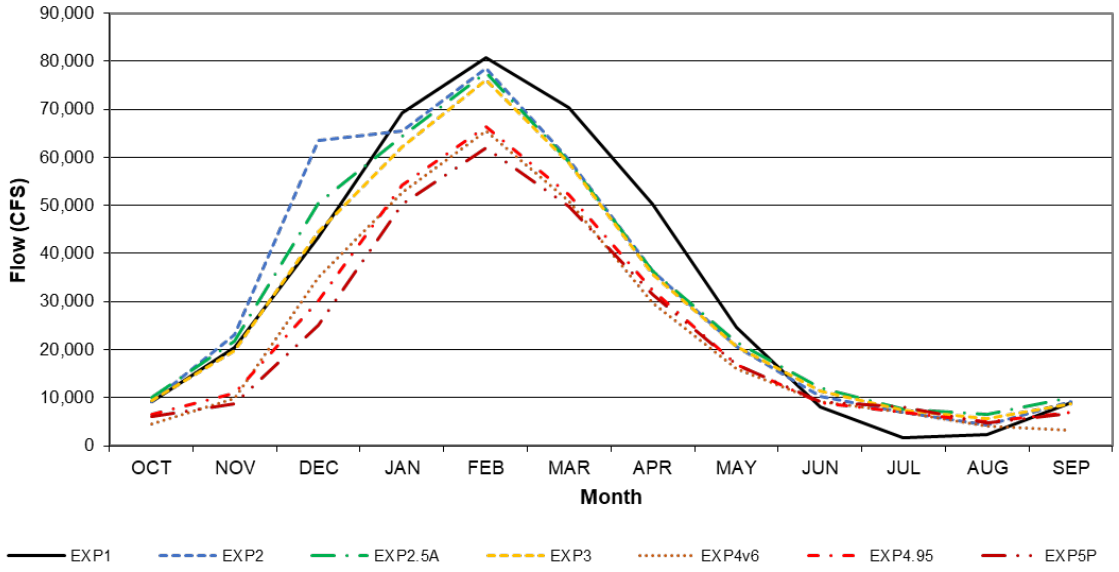


Dry and Critically Dry Years (40-30-30)

