CalSim Allocation Module (CAM) Implementation in CalSim 3

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Outline

1. CAM
   a) Background
   b) Multi-Step Optimization
   c) Reservoir Storage Targets
   d) CAM Priorities and Weights
2. CAM Implementation in CalSim 3
3. Comparison of CAM-based and WSI-DI–based CalSim 3 results
4. Conclusions and Future Work

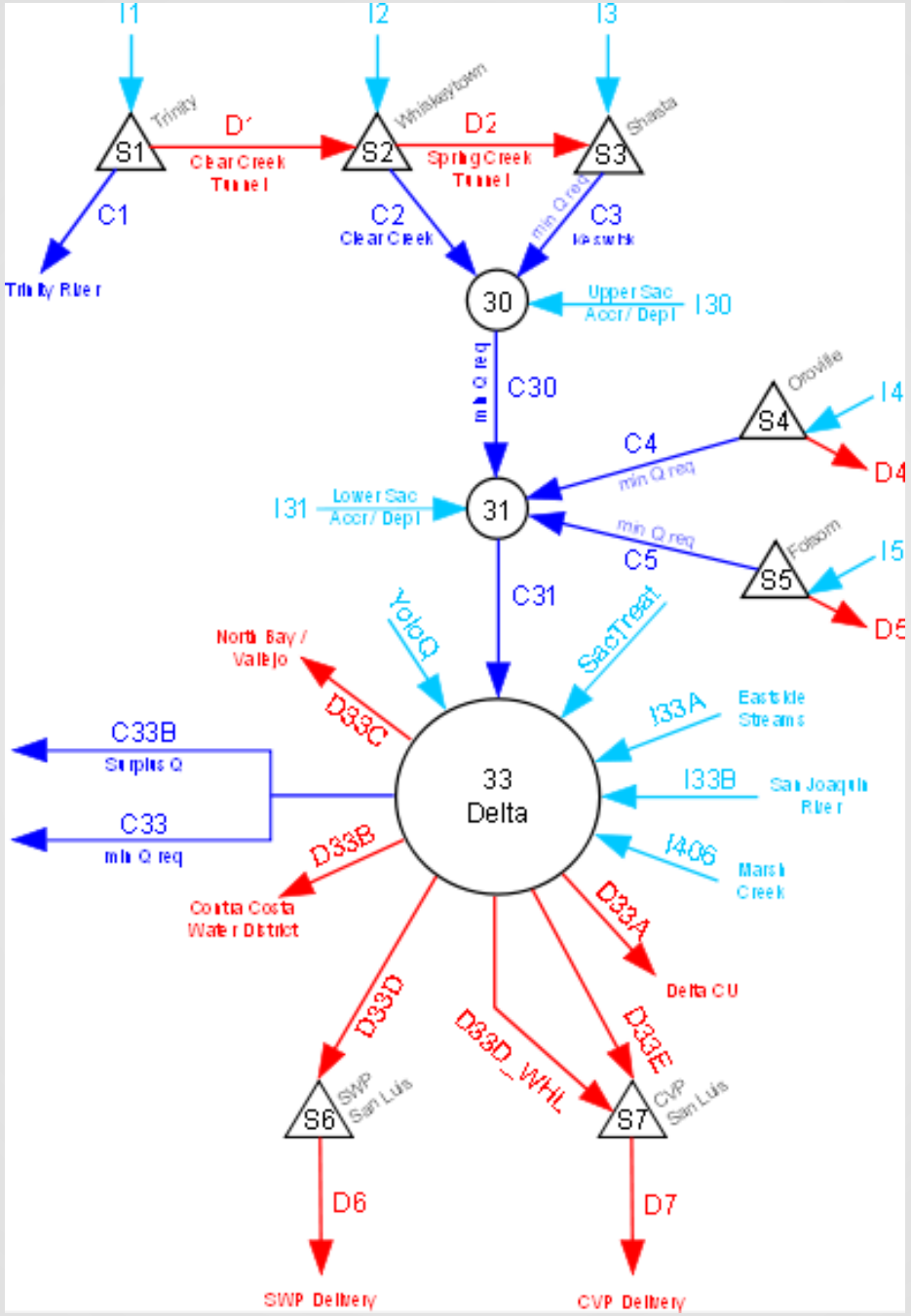
CAM Background

- CAM is a standalone WRIMS model developed by the DWR SWP Operations Control Office (OCO)
- It is a Multi-Step Optimization model used for determining SWP allocations January-May

- **Current project** is to implement CAM in CalSim 3
- Could replace current WSI-DI-based procedure for SWP allocations

CAM Background

- Uses simplified schematic of CVP/SWP system
- From January-May, it forecasts operation through the following December
- Major driving factors of SWP operation are:
  - End of September storage target for Oroville (and other reservoirs)
  - Meet minimum instream flows including Delta outflow
  - Minimize Surplus Delta outflow
  - Meet regulatory export caps and COA
  - Maximizes SOD deliveries within these constraints



CAM Schematic

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Multi-Step Optimization

- Multi-step optimization in CAM defines an LP solution which covers the current and future months, through December
- Inflows and operations are thus forecasted through the end of the year
- For each component of the system, separate decision variables are defined for the current and each future month
- For example, in DSS output, for Oroville storage:
  - S_OROVL__FUT__0 is the current month value
  - S_OROVL__FUT__1, S_OROVL__FUT__2 , S_OROVL__FUT__3, etc. represent forecasted values

Multi-Step Optimization Syntax and Examples

- Output variables for fm decision variables
- S_OROVL__FUT__0, S_OROVL__FUT__1 etc. represent forecasted values

