CalSim 3 Simulation Period Extension

A collaboration between U.S. Bureau of Reclamation, California Department of Water Resources, and Stantec

BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES · STATE OF CALIFORNIA ·

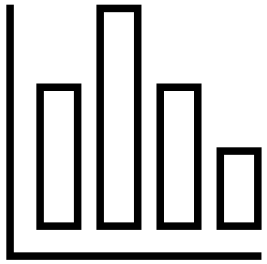
Stantec

Background

CalSim3 period of simulation now runs from WY 1922 – 2021

- When first developed, CalSim II simulated conditions based on water years 1922 – 1994. This period of simulation was later extended through 2003.
- CalSim3 originally ran from 1922 – 2015 prior to this extension.

CalSim3 uses a “level of development” approach (i.e., facilities, land use, contracts, and regulations are held constant over the period of simulation.) Best to interpret results as representing the range of outcomes that could occur for the chosen level of development (2020).



Why extend 94-year period of simulation to 100 years?

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2017 – Oroville Dam Spillway

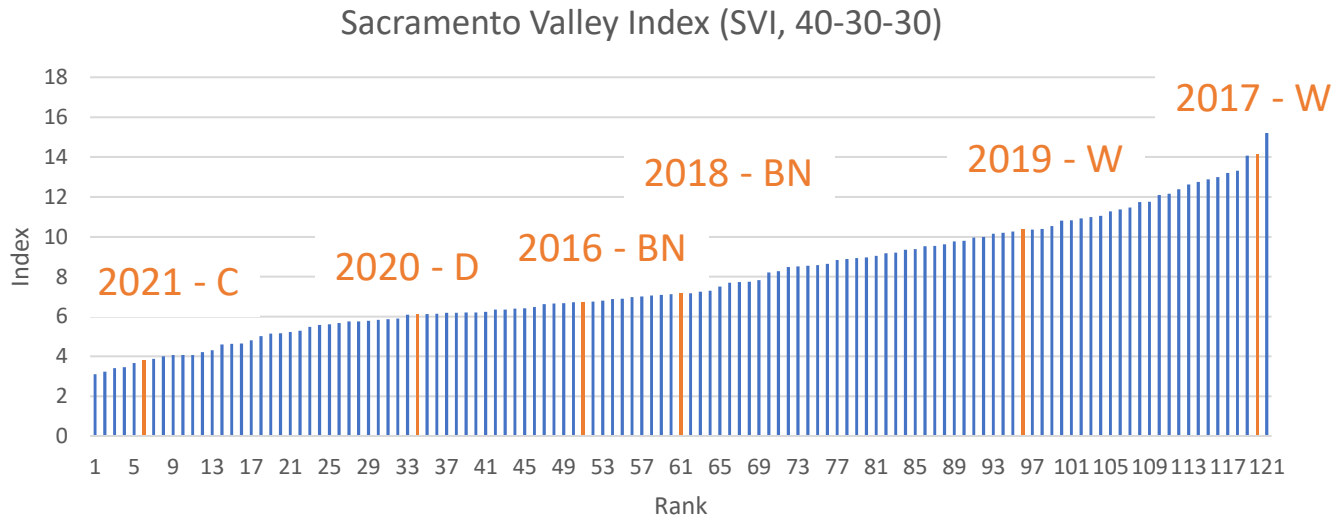
Water flows through a break in the wall of the Oroville Dam spillway Feb. 9, 2017, in Oroville, Calif.

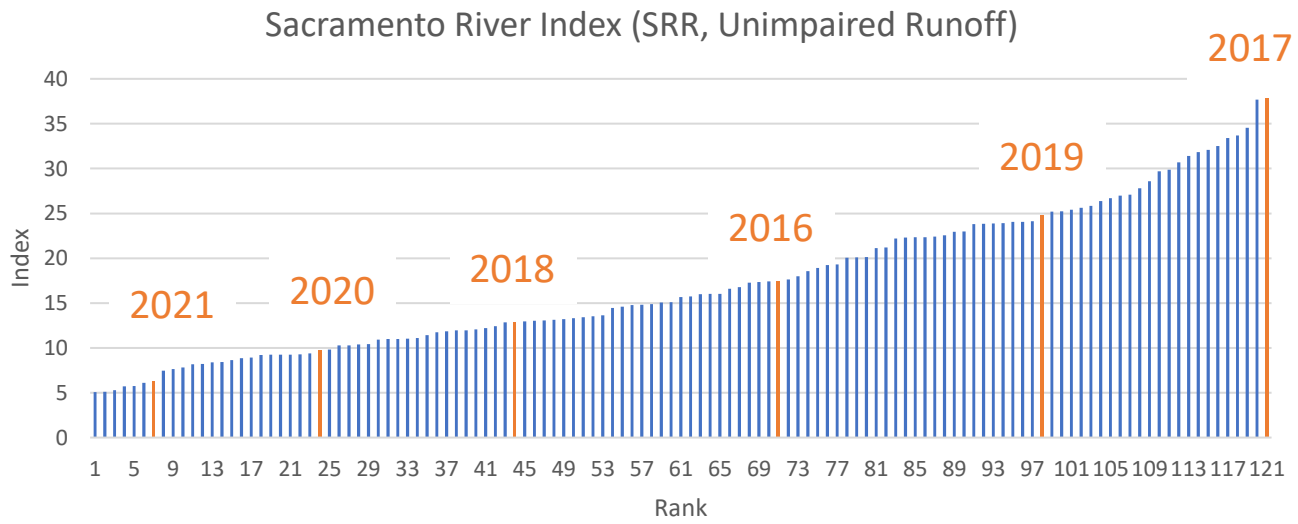
AP PHOTO/RICH PEDRONCELLI

2021 – Folsom Reservoir

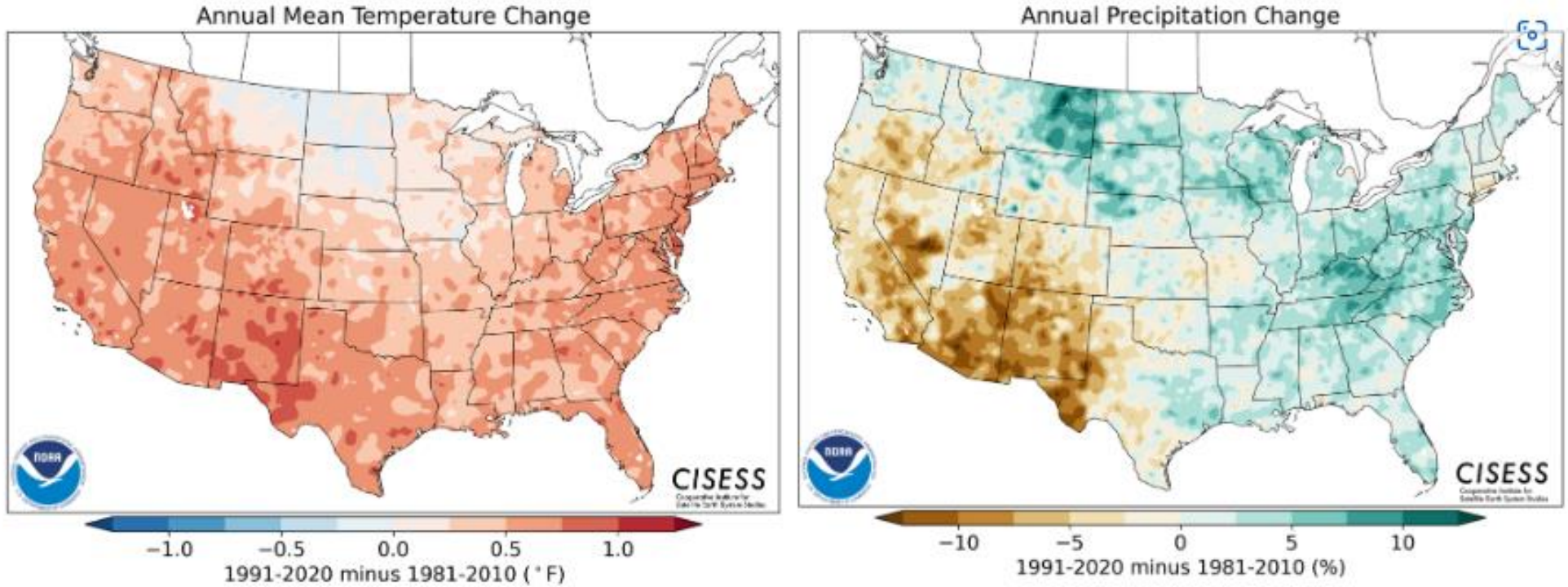
Empty boat docks sit on dry land at the Browns Ravine Cove area of drought-stricken Folsom Lake, currently at 37% of its normal capacity, in Folsom, Calif., May 22, 2021.

Josh Edelson/AP





Why extend 94-year period of simulation to 100 years?

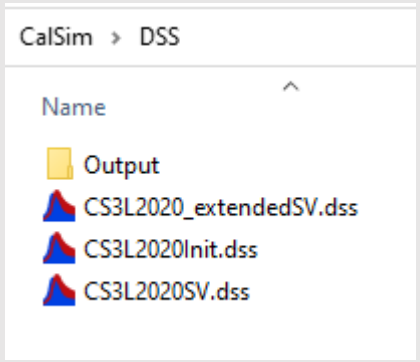


The change in contiguous U.S. annual mean temperatures (°F) and precipitation totals (% change) between the new set of Climate Normals, 1991-2020 (most recent last 3 decades), and the previous set of Normals, 1981-2010. (NOAA NCEI)

Model Input Data

Timeseries Data

2,443timeseries inputs



CS3L2020SV_SJWadj_LYRA.dss - HEC-DSSVue

File Edit View Display Groups Data Entry Tools Advanced Help

File Name: C:/Simulation/C3Studies_DCR/06.68_DCR21_BL_wsidi/CALSIM/DSS/CS3L2020SV_SJWadj_LYRA.dss

Pathnames Shown: 2443 Pathnames Selected: 0 Pathnames in File: 24421 File Size: 45.46 MB

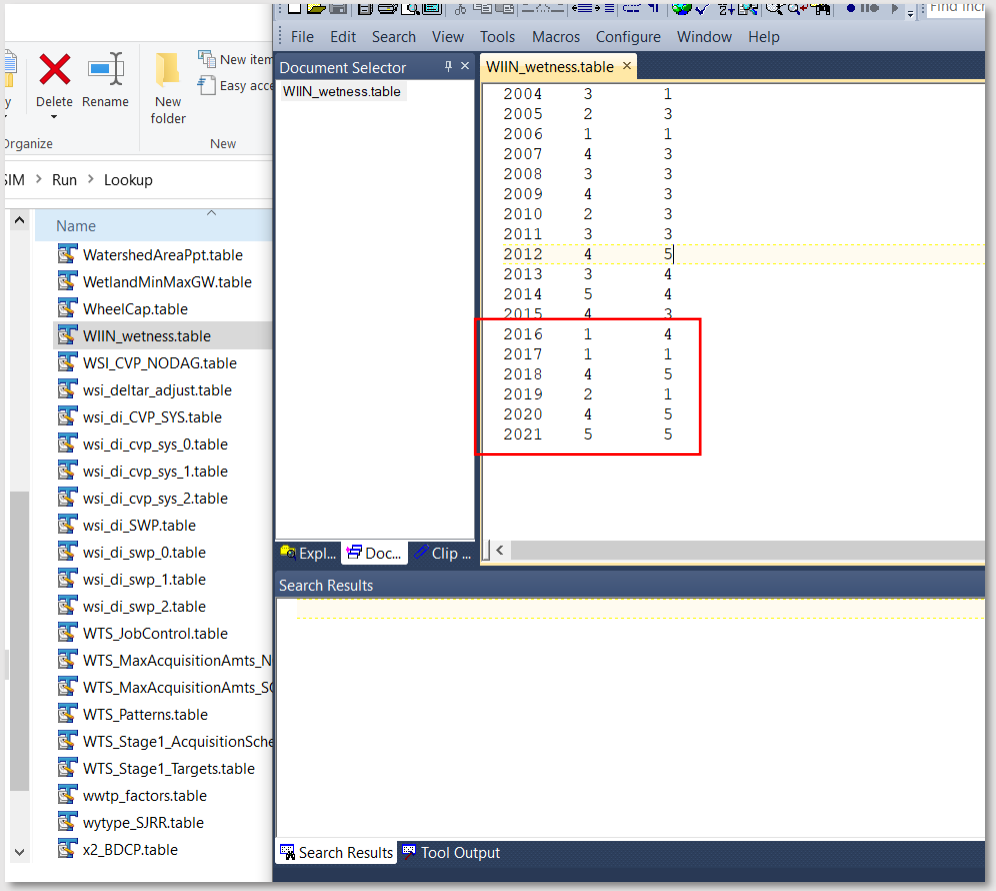
CS3L2020SV_SJWadj_LYRA.dss

Search Pathnames:

Number	Part A	Part B	Part
1	CALSIM	APR_FORECAST_GOODYEAR_B120	FLO
2	CALSIM	APR_FORECAST_SMARTVILLE_B120	FLO
3	CALSIM	AWO_02_NA	APPI
4	CALSIM	AWO_02_PA	APPI
5	CALSIM	AWO_02_SA	APPI
6	CALSIM	AWO_03_NA	APPI
7	CALSIM	AWO_03_PA	APPI
8	CALSIM	AWO_03_SA	APPI
9	CALSIM	AWO_04_NA	APPI
10	CALSIM	AWO_04_PA1	APPI