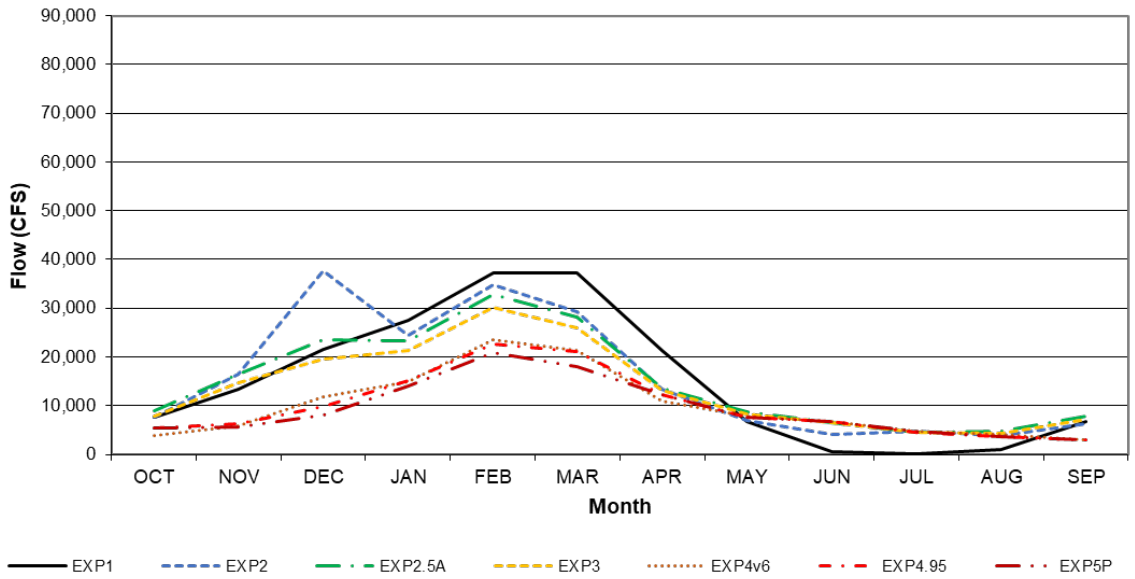


Delta Outflow

Long Term Average

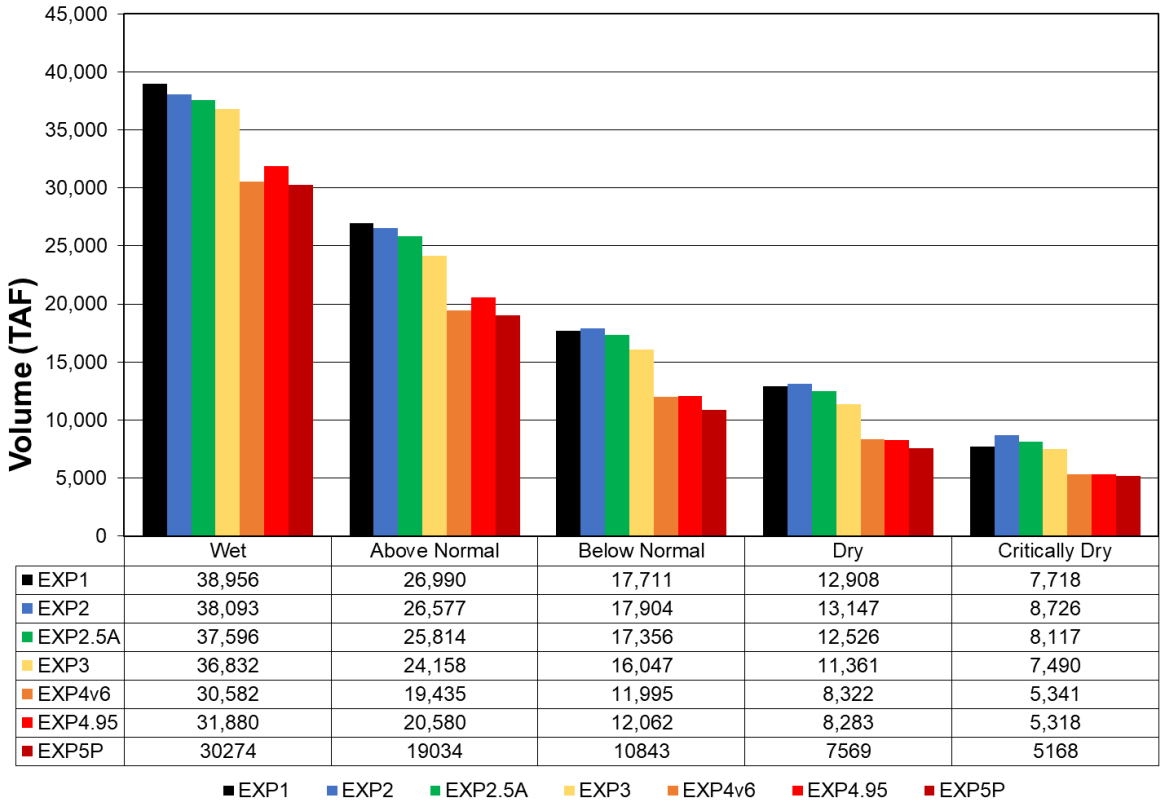


Dry and Critically Dry Years (40-30-30)