	CALSIM S_OROVL__FUT__0	CALSIM S_OROVL__FUT__1	CALSIM S_OROVL__FUT__2	CALSIM S_OROVL__FUT__3	CALSIM S_OROVL__FUT__4	CALSIM S_OROVL__FUT__5	CALSIM S_OROVL__FUT__6	CALSIM S_OROVL__FUT__7	CALSIM S_OROVL__FUT__8	CALSIM S_OROVL__FUT__9	CALSIM S_OROVL__FUT__10	CALSIM S_OROVL__FUT__11
	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE	STORAGE
	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A	L2015A
	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF	TAF
	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER	PER-AVER
31Oct1921	0	0	0	0	0	0	0	0	0	0	0	0
30Nov1921	0	0	0	0	0	0	0	0	0	0	0	0
31Dec1921	0	0	0	0	0	0	0	0	0	0	0	0
31Jan1922	2517	2699	2894	2765	2610	2365	1983	1674	1569	1443	1332	1300
28Feb1922	2642	2835	2880	2821	2601	2013	1688	1576	1443	1334	1300	0
31Mar1922	2922	3265	3476	3394	2729	2086	1722	1545	1362	1300	0	0
30Apr1922	3084	3538	3538	2956	2342	1906	1603	1420	1355	0	0	0
31May1922	3523	3538	2979	2376	1936	1632	1448	1383	0	0	0	0
30Jun1922	0	0	0	0	0	0	0	0	0	0	0	0
31Jul1922	0	0	0	0	0	0	0	0	0	0	0	0
31Aug1922	0	0	0	0	0	0	0	0	0	0	0	0
30Sep1922	0	0	0	0	0	0	0	0	0	0	0	0

Reservoir Storage Targets

Reservoir	Month	Weights (below; above)	Target
Oroville	Sept	-13,000; -1,500	1,600 taf
Oroville	Dec	-13,000; -100	1,000 taf
SWP San Luis	Oct Nov Dec	-10,001; -101 -15,001; -101 -20,001; -101	42 taf + 1/3, 2/3, 3/3 of storage needed for carryover
Shasta, Whiskeytown, Folsom, Trinity	May Sept	-11,000; -100 -12,000; -110	Varies by WY type
CVP San Luis	Dec	-10,003; -113	100 taf

Oroville Storage Target Implementation

```
define(fm) S_Orovl{lower 29.6 upper 3558 kind 'STORAGE' units 'TAF'}  DV definition

define S_Orovl_Sep_hi {std kind 'Penalty' units 'TAF'}      !  Weight -1,500
define S_Orovl_Sep_lo {std kind 'Penalty' units 'TAF'} !  Weight -13,000

goal(fm) S_Orovl_EOS_Sep {
  lhs S_Orovl($m)
  case a {
        condition mv($m)==Sep
        rhs 1600. + carryover_ITP + S_Orovl_Sep_hi - S_Orovl_Sep_lo}
}
```

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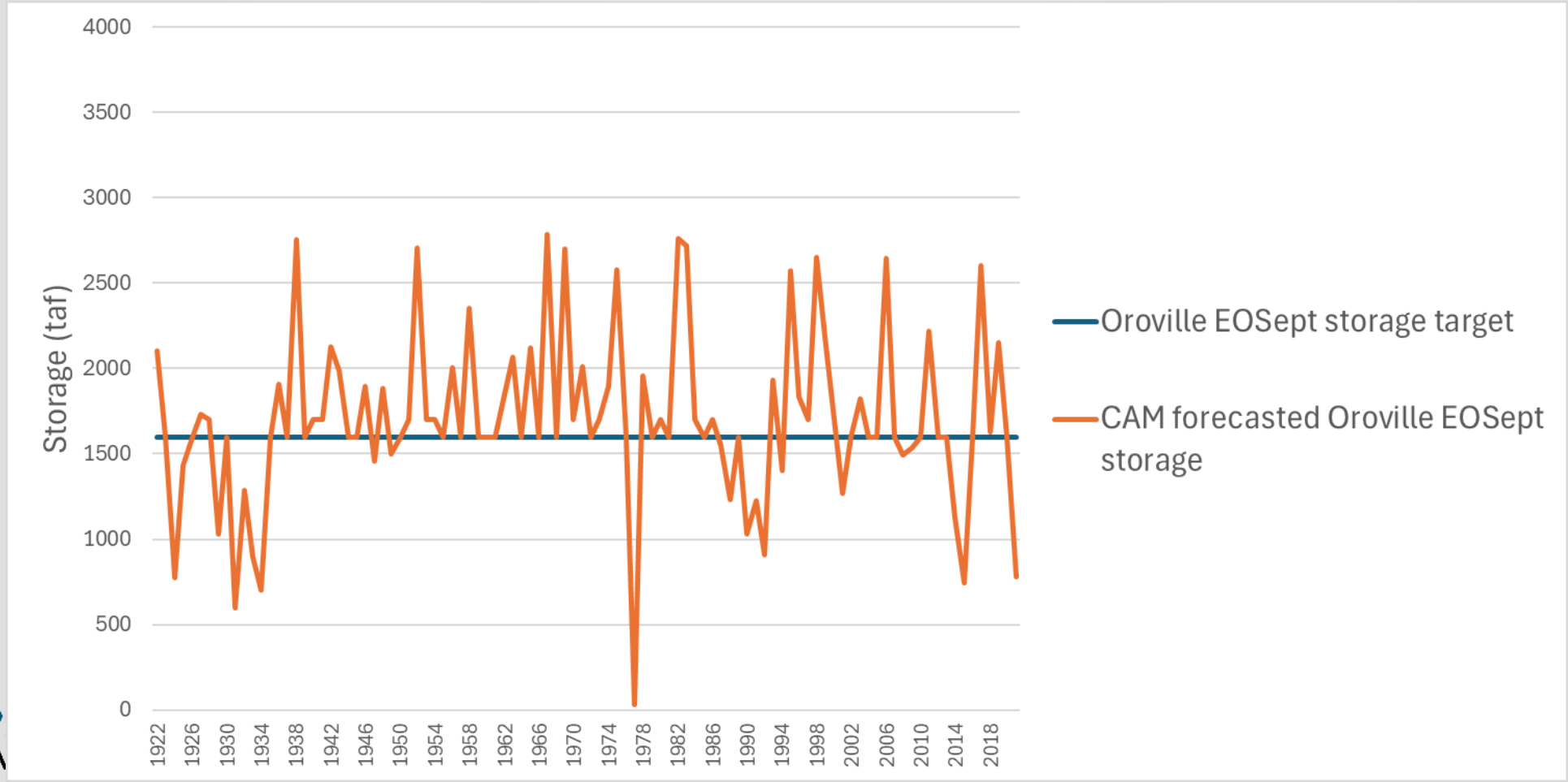
Oroville Storage Target