Relational Data

25 lookup tables updated



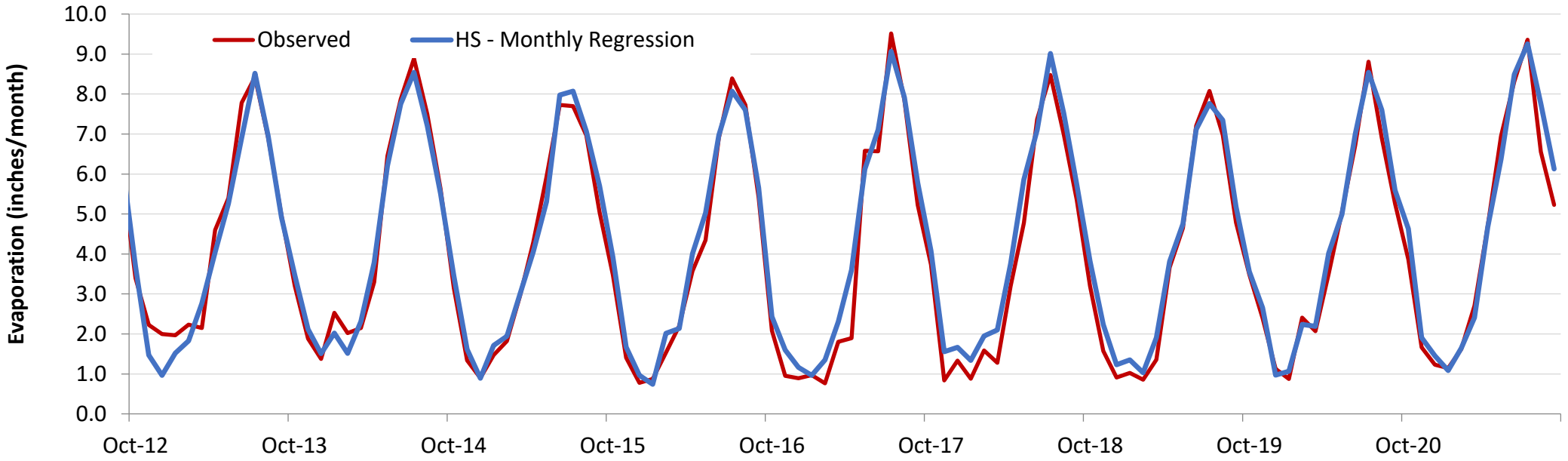
Data Extension Tasks

Updating/extending the following components:

- Reservoir evaporation rates timeseries data
- Rim inflow timeseries
- Land use
- Crop evapotranspiration rates
- CalSimHydro model
- Delta Channel Depletion model
- Groundwater boundary flows
- Lookup tables
- Artificial neural network (ANN)
- Closure Terms & model validation
- Source documentation

Reservoir Evaporation Rates

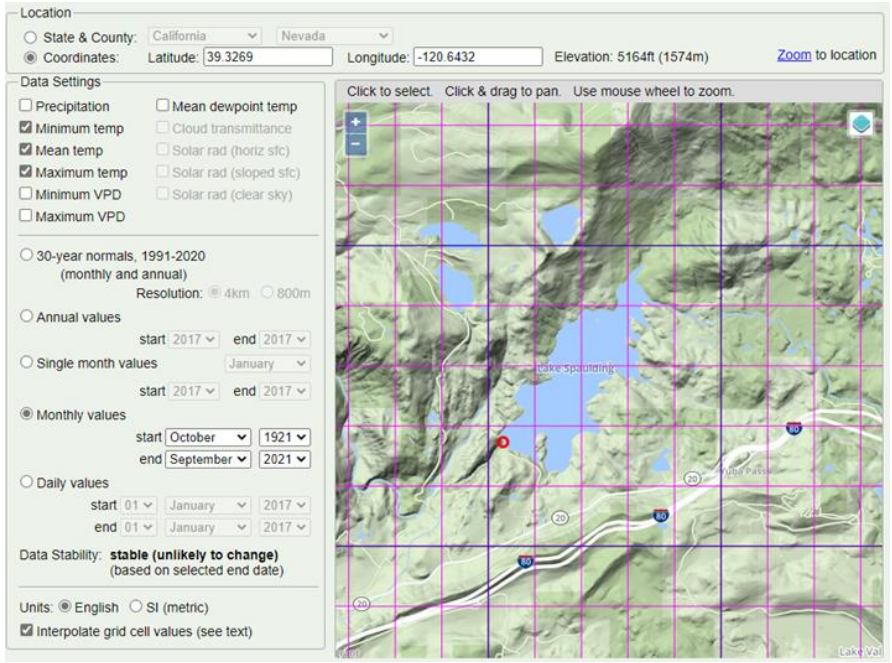
- Reservoir evaporation in Calsim3
  - Dynamically calculated at runtime using reservoir area-capacity tables and reservoir evaporation rates
- Reservoir evaporation rate
  - Calculated from, Hargreaves-Samani, empirical temperature-based equation
  - Calibrated to pan evaporation or reservoir evaporation rates reservoirs operators.
- 52 locations for the Sacramento Valley and 36 locations for the San Joaquin Valley, each contain monthly evaporation rates from October 1921 – September 2021



Reservoir Evaporation Rates

1. Find measured evaporation data ER_{obs} (Lake Spaulding)
2. Estimate ER with Hargreaves-Samani method (HS) with elevation adjustment
   - $ER_{hs}=0.0023(T_{max}-T_{min})^{0.5}(T_{avg}+17.8)\,Ra$
   - Temperature from Prism
3. Correct bias in estimated ER_{hs}
   - Linear regression between ER_{hs} and ER_{obs}
   - Correct bias in ER_{hs}

If no measured evaporation data (French Meadows), use regression parameters from a near by reference lake



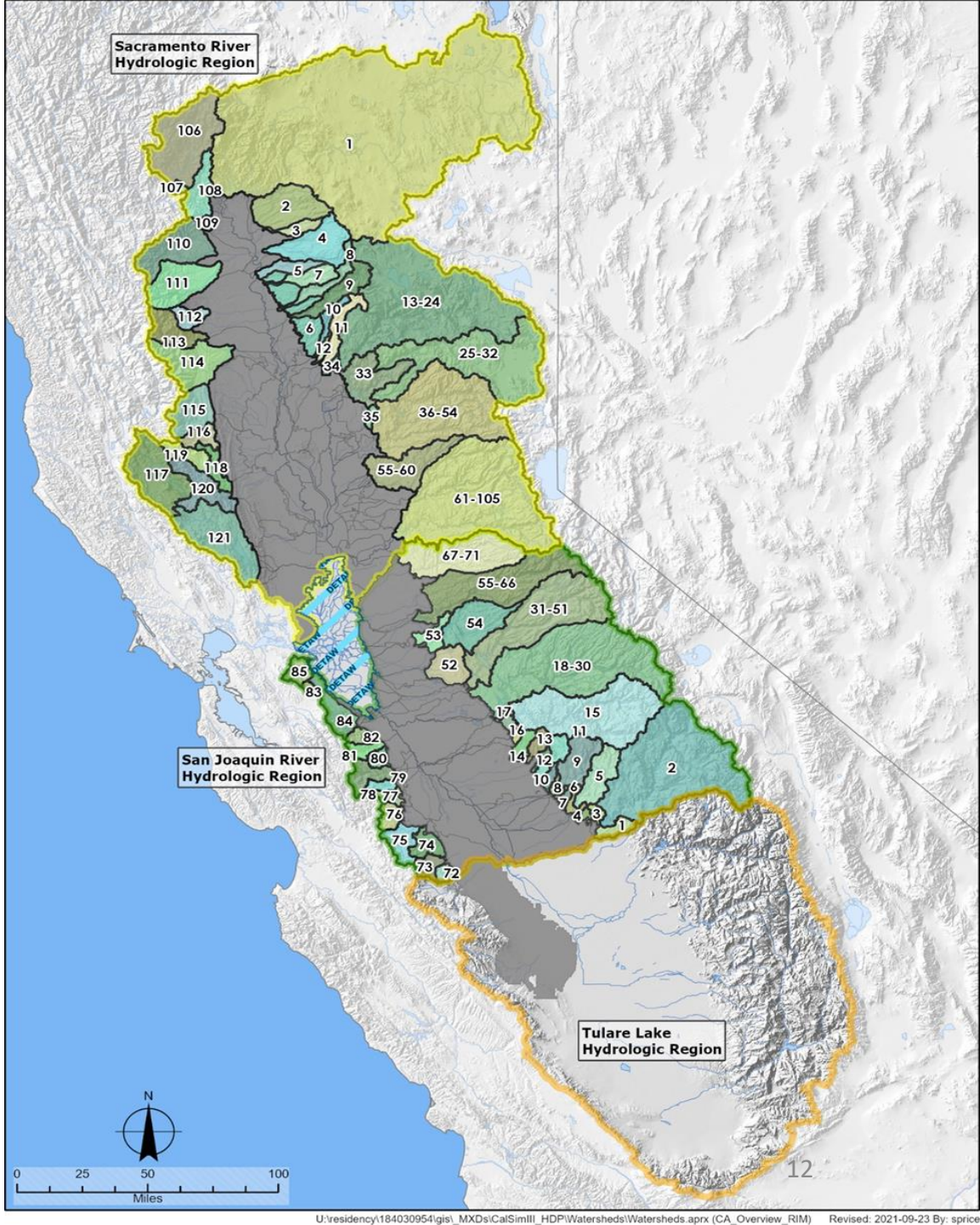
Lake Spaulding regression coefficients

Month	Month No.	Factor	Slope	Intercept
Oct	10	1.42	1.23	0.58
Nov	11	0.61	1.00	-0.65
Dec	12	0.44	0.54	-0.14
Jan	1	0.29	0.26	0.04
Feb	2	0.43	-0.07	0.85
Mar	3	0.54	0.87	-0.89
Apr	4	0.70	0.73	-0.11
May	5	1.11	-0.04	6.15
Jun	6	1.18	0.05	7.33
Jul	7	1.30	-1.06	17.36
Aug	8	1.33	-0.39	11.22
Sep	9	1.28	-1.11	11.62
Annual		1.17	1.47	-1.51

