Climate Change Impacts on Water and Agriculture in the Sacramento and San Joaquin Basins

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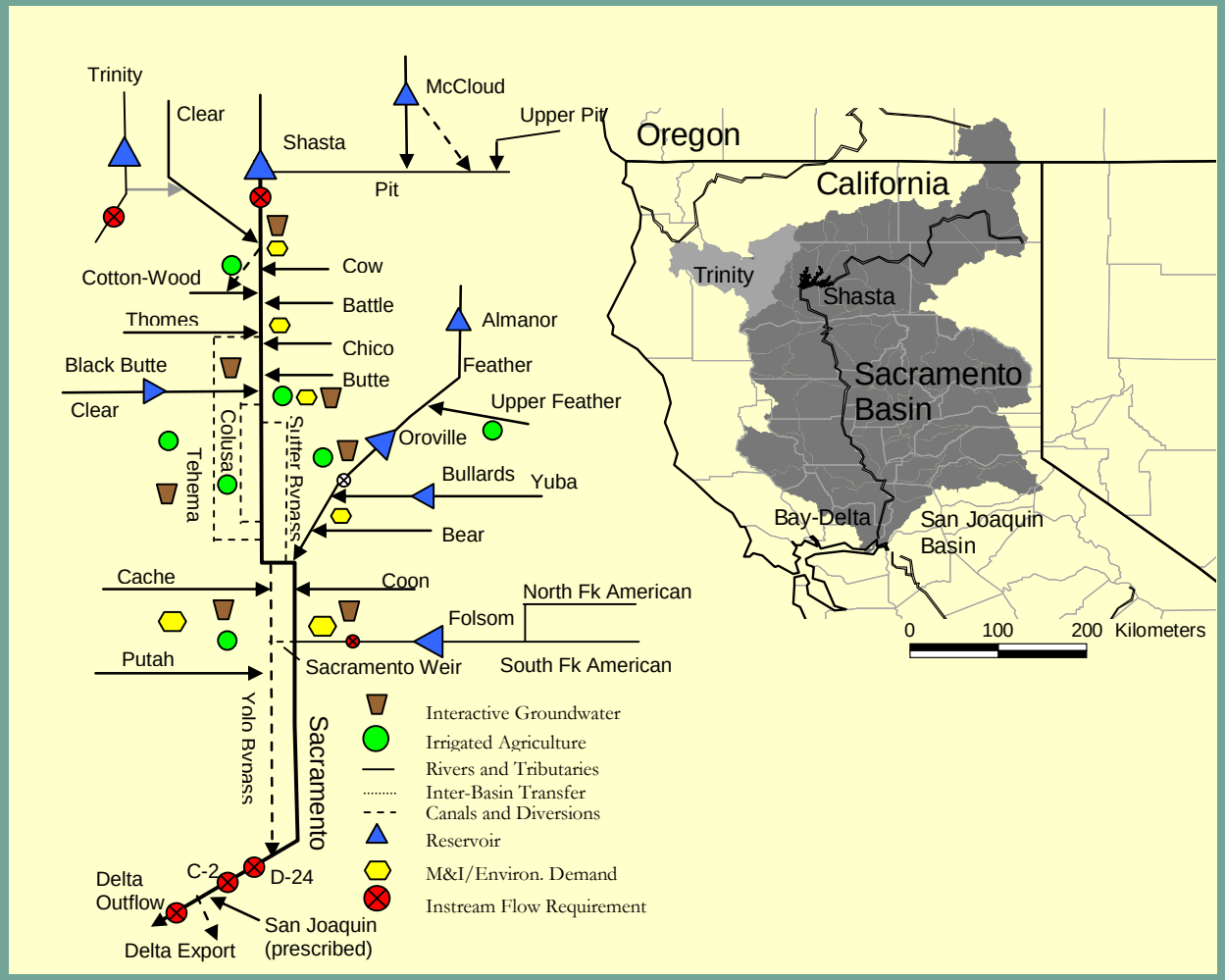
Overview

- Old and new studies of Valley hydrology and agriculture
- Properties of the model
  - Simulation
  - Transparent structure—hydrology and managed system
  - Main features covered (San Joaquin, East side and Delta)
- Output of model
  - Inflows (earlier)
  - Droughts (possibly more frequent)
  - Crop demands (rising)
  - Exports (falling)
  - Groundwater (falling)
  - Crop adaptation

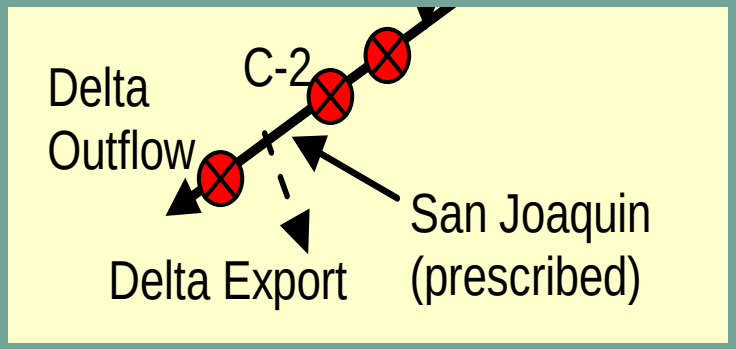
Sacramento Valley WEAP Model



Sacramento, Western San Joaquin and Tulare Basins

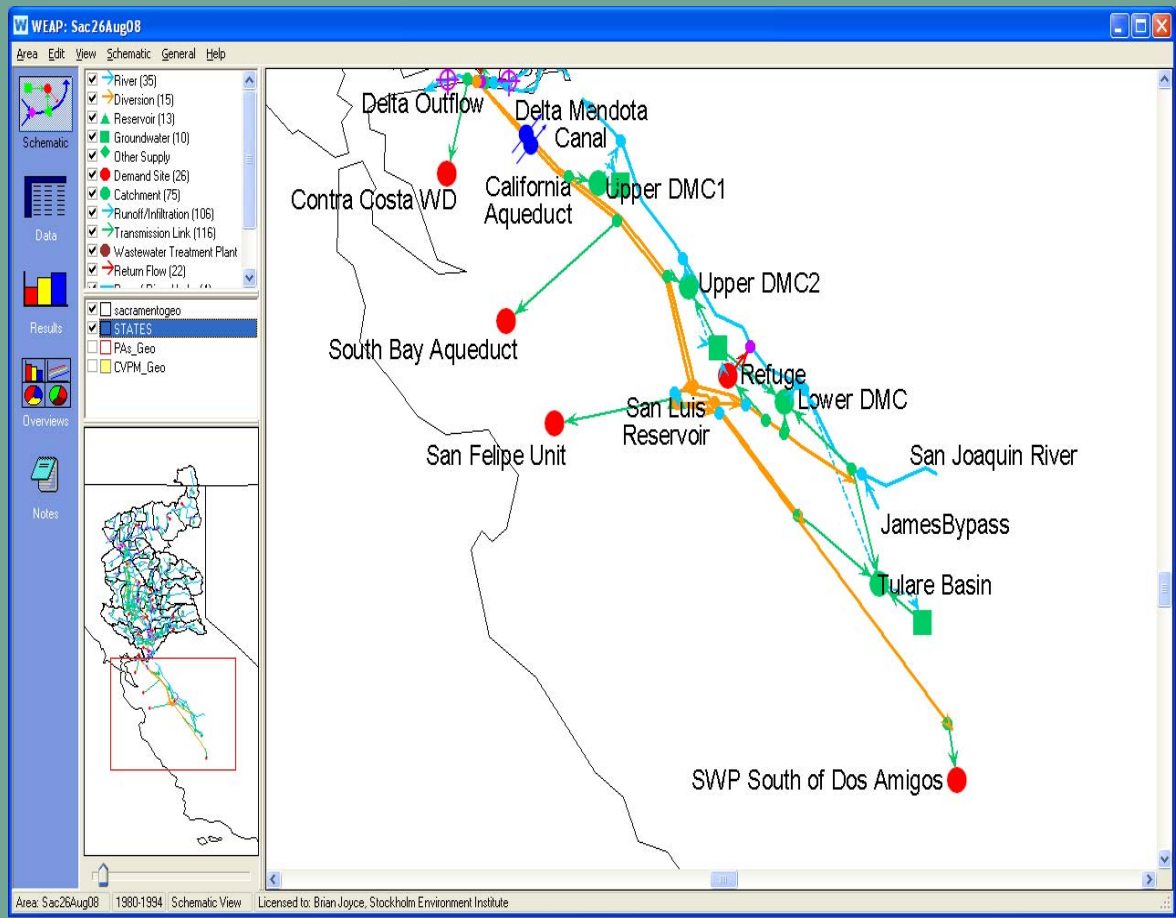
Sacramento-San Joaquin Delta

- Sacramento Valley WEAP model:
  - Fixed San Joaquin River inflows to historical time series
  - Fixed Delta exports to historical time series

