CalSim 3.0 (Sac Valley) Model Calibration

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Background

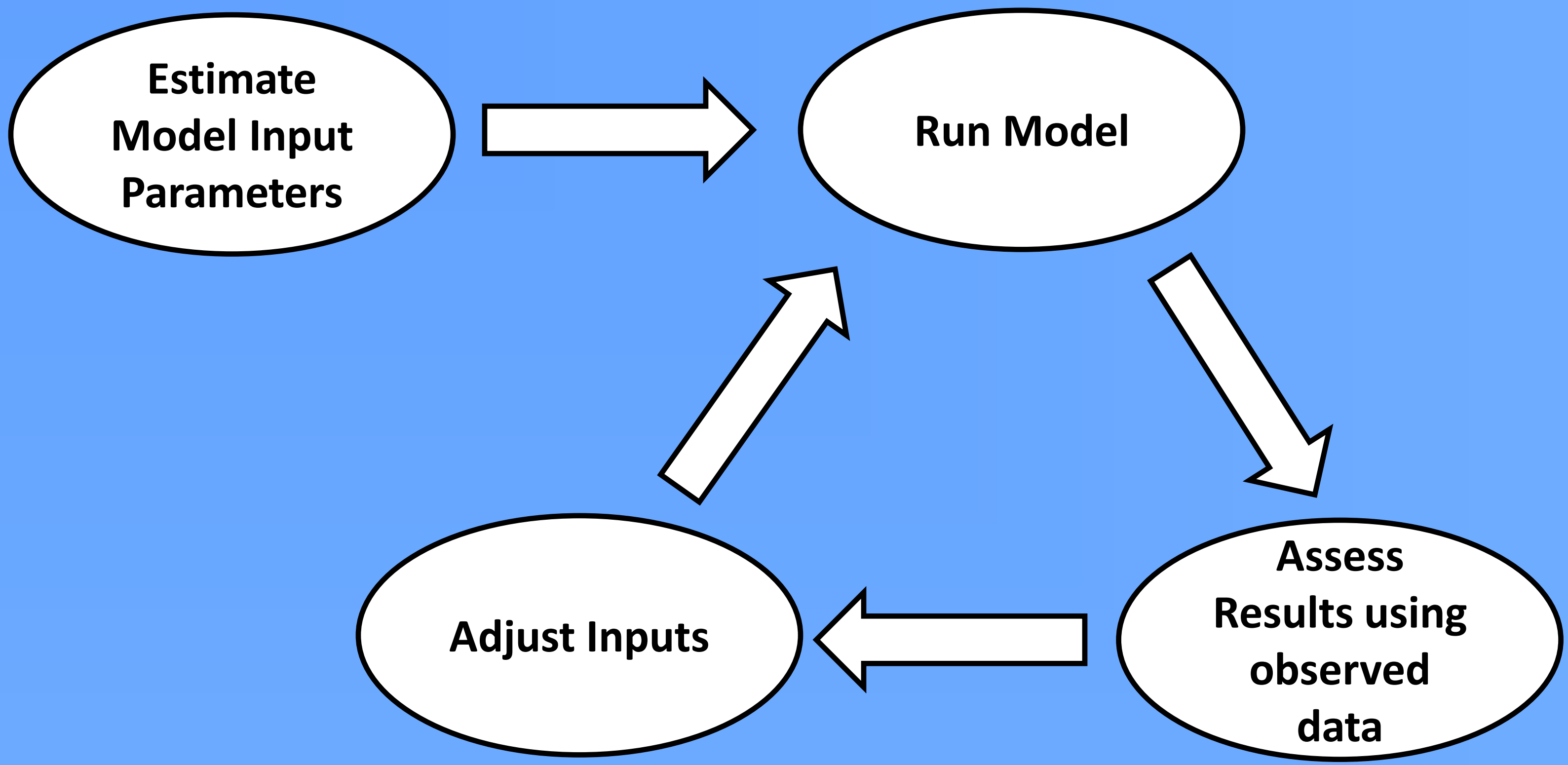
Continuous improvement and updates have been made to CalSim 3.0 and its hydrologic pre-processor CalSimHydro, so it becomes necessary to calibrate CalSim 3.0

Calibration period: WY 1998-2007

- **Actual land use data form DSWIM**
- **CalSim 3.0 existing LOD is using 10yr avg of 1998-2007 land use**

Region: Sacramento Valley

Model Calibration Process -- 1



Model Calibration Process -- 2

Generate closure term (CT)

What is Closure Term? → stream inflow adjustments

These inflow adjustments resulting from:

- **Errors in boundary rim inflows**
- **Precipitation data**
- **Over-simplified rainfall-runoff model**
- **Lack of calibration data**
- **Errors in stream gage**

What parameters to Calibrate?