Delta Outflow

Annual Averages by Water Year Type

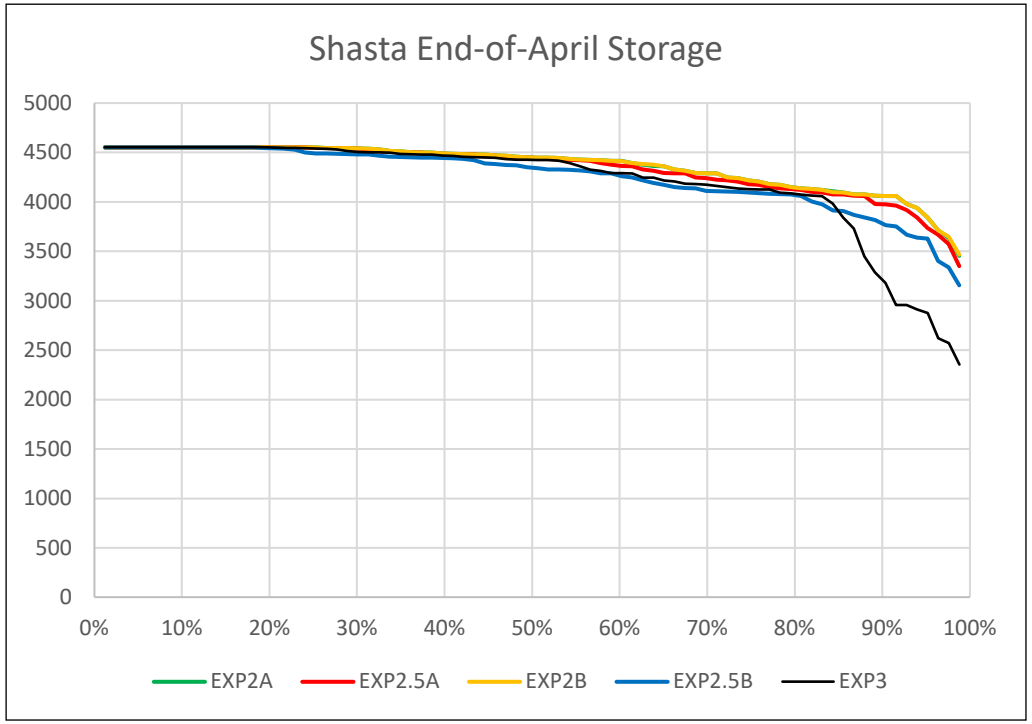


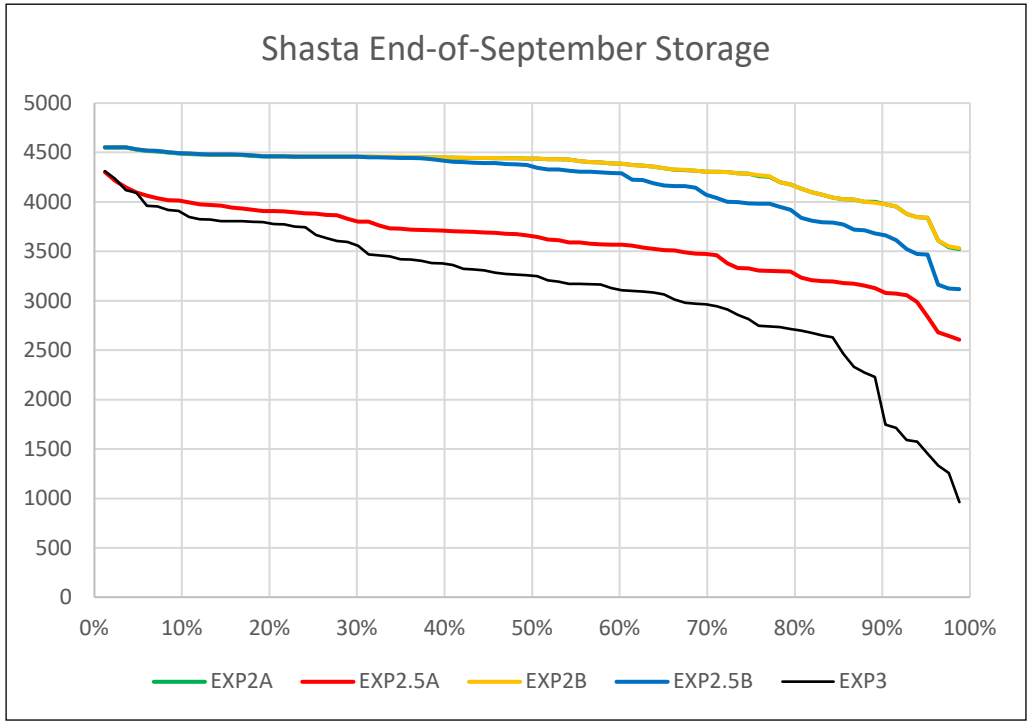
	Wet	Above Normal	Below Normal	Dry	Critically Dry
EXP1	38,956	26,990	17,711	12,908	7,718
EXP2	38,093	26,577	17,904	13,147	8,726
EXP2.5A	37,596	25,814	17,356	12,526	8,117
EXP3	36,832	24,158	16,047	11,361	7,490
EXP4v6	30,582	19,435	11,995	8,322	5,341
EXP4.95	31,880	20,580	12,062	8,283	5,318
EXP5P	30274	19034	10843	7569	5168

EXP2 Variations

- EXP2A – release inflow to meet senior water right deliveries, then allow release of any remaining inflow to meet flow requirements throughout the system, as able
- EXP2.5A – if release of inflow was not sufficient to meet flow req’ts, release stored water to fully meet flow and D1641
- EXP2B – release inflow to meet flow and D1641 standards, then allow release of any remaining inflow to meet senior water right delivery
- EXP2.5B – if release of total inflow was not sufficient to meet flow and D1641 standards, release stored water to fully meet these req’ts