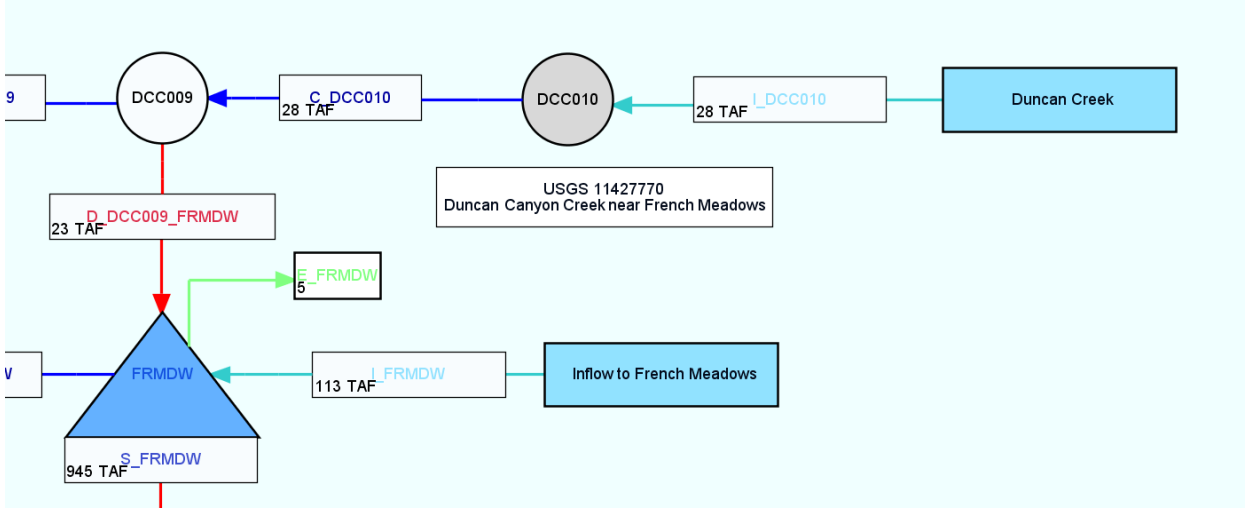
Rim Inflows

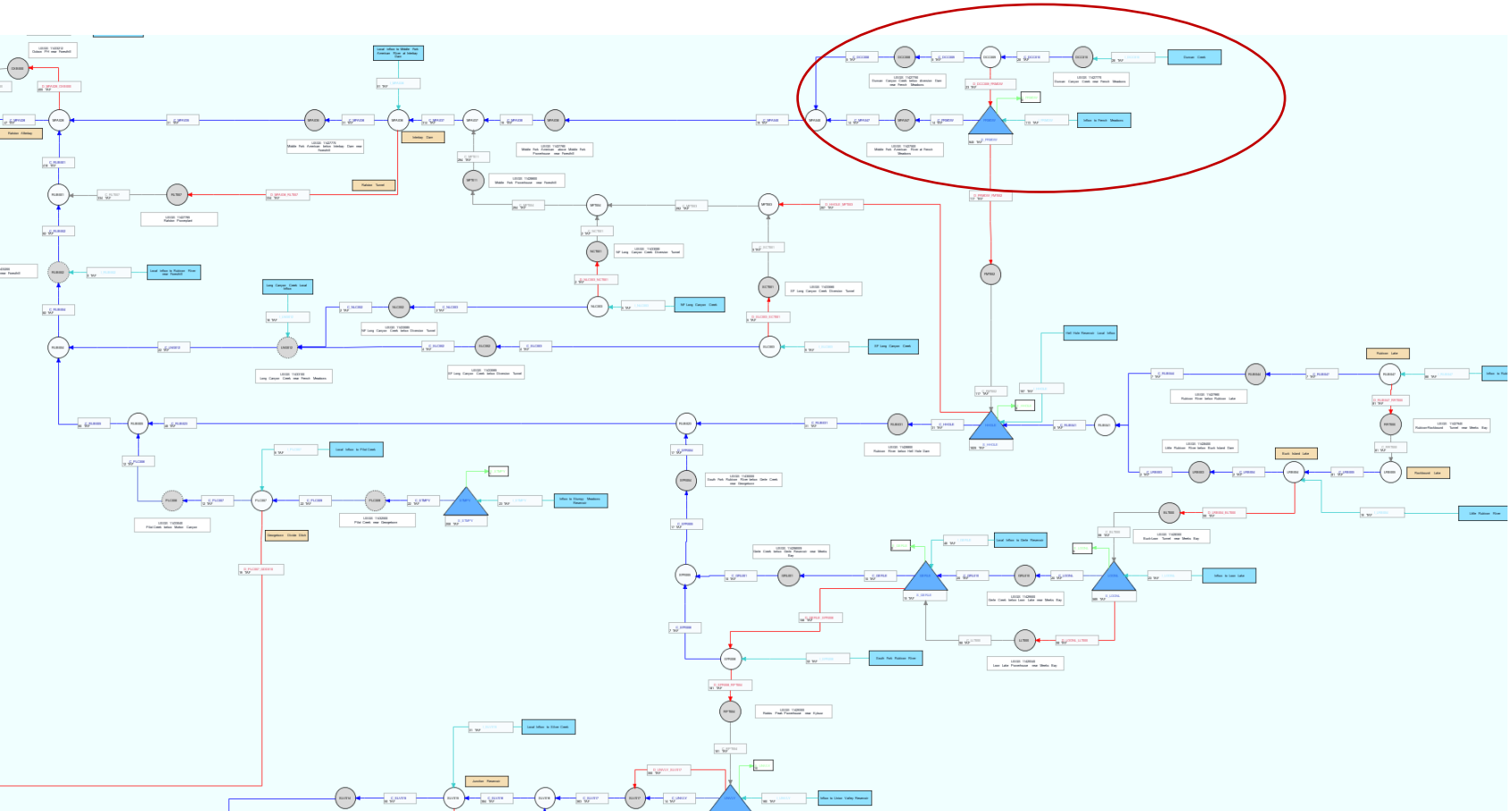
CalSim 3 represents the hydrology of the foothill and mountainous “rim” watersheds that surround the Central Valley as preprocessed timeseries of boundary inflows derived from observed streamflow records.

Data have been developed in a set of Excel workbooks, one for each inflow. There are 122 workbooks for the Sacramento Valley and 95 workbooks for the San Joaquin Valley, each contain monthly unimpaired inflows from October 1921 – September 2015. These data have now been extended through WY 2021.



Rim Inflows


DCC009
C_DCC010
28 TAF
DCC010
28 TAF
I_DCC010
Duncan Creek
USGS 11427770
Duncan Canyon Creek near French Meadows
D_DCC009_FRMDW
23 TAF
E_FRMDW
5
FRMDW
113 TAF
I_FRMDW
Inflow to French Meadows
945 TAF
S_FRMDW



French Meadows Rim Inflow

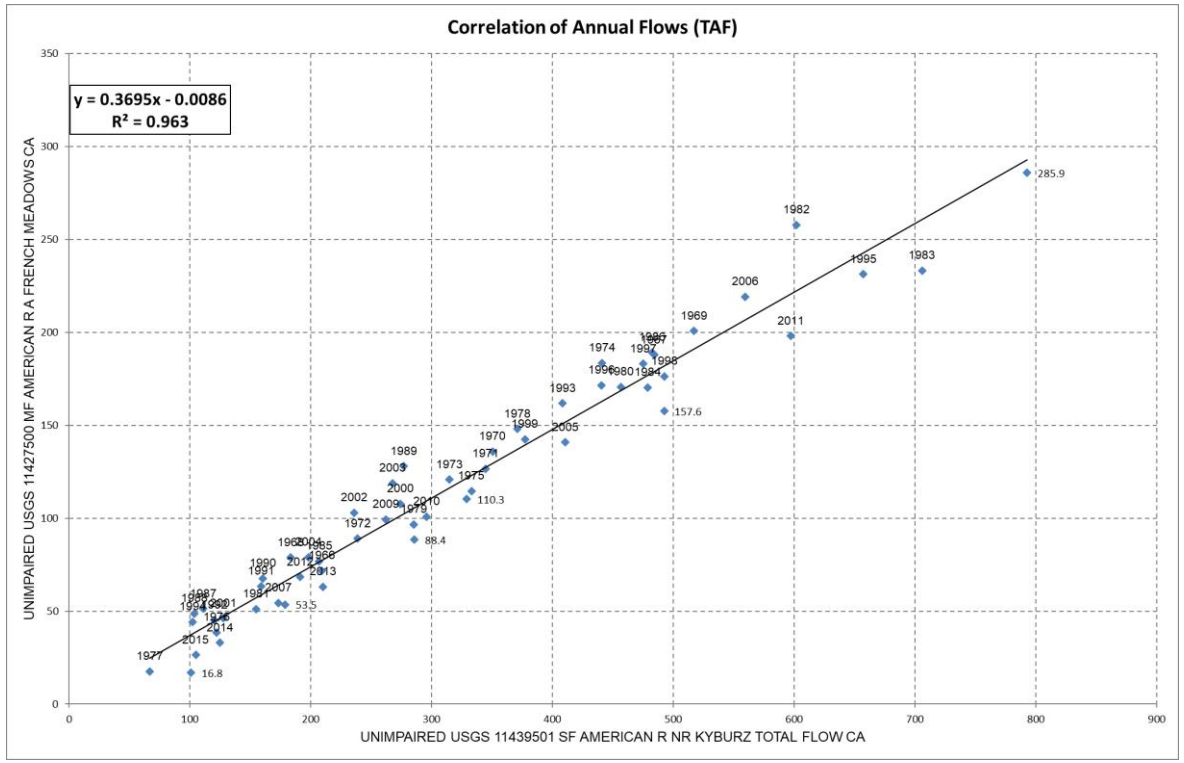
README | USGS Schematic | Middle Fork Project | MODELA | MODELB | Unimp MF American 11427500 | MF American 11427500 | FMeadows Storage | FMeadows Evaporation Rate | FMeadows Evaporation | Duncan 11427700

Unimp Duncan 11427750 | Duncan 11427750 | Duncan Creek Diversion | FMeadows PP 11427200 | FNF American Folsom | FINAL INFLOW | SV INPUT

```
=IF(OR('MF American 11427500'=-901,'FMeadows Storage'=-901,'FMeadows PP 11427200'=-901,'Duncan Creek Diversion'=-901),-901,
'MF American 11427500'
+'FMeadows Storage'[1]-'FMeadows Storage'[0]
+'FMeadows Evaporation'
-'Duncan Creek Diversion'
+'FMeadows PP 11427200')
```

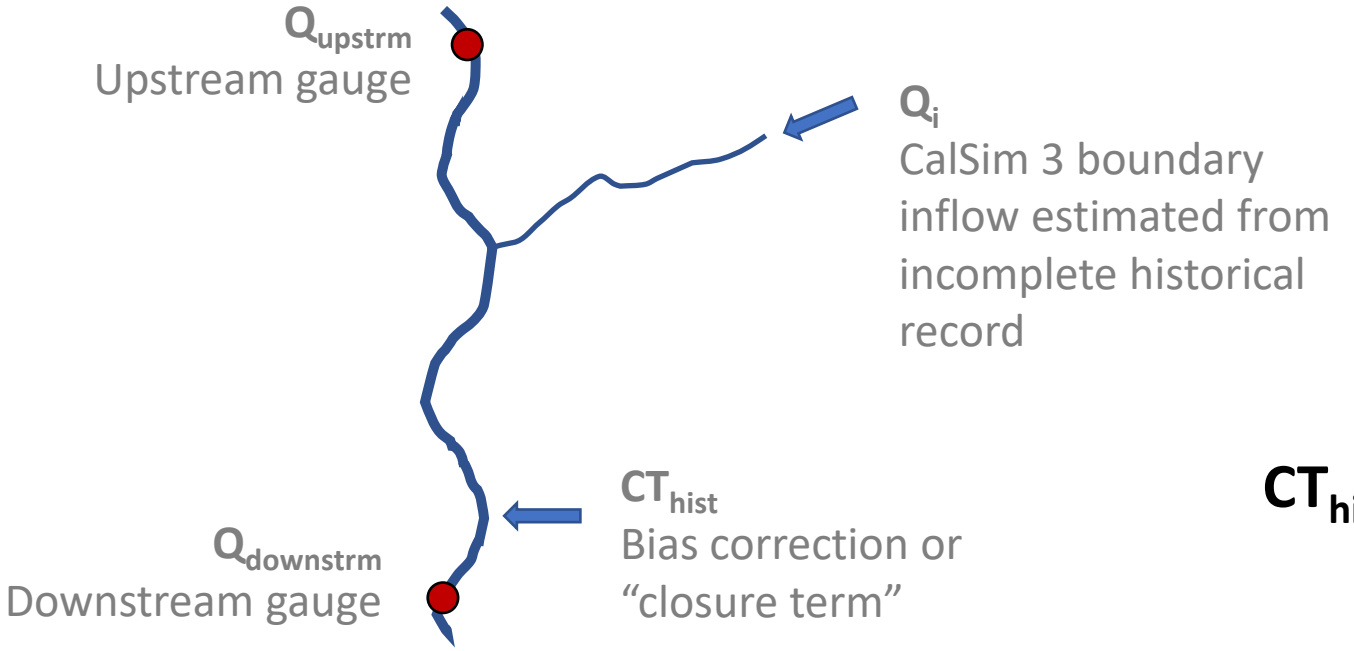
French Meadows Rim Inflow

Water Year	Historical Monthly mean in TAF													Total TAF
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
1922	1	2	5	4	11	9	14	47	39	6	1	0		138.2
1923	0	1	3	5	5	11	21	36	15	5	1	1		104.6
1924	2	2	2	1	3	3	8	9	1	0	0	0		32.3
1925	1	3	4	5	13	15	29	39	18	5	1	1		134.4
1926	1	2	4	2	4	11	21	14	3	1	0	0		62.7
1927	1	5	7	9	13	17	26	38	27	6	1	0		150.8
1928	1	7	3	4	4	26	21	26	5	2	0	0		99.8
1929	0	1	1	1	2	5	11	22	8	1	2	0		53.6
1930	0	0	4	3	5	11	22	19	12	2	1	1		81.3
1931	1	1	1	1	2	5	12	9	2	1	1	0		36.9
1932	0	1	1	2	6	12	23	37	28	6	1	1		118.3
1933	0	0	1	1	1	3	13	20	21	2	0	0		63.9
1934	1	1	3	4	5	12	11	6	3	1	0	0		47.1
1935	0	3	2	4	5	6	27	34	13	3	1	0		104.5
1936	1	1	1	5	9	18	36	41	20	5	1	0		138.3
1937	0	0	1	1	6	9	21	42	14	3	0	0		97.7
1938	1	1	26	7	6	11	30	58	35	7	2	1		183.3
1939	2	3	2	2	3	10	19	11	3	1	0	1		56.3
1940	2	1	1	14	13	25	26	37	12	2	1	0		133.3
1941	0	1	4	5	8	13	17	46	19	5	1	1		121.4
1942	1	3	14	14	9	10	27	35	34	9	2	1		158.0
1943	0	6	12	17	11	22	30	31	15	5	1	1		150.5
1944	1	1	1	3	3	6	12	32	11	3	1	0		72.7
1945	1	5	7	5	18	8	22	35	20	4	1	0		127.2
1946	3	7	13	11	6	13	26	34	12	3	1	1		128.3
1947	1	4	4	3	6	10	15	20	5	1	0	0		69.3
1948	3	2	2	6	3	4	18	34	27	5	1	0		106.1
1949	1	2	2	2	2	4	28	30	9	1	1	0		81.1
1950	0	1	1	5	8	13	32	41	22	5	1	1		129.3
1951	1	52	44	10	10	8	18	19	9	2	1	1		176.0
1952	1	3	5	5	8	11	41	70	38	12	3	1		198.3
1953	1	1	2	8	6	9	26	25	28	9	1	1		116.5
1954	1	2	2	3	5	15	24	24	6	1	0	0		83.0
1955	0	1	3	3	4	6	13	28	14	2	1	0		74.6
1956	1	1	38	25	11	13	24	45	29	7	2	1		195.8
1957	2	3	4	3	9	14	19	29	19	3	1	0		105.2
1958	1	1	2	3	10	9	26	65	30	7	2	1		157.2
1959	0	1	1	5	5	10	17	13	5	1	0	1		58.6
1960	0	0	1	1	5	13	19	16	7	1	0	0		63.0
1961	0	1	1	1	4	5	13	15	6	1	0	1		48.9
1962	0	1	2	2	6	6	34	26	18	3	1	0		99.5
1963	5	2	6	11	33	6	13	40	18	4	1	1		141.4
1964	1	10	5	4	3	5	15	20	9	2	1	0		75.8
1965	0	2	57	18	10	11	20	34	22	7	4	1		185.9
1966	1	3	2	3	2	10	27	19	3	1	0	1		71.8
1967	5	7	10	10	9	21	8	48	50	15	2	1		187.9
1968	0	1	1	3	19	12	17	17	5	2	2	1		78.8
1969	1	5	3	25	7	6	27	86	31	7	2	1		200.8
1970	1	0	16	54	10	10	9	22	10	1	2	0		135.9
1971	0	6	4	6	7	12	18	35	27	8	2	1		126.6
1972	0	2	2	1	3	25	18	26	9	1	0	2		89.1
1973	2	4	11	13	4	6	23	44	11	3	1	0		120.8
1974	0	18	12	28	6	21	22	42	23	9	2	1		183.6
1975	1	1	1	3	3	8	8	48	33	7	2	1		114.7
1976	4	4	2	2	2	5	8	9	2	0	1	0		38.6
1977	0	0	0	1	1	1	4	6	4	0	0	0		17.7
1978	0	1	3	13	6	21	23	39	25	7	1	2		148.0
1979	0	1	1	5	4	10	20	42	10	2	1	0		96.7
1980	2	2	2	49	20	10	24	33	19	9	1	0		170.7
1981	0	0	1	2	6	7	20	13	2	0	0	0		51.2
1982	1	33	42	10	32	17	31	51	25	9	2	3		257.8
1983	8	9	10	8	10	24	14	53	64	25	6	2		233.4
1984	3	34	33	14	9	15	16	28	14	3	0	0		170.3
1985	0	5	2	3	4	7	27	18	5	1	1	2		76.8
1986	1	2	6	18	60	39	20	24	13	3	2	2		189.2
1987	1	0	1	1	4	9	18	10	2	2	2	0		51.3
1988	0	1	4	3	5	9	11	9	4	1	0	0		48.7
1989	0	5	3	3	5	37	35	22	11	3	2	1		128.0
1990	2	2	2	4	3	11	19	12	8	3	1	0		67.6
1991	0	0	0	0	1	10	15	23	12	3	0	0		63.4
1992	0	1	1	1	7	11	15	6	1	1	0	0		45.1
1993	1	1	3	10	7	27	29	48	27	8	2	1		161.8
1994	1	0	1	1	2	9	13	12	3	1	0	0		44.2
1995	0	2	3	23	13	35	28	55	46	21	5	2		231.3
1996	1	0	9	11	35	20	29	48	13	3	1	0		171.6
1997	0	7	43	49	9	17	24	21	9	2	1	1		183.1
1998	1	1	2	15	10	23	19	37	49	15	2	2		176.3
1999	0	3	5	13	14	14	20	43	23	5	2	1		142.6
2000	1	1	1	10	15	14	28	28	8	1	1	0		107.7
2001	0	0	1	1	2	10	15	16	2	1	0	0		46.2
2002	0	2	4	7	8	13	23	26	11	2	1	0		102.9
2003	0	3	7	13	9	16	16	34	15	2	1	0		118.8
2004	0	0	5	2	7	21	22	17	5	1	0	0		79.0
2005	1	0	2	4	6	15	20	59	26	5	1	0		140.8
2006	0	0	45	19	20	14	36	58	20	4	1	1		219.2
2007	0	0	2	2	9	13	13	12	2	0	0	0		54.5
2008	1	1	1	3	3	8	15	22	6	1	1	0		62.9
2009	0	2	0	3	9	17	21	38	7	2	0	0		99.4
2010	0	0	0	2	3	9	18	30	33	5	1	0		100.8
2011	4	3	20	8	7	12	28	39	53	21	3	0		198.0
2012	2	0	0	2	1	15	28	16	3	1	0	0		68.4
2013	0	5	19	4	4	10	12	8	2	0	0	0		63.1
2014	0	0	0	0	6	9	10	6	0	0	0	0		33.0
2015	0	0	5	2	10	3	3	3	0	0	0	0		26.4
2016	0	0	4	13	13	32	24	18	6	0	0	0		110.3
2017	7	5	29	38	56	26	38	54	27	6	1	0		285.9
2018	0	6	1	8	3	18	32	13	4	1	0	0		88.4
2019	0	0	0	7	16	15	41	39	33	7	1	0		157.6
2020	0	0	3	1	2	4	15	22	5	1	0	0		53.5
2021	0	0	0	0	0	2	8	6	0	0	0	0		16.8