1. **Water use efficiency factors:**

   RPF -- coefficient of Riparian & Miscellaneous Evaporative Losses

   EVF -- evaporative loss fraction
   DPF -- deep percolation loss fraction
   LFF -- lateral flow loss fraction
   OSF -- canal operating spill fraction

   RUFr -- Reuse factor for rice
   RUFo -- Reuse factor for other crops
   RUFw -- Reuse factor for wetland

   GPMINF -- minimum groundwater pumping fraction

2. **Curve Number**

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

Input

- Observations:
  - Stream Flow Records
  - Diversions
  - Reservoir Storages
  - Reservoir Releases
- Model Results
  - Applied Water Demands
  - Surface Runoff
  - Tailwater/Wastewater
  - Stream Gain/Loss

Assimilated Output

- Consistent Flow Conditions:
  - Channel Flow
  - Diversions
  - Reservoir Storage
  - Reservoir Release
  - Return Flow
  - Stream Gain/Loss
  - Conveyance Losses
  - Closure Term

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

Input

- Observations:
  - Stream Flow Records
  - Diversions
  - Weir Spills
  - Reservoir Storages
  - Reservoir Releases

  (USGS gage, CDEC gage, USBR CVO, USBR Willow Office, DWR WDL, Diversion data from SWPAO, etc)

- Model Results
  - Applied Water Demands
  - Surface Runoff
  - Tailwater/Wastewater

  (CalSimHydro Using Historical Land Use Data)

  - Stream Gain/Loss

  (groundwater DLL in CalSim 3.0 Dynamically simulated)

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

For adjusting parameters: water use efficiency and curve number

Assimilated Output

- Consistent Flow Conditions:
  - Channel Flow → **No Constrains**
  - Diversions → **Soft Constrains w/ high penalties for summer when simulate diversion is higher than Observed**
  - Spill from Weirs
  - Reservoir Storage
  - Reservoir Release

    (Spill from Weirs, Reservoir Storage, Reservoir Release) → **Soft Constrains w/ highest penalties (penalties = 99999)**
  - Return Flow → **Simulated based on reuse factor**
  - Stream Gain/Loss → **Model Coupling Correction**
  - Conveyance Losses → **Simulated based on Conveyance Losses factors**
  - Closure Term

Adjust Water Use efficiency factors

So the simulated diversions will be close to observed historical diversion

CalSim 3.0 Demand Unit Balance Equations

DG+RU+GP = AW +RP +EV +DP +LF +OSF

RP = AW*RPF Riparian & Miscellaneous Evaporative Losses

EV = DG*EVF Evaporative loss
DP = DG*DPF Deep percolation loss
LF = DG*LFF Lateral flow loss fraction
OS = DG*OSF Operating spill

RU = Min(TW, AWo*RUFo + AWr*RUFr + AWw*RUFw) Reuse

GP > GPMINF * { AW + RP –RU } Minimum GW Pumping

DG = sum of all diversions to one demand unit

If the demand unit doesn’t need that much water, even the simulated diversion is softly constrained to observed diversion, simulated diversion will be less than observed diversion.

Sacramento Valley Hydrological Data Assimilation Model (SacDAM)

Soft Constrains with different penalties for Diversions

```
goal setD_THRMA_JBC000  {lhs D_THRMA_JBC000 case OTHER {condition always
                         rhs D_THRMA_JBC000_HT
                         lhs>rhs penalty DPGT
                         lhs<rhs penalty DPLT} }
```

```
define DPGT  { case summer {
                    condition month >= APR .and. month <= SEP
                    value 99999}
               case other  {
                    condition always
                    value 5000}}
define DPLT   {value 5000}
```

Adjust Water Use efficiency factors

RPF -- coefficient of Riparian & Miscellaneous Evaporative Losses

EVF -- evaporative loss fraction
DPF -- deep percolation loss fraction
LFF -- lateral flow loss fraction
OSF -- canal operating spill fraction

RUFr -- Reuse factor for rice
RUFo -- Reuse factor for other crops
RUFw -- Reuse factor for wetland

GPMINF -- minimum groundwater pumping fraction

Adjust Water Use efficiency factors Example: Glenn – Colusa ID

Demand Unit: 08N_SA2 and 08S_SA2

- **Rice dominated --- 80% of crop land is rice (101,634Acres Rice/ 126818 Acres)**
- **Small private wetland – 2327 Acres**