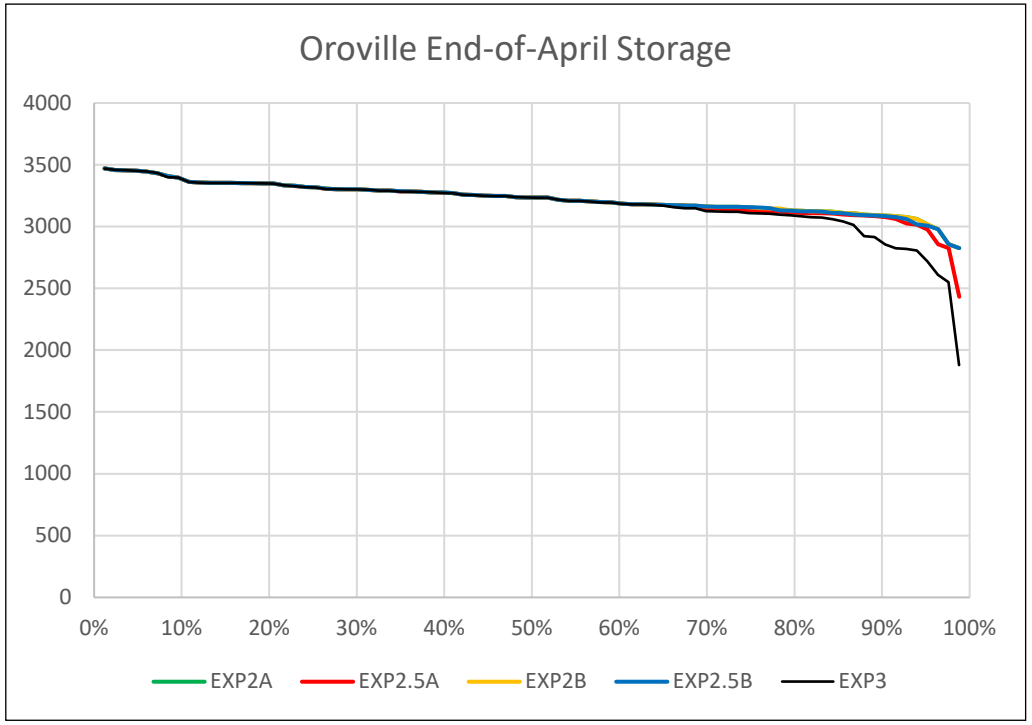
Shasta Storage

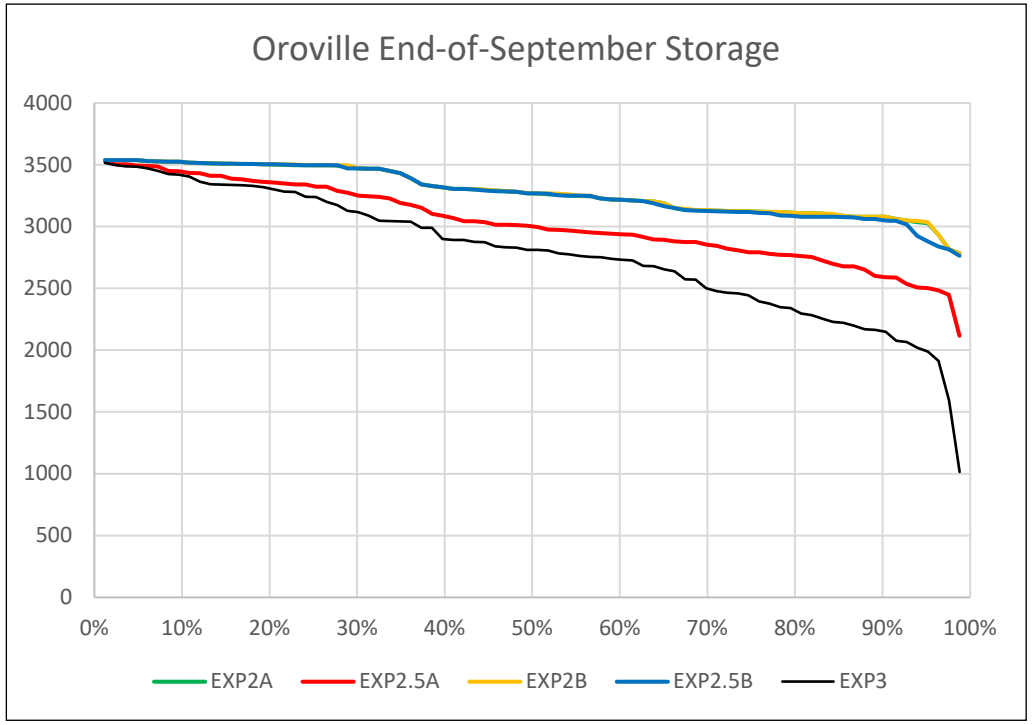




- 2A & 2B are nearly identical – neither allows release of stored water
- 2.5A meets delivery first – limited remaining inflow is augmented with significant storage release to fully meet D1641
- 2.5B meets D1641 first – storage release is required when inflow alone cannot meet standards