- CAM Oroville end of September storage target compared to CAM forecast of Oroville storage at end of September



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CAM Priorities and Weights

- Required Delta outflow set = requirement with adjustments for ITP outflow
- Export caps and meeting COA are generally hard constraints

CAM Weights:

-50,000	Penalty on SWP SOD delivery shortages
-50,000	Penalty on not meeting instream flow requirements
-13,000	Oroville storage below Sept, Dec targets
-10,001 - -20,001	SWP San Luis below Oct-Dec targets
-11,000 - -12,002	CVP NOD storage below May, Sept targets
-10,003	CVP San Luis below Dec target
-2,500	Surplus Delta Outflow
-1,500	Oroville storage above Sept target
-900	Unused Federal Share and State share
-101 - -103	CVP and SWP SL storage above Oct-Dec target
-110	CVP NOD storage above May, Sept targets
-100	Oroville storage above Dec target
3-36	SWP and CVP San Luis storage
2,000	SWP SOD deliveries
2,000	CVP SOD deliveries

CAM Implementation in CalSim 3

- Implemented in two new cycles (CAM1 and CAM2), occurring after the San Joaquin cycles and before full system cycles
  - Second cycle implements SMSCG standards and ITP export cut, and calculates X2 location
- Variable **SWP_Delivery** is CAM-calculated forecasted SOD Table A deliveries for calender year.
- **SWP_Delivery** used in later cycles in CalSim 3 to calculate the SWP Table A allocation

CAM Implementation in CalSim 3

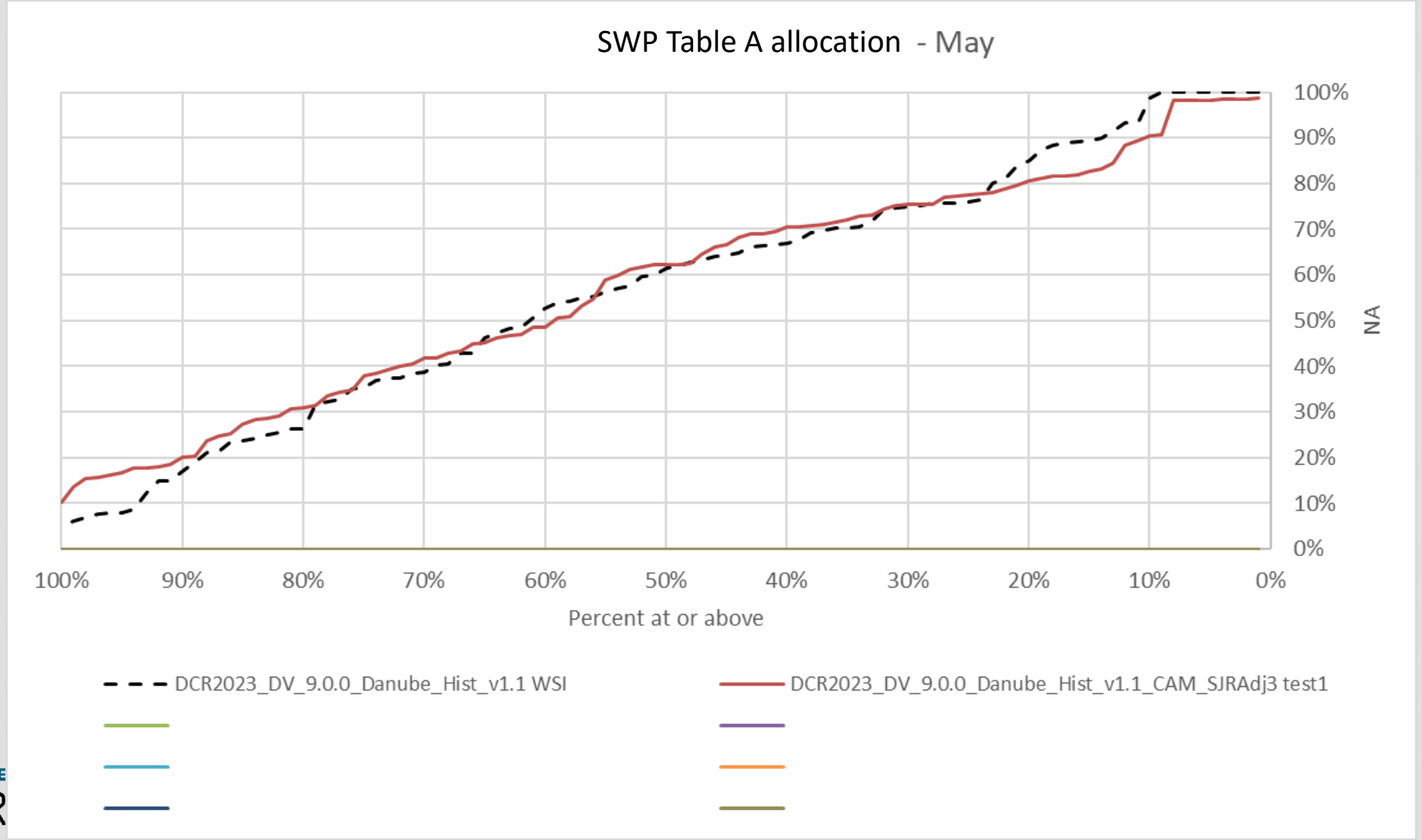
Code from delcar_swp.wresl

```
define cam_swpdel {
  case JantoMay {
       condition  month >=JAN .and. month <=may .and. simulateCAM > 0.5
       value      SWP_Delivery[CAM2] + 64.5 + SWPC_NTHRM_A56 +
SWPC_STHRM_A56 + NBV_A56}
  case start {
       condition  wateryear==bgnWY .and. month==oct
       value      0.}
  case otherwise {
       condition  always
       value      0.}
}
```