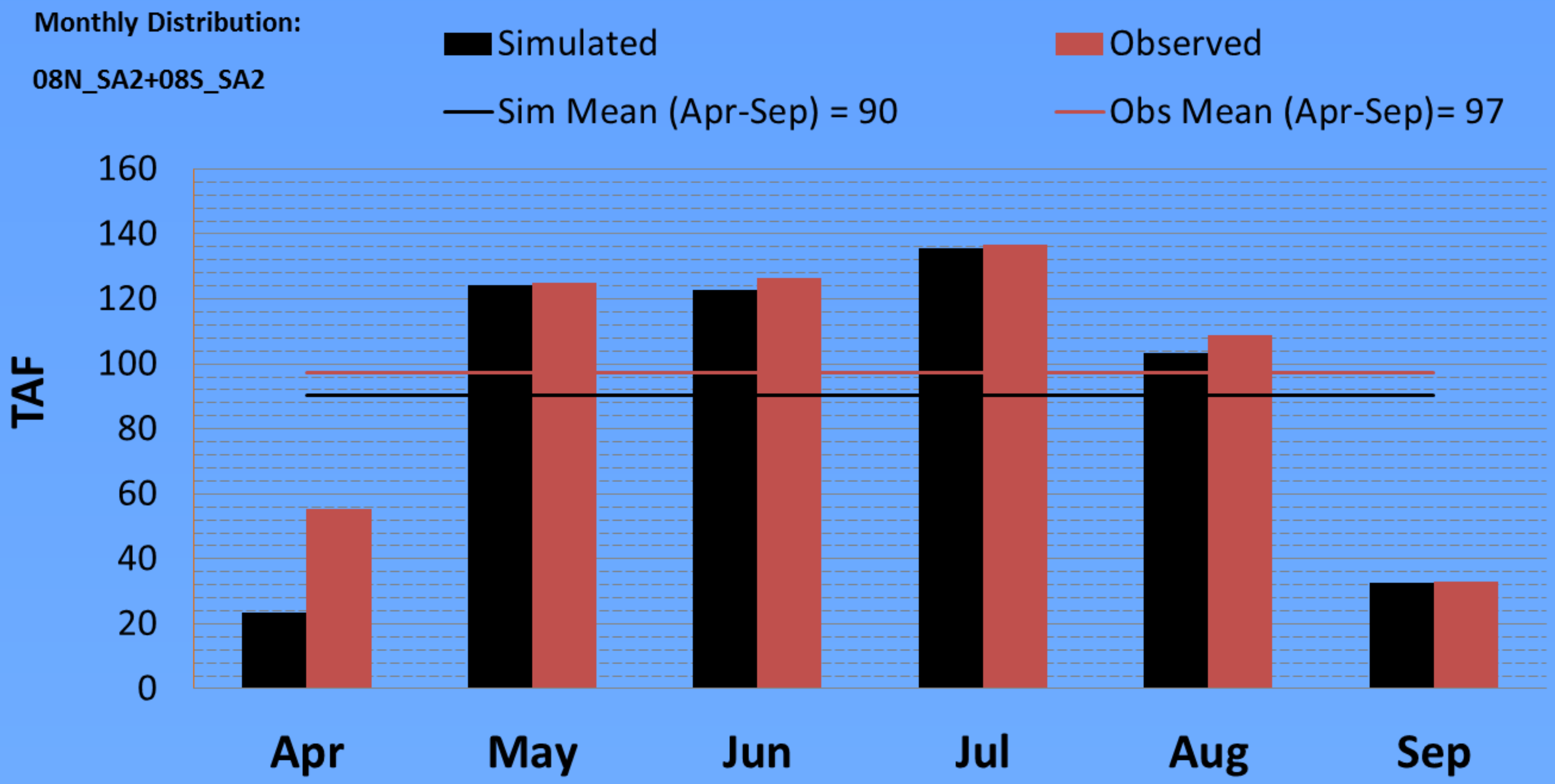
	LFF	DPF	OSF	EVF	RUFO	RUFR	RUFW	RP	MinGW
08N_SA2	0.07	0.09	0.03	0.01	0.05	0.7	0.15	0	0.04
08S_SA2	0.07	0.09	0.03	0.01	0.05	0.7	0.15	0	0.04

Adjust Water Use efficiency factors Example: Glenn – Colusa ID

Demand Unit: 08N_SA2 and 08S_SA2

Summer (Apr – Sep) total simulated diversion = 542 TAF → 7% less than observed

Summer (Apr – Sep) total observed diversion = 585 TAF

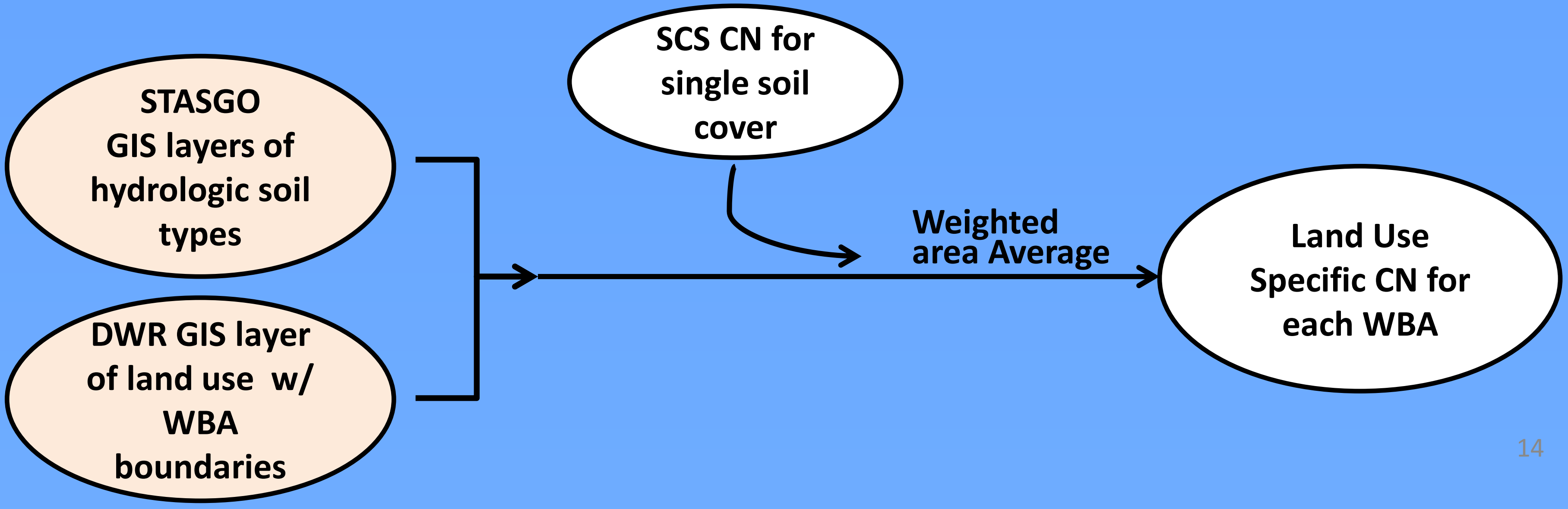


Adjust Curve Number (CN)