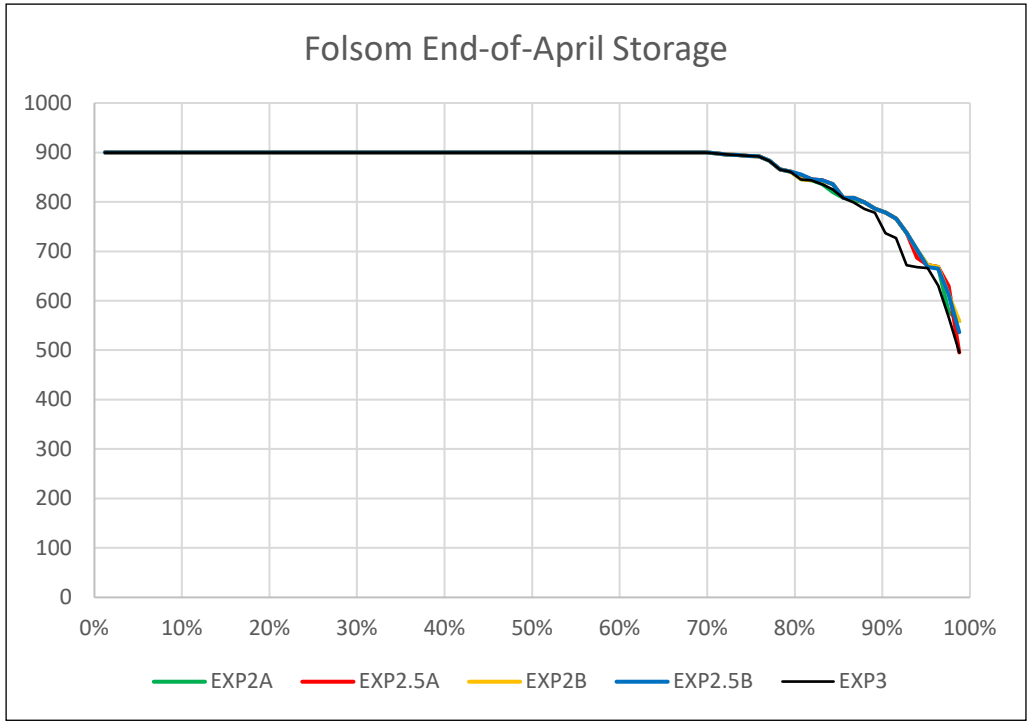
Oroville Storage

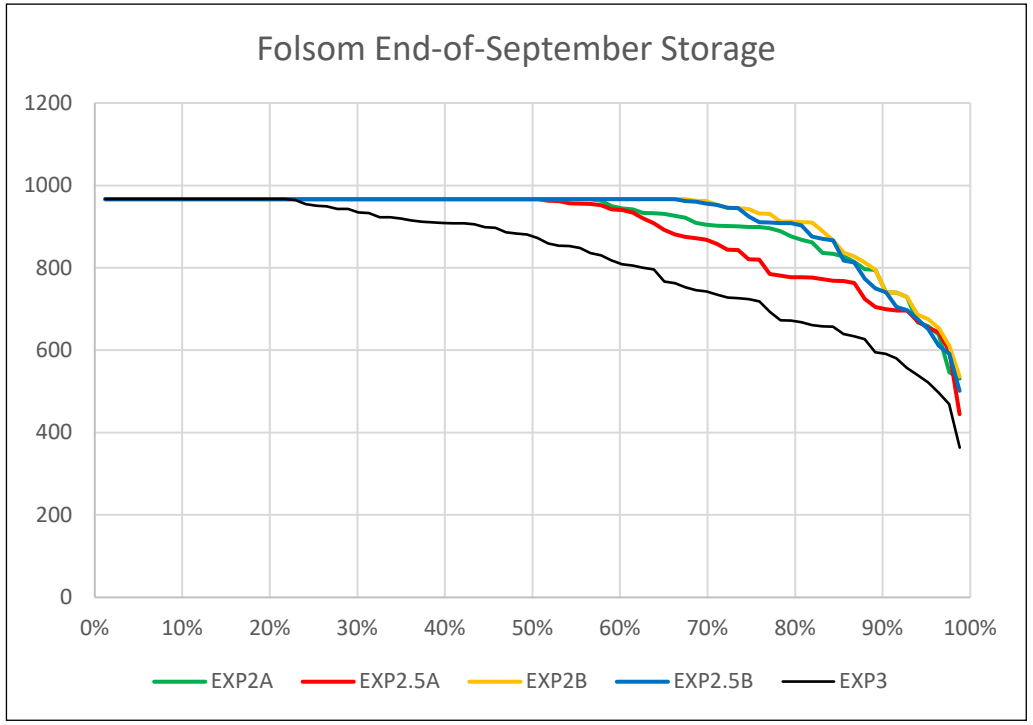




- Oroville has significant storage cost for meeting D1641 in 2.5A
  - Red line lower than green line
- If inflow meets D1641 first, storage cost is small
  - Blue line close to yellow line