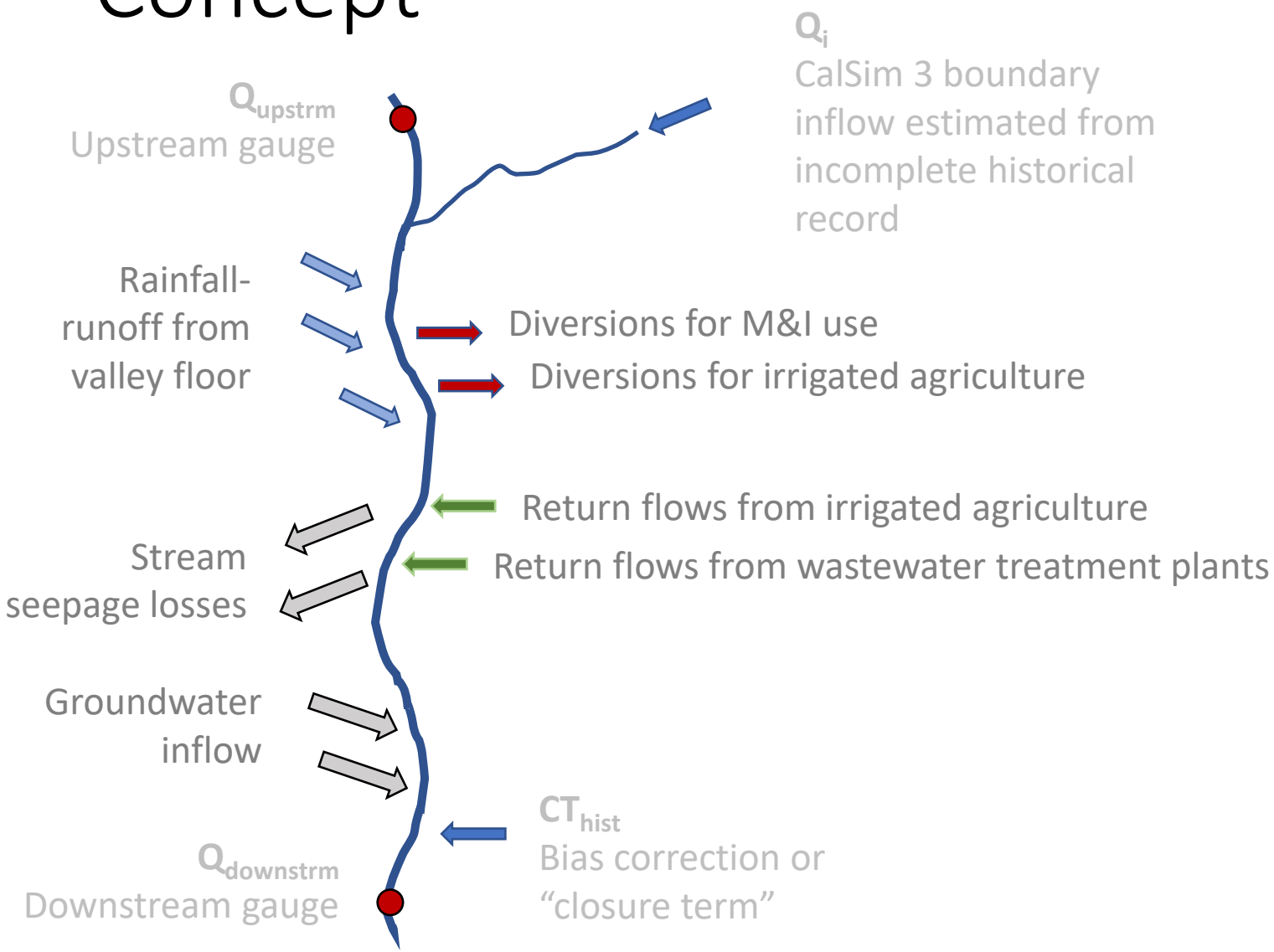
Closure Terms

CalSim 3 uses ‘closure terms’ to adjust surface water supplies using historical streamflow data as a reference or control. These terms can be regarded as a bias correction of rim inflows and/or rainfall runoff so that simulated and recent observed streamflow data are more consistent. Data has been developed in a set of Excel workbooks, one for each closure term. These data have now been extended to include October 2015 – September 2021.



$$CT_{hist} = Q_{upstrm} + Q_i - Q_{downstrm}$$

Concept

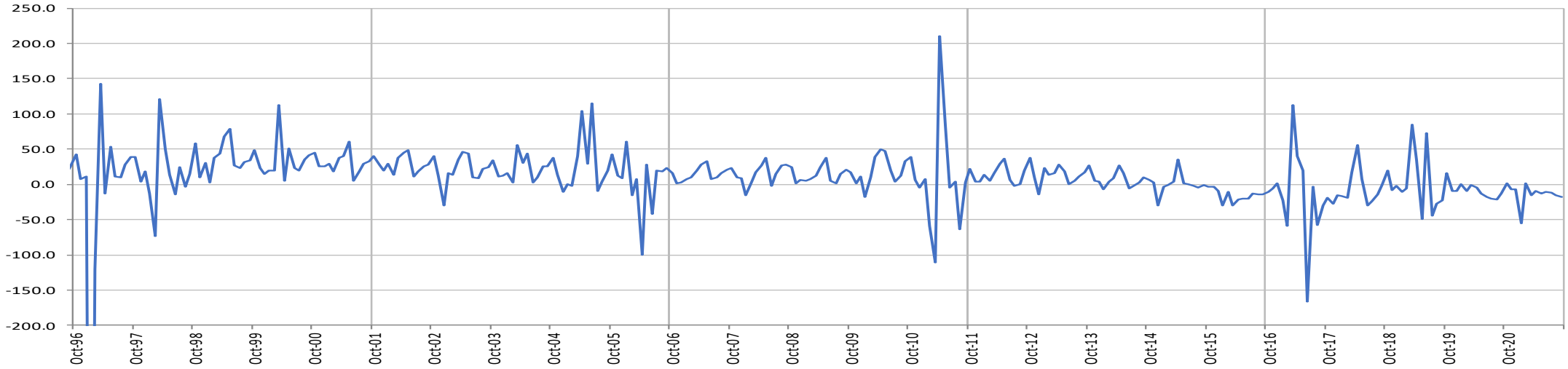


Bias correction for rim inflows and rainfall runoff complicated by many other types of inflows and outflows along stream reach.

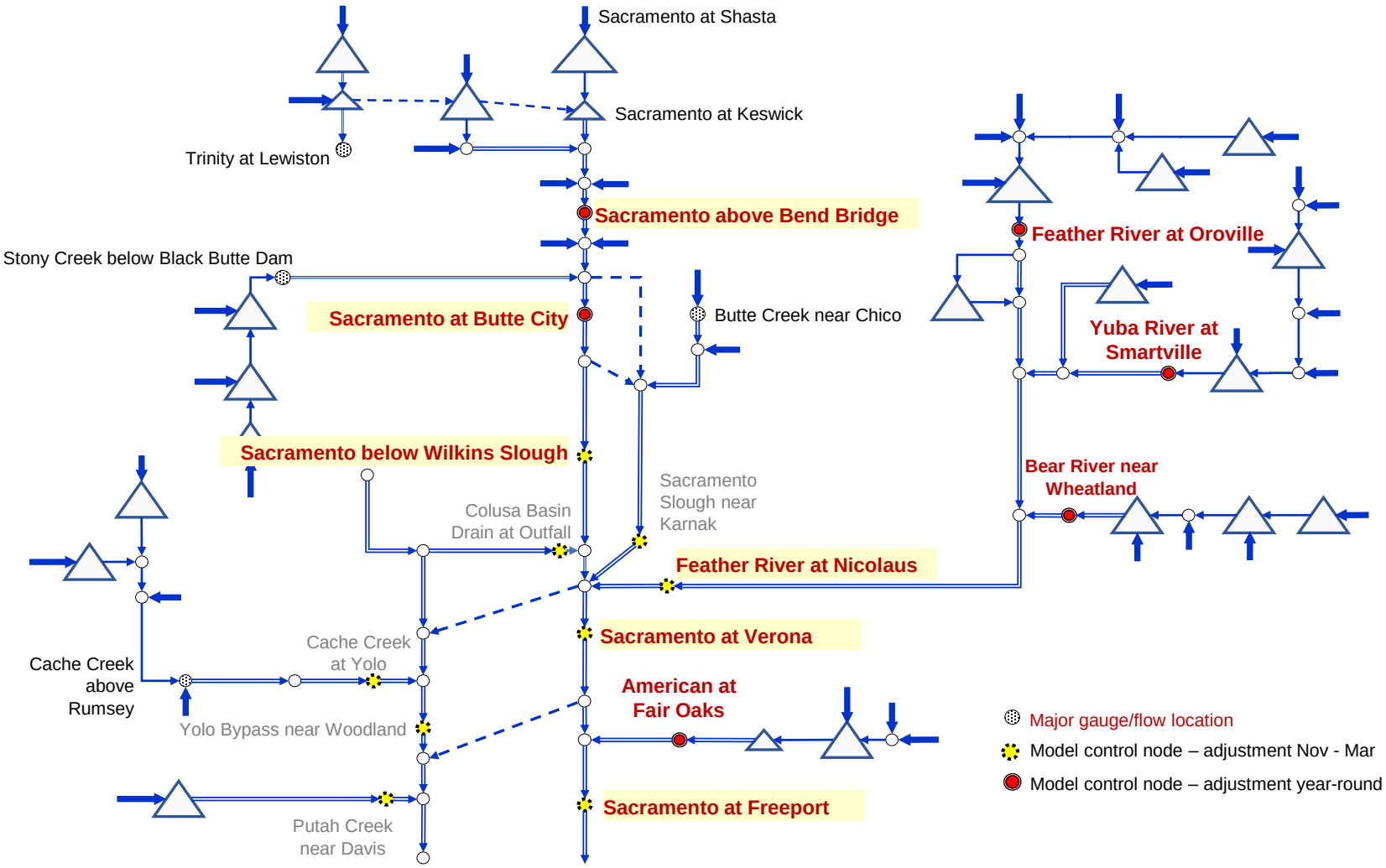
Apply closure terms when rim inflows and rainfall runoff dominant components of water balance

Extension to 2021 - Challenges

- Historical Data availability and limitations
- Lack of information on Agricultural Return Flows
- Inconsistencies between C2VSIM and GW DLL
- Changes in Hydrology over time
- No consistent monthly bias seen in at few locations