CN – Parameter in CalSimHydro Rainfall Runoff module to calculate surface runoff

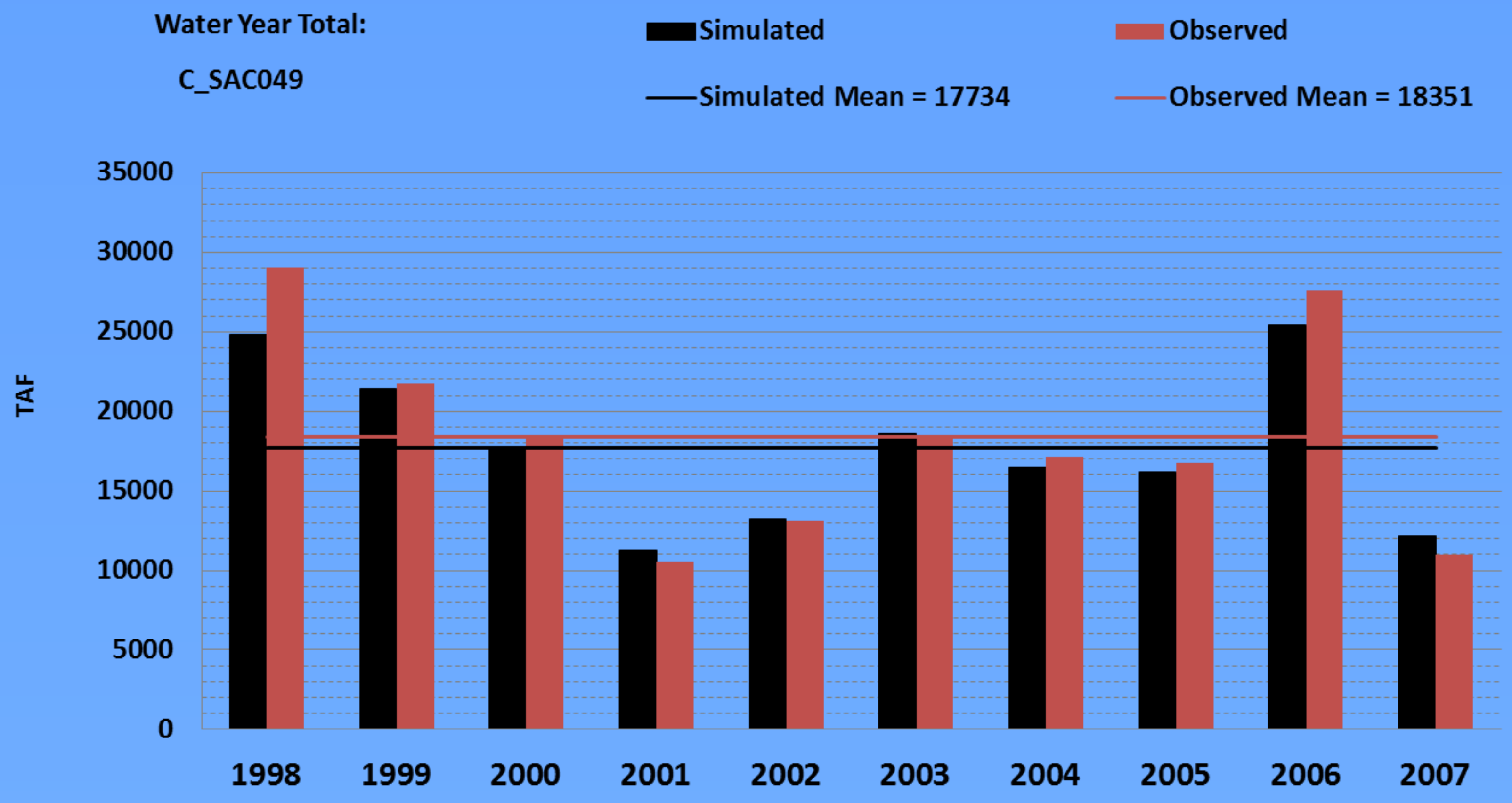
- Increase CN, increase surface runoff, decrease infiltration of rain, decrease DP in Winder
- CN are Land use specific and Water Budget Area specific

How were CalSimHydro's CN values developed:



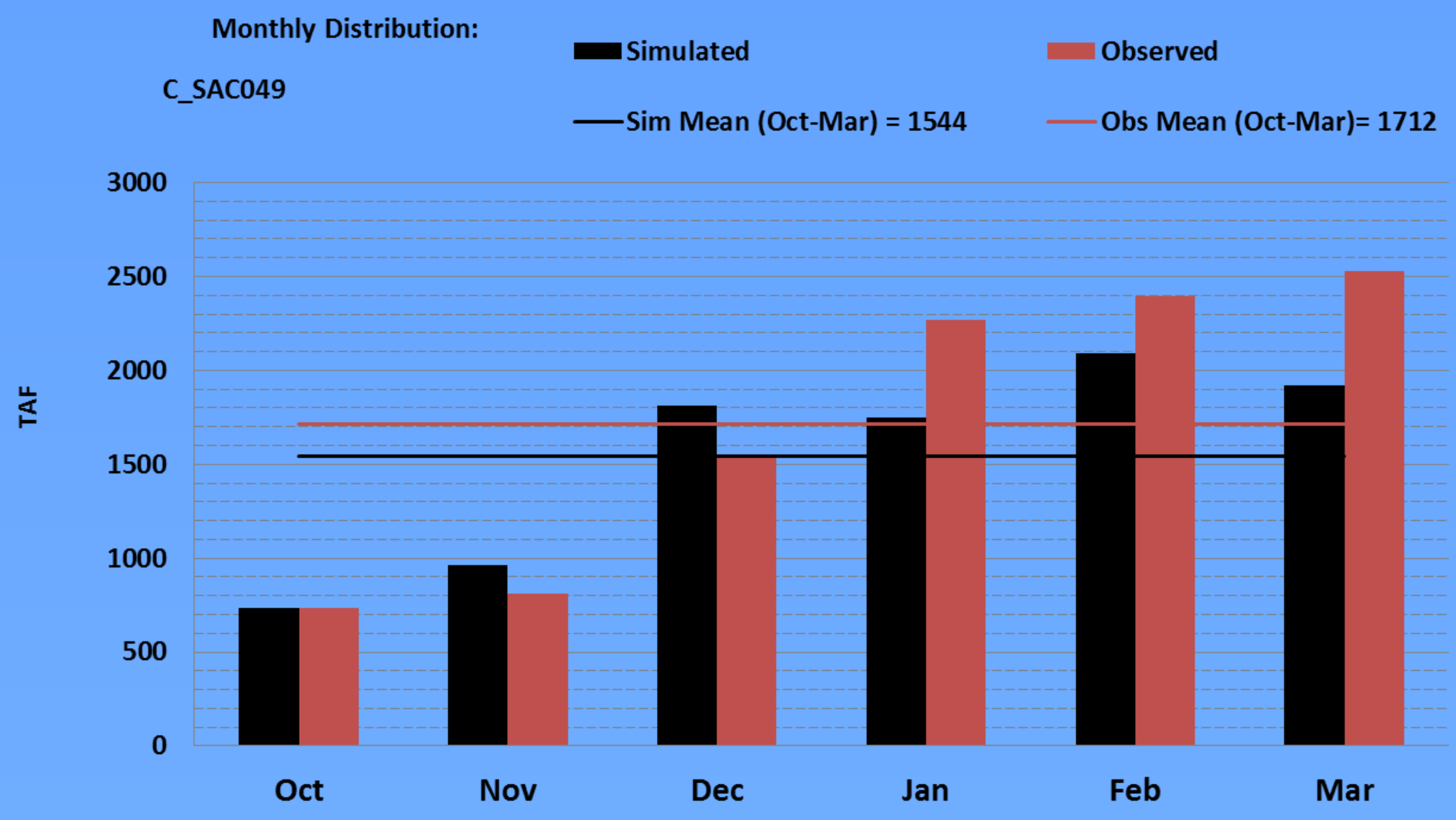
Stream Flow at Sac River near Freeport (SAC 049)

For original CN values:
Annual total simulated flow= 17734 TAF → 3% less than observed
Annual total observed flow = 18351 TAF



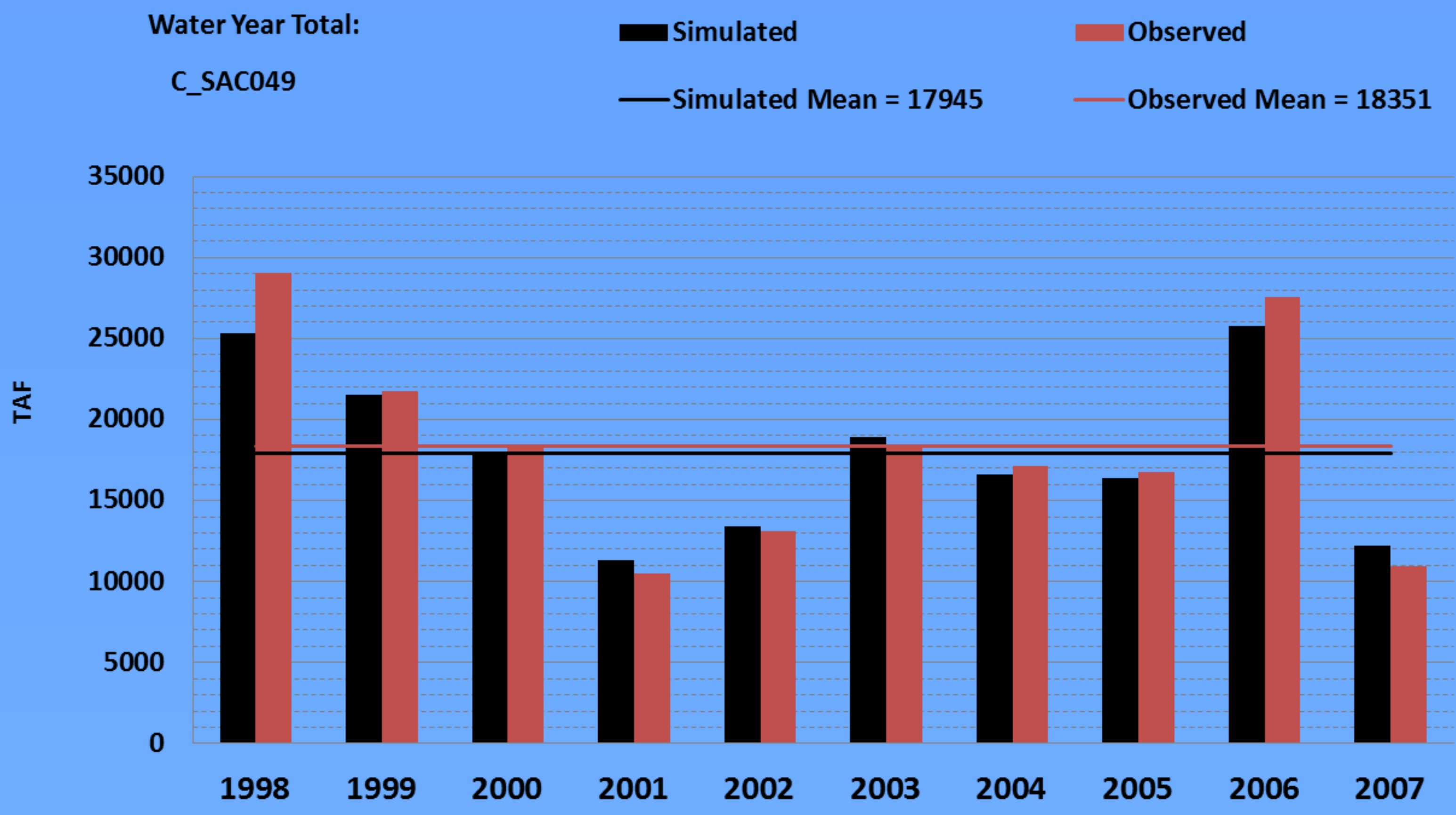
Stream Flow at Sac River near Freeport (SAC 049)