CAM Implementation in CalSim 3

Model component changed	CAM	CAM in CalSim 3
Delta Outflow requirements	Some inconsistencies with CalSim 3	Table based on outputs from a prior CalSim 3 run
Forecasted Reservoir inflows and Water Year types	Some inconsistencies with CalSim 3	Same forecast variable as CalSim 3
San Joaquin flow forecasts	90% exceedance	In May for Wet and Superwet years only, use averages based on outputs from a prior CalSim 3 run
Weight changes	NA	Corrections for unrealistic unused Federal and State share operations (ongoing)
CalSim 3 maximum export release from Oroville	NA	When CAM is active, now based on CAM forecast of Oroville Sept storage
Other	NA	Miscellaneous minor fixes and corrections

Comparison of CAM- and WSI-DI-based CalSim 3 models



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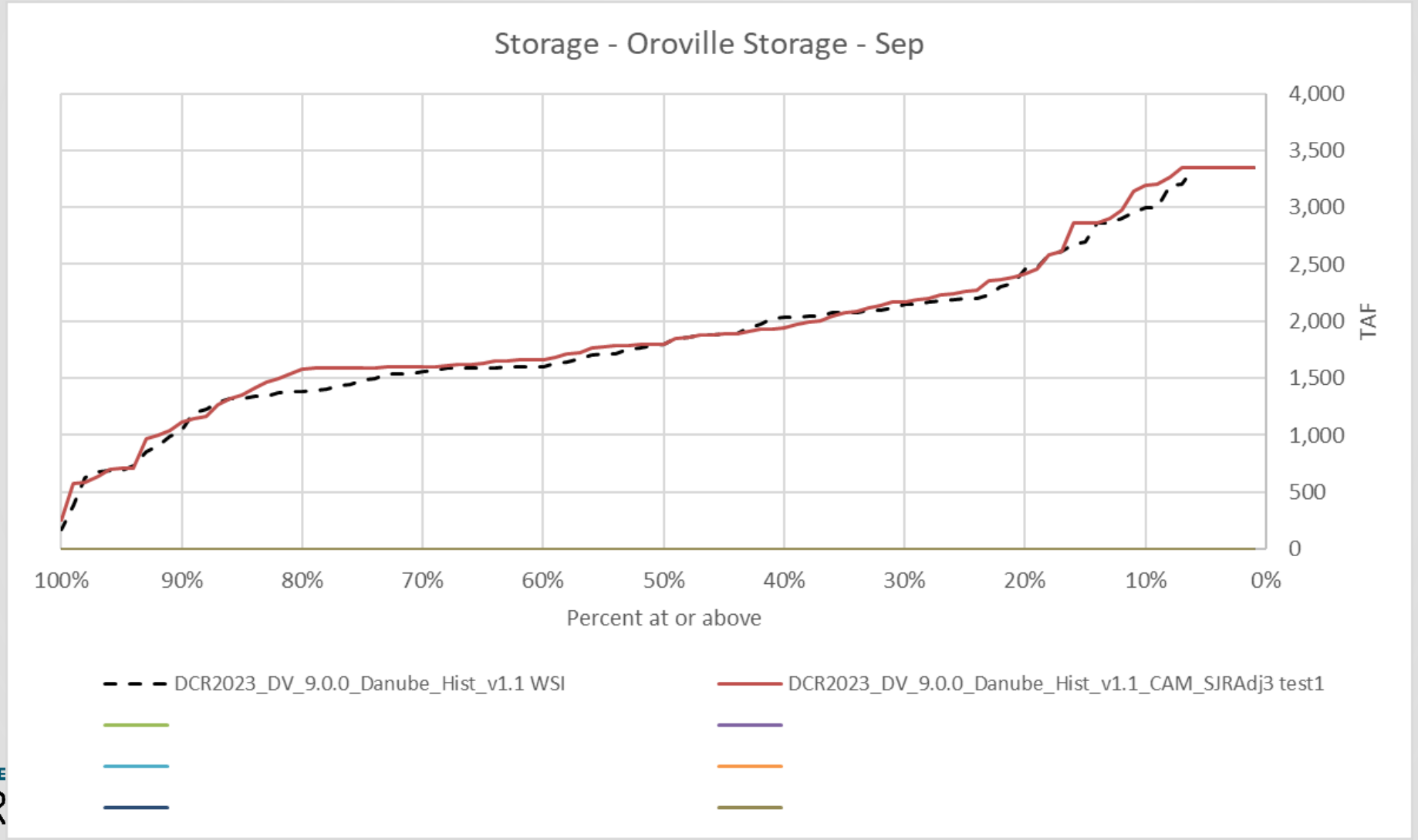