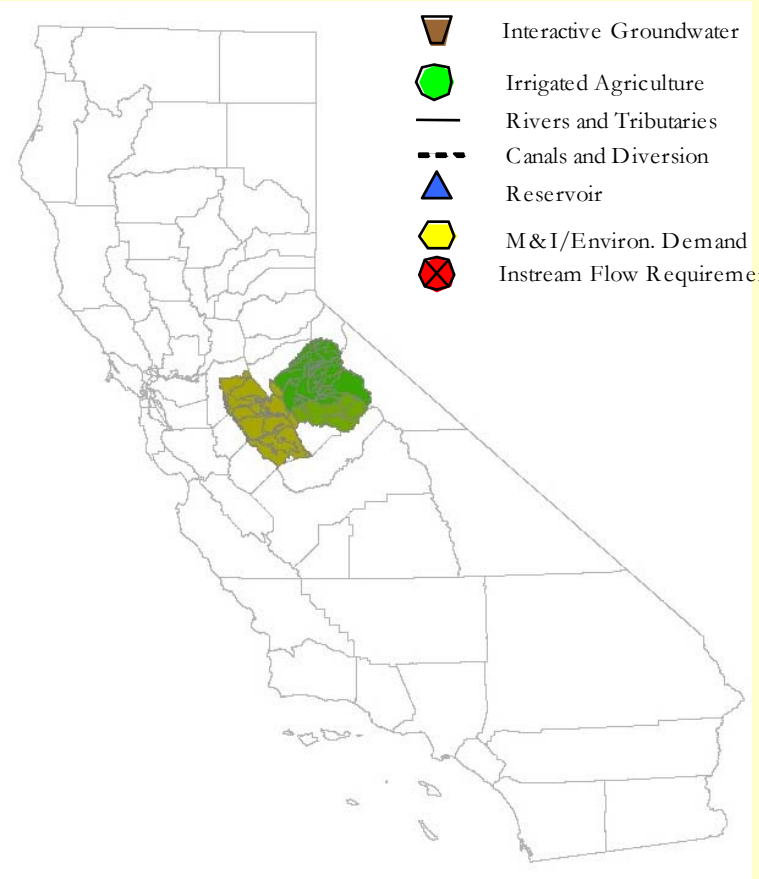


Adding Westside San Joaquin Demands

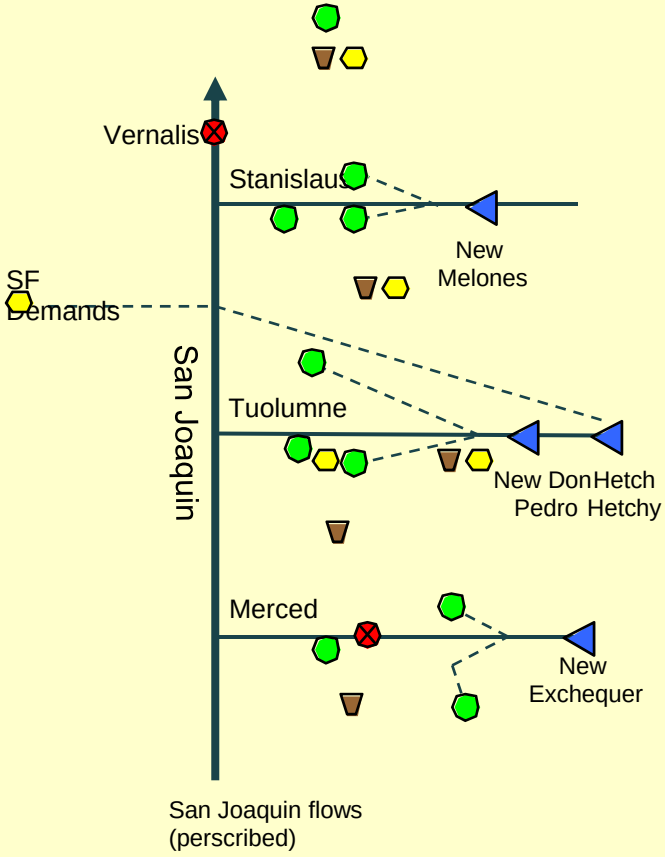
- Disaggregates delta exports to principal agricultural and M&I demand areas
- Agricultural demands are climate driven
- Includes main infrastructural components: California Aqueduct, Delta-Mendota Canal, San Luis Reservoir.



Adding East Side San Joaquin Demands, the Stanislaus, Tuolumne, Merced River Basins

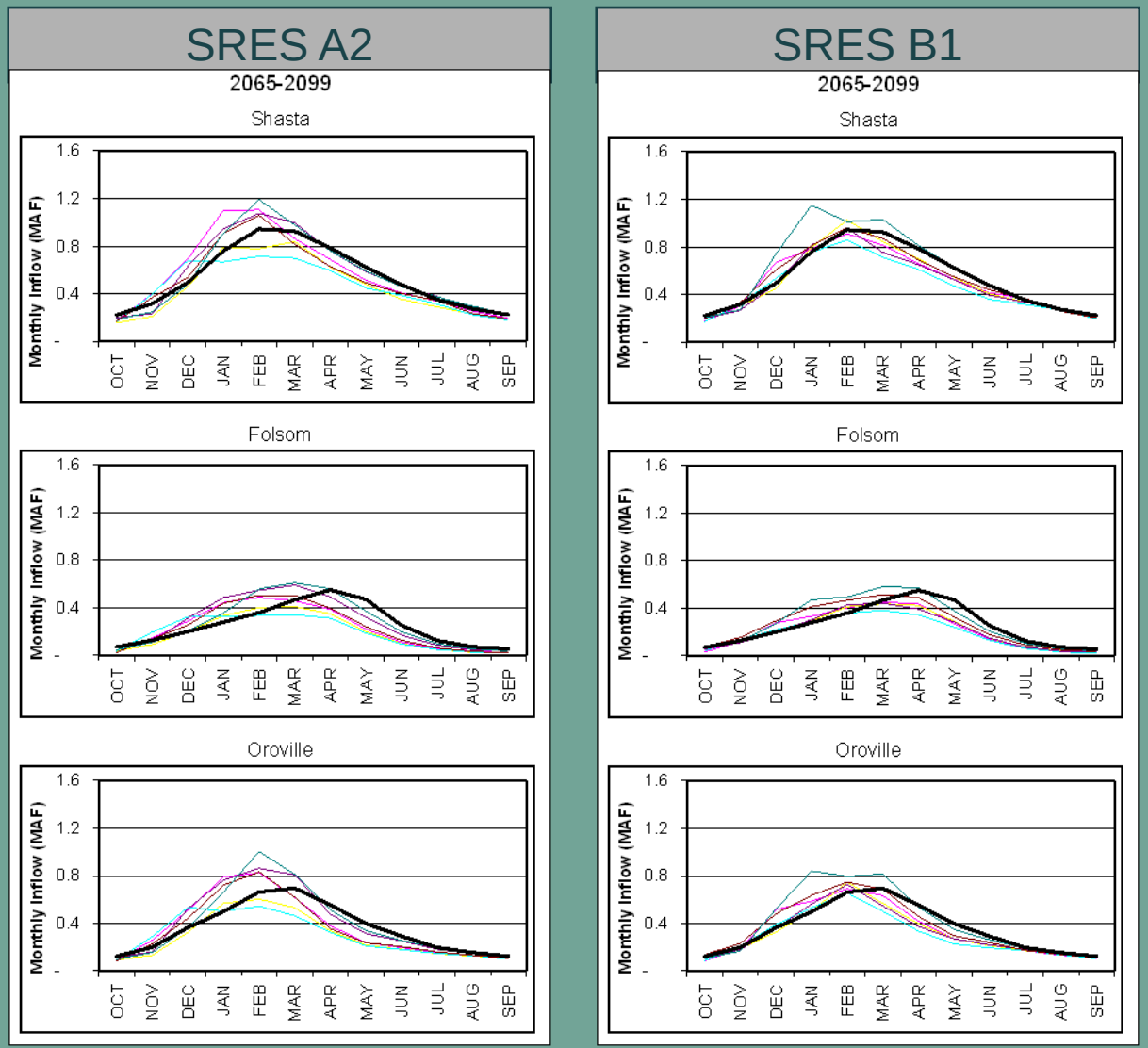


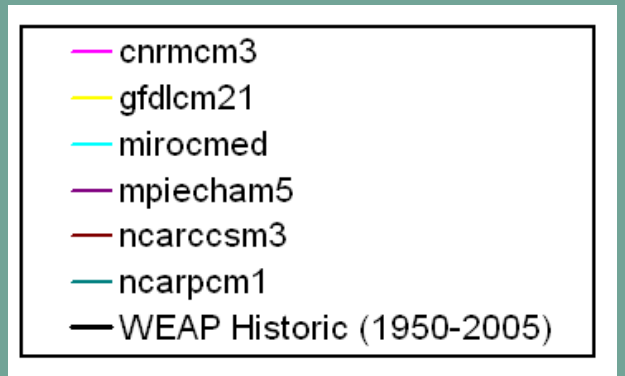
Simplified schematic:



Reservoir Inflows 2065-2099

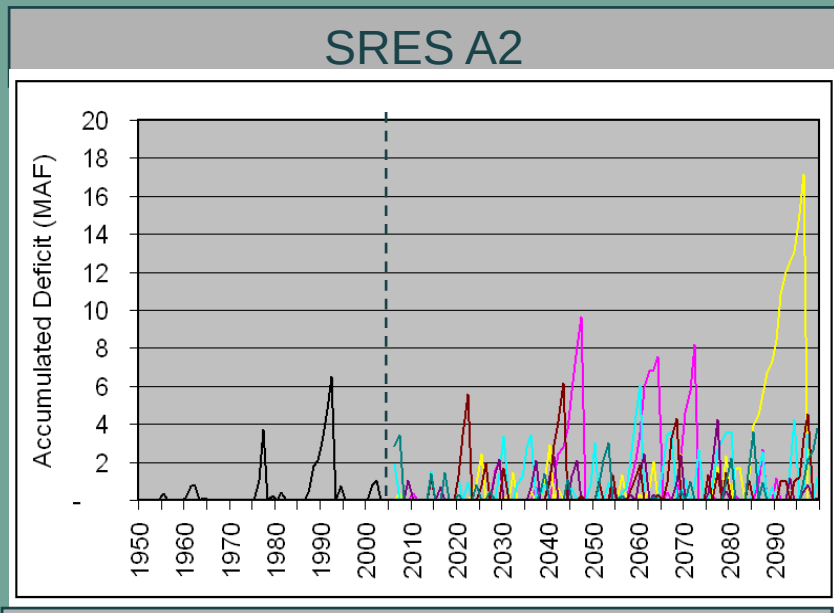
- Earlier runoff into reservoirs by end of century
- Annual runoff volume about the same

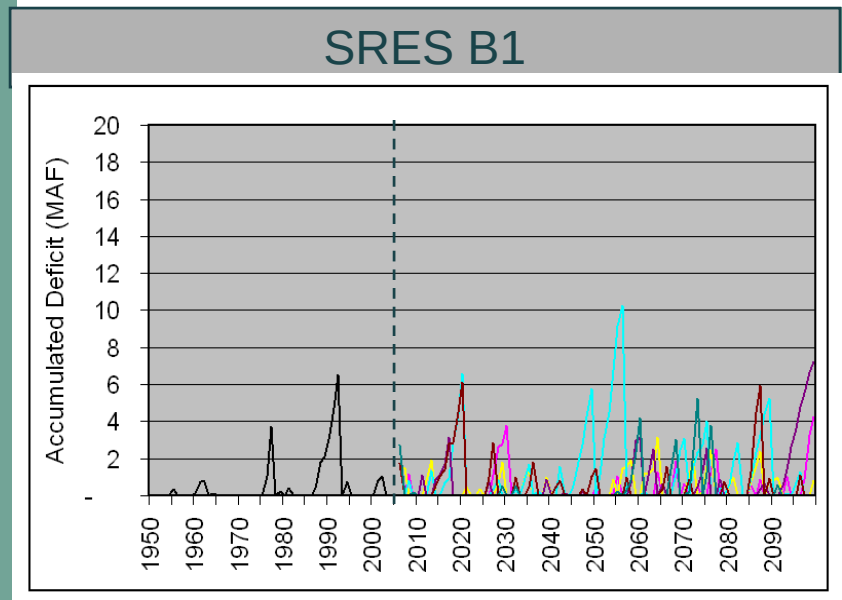


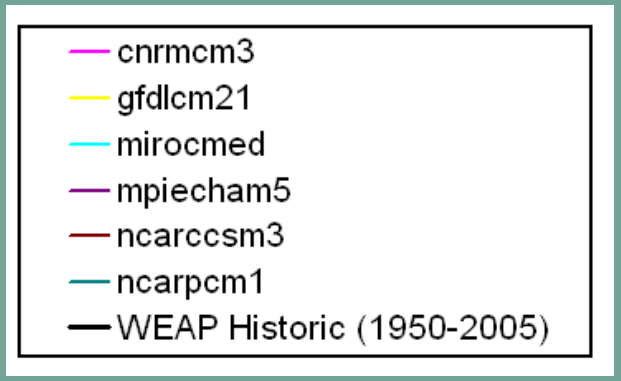


Accumulated Deficits for Sacramento Valley Rivers

- Accumulated deficits suggest stronger drought signals with certain scenarios





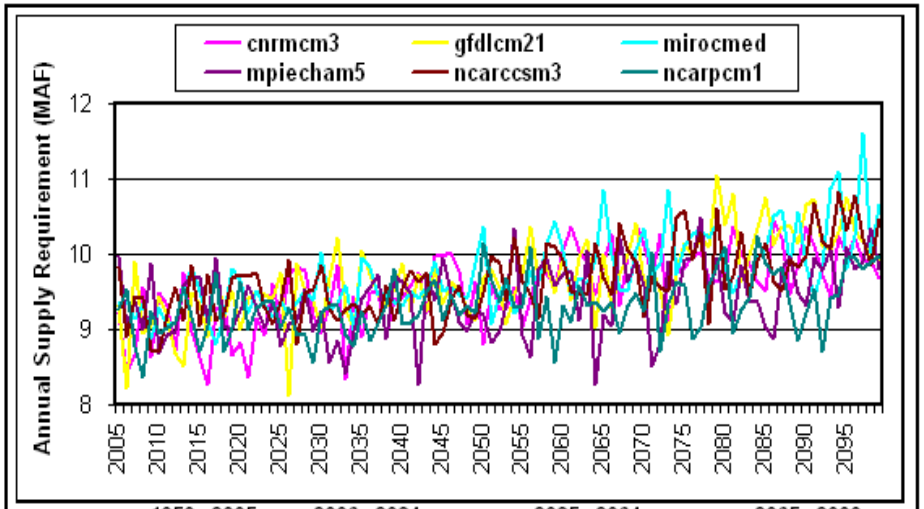


Supply Requirements Sacramento Valley

- Increasing agricultural demands for A2 (~10%) and B1 (~7%) by end of century

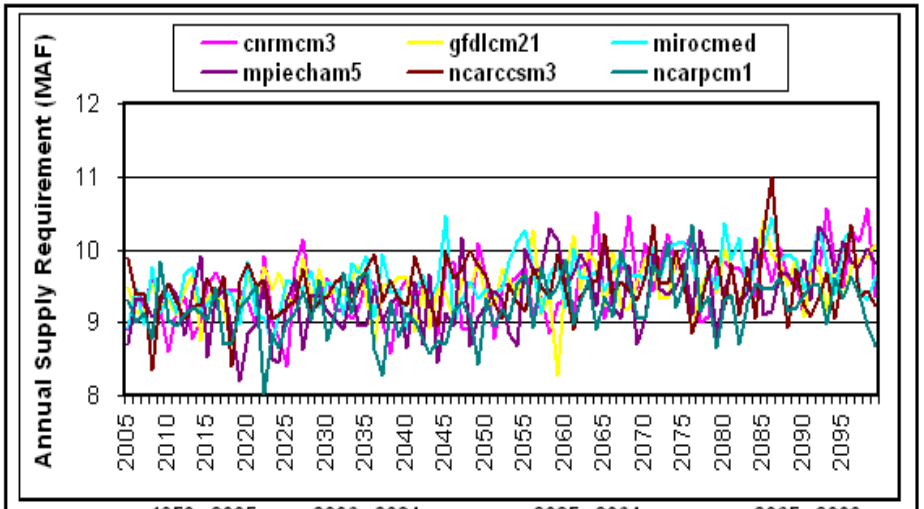
Sacramento Valley Agriculture

SRES A2



	1950 - 2005	2006 - 2034		2035 - 2064		2065 - 2099	
	average (maf)	average (maf)	difference (%)	average (maf)	difference (%)	average (maf)	difference (%)
cnrmcm3	8.98	9.10	1%	9.55	6%	9.90	10%
gfdlcm21	9.09	9.27	2%	9.61	6%	10.13	11%
mirocmed	9.08	9.34	3%	9.65	6%	10.16	12%
mpiecham5	9.10	9.17	1%	9.37	3%	9.61	6%
ncarccsm3	9.09	9.36	3%	9.53	5%	9.99	10%
ncarpcm1	9.10	9.10	0%	9.34	3%	9.48	4%