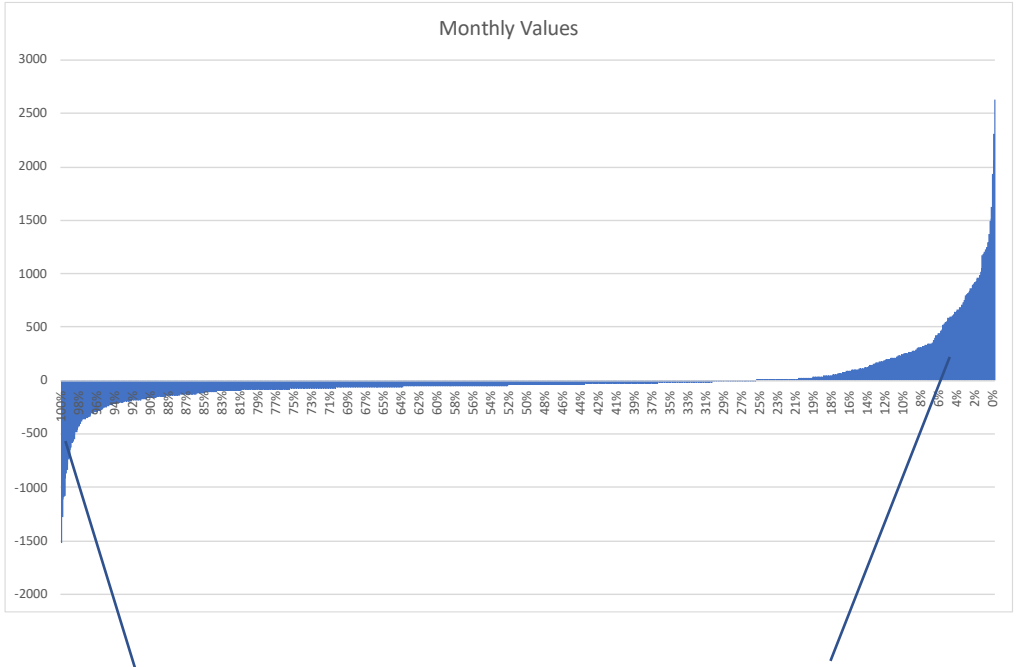


Sacramento Valley



Sacramento Valley

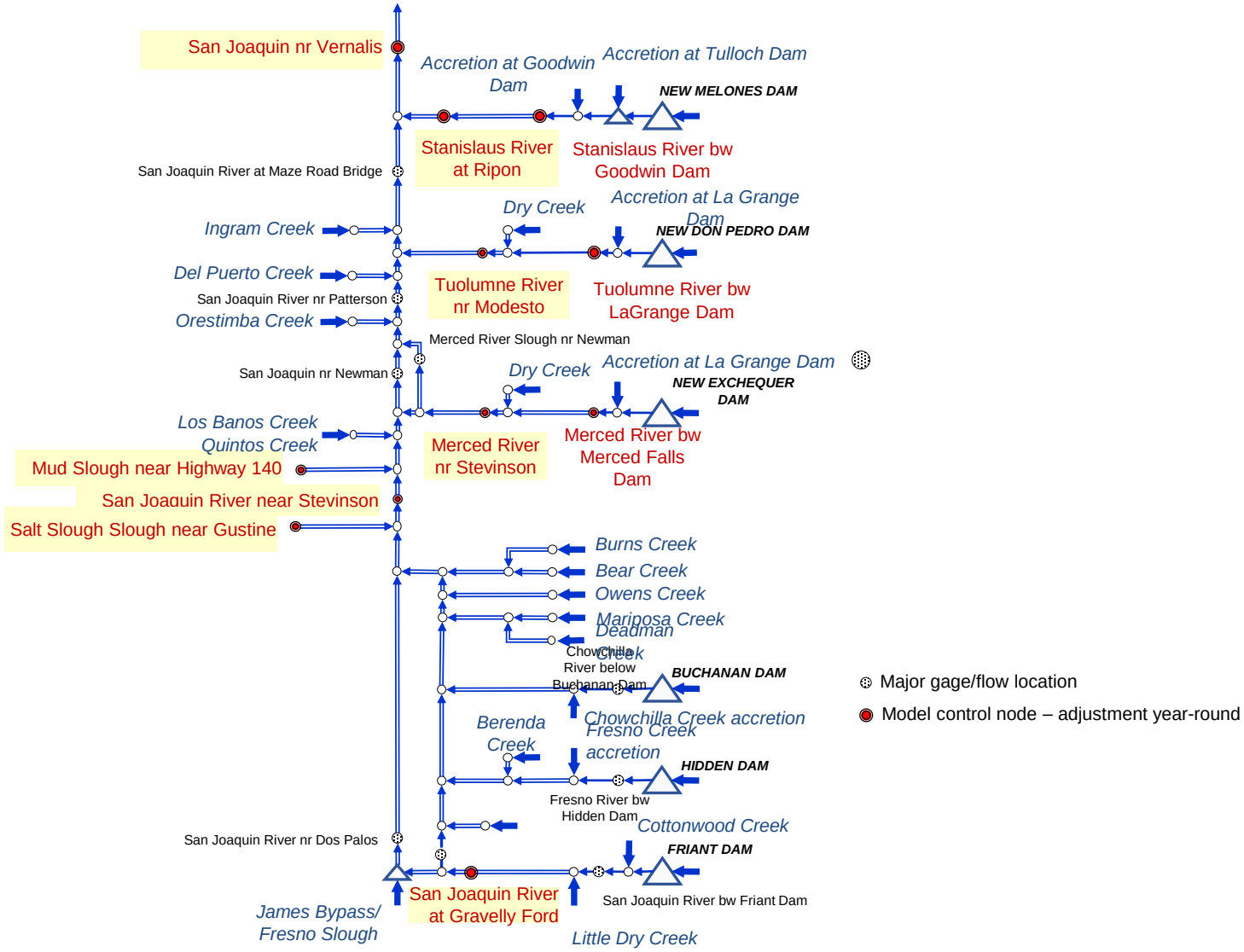
	Average	Max Monthly	Min Monthly	Comment
	(TAF/year)	(TAF)	(TAF)	
CT_BENDBRIDGE_SV	144	368	-270	
CT_BUTTECITY_SV	-90	1165	-527	
CT_COLUSA_SV	0	0	0	No longer used
CT_DAVIS_SV	0	0	0	No longer used
CT_FAIROAKS_SV	-81	0	-114	
CT_FREEPORT_SV	95	309	-417	
CT_NICOLAUS_SV	107	513	-659	Nov – Mar only
CT_OROVILLE_SV	-24	0	-157	
CT_SACSLOUGH_SV	0	0	0	No longer used
CT_SMARTVILLE_SV	-25	0	-73	
CT_VERONA_SV	-36	1891	-1159	Nov – Mar only
CT_WHEATLAND_SV	13	70	-60	
CT_WILKINSSL_SV	-4	575	-300	
CT_WOODLAND_SV	0	0	0	No longer used
CT_YOLO_SV	0	0	0	No longer used
Total	97	2,628	-1,522	



High flow events but errors in gauged flow over weirs causing large negative values

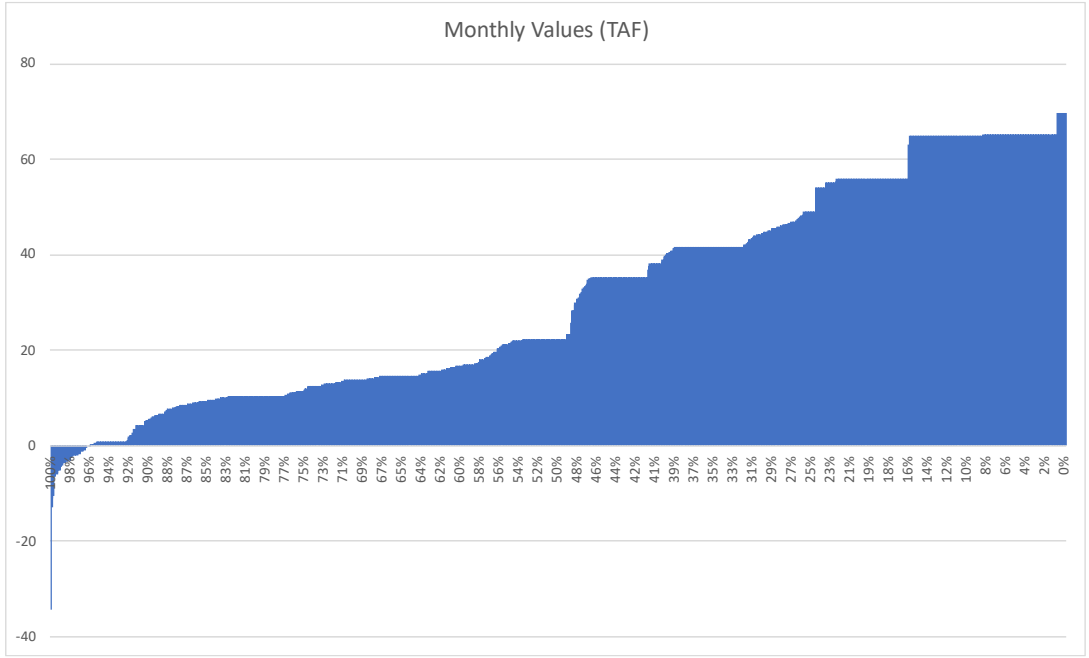
High flow events

San Joaquin Valley



San Joaquin Valley

	Average (TAF/year)	Max (TAF)	Min (TAF)	Comment
CT_GRAVFORD_SV	-48	6	-9	
CT_MELON_SV	-21	0	-45	
CT_MERCED_SV	164	21	7	
CT_MODESTO_SV	98	18	0	
CT_MUDSLOUGH_SV	0	0	0	No longer used
CT_PEDRO_SV	-1	0	-16	
CT_RIPON_SV	113	18	3	
CT_SALTSLOUGH_SV	-48	2	-15	
CT_STEVINSON_SV	115	30	-5	
CT_VERNALIS_SV	0	0	0	No longer used
Total	371			



CalSimHydro Input Extension

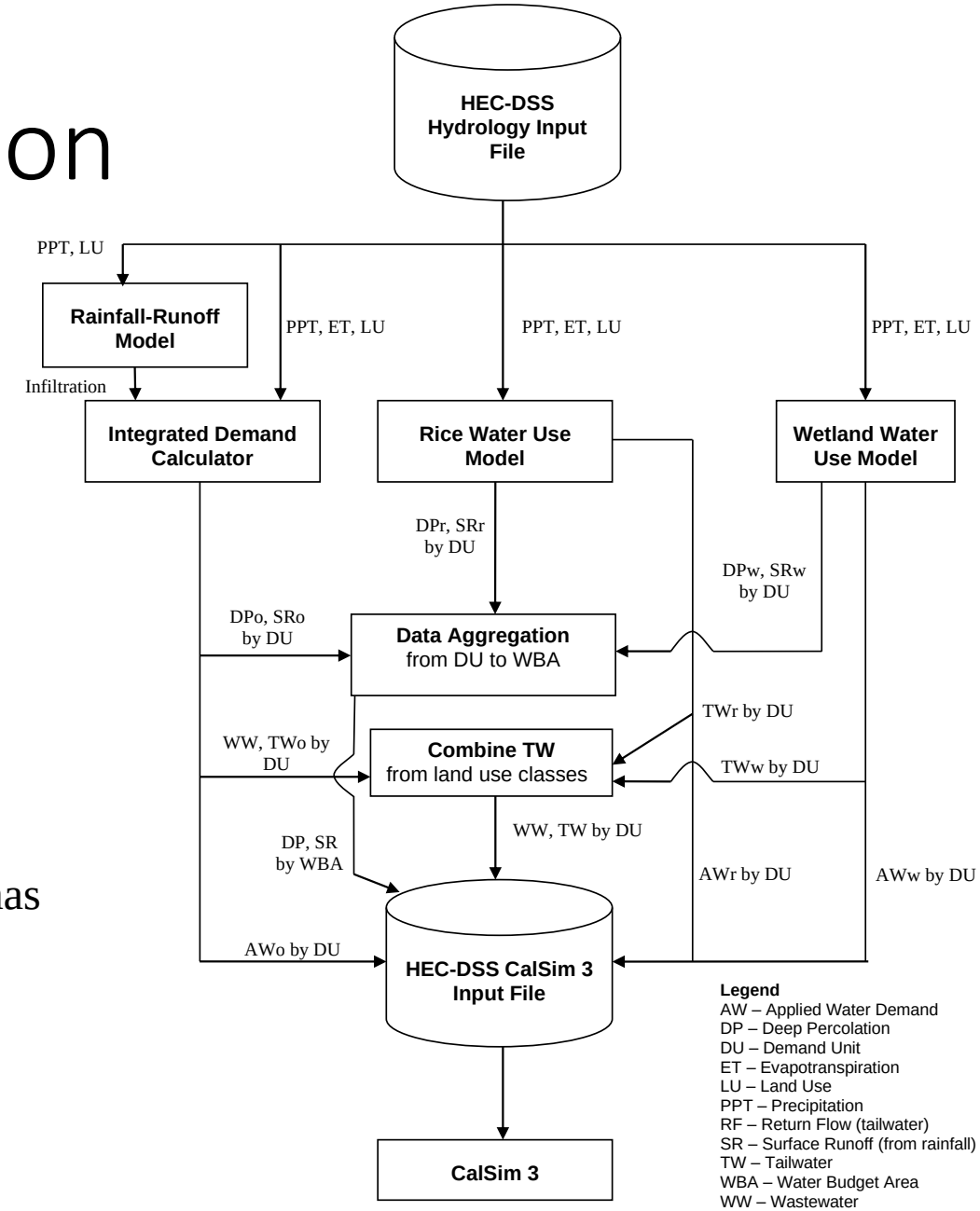
- PPT extended using the PRISM database.
- ET extended using temperature and PPT data from PRISM.
- Land use data extended through the DWR Atlas database.
- Modified Fortran-based IDC code.