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Oroville Storage Target

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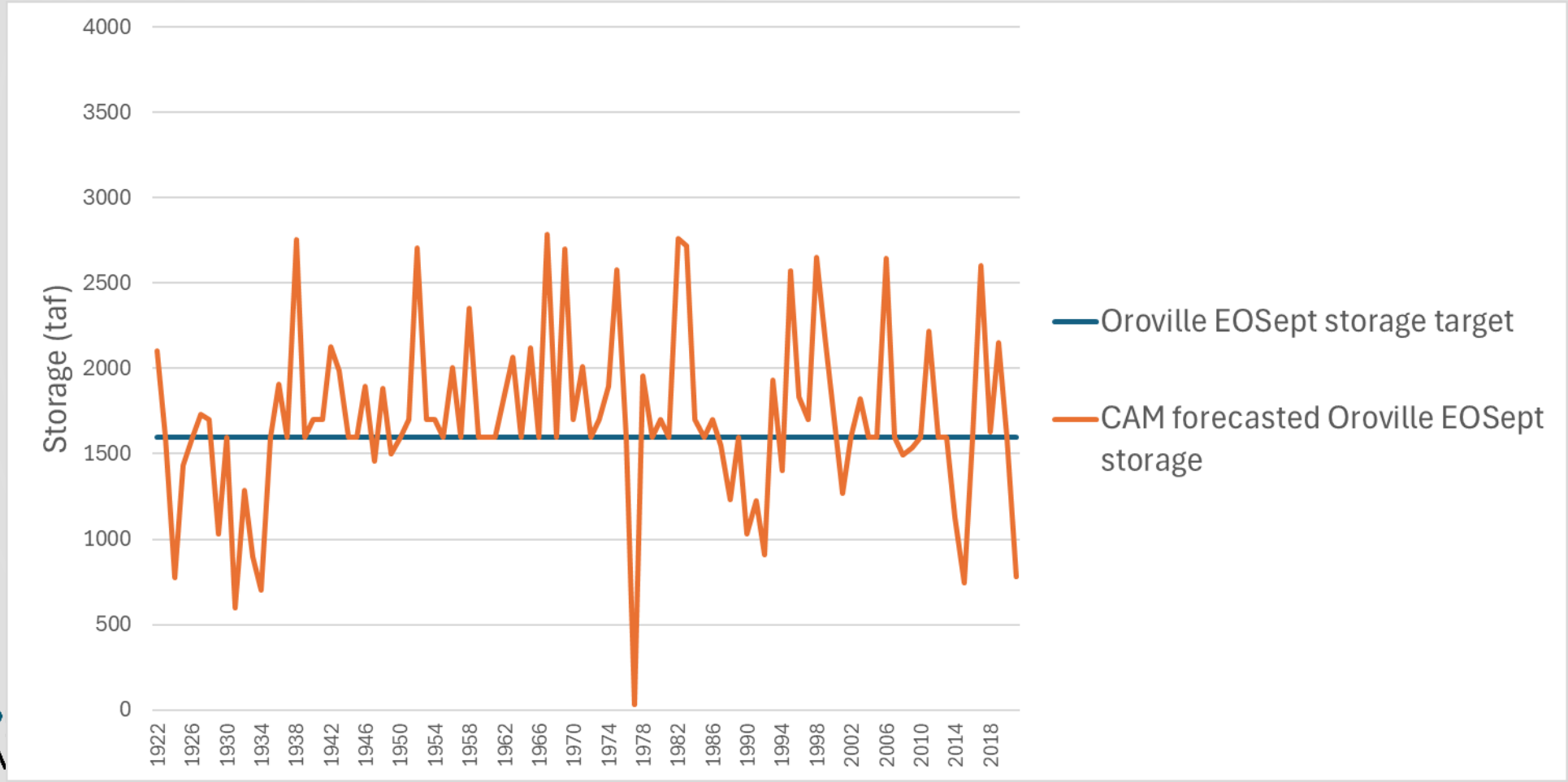