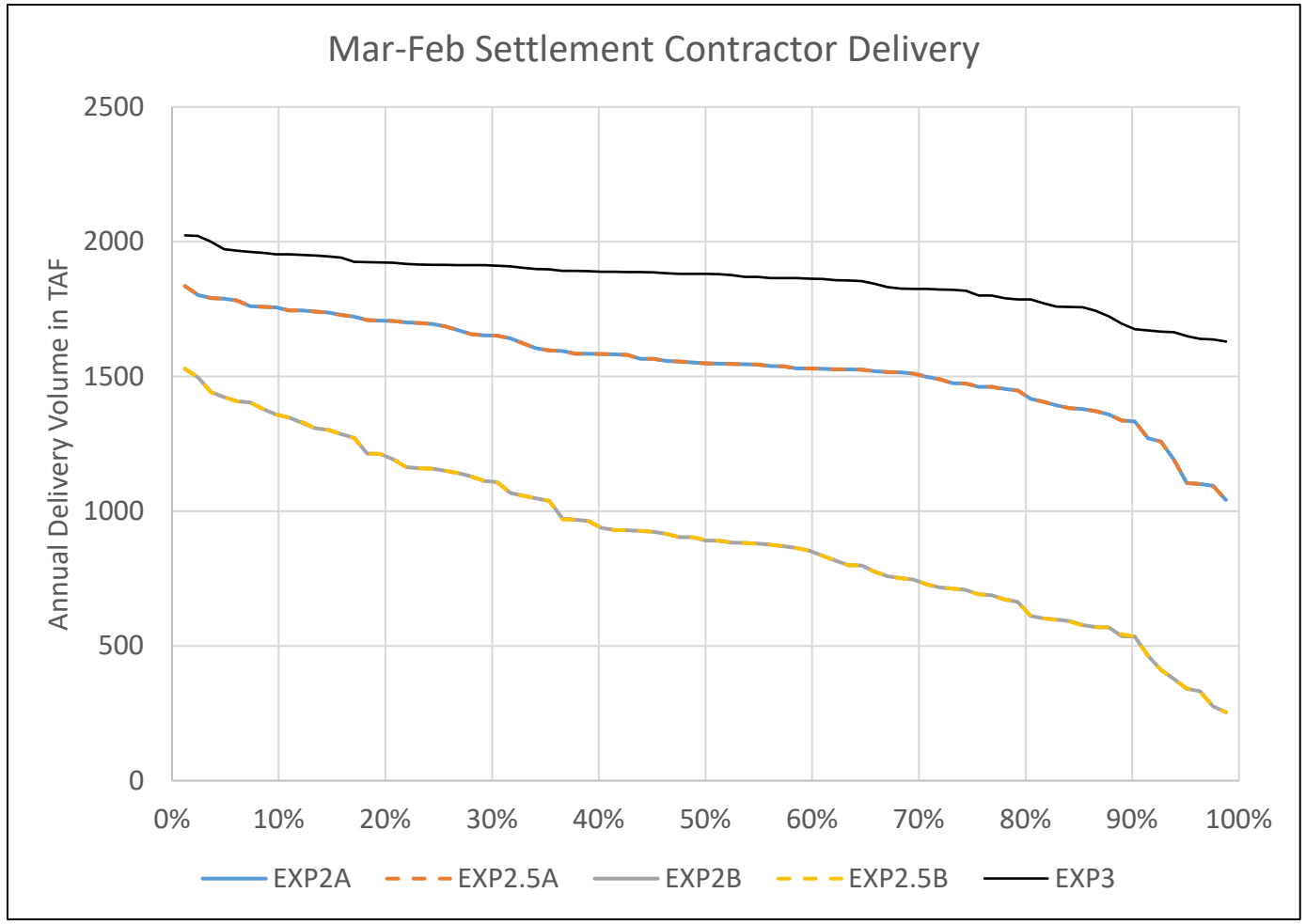
Folsom Storage





- Storage withdrawals to meet D1641 are greater in A than in B
- Results still under review