For original CN values:
Winter (Oct-Mar) total simulated flow= 9263 TAF → 10% less than observed
Winter (Oct – Mar) total observed flow = 10273 TAF



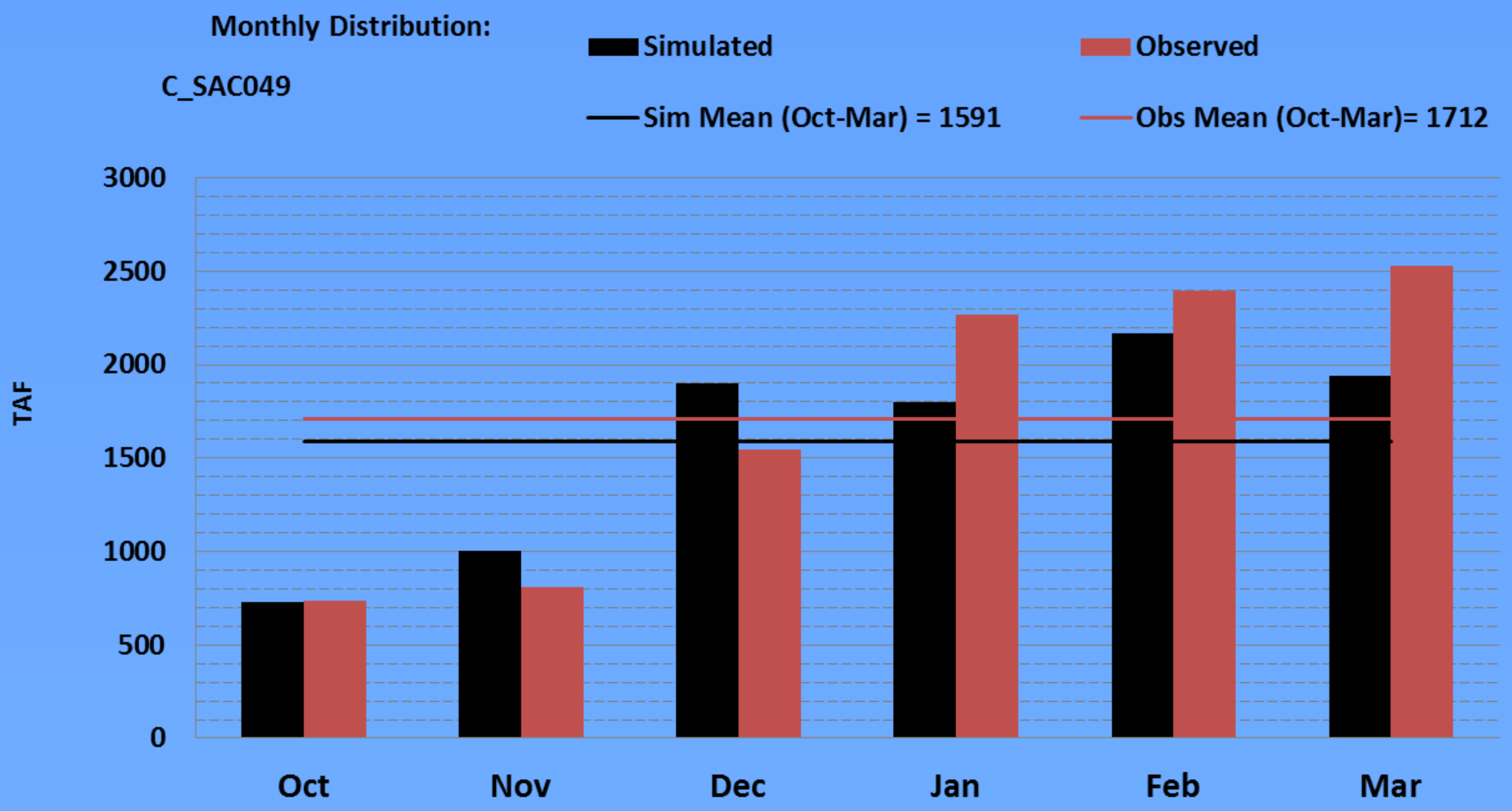
Stream Flow at Sac River near Freeport (SAC 049)