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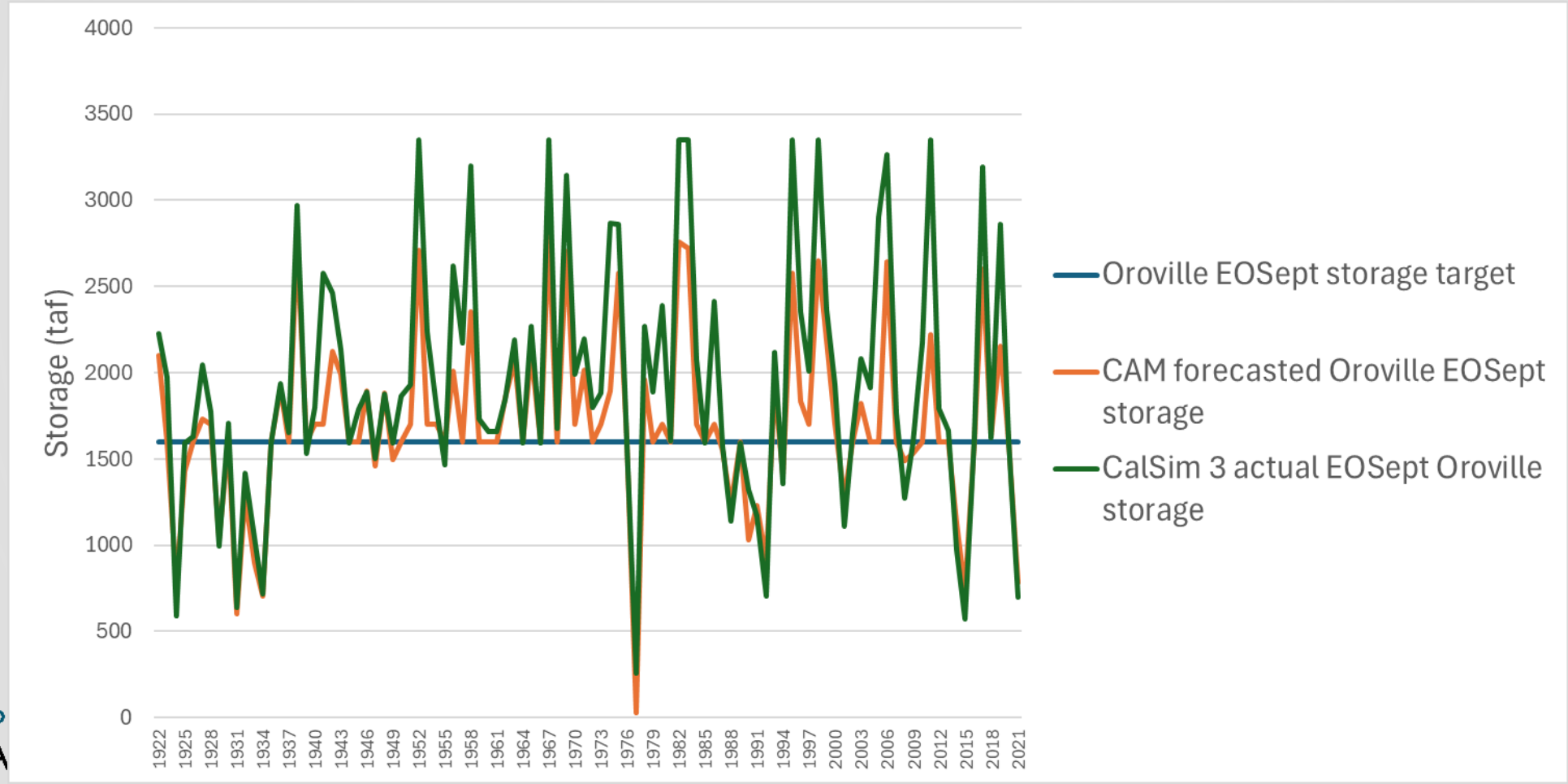
Oroville Storage Target

- With CalSim 3 actual end of September storage added



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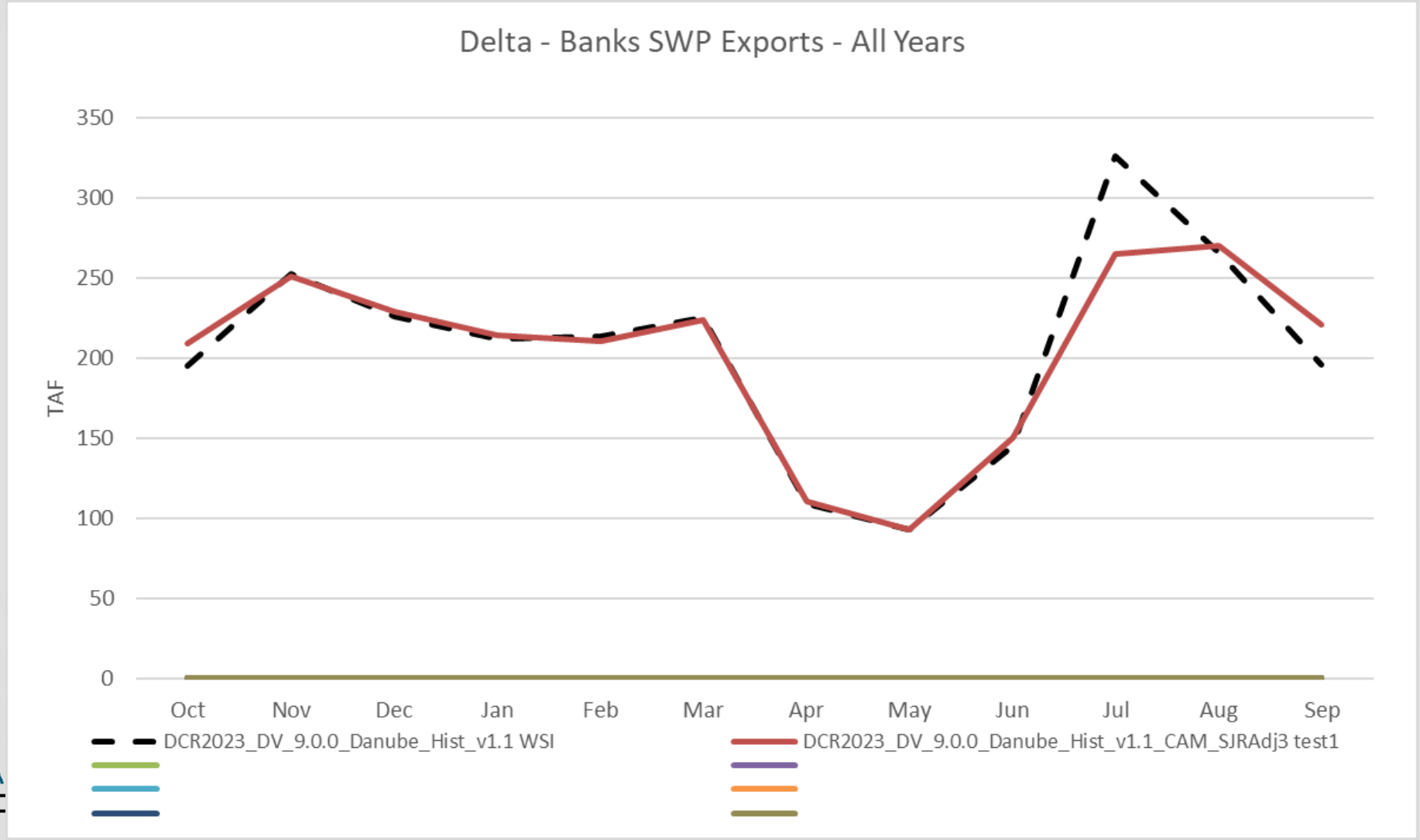