SRES B1



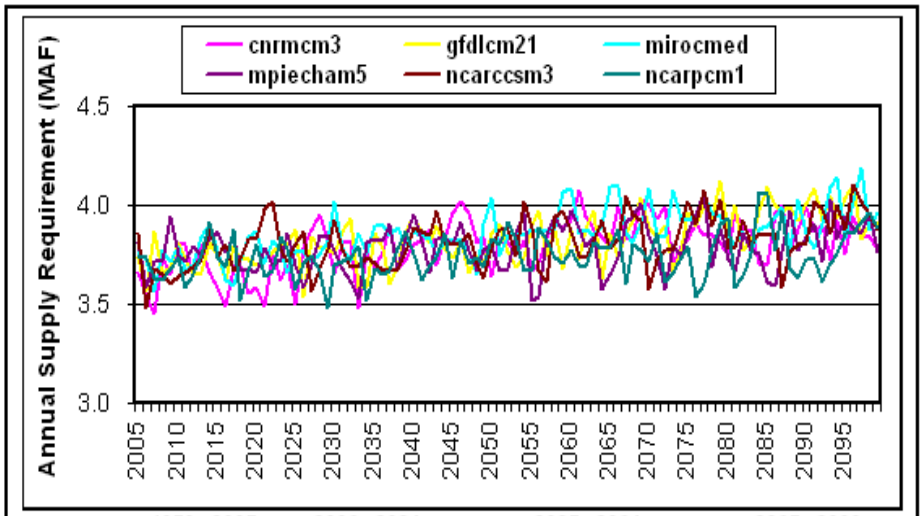
	1950 - 2005	2006 - 2034		2035 - 2064		2065 - 2099	
	average (maf)	average (maf)	difference (%)	average (maf)	difference (%)	average (maf)	difference (%)
cnrmcm3	9.08	9.27	2%	9.41	4%	9.75	7%
gfdlcm21	9.09	9.38	3%	9.46	4%	9.63	6%
mirocmed	9.08	9.38	3%	9.58	5%	9.81	8%
mpiecham5	9.07	9.13	1%	9.35	3%	9.60	6%
ncarccsm3	9.06	9.33	3%	9.50	5%	9.58	6%
ncarpcm1	9.07	9.11	0%	9.12	1%	9.37	3%

Supply Requirements Westside San Joaquin

- Increasing agricultural demands for A2 (~6%) and B1 (~5%) by end of century

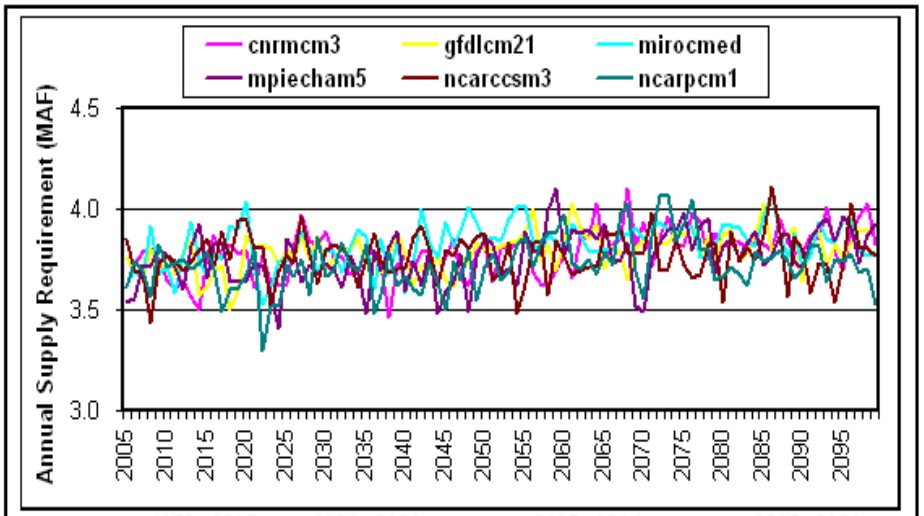
San Joaquin Valley Agriculture

SRES A2



	1950 - 2005	2006 - 2034		2035 - 2064		2065 - 2099	
	average (maf)	average (maf)	difference (%)	average (maf)	difference (%)	average (maf)	difference (%)
cnrmcm3	3.67	3.68	0%	3.83	4%	3.86	5%
gfdlcm21	3.68	3.74	2%	3.80	3%	3.93	7%
mirocmed	3.68	3.76	2%	3.86	5%	3.94	7%
mpiecham5	3.68	3.74	2%	3.79	3%	3.82	4%
ncarccsm3	3.67	3.75	2%	3.81	4%	3.88	6%
ncarpcm1	3.67	3.70	1%	3.75	2%	3.78	3%

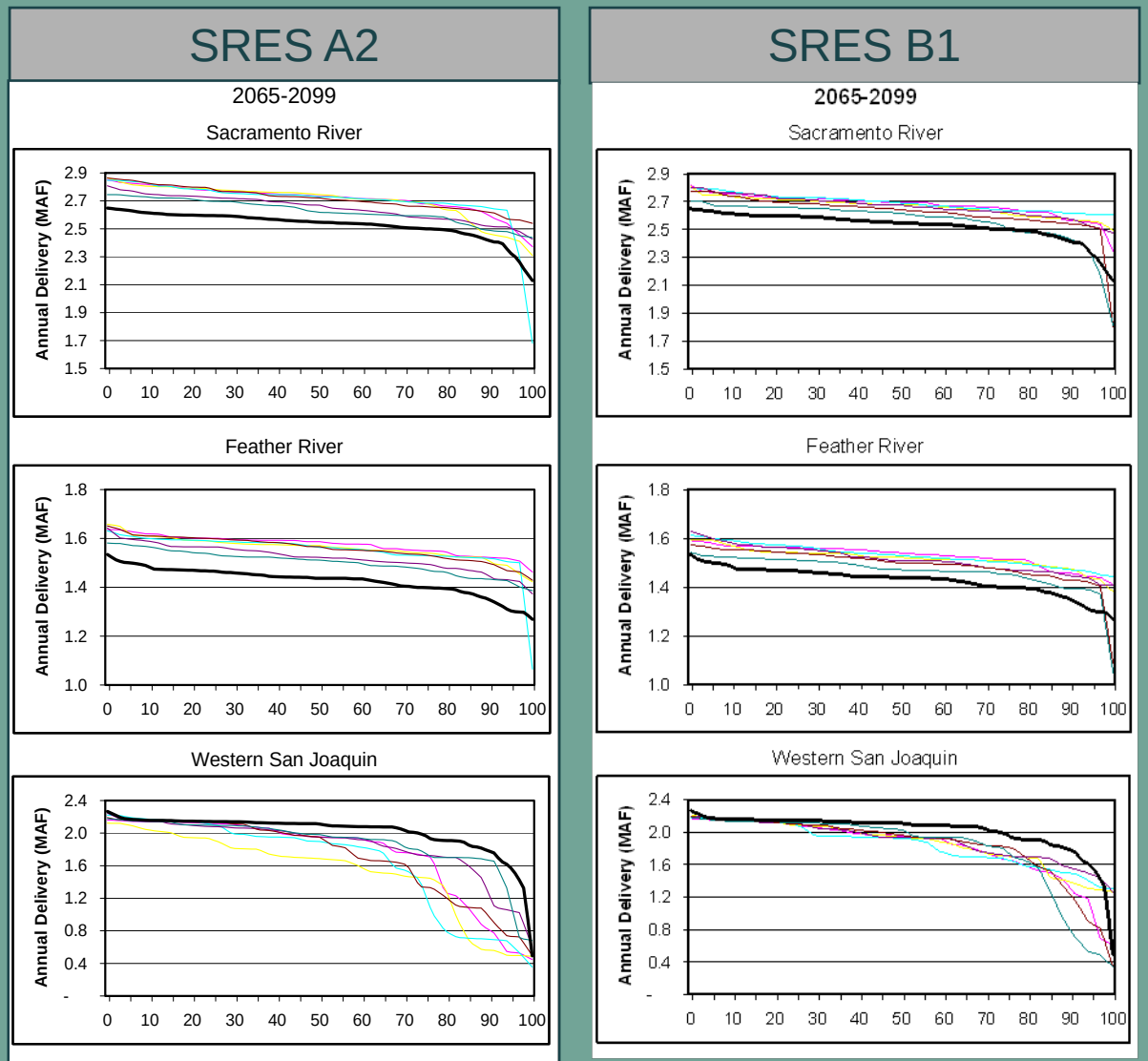
SRES B1

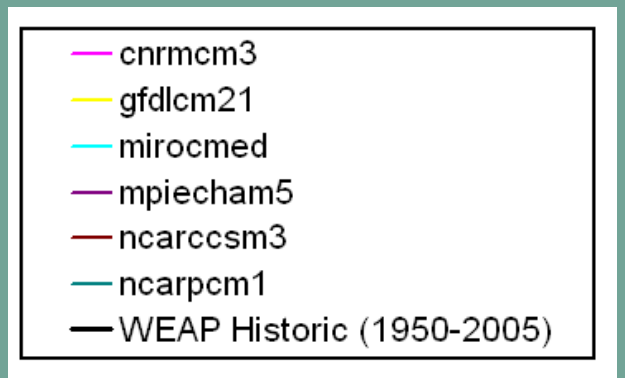


	1950 - 2005	2006 - 2034		2035 - 2064		2065 - 2099	
	average (maf)	average (maf)	difference (%)	average (maf)	difference (%)	average (maf)	difference (%)
cnrmcm3	3.68	3.73	2%	3.75	2%	3.86	5%
gfdlcm21	3.68	3.74	2%	3.79	3%	3.83	4%
mirocmed	3.67	3.76	2%	3.85	5%	3.86	5%
mpiecham5	3.67	3.71	1%	3.76	3%	3.82	4%
ncarccsm3	3.66	3.75	3%	3.75	2%	3.79	3%
ncarpcm1	3.67	3.68	0%	3.71	1%	3.78	3%