<u>Challenges</u>:

Holes in the land use data provided by the DWR Atlas database.

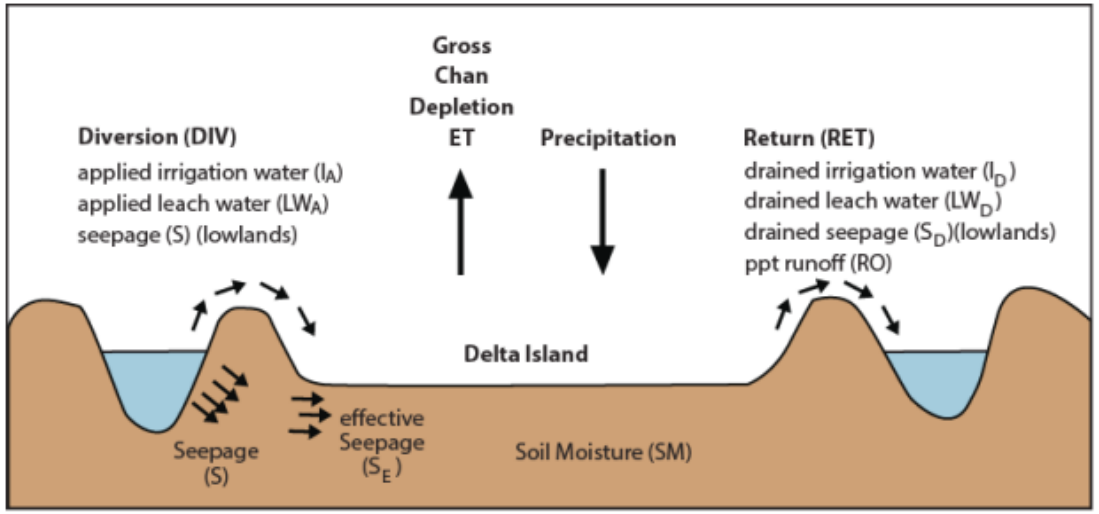
Land use data only available for 2016, 2018, and 2019. 2020 available (3/8/2023) with 2021 expected soon.

The temperature data for the entire period-of-record in PRISM has changed.



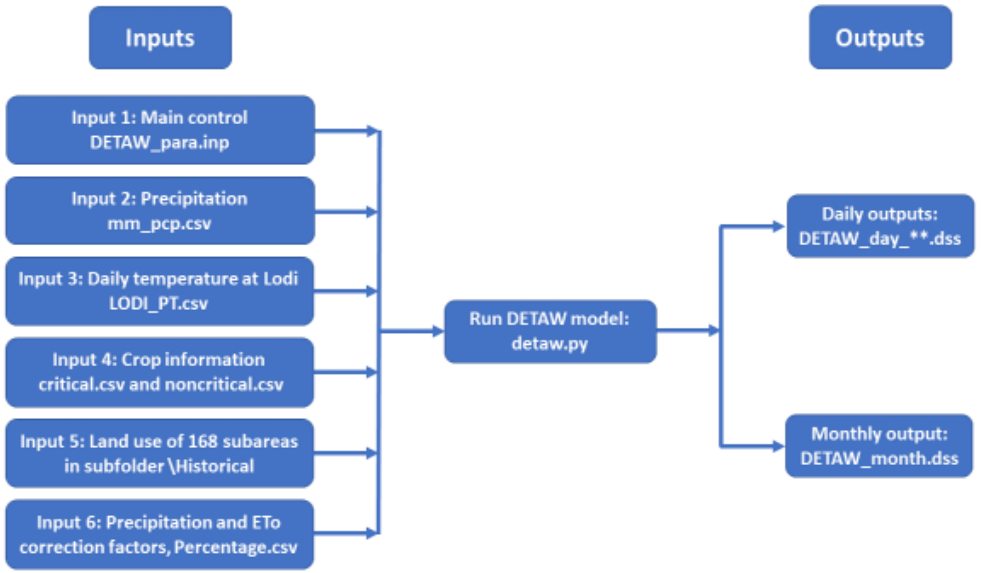
DETAW & DCD: Delta Net Channel Depletion

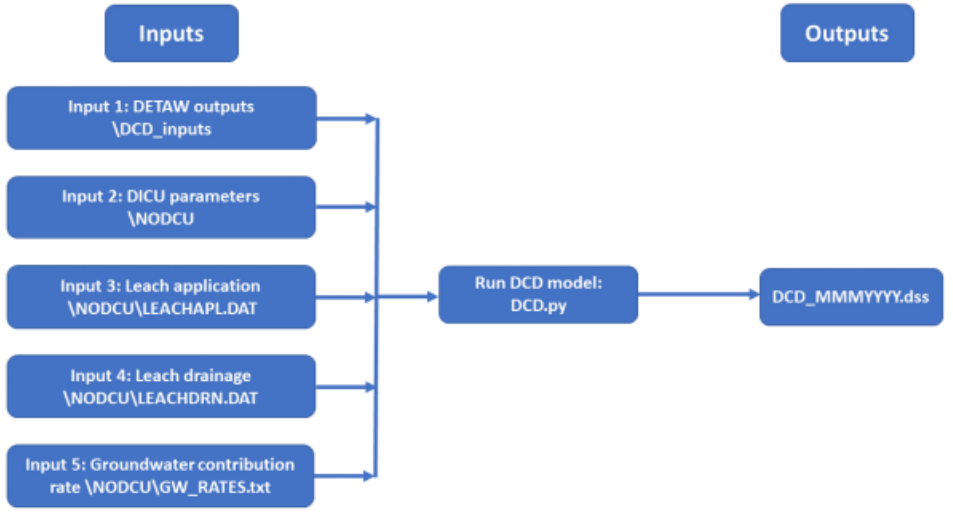
- Simulates channel depletions in the Sacramento-San Joaquin Delta.
- Evolution of DICU (Delta Island Consumptive Use) Model.
- Simulates farming practices, irrigation efficiencies, and allocation factors to distribute island values to DSM2 nodes.
- Outputs diversions to islands, drainage from islands, and seepage on DSM2 nodes.



DETAW & DCD Extension

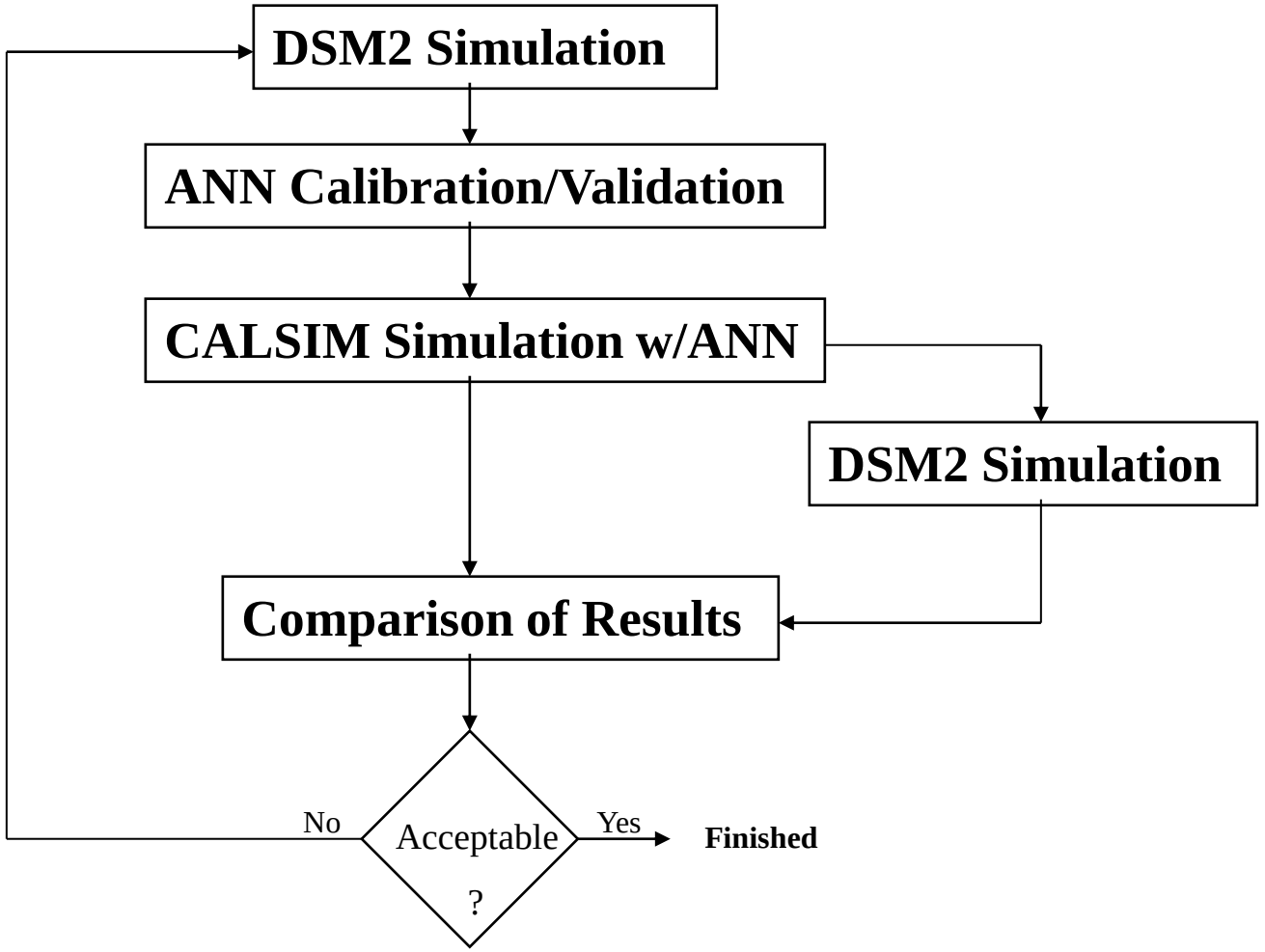
- DCD uses station meteorological data as inputs.
- Observations before 2016 were sourced from different networks e.g. NCDC, CIMIS, were left unchanged.
- Update for 2016 – 2021/present uses observations from the CIMIS network.
- Future work
  - Evaluate the benefits of using PRISM, HRRR as input sources.
  - How does changing to newer inputs impact DCD output?





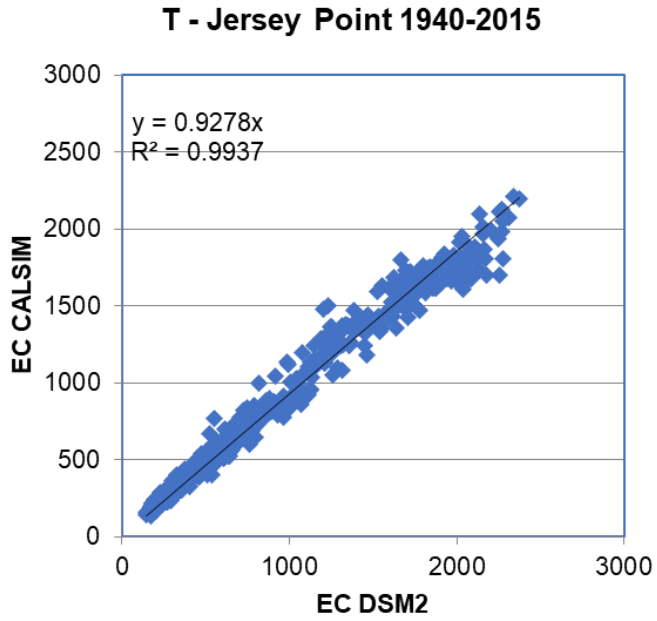
ANN: a DLL in CalSim 3

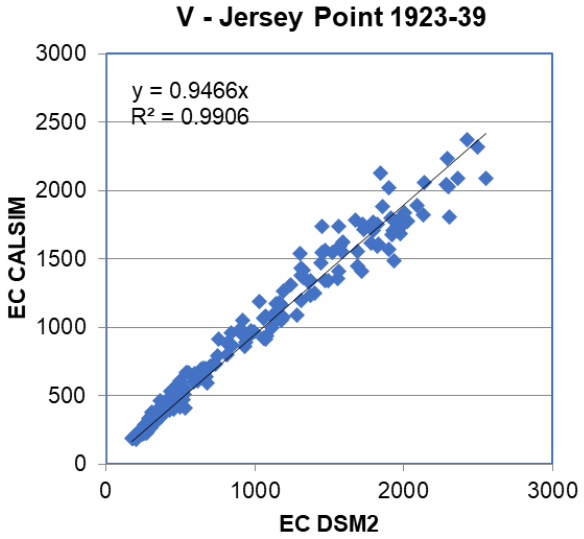
- Provides flow-salinity relationships in the Delta.
- DSM2 is the standard DWR model for hydro dynamics and water quality.
  - The running time of DSM2 makes it too expensive for CalSim 3;
  - 1 hour of computing time to simulate 1 year of salinity.