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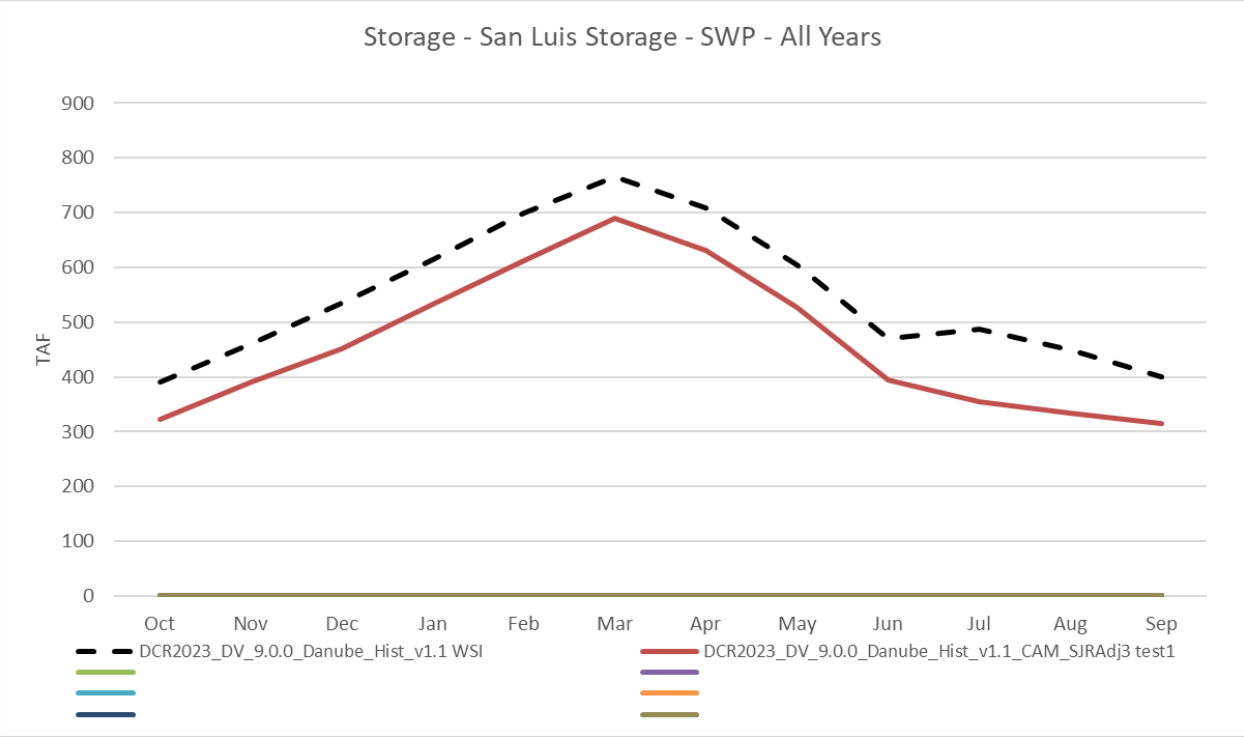