Agricultural Deliveries 2065-2099

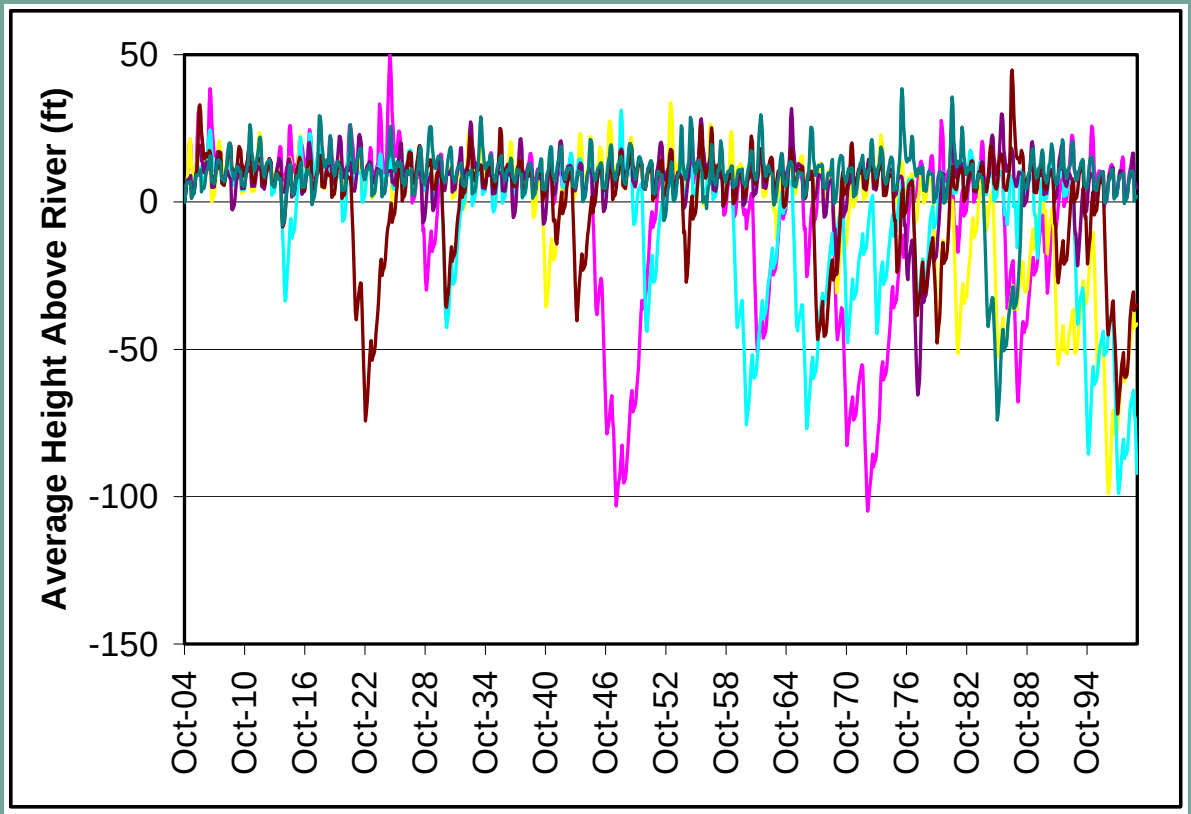
- Higher consumptive water use in Sacramento Valley may restrict delta exports



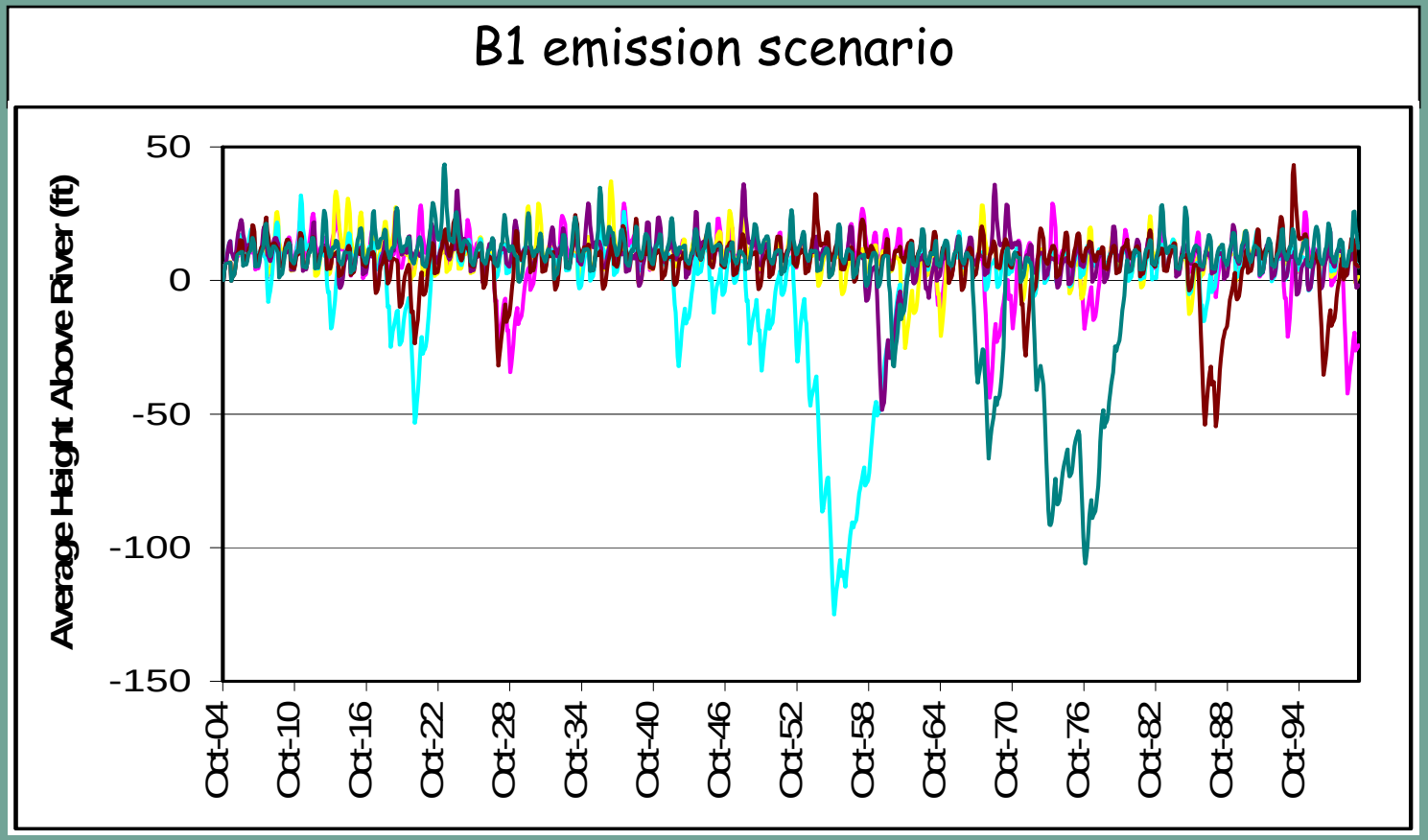


Average groundwater depths in the western San Joaquin Valley

A2 emission scenarios



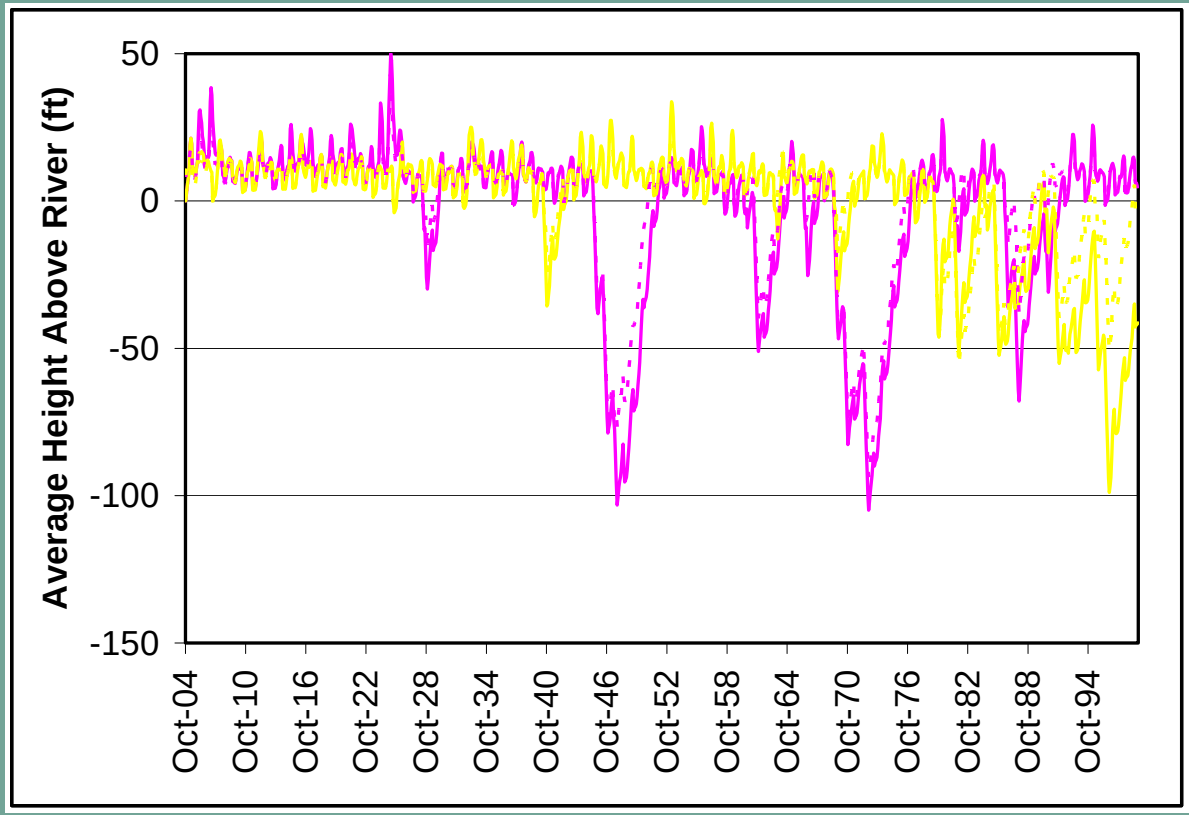
Average groundwater depths in the western San Joaquin Valley