SRSC Delivery



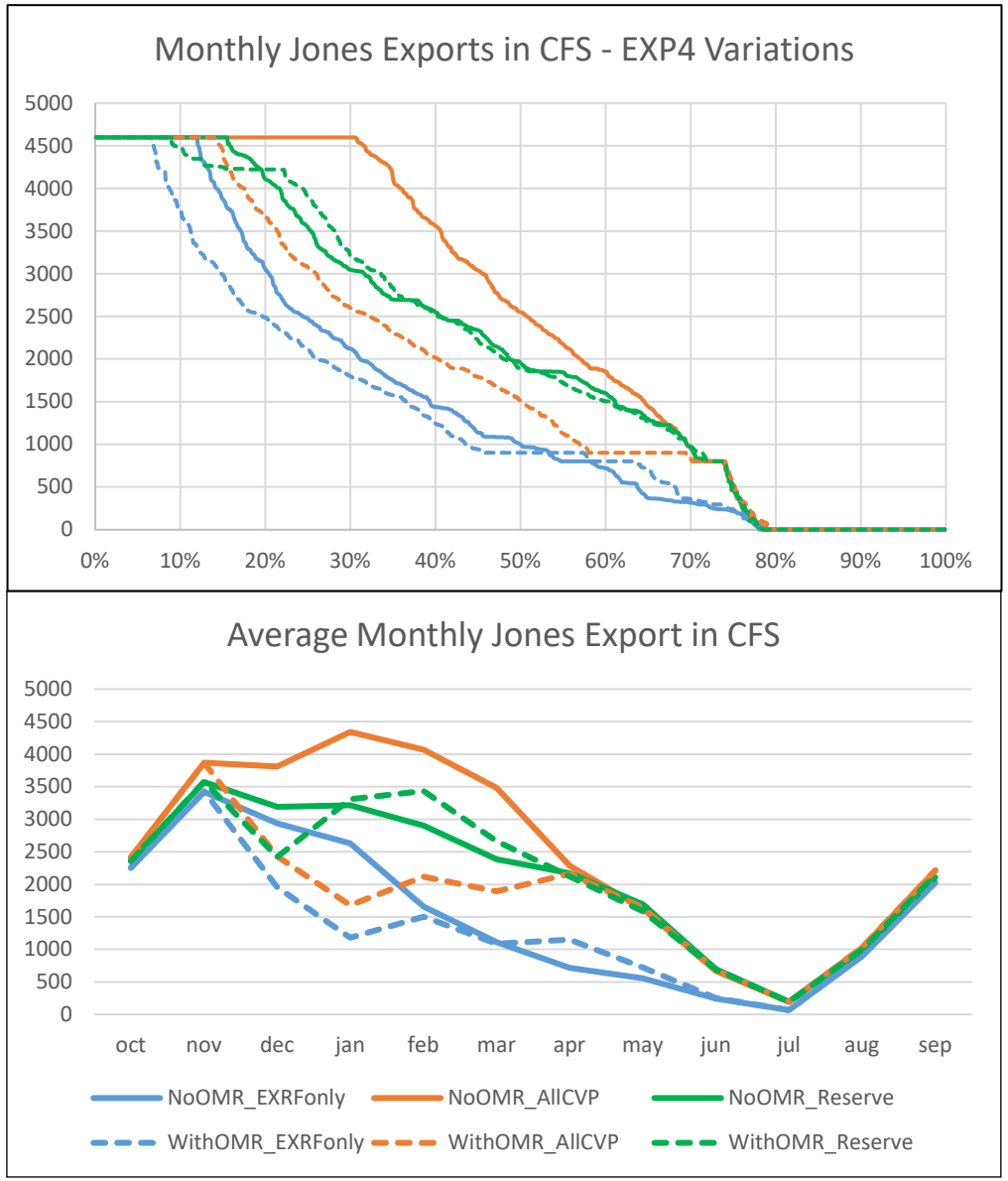
- 2A and 2.5A meet delivery with inflow first.
- 2B and 2.5B meet delivery with remaining inflow after D1641 is fully met.
- No storage withdrawal for delivery in any of the 4 EXP2 runs.

EXP4 Variations

- EXP4 v1 – No OMR; Delivery to EX/RF only and then store in CVPSL
- EXP4 v2 – No OMR; Deliver to all water users and then store in CVPSL
- EXP4 v3 – No OMR; Reserve CVPSL for EX/RF based on v1 results; Ag & MI can take exports and/or SL releases from storage above v1 levels