For 4% increase on CN values:
Annual total simulated flow= 17945 TAF → 2% less than observed
Annual total observed flow = 18351 TAF



Stream Flow at Sac River near Freeport (SAC 049)

For 4% increase on CN values:
Winter (Oct-Mar) total simulated flow= 9546 TAF → 7% less than observed
Winter (Oct – Mar) total observed flow = 10273 TAF



CN Sensitivity Analysis

			Mean Erro (Sim - Obs)	RMSE			
#	Channel Flo	Observed Mean	Original CN	- 2% CN	Original CN	+2% CN	+4% CN
1	C_AMR022	1268	-29	54	53	52	49
2	C_BRR011	214	-20	21	22	24	21
11	C_CBD000	130	16	63	66	76	91
12	C_CBD038	428	-146	190	178	162	141
13	C_CCH012	363	-86	113	108	107	104
21	C_FTR008	2990	288	343	348	355	370
22	C_FTR051	1606	385	411	410	408	406
23	C_FTR059	1612	383	413	413	412	411
29	C_OROVL	1820	342	375	375	375	375
30	C_PTH007	135	-25	27	30	32	35
31	C_PTH024	149	-32	41	41	40	39
33	C_SAC049	10273	-1011	1599	1506	1413	1248
34	C_SAC081	8847	-779	1346	1263	1183	1046
35	C_SAC097	4913	-561	705	647	593	504
36	C_SAC120	4764	-452	617	562	510	423
37	C_SAC146	5409	-340	551	500	453	379
38	C_SAC169	6446	-83	311	282	264	257
39	C_SAC185	6476	-96	256	223	204	203
40	C_SAC201	5980	41	328	308	304	318
41	C_SAC217	6189	-238	443	394	355	288
42	C_SAC257	5308	-142	232	193	167	123
43	C_SAC299	3455	-109	145	140	137	130
48	C_SSL001	3067	-400	564	550	539	514
57	C_YBP032	2418	536	1250	1264	1274	1277
58	C_YUB006	878	-61	95	94	93	92
			Total RMSE	**10491**	**9969**	**9530**	**8844**