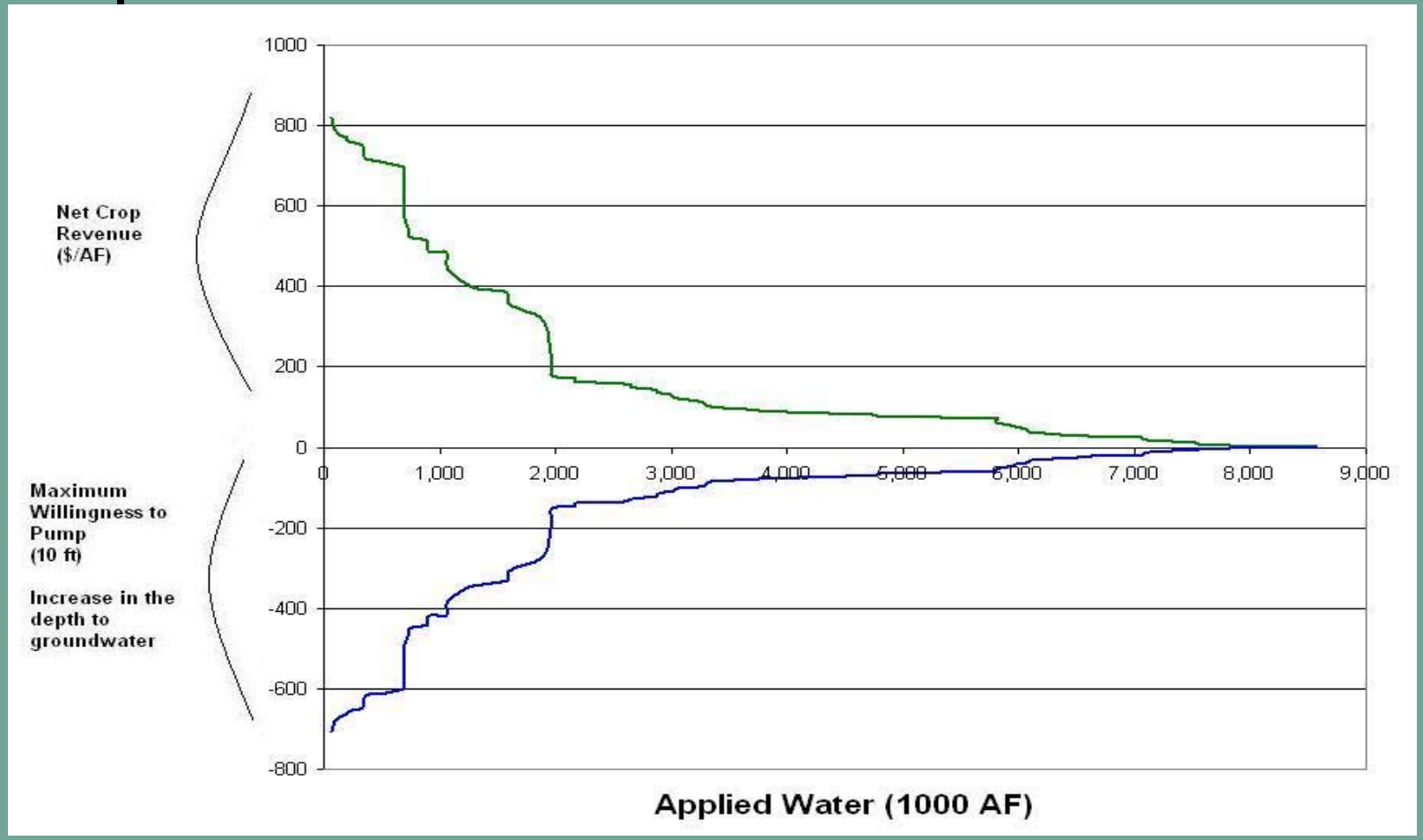
Average groundwater depths in the western San Joaquin Valley

A2 emission scenarios

- Cropping shifts reduce groundwater drawdown by reducing crop water demands



Crop response:
…to lower Groundwater Levels



Crop limits to groundwater depth.
Maximum depth willing to pump, inferred @ .08/kWh

Conclusions

- WEAP model directly evaluates future climate scenarios.
- Estimates increases in water demand associated with higher temperatures.
  - Indicates higher crop water requirements above the Delta
  - Lower exports and deliveries to the San Joaquin Valley
  - Lower groundwater levels.
- Cropping will adapt to changing hydrology

CVPM Response Functions

Estimation Technique

Generate multiple CVPM model outputs:

- base water supply and groundwater depth,
- 10% -20% decrease from base water supply
- 100 –200 foot drop in the groundwater depth
- Model runs provide multiple estimates of crop shares across a range of regional, water supply and groundwater depth inputs.

CVPM Response Function

Multinomial Logit coefficients

	Cereal B1	Orchard B2	Pasture B3	Row B4	Rice B5
Depth (ft)	-0.004	-0.004	-0.005	-0.005	-0.004
Percent supply	6.225	5.992	6.799	6.568	5.999
region 3	-1.287	-2.473	-1.569	0.609	-0.414
region 4	-0.130	-1.412	-2.201	0.681	0.111
region 5	-1.361	-0.405	-1.518	0.931	-2.074
constant	-2.683	-2.235	-3.481	-3.817	-3.074

Obs.	173597
Log Likelihood	-2.592
Outcome	Fallow is the comparison crop.

Accuracy of Response Function

Logit verses historical crop shares

Historic Crop Shares

Year	Cereals	Orchard	Pasture	Rice	Vegetables	Fallow
1989	24.0%	21.5%	17.5%	33.9%	3.1%	0.0%
1990	26.3%	21.7%	16.9%	30.7%	3.0%	0.9%
1991	22.8%	22.6%	18.7%	26.1%	2.3%	5.5%
1992	22.4%	24.1%	17.9%	31.2%	1.6%	2.0%
1993	25.5%	25.2%	20.0%	37.8%	2.0%	-7.6%

Predicted Crop Shares

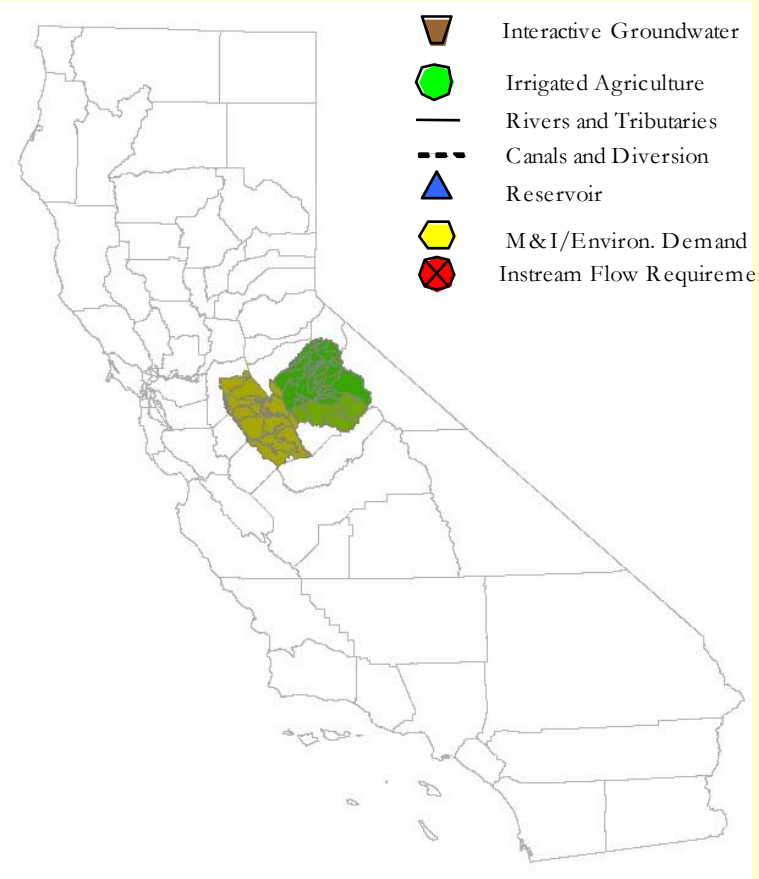
Year	Cereals	Orchard	Pasture	Rice	Vegetables	Fallow
1989	23.7%	21.2%	17.4%	33.6%	3.1%	1.0%
1990	23.8%	21.6%	17.0%	33.2%	3.1%	1.3%
1991	23.7%	22.5%	15.0%	30.8%	3.2%	4.7%
1992	23%	23%	14%	30%	3%	7%
1993	24%	22%	16%	32%	3%	3%