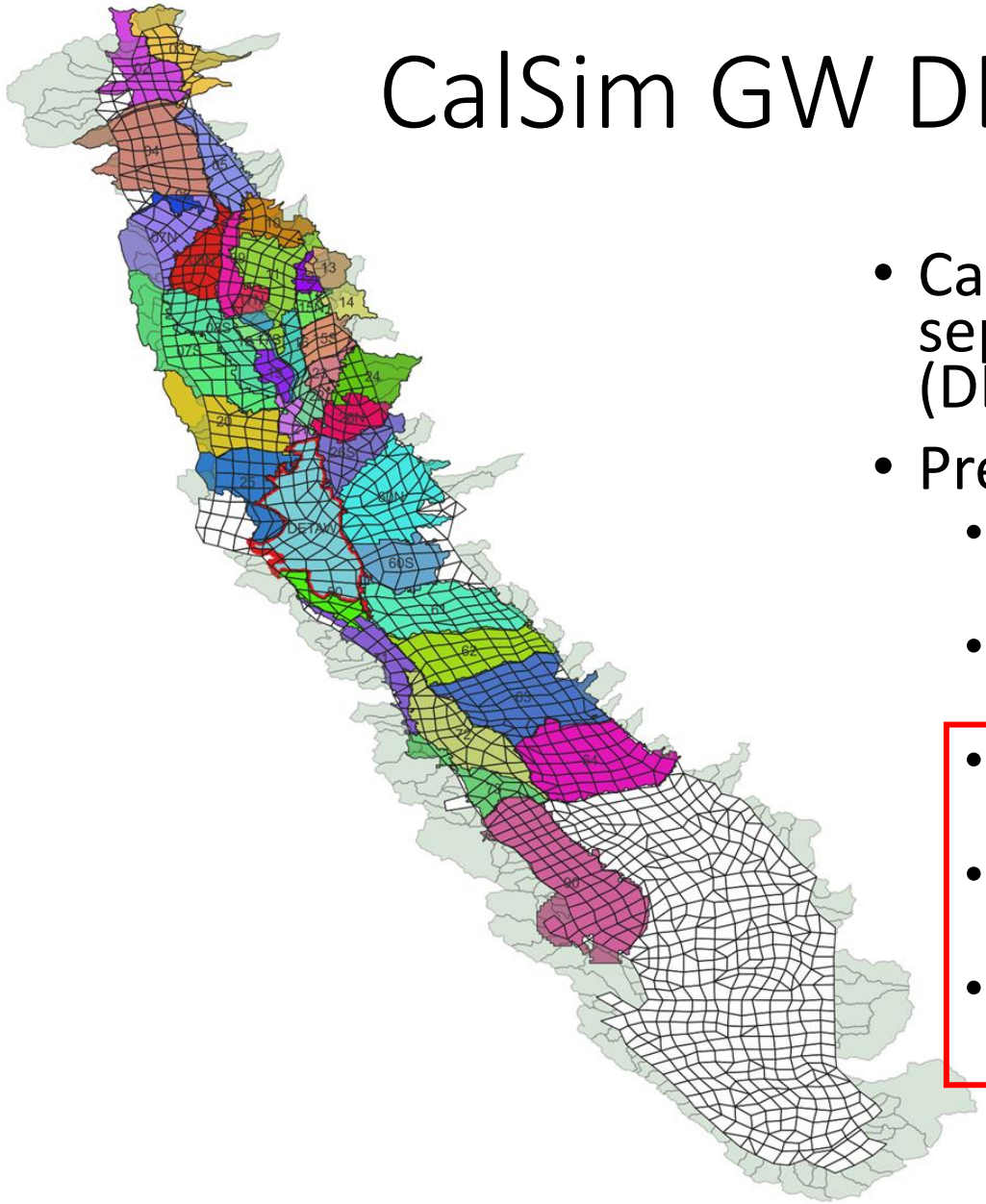
Extension of the ANN DLL

- As of July 2022 CalSim 3 ANN DLL was capable of running between October 1921 to September 2016.
- 15mins Tidal data for Golden gate was updated up to 2025, and the ANN DLL is now capable running up until 2025.
- ANN has been calibrated for the period of for 1940-2015, and validated for the period of 1923-1939. Salinity (EC) Regression analysis shows $R^2 > 0.9$ for control stations.
- Current version of ANN DLL is suitable for running extended period (up until 2021) without re-training.
- Recent SMSCG ops studies proved that ANN DLL works well without new training.





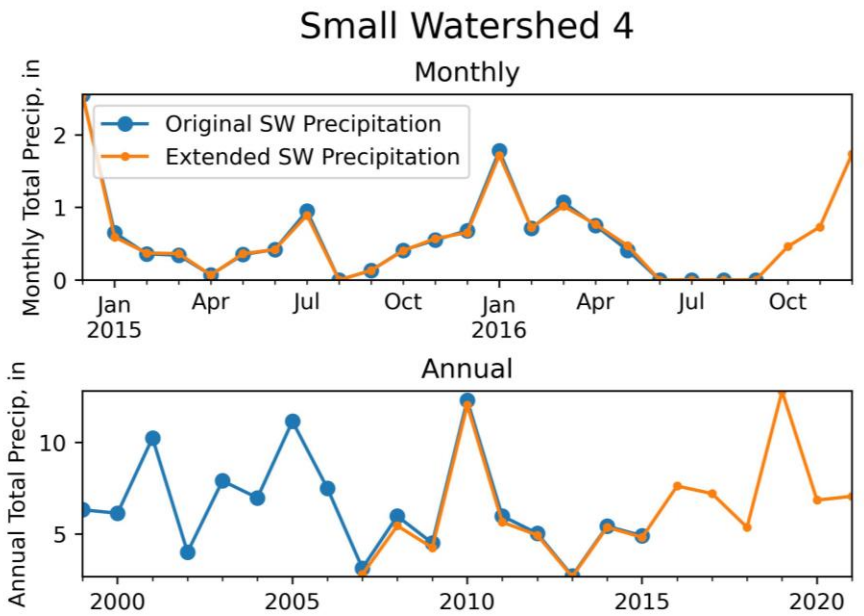
CalSim GW DLL Timeseries Input Extension



- CalSim GW DLL: Simulation module of IWFM was separated and compiled into a dynamic-link library (DLL)
- Preprocessed input timeseries:
  - Water Budget Areas on GW Elements
    - Deep percolation from CalSimHydro
  - Delta Area on GW Elements
    - DCD Model
  - GW Elements outside the WBA
    - Deep percolation from CalSimHydro with Native Vegetation
  - Small watershed areas outside of the GW Elements
    - Boundary recharge from the Small Watershed model
  - GW element areas in the Tulare Basin
    - Groundwater pumping developed from C2VSim-FG

Small Watersheds Extension

- Standalone version of the C2VSim Small Watershed simulation module
  - Provides subsurface lateral inflow to boundary groundwater nodes
- Model Timeseries Inputs:
  - Monthly Precipitation
    - Extended for each Small Watershed using PRISM
  - Monthly Average ET
    - Not modified
  - No changes were made to pre-extension input datasets
  - Comparison of extended datasets showed minimal differences
- Boundary recharge extended through September 2021



External Elements Extension

- C2VSim Elements not covered by the WBAs
- Deep percolation is modeled using the RFRO and IDC models from the CalSimHydro model
  - Assumes Native vegetation
- Model Timeseries Inputs:
  - Monthly Precipitation
    - Extended for each Element using PRISM
  - Monthly ET – From nearby WBA ETc for native vegetation
    - Extended for each Element from the Extended CalSimHydro Model
  - Comparison of extended dataset showed minimal differences
- Deep percolation from the external elements was extended through September 2021

Tulare Groundwater Pumping Extension

- Original inputs based on the C2VSim-FG model, which was not available for the extension period.
- Dataset was extended through September 2021 using the most similar water years
  - Similar water year closest to total annual full natural flow (FNF) volume at San Joaquin below Friant

Water Year	Annual FNF (TAF)	Matched Water Year	Annual FNF (TAF)
2016	1,127	1947	1,129
2017	4,341	1938	3,526
2018	1,409	2003	1,412
2019	2,668	1941	2,600
2020	921	1991	933
2021	699	1990	758

Miscellaneous Timeseries

The majority of CalSim 3 timeseries input data consist of rim inflows, reservoir evaporation, closure terms, and CalSimHydro output. Other inputs include (approximate number given in parenthesis):

- Inputs based on C2VSim groundwater modeling (329)
- Delta Channel Depletion (27)
- Precipitation (26)
- CDEC unimpaired flows (10)
- Applied water (11)
- **Uncategorized (62)**

Miscellaneous Timeseries

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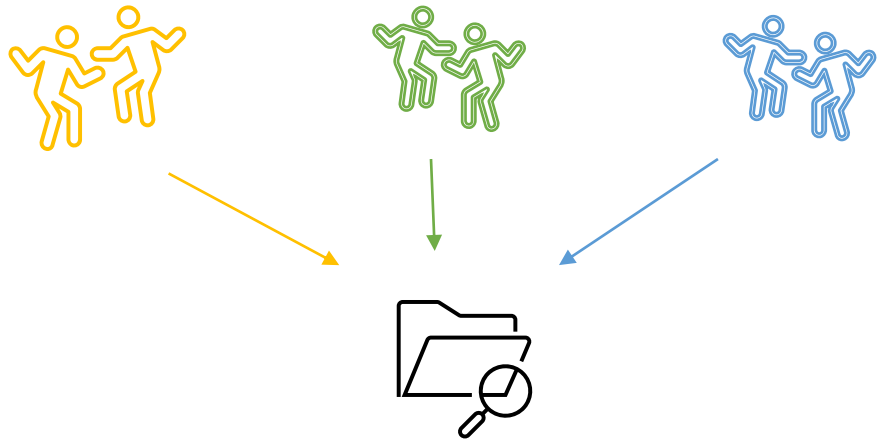
Many sources missing documentation or source material

Source Documentation Effort: Purpose

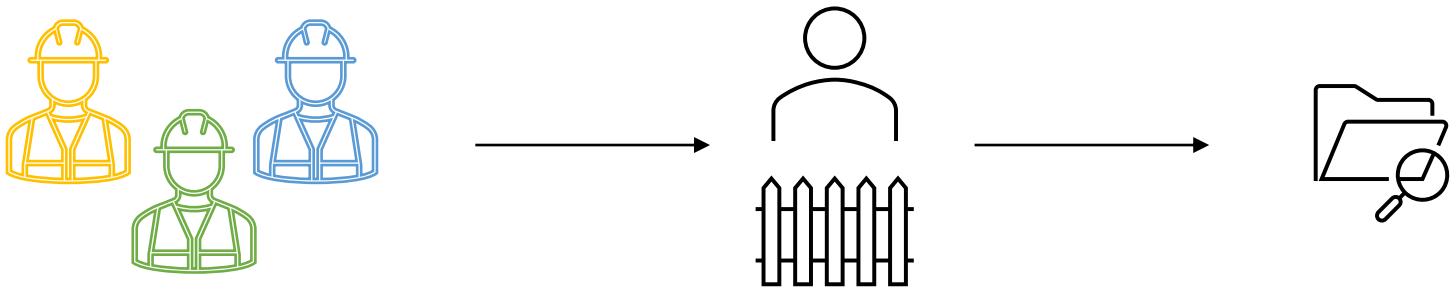
To identify and document the sources (models, spreadsheets, etc.) to generate input data for the base CalSim3 model

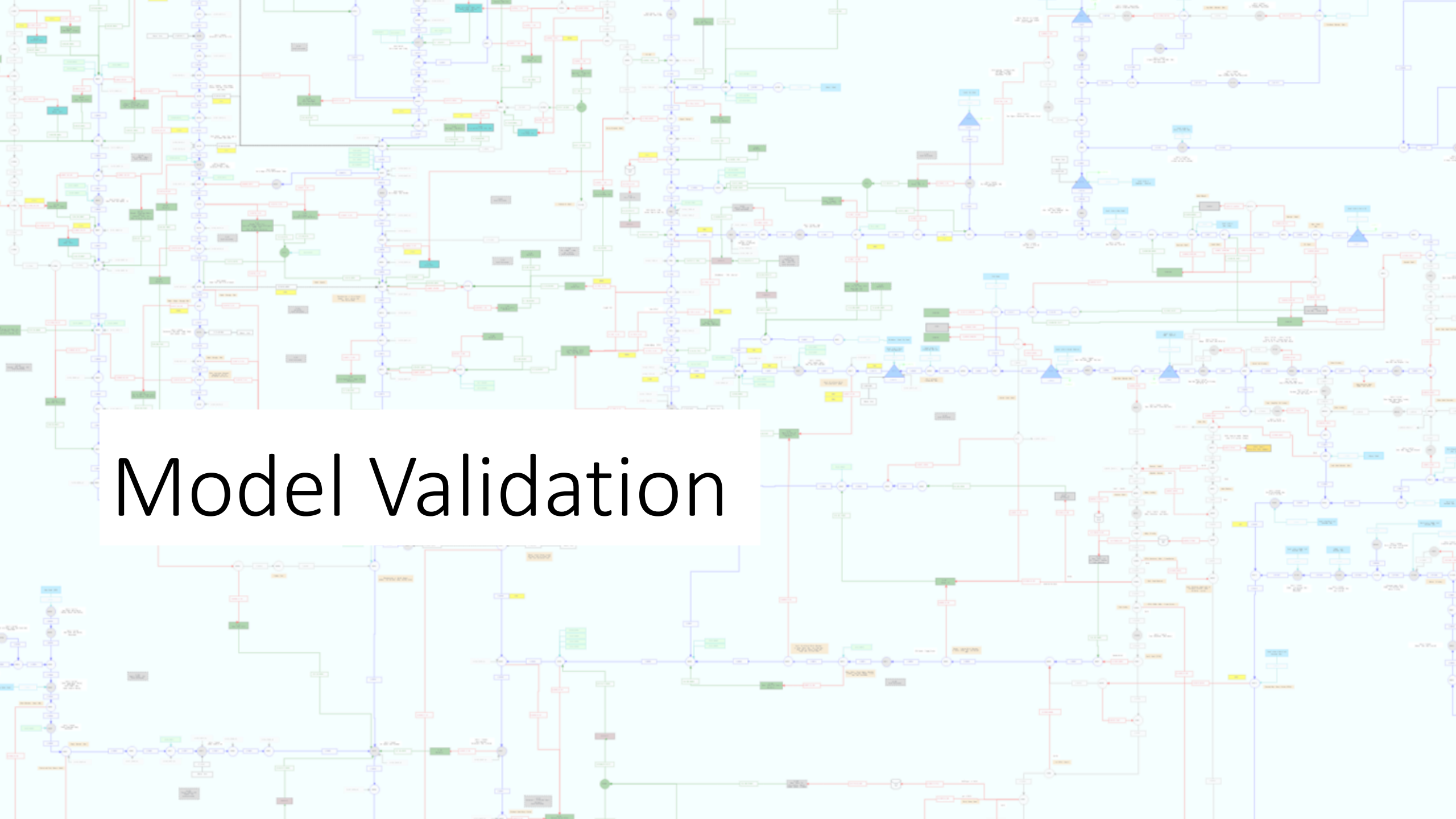
Documentation of the input data will be stored in a centralized repository for use for the broader CalSim modelling community.