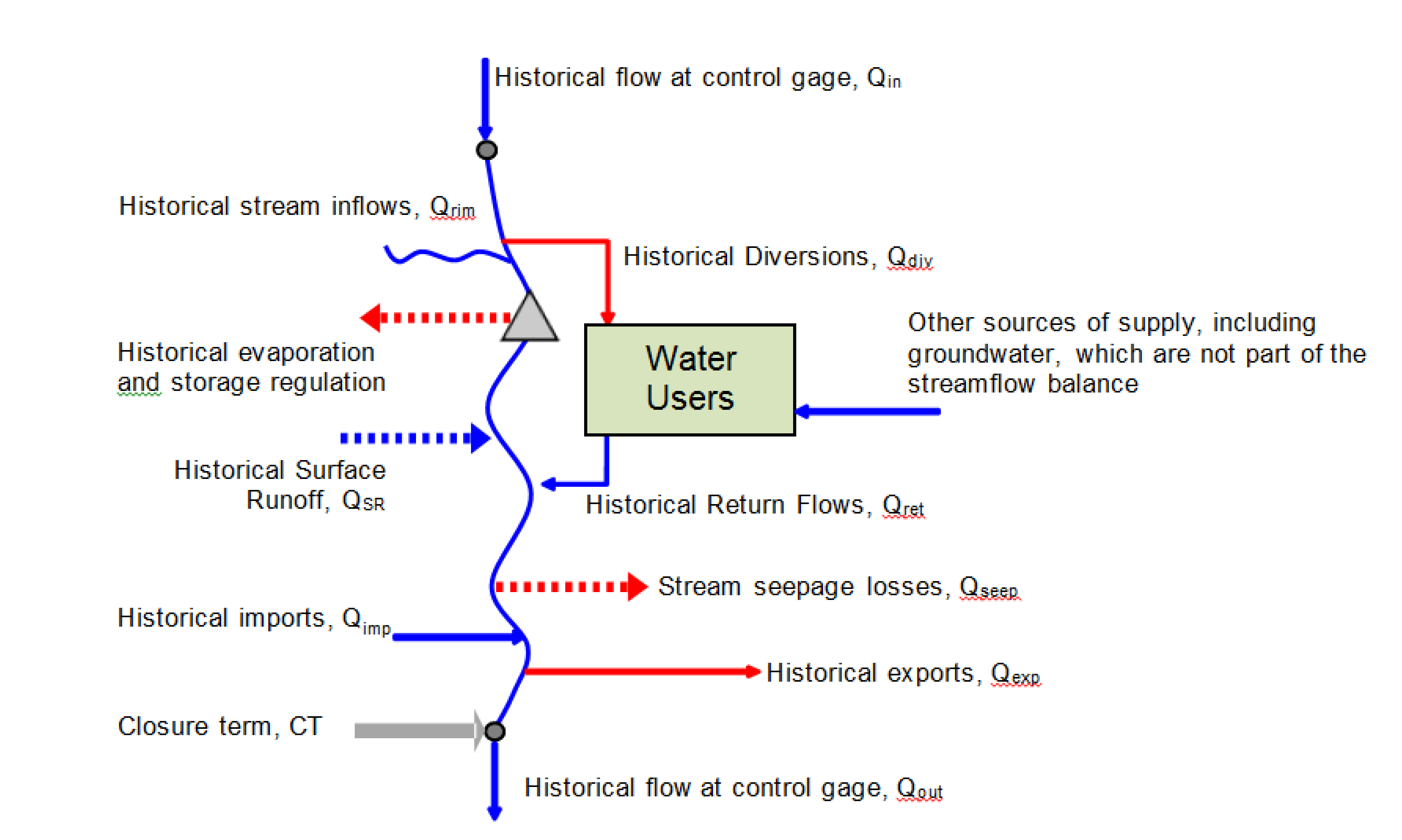
CN Sensitivity Analysis

	10 yr avg Annual (TAF)			
CS3 Water Balanace Term	- 2% CN	Original CN	+2% CN	+4% CN
Rim Inflow	16800	16800	16800	16800
Boundary Inflow (internal)	5557	5558	5558	5557
Import	855	855	855	855
Surface Runoff to Internal Stream	**2101**	**2314**	**2556**	**2949**
Return	1895	1895	1896	1896
Stream Gain from Groundwater	**31**	**-99**	**-253**	**-464**
Total Inflow	27240	27322	27410	27592
Inflow to Delta	**21499**	**21581**	**21666**	**21849**
Diversions to WBA, export , Loss	5298	5300	5301	5304
Reservoir ET	516	516	516	516
Reservoir Storage Change	-73	-75	-73	-76
Total Outflow	27240	27322	27410	27592
Inflow	27240	27322	27410	27592
Outflow	27240	27322	27410	27592
Diff	0.0	0.0	0.0	0.0

Model Calibration Process – 2

Generating Closure Term using the Data Assimilation Model

What is Closure Term? → stream inflow adjustments



Model Calibration Process – 2

Generating Closure Term using the Data Assimilation Model

Historical Water Balance:

$$\text{Closure Term} = Q_{out} + Q_{exp} + Q_{div} + Q_{seep} + E + \Delta S - Q_{in} - Q_{rim} - Q_{ret} - Q_{imp} - Q_{SR}$$

Same model

But adding Closure Terms to the Continuity Equations

```
goal continuitySAC265    {C_SAC269 + SG223_SAC265_37 + SR_03_SAC265 - C_SAC265
goal continuitySAC259    {C_SAC265 + SG224_SAC259_37 + SG227_SAC259_39 - C_SAC259
goal continuitySAC257    {C_SAC259 + SR_02_SAC257 + CT_BendBridge - C_SAC257
goal continuitySAC254    {C_SAC257 + SG228_SAC254_39 - C_SAC254
goal continuitySAC250    {C_SAC254 + SG229_SAC250_39 + C_PYN001  - C_SAC250
```

Model Calibration Process – 2
Generating Closure Term using the Data Assimilation

Assimilated Output

- Consistent Flow Conditions:
  - Channel Flow → **soft Constrains w medium penalties (9999)**
  - Diversions → **Soft Constrains w/ high penalties for summer when simulate diversion is higher than Observed**
  - Spill from Weirs
  - Reservoir Storage
  - Reservoir Release

    } **Soft Constrains w/ highest penalties (penalties = 99999)**
  - Return Flow → **Simulated based on reuse factor**
  - Stream Gain/Loss → **Model Coupling Correction**
  - Conveyance Losses → **Simulated based on Conveyance Losses factors**
  - Closure Term → **Generated as CT will complete the water balance**
    Soft Constrain w small penalties to push CT=0

Q & A

Adjust Water Use efficiency factors
Example: Richvale ID; Biggs-West Gridley, Butte WD; Sutter Extension WD

Demand Unit: 11_SA2, 11_SA3, and 11_SA4

- **Rice dominated --- 70% of crop land is rice (69679Acres Rice/ 98397 Acres)**
- **Small private wetland – 2855 Acres**

	LFF	DPF	OSF	EVF	RUFO	RUFR	RUFW	RP	MinGW
11_SA2	0.06	0.03	0.05	0.01	0.1	0.5	0.15	0.05	0
11_SA3	0.03	0.13	0.03	0.01	0	0.1	0.15	0.1	0.09
11_SA4	0.07	0.05	0.07	0.01	0	0.1	0.15	0.1	0.04

Adjust Water Use efficiency factors
Example: Richvale ID; Biggs-West Gridley, Butte WD; Sutter Extension WD

Demand Unit: 11_SA2, 11_SA3, and 11_SA4
Summer (Apr – Sep) total simulated diversion = 452 TAF → 11% less than observed
Summer (Apr – Sep) total observed diversion = 508 TAF