Estimation Error, Predicted Minus Historic Crop Shares

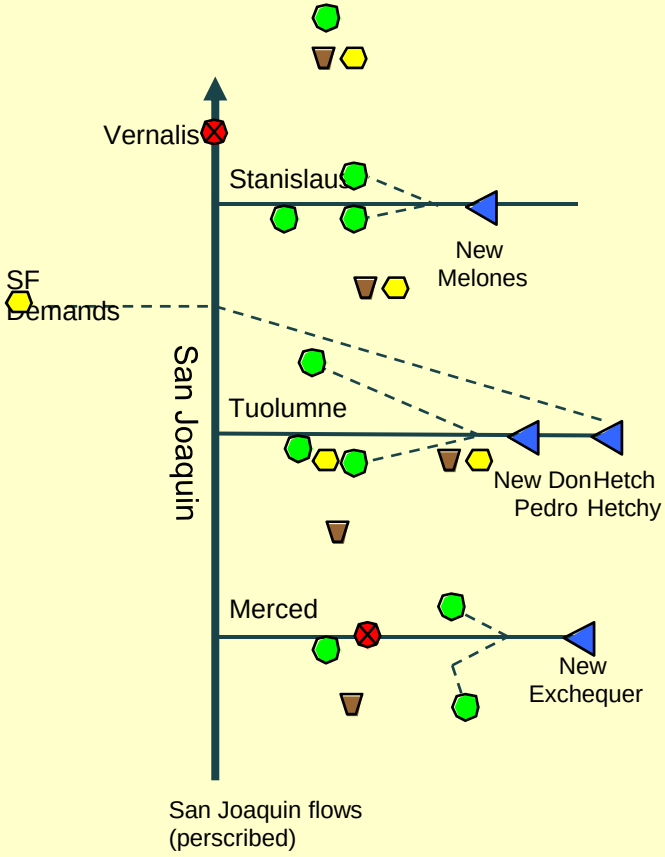
Year	Cereals	Orchard	Pasture	Rice	Vegetables	Fallow
1989	-0.2%	-0.2%	-0.2%	-0.3%	0.0%	1.0%
1990	-2.5%	-0.1%	0.0%	2.5%	0.1%	0.4%
1991	0.9%	-0.1%	-3.7%	4.7%	0.9%	-0.8%
1992	0.9%	-1.5%	-3.7%	-1.5%	1.6%	4.9%
1993	-1.6%	-2.9%	-4.2%	-6.0%	1.2%	10.7%

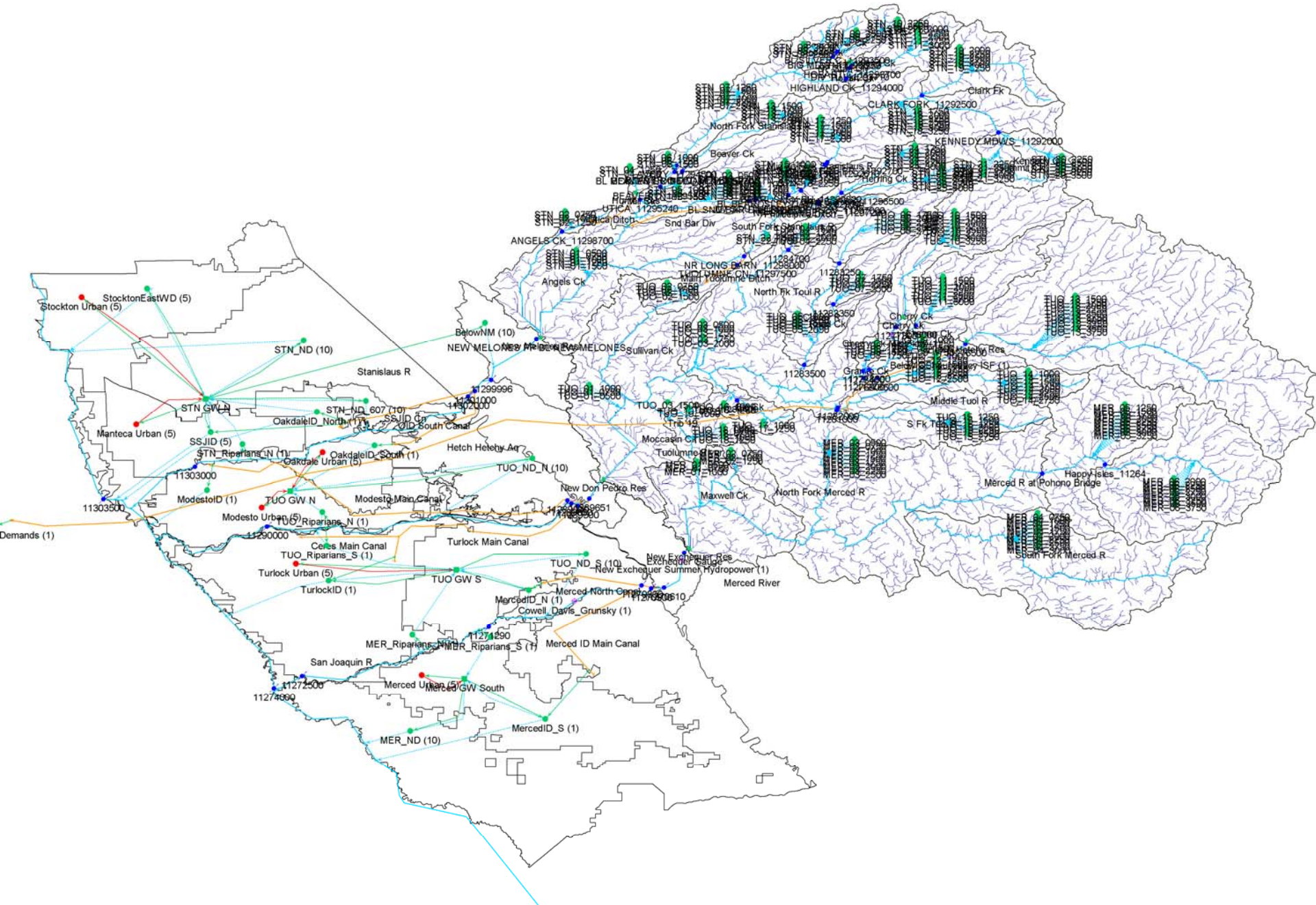
Source:
Historic crop shares from County Agricultural Commissioner Reports for Glenn and Colusa County.
Predicted shares from logit model crop share equations, calibrated to fit Glenn and Colusa Coutny 1989 crop shares

Stanislaus, Tuolumne, and Merced River Basins



Simplified schematic:





HIGHLAND CK_11294000
Clark Fk
CLARK FORK_11292500
KENNEDY MDWS_11292000
North Fork Stanislaus R
Beaver Ck
Herring Ck
UTICA_11295240
Utica Ditch
Snd Bar Div
South Fork Stanislaus R
ANGELS CK_11298700
Angels Ck
NR LONG BARN_11298000
Main Tuolumne Ditch
North Fk Toul R
Cherry Ck
Sullivan Ck
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StocktonEastWD (5)
BelowNM (10)
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OID South Canal
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Exchequer Gauge
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San Joaquin R
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Merced GW South
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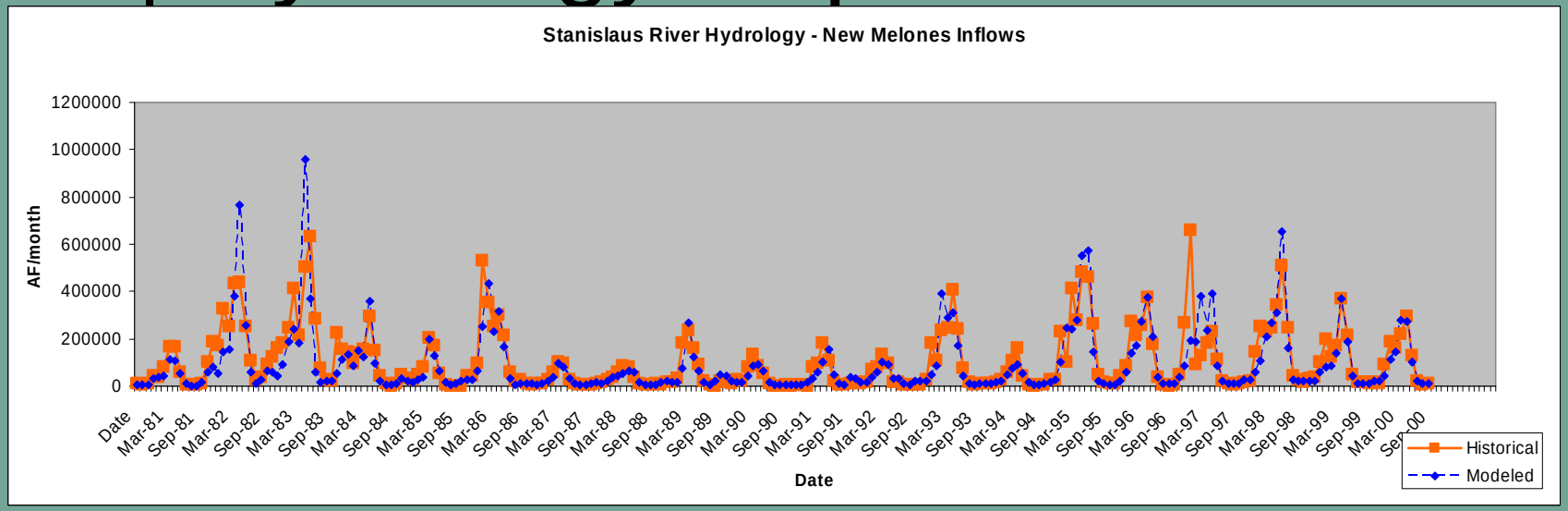
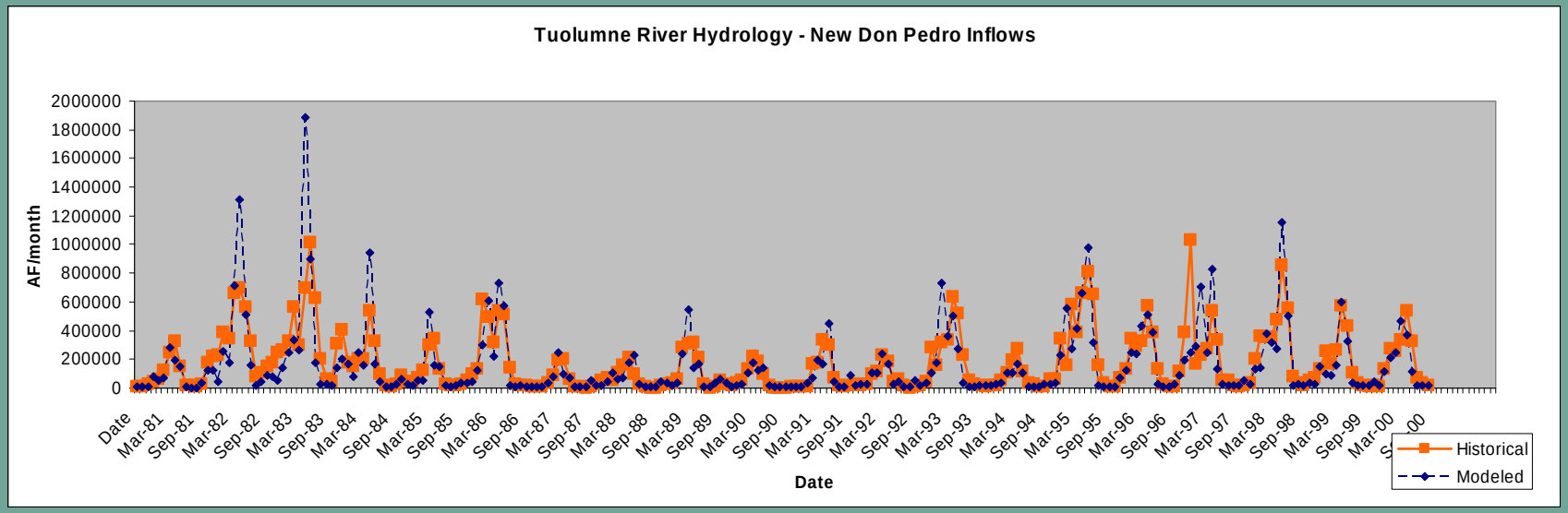
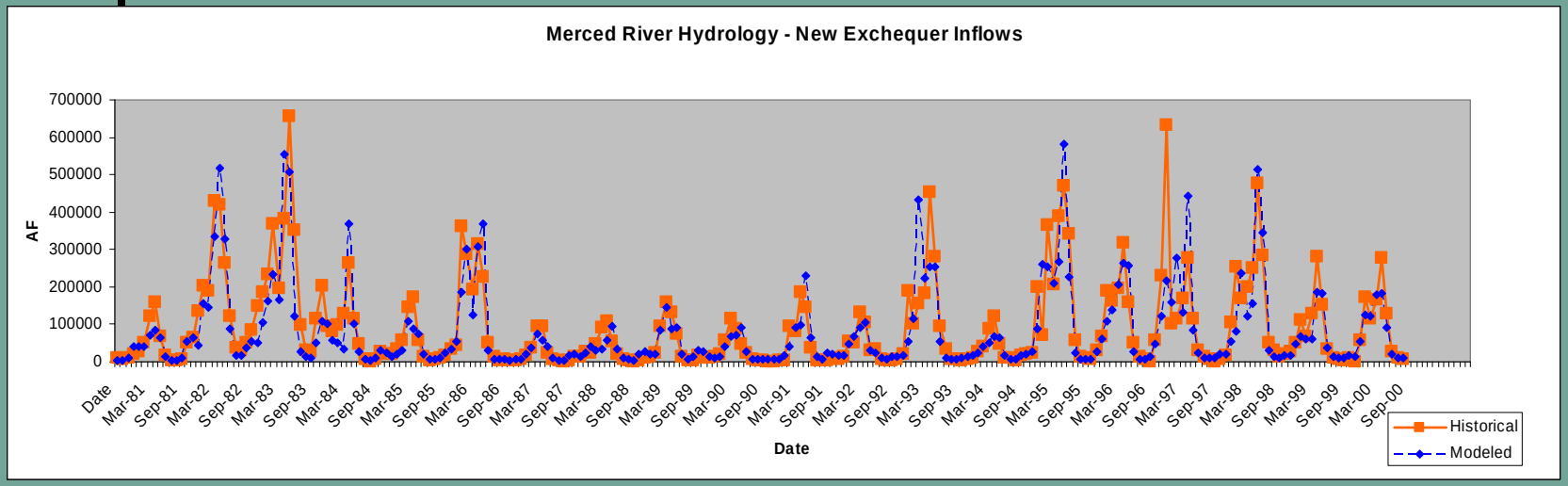
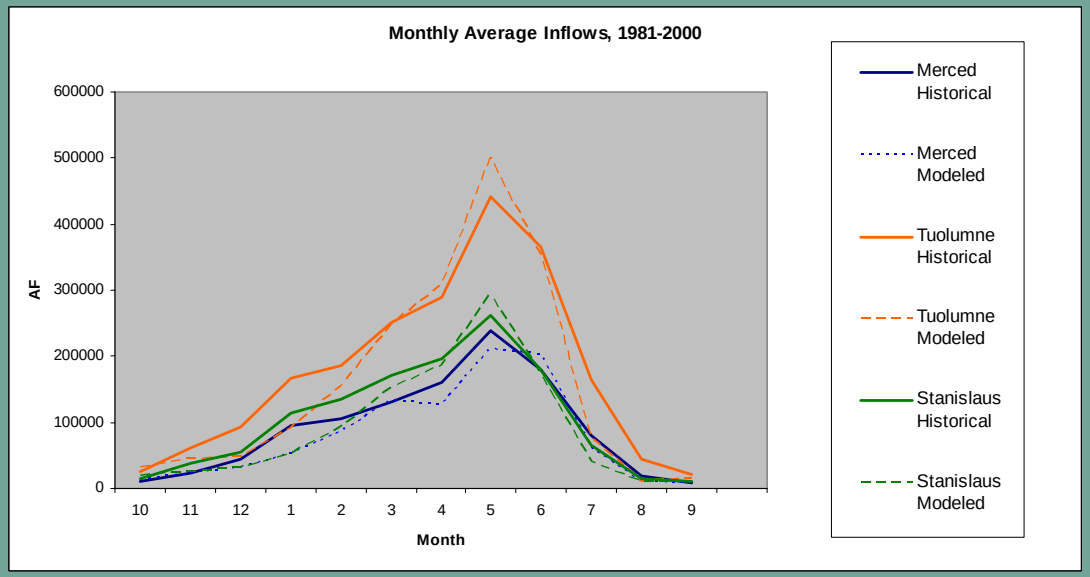
Middle Tuol R
S Fk Tuol R
Moccasin Ck
Tuolumne River
Maxwell Ck
North Fork Merced R
Merced R at Pohono Bridge
Happy Isles_11264
South Fork Merced R

Hydrology Representation





Hydrology Representation