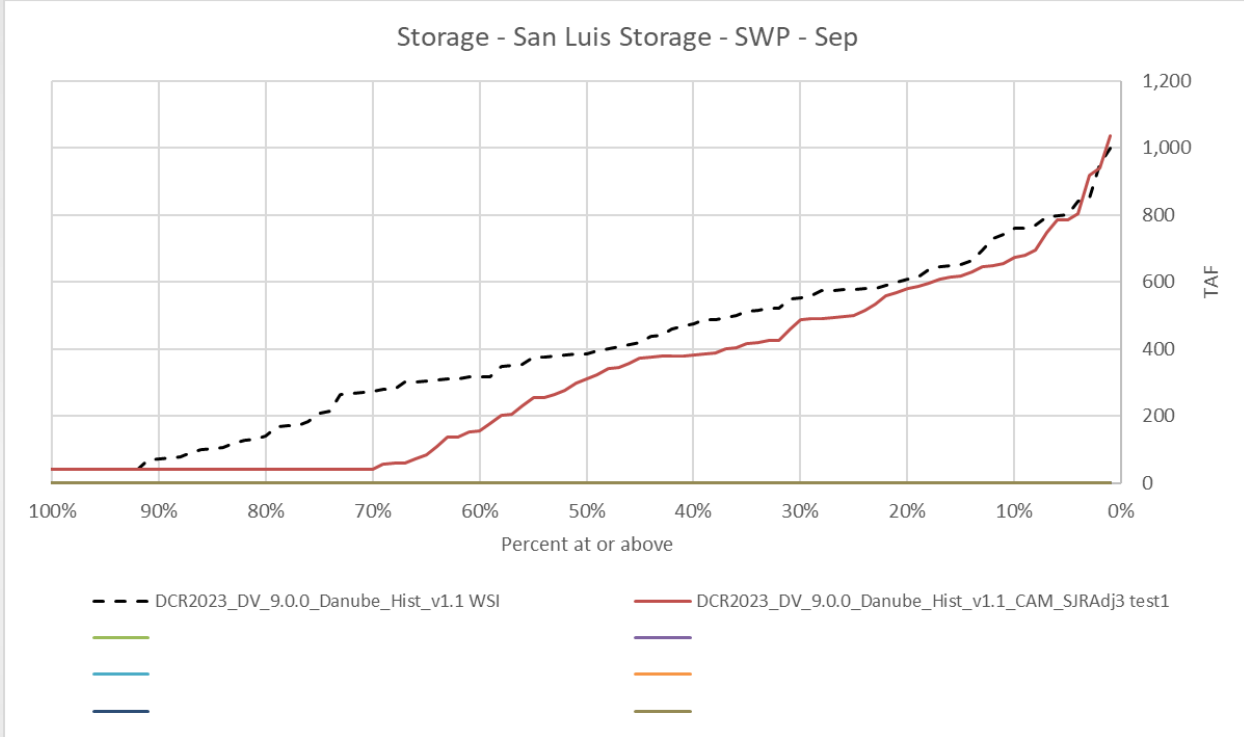

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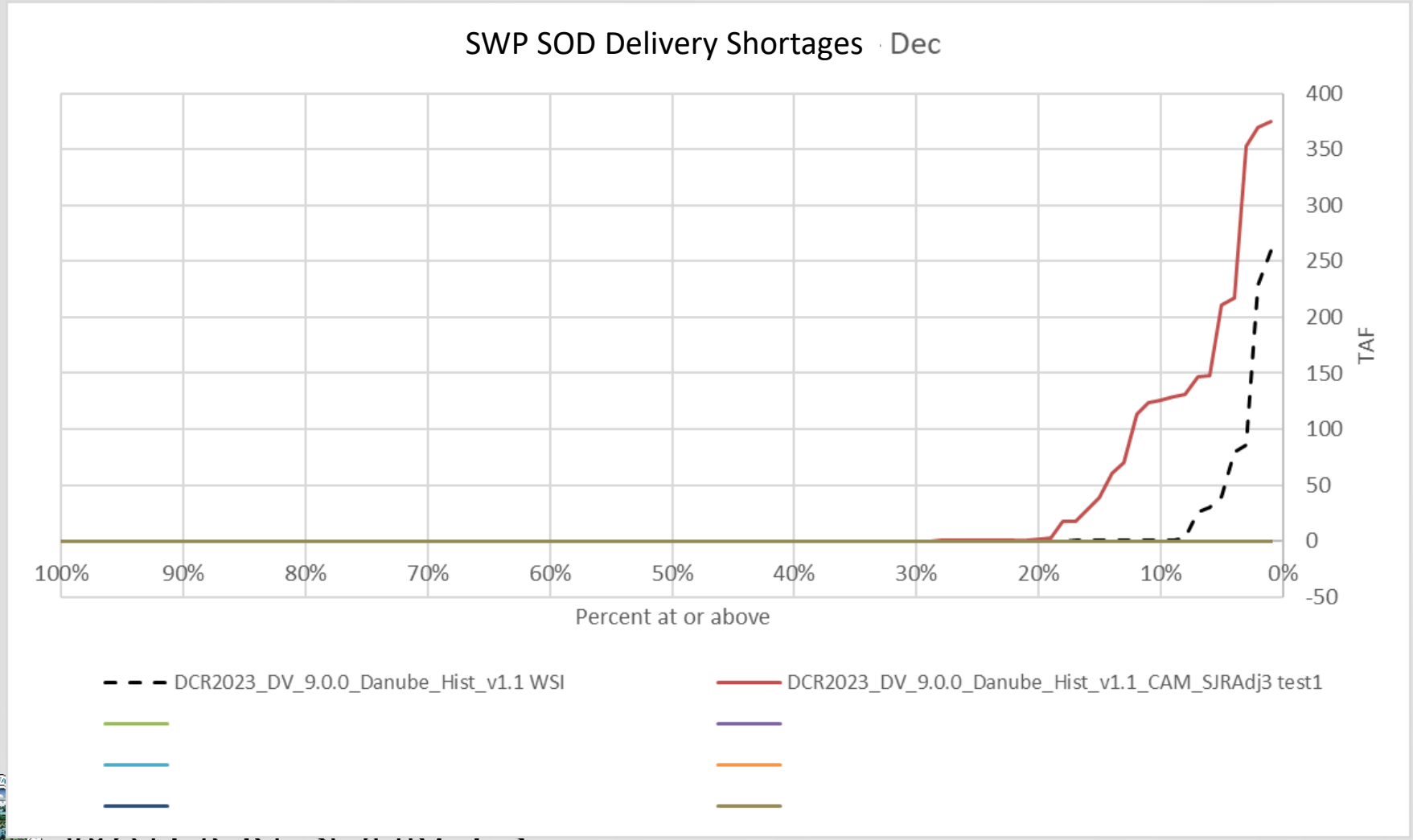

Delivery shortages (taf in December)

CAM: 27 taf

WSI-DI: 8 taf

Conclusions and Future Work

- CAM provides a potential improvement to SWP allocation logic in CalSim 3
- Challenge is that it can be challenging to evaluate results, hence need to improve post-processing and QA-QC tools
- Future work:
  - Fix issue with wet year allocations not reaching 100%
  - Further work on correcting problems with unrealistic exports of unused Federal and State share
  - Further review and QA-QC of operations
  - Implementation in climate change models