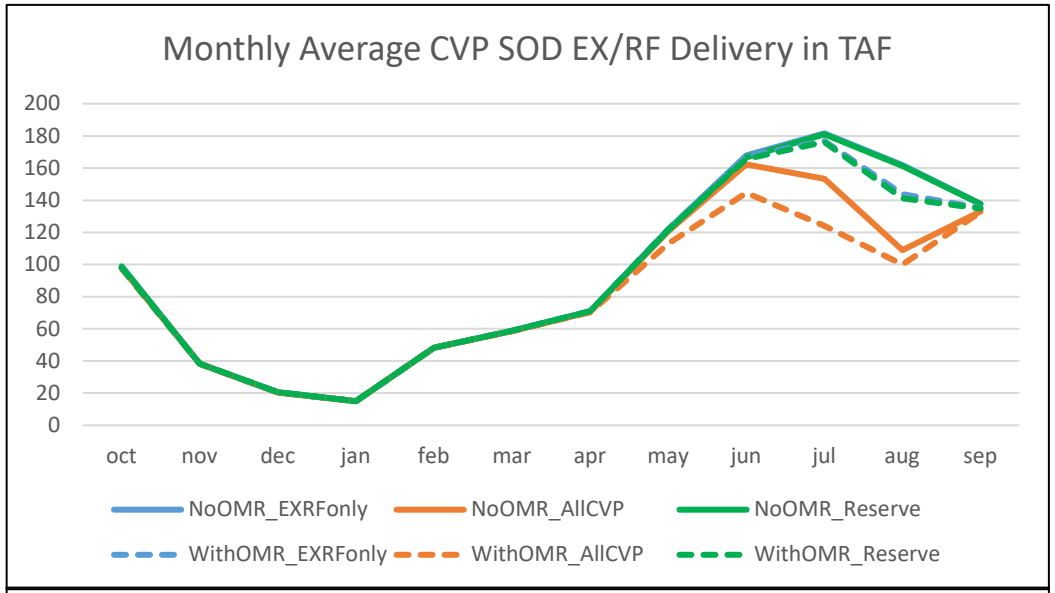
- EXP4 v4 – v1 with OMR limits restricting exports
- EXP4 v5 – v2 with OMR limits restricting exports
- EXP4 v6 – v3 with OMR limits restricting exports

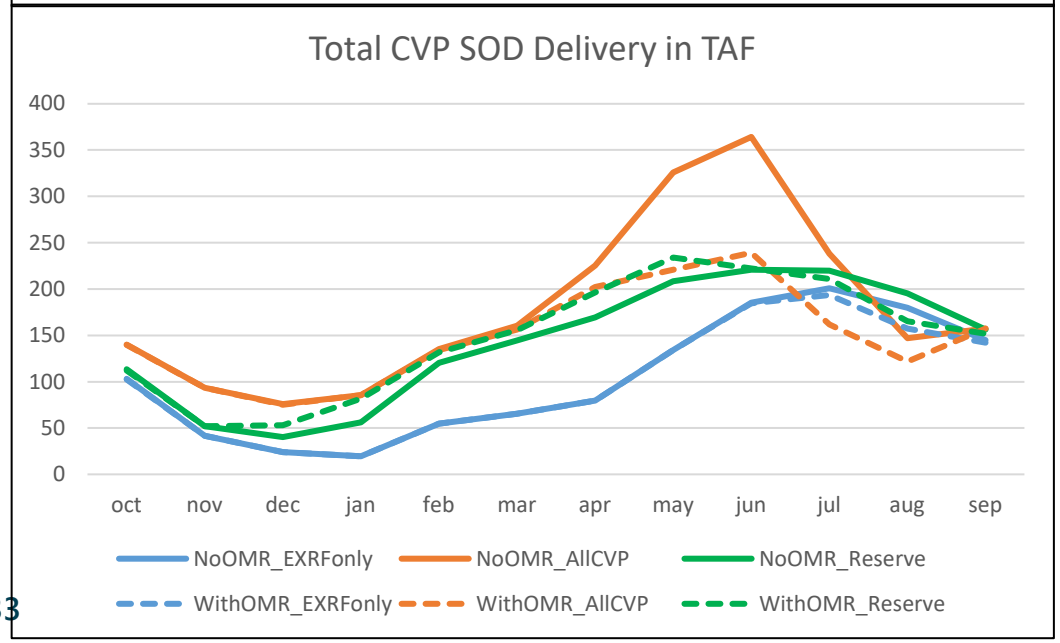
CVP Exports in EXP4



- EXP4 allows export of surplus only
  - Export can be delivered or stored in SL
- Scenarios w/wo OMR limits
  - Export available to EX/RF (senior) only
  - Export available to any CVP demand
  - Reserve storage for EX/RF and then deliver to Ag/MI
- Blue to Orange – total ability to deliver or store water increases when all demands can take export or SL release
- Green lines – CVPSL storage is reserved to support EX/RF

CVP Delivery in EXP4





- If export of surplus serves all CVP water users indiscriminately, EX/RF delivery in summer months falls from Blue to Orange as San Luis resources wane.
- If San Luis resources are reserved for senior Exchange and Refuge uses, senior delivery returns to maximum potential
- Ag uses San Luis storage in May-Jul if not restricted (solid orange line)

CVP Delivery in EXP4