Source Documentation Effort: Version Control

- It was determined that a ‘gatekeeper(s)’ will be assigned to:
  - Review issues and updates forwarded to them
  - Request further info (ask about impact of revisions, etc.)
  - Perform QC (e.g., check for unused timeseries)
  - Incorporate revisions into the SV DSS file and documentation
- A standardized procedure to incorporate revisions will be developed





Model Validation

Model Validation Metrics: Delta Inflow

Assess the overall performance of CalSim 3 through comparison of historical and simulated inflows from the Sacramento Valley to the Delta

This comparison provides an aggregate measure of the validity of:

- rim inflows
- surface runoff
- groundwater inflows to the stream system
- surface water diversions
- surface water return flows

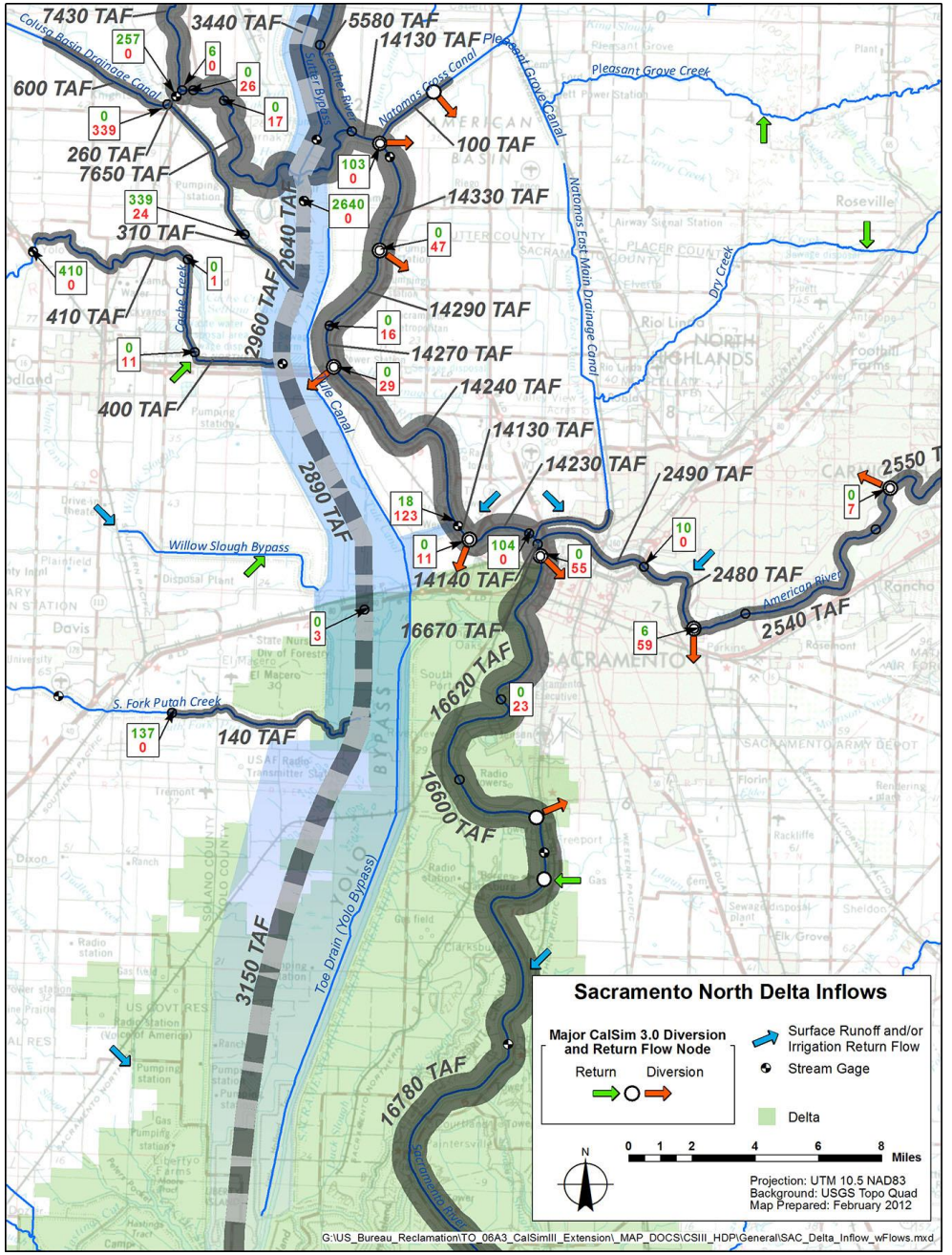
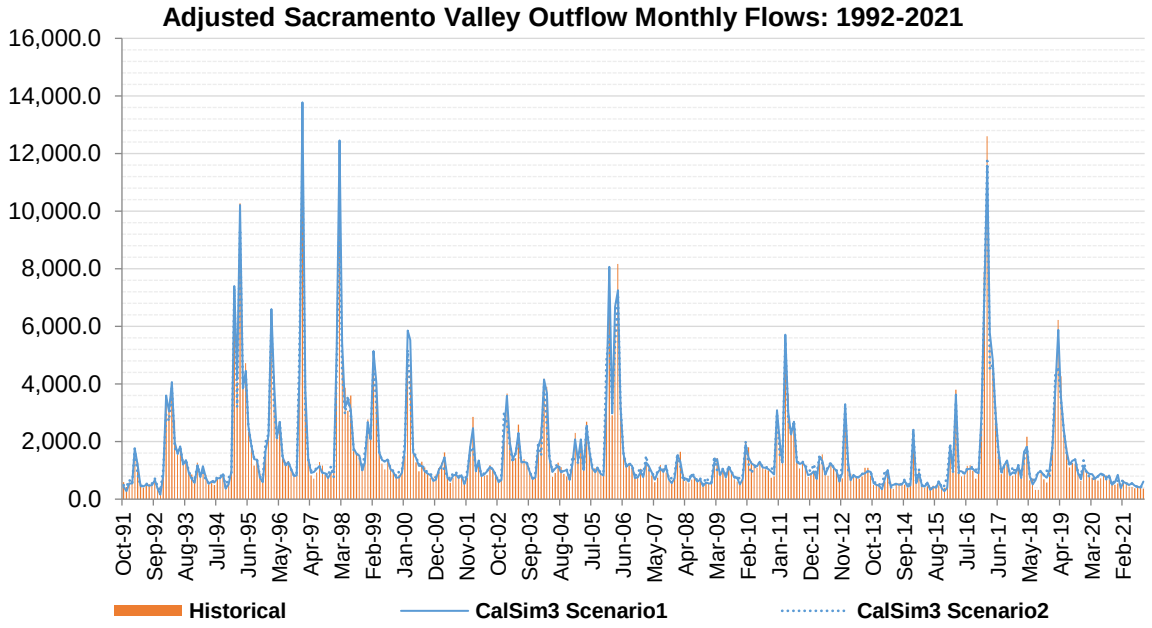
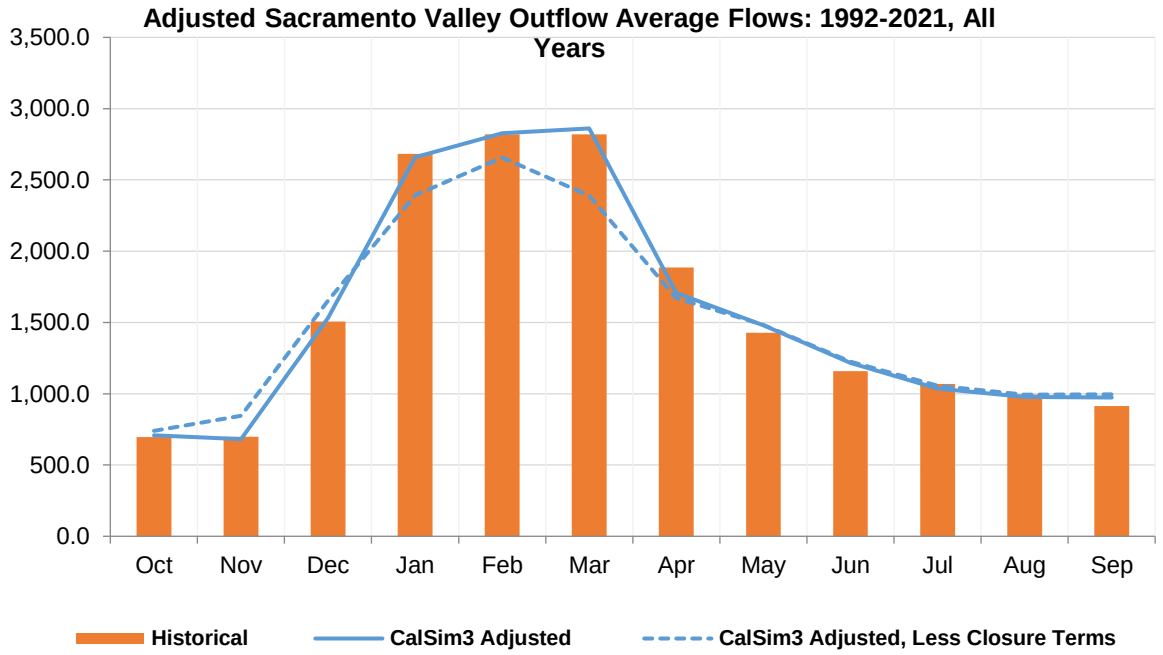
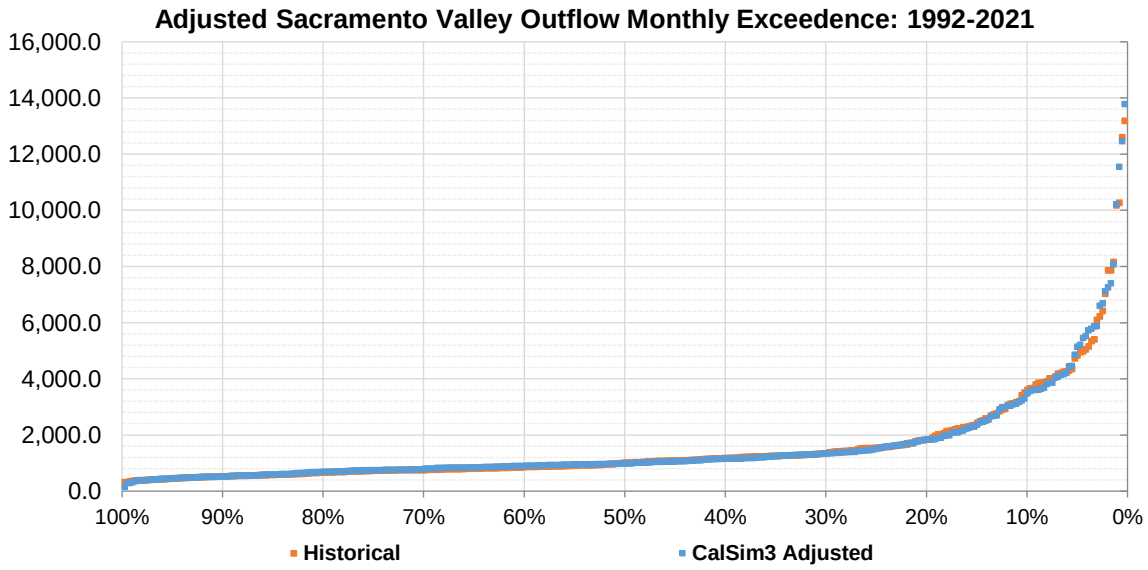


Figure: Historical Average Annual Inflows to the Delta for Water Year 1990-2009


Adjusted Sacramento Valley Outflow Monthly Flows: 1992-2021
16,000.0
14,000.0
12,000.0
10,000.0
8,000.0
6,000.0
4,000.0
2,000.0
0.0
Oct-91
Sep-92
Aug-93
Jul-94
Jun-95
May-96
Apr-97
Mar-98
Feb-99
Jan-00
Dec-00
Nov-01
Oct-02
Sep-03
Aug-04
Jul-05
Jun-06
May-07
Apr-08
Mar-09
Feb-10
Jan-11
Dec-11
Nov-12
Oct-13
Sep-14
Aug-15
Jul-16
Jun-17
May-18
Apr-19
Mar-20
Feb-21
Historical
CalSim3 Scenario1
CalSim3 Scenario2


Adjusted Sacramento Valley Outflow Average Flows: 1992-2021, All Years
3,500.0
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
0.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Historical
CalSim3 Adjusted
CalSim3 Adjusted, Less Closure Terms


Adjusted Sacramento Valley Outflow Monthly Exceedence: 1992-2021
16,000.0
14,000.0
12,000.0
10,000.0
8,000.0
6,000.0
4,000.0
2,000.0
0.0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Historical
CalSim3 Adjusted

Thank you!

Co-presenters

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- Jim Polsinelli James.Polsinelli@water.ca.gov
- Kunxuan Wang KWang@usbr.gov
- Lauren Thatch LThatch@usbr.gov
- Mechele Pacheco MPacheco@usbr.gov
- Puneet Khatavkar Puneet.Khatavkar@stantec.com